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# Impact of STCW 95 on marine engineering education and training in India

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# IMPACT OF STCW 95 ON MARINE ENGINEERING EDUCATION AND TRAINING IN INDIA.

By

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# DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred to me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.


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# ABSTRACT

Today the implementation of the revised STCW Convention is the buzzword in Maritime Training Institutes. The competence of seafarers is a critical factor in the safe and efficient operation of ships. Unlike in other professions, i.e. medicine, engineering, and law, marine engineering education and training is not uniform in a number of countries including the developed ones. It is mainly due to the traditional method of training and the cyclic nature in the demand for marine engineers. Considering all aspects, i.e. safety, operation, safety to environment, providing a standard education and training systems for engineers has now become essential.

In India a number of different systems of education and training are prevalent for engineers taking up a career at sea. The dissertation examines the existing state of marine engineering education and training in India. The main changes to the STCW Convention are identified and current model course programs relevant to MET are evaluated. A number of MET systems covering marine engineering training in other countries are examined and analysed. This paper analyses the different systems of marine engineering education and training in the light of revised STCW Convention focusing on fundamental knowledge requirements for the certification of marine engineers. It then proposes corrective measures (short courses) to those who are falling short of the mandatory requirements.

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| | |
|---|---|
| AFFC | Advance Fire Fighting Course |
| AMC | Australian Maritime College. |
| AMSA | Australian Maritime Safety Authority |
| B.E | Bachelor of Engineering. |
| HND | Higher National Diploma. |
| ILO | International Labour Organisation. |
| IMO | International Maritime Organisation. |
| ISM | International Safety Management. |
| IST | Institute of Sea Training |
| MERI | Marine Engineering and Research Institute. |
| MET | Maritime Education and Training. |
| MMA | Merchant Marine Academy. |
| MMD | Mercantile Marine Department. |
| MSA | Marine Safety Administration. |
| NVQ | National Vocational qualification. |
| OND | Ordinary National Diploma. |
| STCW | Seafarers' Training, Certification and watchkeeping. |
| UK | United Kingdom. |
| USA | United States of America. |

# CHAPTER 1

## Introduction

### 1.1 Background

India is one of the major maritime nations in the world today. Apart from shipping, it is engaged in ship construction, ship repairing, dredging, off-shore drilling and many other allied activities. It has a large number of major and minor ports. For efficient functioning of the entire maritime field it requires well-educated, competent and dedicated personnel. Realising the need for trained personnel, Government of India took the decision of establishing its own Maritime Training Institutes soon after its independence. Thus the Directorate of Marine Engineering training (DMET) in Calcutta with a branch office in Bombay was established in 1948. The main aim of this institute is to ensure the availability of well trained engineer officers in the maritime sector

The shipping industry in India witnessed phenomenal growth in the late sixties and early seventies and that created a severe shortage of marine engineers in the industry. The high demand for well trained officers could not be met by the DMET alone. It was then decided to introduce another training scheme which allowed mechanical and electrical engineers to enter the marine engineering profession. The training programme was made short and flexible in order to overcome the shortage of marine engineers in shipping industry. The training programme for graduate engineers was a success and popular in the industry. Apart from these two main schemes the traditional training, apprenticeship scheme, was also continued for those who were interested in taking up a career at sea.

### 1.2 Objectives of the Study

The shipping industry witnessed a series of serious marine casualties in the last three decades. Formal investigations into these accidents resulted in most of them being attributed to human error. The International Maritime Organisation which deals with international maritime matters observed from their investigations that

incompetence and lack of knowledge of the personnel employed on board were the main cause behind these casualties. All were of the opinion that proper education and training would play an important role in minimising the factors behind human error. Therefore, minimum standards of education and training for the certification of the maritime officers at global level was adopted in 1978 and was made effective from 1984. Even with the enforcement of STCW 78 Convention, the occurrence of maritime accidents did not show much improvement. Critical investigations into the accidents which occurred in early nineties exposed the short comings of the 1978 Convention. In order to overcome the short comings of the 78 Convention and to ensure overall world wide improvement in MET systems IMO revised the Convention in 1995, which was made effective from 1 St February 1997. The marine engineering system in India therefore needs to be analysed in compliance with the mandatory minimum requirements of the Convention .

### 1.3 Methodology

This paper has been divided into seven chapters. The first chapter gives the introduction to this paper. The different avenues to take up a career as a marine engineer and examination rules for certificates of competency will be discussed in chapter two. The development and impact of revised STCW Convention are described in chapter 3.

In order to comply with the requirements of STCW Convention IMO has developed a number of model courses. An analysis of these model courses will be made in chapter 4.

To suit the specific needs of the industry, maritime education and training has undergone significant changes in developed countries. Their current marine engineering system will be analysed in chapter 5.

In chapter 6, an assessment of current Indian MET system against the mandatory knowledge requirement of the revise STCW convention will be made. This chapter then will propose a solution for those who do not comply with the minimum requirement for watchkeeping engineer and chief/ second engineer certification.

Conclusions and recommendations are discussed in chapter 7.

# CHAPTER 2

## Current MET and Examination System in India

### 2.1 Pathways to Marine Engineering

Marine engineers serving on Indian ships have different educational and training backgrounds. A majority of engineer officers have undergone one of the following education and training systems.

- A four year pre-sea course in marine engineering education and training at Marine Engineering Research Institute (MERI), Calcutta.
- A five year Bachelor of Engineering (B.E) degree course in mechanical engineering at one of the recognised engineering colleges and also one year marine orientation course at MERI, Mumbai, port trusts or ship building yards.
- A four year marine apprenticeship training at one of the recognised marine repair workshops, port trusts or ship building yards.

A very small percentage of marine engineers has a different background of education and training than as mentioned above. They have undertaken their education and training at diploma engineering colleges followed by two years marine orientation course, or in the Indian navy. It is also not unusual to find engine room ratings serving on board as engineer officers. These ratings have presented themselves for and passed certificate of competency examinations without any formal education. The above thus indicates that there are a number of pathways for becoming a marine engineer officer on Indian Merchant Marine. It shows clearly that the education and training of them are not uniform though the majority have undertaken very good education and training programme before proceeding to sea.

The number of engineers entering Indian Merchant Marine under various training schemes is shown in table 1-a

| Institute & Others | Course | Quantity | Percent |
|---|---|---|---|
| MERI, Calcutta | A 4 years degree course in marine engineering after 10 plus 2 schooling | 125 | 17% |
| MERI, Mumbai | 12 / 18 months marine orientation course for degree mechanical / electrical engineers | 156 | 21% |
| Shipyards | 12 months workshop training for mechanical engineers | 180 | 24% |
| Workshops/ Port trusts | A four year apprentice engineer scheme after 10 plus 2 schooling | 150 | 21% |
| Port trusts | 12 months workshop training for B.E degree holders | 80 | 11% |
| Indian Navy | A four year course in Indian Navy | 50 | 6% |
| | Total | 741 | 100 |

Table 1-1 Marine engineering training systems in India

### 2.1.1 Marine Engineering and Research Institute

The institutionalised training for marine engineers first began in India in 1935 on board a training vessel T. S. Dufferin. This training was shifted ashore when the Government established the Directorate of Marine Engineering Training (D.M.E.T) at Calcutta with a branch in Mumbai (previously called Bombay). It is the only institute in India offering a recognised proper marine engineering training programme for engineers. Since its inception in 1949, it has been providing the bulk of trained personnel to Indian shipping companies. In the beginning DMET laid more emphasis on practical engineering knowledge than theoretical as in the professional career engineer officers are required to have a sound knowledge of overhauling and maintenance of shipboard machinery. So a good part of the training period was spent in the college laboratories and external recognised marine workshops for acquiring practical knowledge in shipboard machinery. The Mumbai branch conducted only the first three years of training and then the trainees were sent to Calcutta to join their counterparts for the 4th year of study. After successful completion of the training and examinations, the trainees were issued "passing out certificates" and with that they qualified for exemption from part A of class II examination.

This course underwent substantial revision in the late seventies and early eighties due to technological developments in the shipping industry and also due to the discontent among engineer officers as their passing out certificates was not treated on a par with engineering degree certificates issued by the universities. The revision of the course led to substantial change in the curriculum and training pattern with more emphasis on providing theoretical knowledge than practical skill. These changes earned recognition at the national level and also led to the restructuring of institutes. The complete four year marine engineering course was shifted to Calcutta and D.M.E.T in Mumbai was entrusted with conducting marine engineering orientation courses for graduate mechanical and electrical engineers. The D.M.E.T in Calcutta and Mumbai was renamed as Marine Engineering and Research Institute in 1992.

Those who are desirous to go to sea as marine engineers are required to pass the two year pre-university course examination or All India Senior School Certificate Examination (10 plus 2 level) with physics, mathematics, and chemistry as subjects before seeking admission at MERI, Calcutta. The admission to the course is granted according to the merit obtained in the competitive entrance examination conducted on All India level basis.

The Institute has a well qualified and experienced faculty, and good facilities such as library, laboratories, power plant, simulators and workshops for training the students. The four year course is distributed into eight equal semesters of period 22 weeks. At the end of each semester an examination is conducted for students and only the successful ones will go to the next semester. The pass mark in each subject is 50% of total marks for the subject. A carry over system has also been provided for the unsuccessful trainees to go into the next semester but they should reappear and pass the test in the supplementary examinations. Workshop skill assessment is done throughout the semester by conducting periodic tests. They should also pass the

physical fitness and swimming test before they are awarded the final degree certificate. The medium of education, training and examination is English.

The subjects covered in each semester of the four year course are listed below.

Semester-I

| *Subjects* | L | T | PR |
|---|---|---|---|
| English language | 3 | 0 | 0 |
| Mathematics | 3 | 1 | 0 |
| Applied mechanics | 3 | 1 | 0 |
| Geometrical drawing | 0 | 3 | 0 |
| Workshop technology | 3 | 0 | 0 |
| Applied Electricity | 3 | 1 | 0 |
| Seaman ship | 2 | 0 | 0 |
| Laboratory | | | |
| Workshop Practical | 0 | 0 | 4 |
| Electrical Laboratory | 0 | 0 | 2 |
| Total | 17 | 6 | 7 |

Semester-II

| *Subjects* | L | T | PR |
|---|---|---|---|
| Sociology/Psychology/Political science | 2 | 0 | 0 |
| Mathematics | 2 | 1 | 0 |
| Thermodynamics | 3 | 0 | 0 |
| Mechanics of materials-I | 3 | 1 | 0 |
| Material Science-I | 2 | 0 | 0 |
| Applied Mechanics-II | 3 | 1 | 0 |
| Engineering Drawing | 0 | 3..5 | 0 |
| Electrical Measurements | 2 | 0 | 1 |
| Laboratory | | | |
| Material Laboratory | 0 | 0 | 1.5 |
| Applied Heat Laboratory | 0 | 0 | 1.5 |
| Mechanical Laboratory | 0 | 0 | 1.5 |
| Workshop practical | 0 | 0 | 4 |
| Total | 17 | 6.5 | 9.5 |

Semester-III

| *Subjects* | L | T | PR |
|---|---|---|---|
| Mathematics | 3 | 1 | 0 |
| Basic Electronics | 3 | 0 | 0 |
| Material Science | 3 | 0 | 0 |
| Machine Drawing | 1 | 3 | 0 |
| Applied Thermodynamics | 3 | 1 | 0 |
| Mechanics of Materials-II | 3 | 1 | 0 |
| Economics & Commercial Geography | 3 | 0 | 0 |
| Electrical Machines | 2 | 0 | 0 |
| laboratory | | | |
| Electrical Laboratory | 0 | 0 | 2 |
| Workshop particles | 0 | 0 | 3 |
| Total | 21 | 6 | 5 |

Semester-IV

| *Subjects* | L | T | PR |
|---|---|---|---|
| Electronics | 3 | 0 | 0 |
| Mechanics of Materials | 3 | 1 | 0 |
| Applied Thermodynamics | 3 | 1 | 0 |
| Marine Auxiliary Machines-I | 3 | 0 | 0 |
| Electrical Machines-II | 4 | 0 | 0 |
| Marine Engineering Drawing | 1 | 3 | 0 |
| Basic ship structure | 3 | 0 | 0 |
| Laboratory | | | |
| Electronics Laboratory-II | 0 | 0 | 2 |
| Workshop particles | 0 | 0 | 2 |
| Total | 20 | 5 | 5 |

Semester-V

| *Subjects* | L | T | PR |
|---|---|---|---|
| Computer Science | 3 | 0 | 0 |
| Electrical machines-II | 3 | 1 | 0 |
| Ship Construction | 2 | 0 | 0 |
| Mechanics of Fluids | 3 | 1 | 0 |
| Elementary Design & Drawing | 2 | 3 | 0 |
| Mechanics of machines-I | 3 | 1 | 0 |
| Marine Auxiliary Machines-II | 3 | 0 | 0 |
| Laboratory | | | |
| Workshop | - | - | - |
| Computer Practical | 0 | 0 | 3 |
| Electrical Machines Laboratory | 0 | 0 | 2 |
| Total | 19 | 6 | 5 |

Semester-VI

| *Subjects* | L | T | PR |
|---|---|---|---|
| Mechanics of Machines-II | 3 | 1 | 0 |
| Management Science | 4 | 0 | 0 |
| Marine Internal comb Engg- I | 4 | 0 | 0 |
| Computer Science-II | 3 | 0 | 0 |
| Marine Auxiliary Machines-III | 4 | 0 | 0 |
| Marine Steam Engineering | 3 | 0 | 0 |
| Marine Boiler | 3 | 0 | 0 |
| Marine Electrical Technology | 3 | 0 | 0 |
| Laboratory | | | |
| Workshop(External) | 0 | 0 | 0 |
| Computer Practical | 0 | 0 | 3 |
| Boiler chemical Laboratory | 0 | 0 | 2 |
| Total | 27 | 1 | 5 |

Semester-VII

| *Subjects* | L | T | PR |
|---|---|---|---|
| Fluid Mechanics & Dimensional Analysis | 3 | 1 | 0 |
| Naval Architecture | 3 | 1 | 0 |
| Marine Internal combustion Engg-II | 4 | 0 | 0 |
| Marine Heat Engines & Marine Air Conditioning | 3 | 1 | 0 |
| Ship Fire prevention and Control | 3 | 0 | 1 |
| Marine Machinery /System design | 0 | 4 | 0 |
| Marine Electrical Technology -II | 3 | 0 | 0 |
| Laboratory | | | |
| Mechanical Laboratory | 0 | 0 | 2 |
| Fire control Laboratory | 0 | 0 | 2 |
| Total | 19 | 7 | 5 |

Semester-VIII

| *Subjects* | L | T | PR |
|---|---|---|---|
| Ship Operation & Management | 4 | 0 | 0 |
| Marine Control & Automation | 4 | 0 | 0 |
| Naval Architecture-II | 3 | 1 | 0 |
| Safe Watchkeeping & Class IV Preparation | 2 | 0 | 0 |
| Elective | 4 | 0 | 0 |
| Technical Paper & Project | 0 | 0 | 4 |
| Laboratory | | | |
| Power Plant Operation | 0 | 0 | 4 |
| Control & Simulator Laboratory | 0 | 0 | 2 |
| Total | 17 | 1 | 10 |

For above tables:
L=Lecture Contact hours per week
T=Tutorial Contact per week
PR= Practical contact hours per week

The students who have successfully completed the course are now exempted from taking part A of statutory examination of class III, class II and class I examination conducted by Mercantile Marine Department of Ministry of Transport.

### 2.1.2 Degree Engineering Colleges

During the early seventies, the Indian merchant fleet was growing rapidly and a severe shortage of trained engineering officers for operating Indian ships was being experienced. At the same time a large number of graduate engineers were finding difficulty to get employment in Indian industries and hence unemployment with graduate engineers was growing. In order to solve both the problems, the government of India authorised the Director General of Shipping to work out the method for sending graduate engineers to merchant ships. The biggest handicap for graduate engineers taking up the profession of marine engineer was that they were not educated and trained in the marine field though they had studied engineering subjects in detail. So after many deliberations, it was finally decided to allow desirous graduate mechanical and electrical engineers to take up a career in the merchant navy, but only after completing a marine engineering orientation course of 8

months for mechanical engineer and 12 months for electrical engineers at recognised marine workshops or ship building yards. This helped a large number of graduate mechanical engineers to take up this profession and since then they have been successfully serving on Indian and foreign flag ships.

Graduate mechanical and electrical engineers undertake normally 4 years academic studies at Government recognised engineering colleges. The minimum entry standard to these colleges is satisfactory completion of two year pre-university course conducted by the education board of any state with physics, chemistry and mathematics as optional or completing the all India higher secondary school certificate. Looking into the syllabus of the mechanical engineering course at one of the recognised engineering colleges (here reference taken of Karnataka Regional Engineering College, Mangalore university), it can be said that the subjects studied in a four year academic course includes many engineering subjects but none from the marine engineering field. However these subjects do cover general principles of marine engineering subjects but not in detail. It is not the same for electrical engineering which covers more of electrical engineering subjects. Mechanical and electrical engineers do not undertake any extensive workshop training required for the marine engineers during their 4 year course. Therefore it is necessary for both mechanical and electrical graduates to undergo a marine engineering orientation course before taking up a career at sea. The medium of instruction and examination in all engineering colleges is English. The four years training programme is distributed over eight semesters.

The total length of working periods for each semester are as follows:

| | |
|---|---|
| Total number of working weeks for each semester | 16 |
| Number of lectures per week | 15-26 hours |
| Number of practical/Drawing /projects hours per week | 6-16 hours |

The transition from one semester to the next semester is allowed only after completion of an internal assessment followed by a written examination of 3 hours period on each subject at the end of every semester. Each successful candidate needs to get 40% of the aggregate marks in the written examination and internal assessment.

Although the marine engineering orientation course period and training structure has been subjected to change from time to time, now a graduate mechanical engineer pursuing a career in the marine engineering field is required to undergo a 12 months orientation course ( basically workshop training) conducted either at MERI, Mumbai or at recognised marine workshops. Out of 12 months, 8 months are devoted only to fitting, erecting or repairing machinery of power 350 kilowatt. The remaining four months are devoted to onboard training. The trainees are also exempted from appearing for part A of class II and class I certificate of competency examinations after completion of the course.

Similarly an electrical graduate engineer taking up a career in marine engineering field is now required to undergo 18 months of a marine orientation course. Out of 18 months, 12 months are devoted only to fitting, erecting or repairing machinery of 350 kilowatt power. Unlike a mechanical engineer, he is required to appear and pass the drawing paper (other papers exempted) of part A of class II examination before proceeding to sea.

### 2.1.3 Marine Workshop Apprentice Engineers

Large marine related workshops have in house training schemes for apprentice engineers. As the employment in the organisation after training is not fully guaranteed, these apprentice engineers are allowed to take up a career as marine engineers. The trainees undergo four year training in a number of departments related to shipboard machinery. In this training, emphasis is placed on learning skills rather than acquiring theoretical knowledge. Out of four year training, one year training is

devoted to only fitting, erecting, or repairing machinery of 350 kilowatt power at the work place. In the remaining three years the apprentice engineer is to take up any of the work specified below with the maximum time limit specified against the work.

| Work | Time limit |
|---|---|
| Metal turning | Maximum 1 year |
| Brass fitting | Maximum 3 months |
| Boiler making or repairs | Maximum 1 year |
| Pattern making | Maximum 3 months |
| Planning, slotting, & milling | Maximum 1 year |
| Tool Room | Maximum 6 months |
| Training in the use of hand and small machine tools | Maximum of 1 year |
| Welding | Maximum of 6 months |
| Smith work | Maximum of 3 months |
| Coppersmith work | Maximum of 3 months |
| Draftsman or Engineer engaged on machine design | Maximum 1 year |
| Electrical work, shop or repair | Maximum 1 year. |

Apart from an apprentice engineer, a trade apprentice (fitting or equivalent) together with service as a fitter for a period of minimum six years is also allowed to take up a career in a marine engineering field. During the training, both apprentice engineer and apprentice trade are required to pursue a technical distance (correspondence) education of a standard equivalent to section "A" of the Institution of Engineers (India) examination or a recognised diploma examination in mechanical engineering. The minimum educational level required to join an apprentice scheme is passing of the twelfth standard examination conducted by the Central Board of Secondary School education, Delhi or the examination two year pre-university course conducted by the state board.

### 2.1.4 Other Sources of Marine Engineers

The following mentioned categories can seek a career in the merchant navy but their share in the total number of engineer officers being trained under different schemes will not be more than seven to eight percent.

*Diploma mechanical engineers*:

A course in diploma in mechanical engineering consists of three year studies in elementary mechanical engineering subjects. The minimum admission requirement is the completion of ten years schooling. After completion of a diploma of mechanical engineering course, those who are desirous to go to sea are required to undertake twenty-four months marine orientation course at large marine workshops. In these, twelve months are devoted only to fitting, erecting or repairing of shipboard machinery of 350 kilowatt power. After the orientation course they are required to appear and pass part A examination of class the II certificate of competency.

*Indian Navy*:

Personnel leaving the Indian Navy after ten or fifteen years of service can pursue their career in the merchant navy depending upon their education and training obtained during the service. If they have completed a four year course in marine engineering either in the Navy or in the Indian Naval Dockyard and worked as responsible engineer officers on navy ships during their service, then they can join in the merchant navy after taking class II certificate of competency examinations. They are required to attend approved fire fighting, first aid, and survival at sea courses before joining the merchant ships.

*Ratings*:

Engine room ratings can also seek a career path to marine engineers. After certain years' sea service they have to appear and pass "Deep Sea" certificate of competency examination before qualifying as junior engineer officer on board. They do not

undergo any type of formal training programme while seeking a career as engineer officers. This category hardly exists these days as it is not easy for ratings to get through the competency examinations without any formal training.

### 2.2 Examination and Certification System

After completion of initial training, a trainee is required to appear and pass part A class II examination before pursuing career as a marine engineer. However before receiving the certificate they are required to attend mandatory courses like first aid, basic fire fighting and survival at sea conducted at other institutes. The highest rank in the engine department is the grade of chief engineer. For reaching the highest rank the fifth engineer is required to take up certificate of competency examinations at various stages and must obtain a class I certificate of competency. The certificate of competency for each grade is issued by the Mercantile Marine Department (Ministry of Transport) after conducting written and oral examinations for each grade.

#### 2.2.1 Certificate of Competency for Marine Engineers

The certificate of competency for marine engineer officers is granted for each of the following grades, namely:

Marine Engineer class IV (Steam or Motor or Steam and Motor)

Marine Engineer officer class III (Motor-Limited ships)

Marine Engineer officer class II (Motor or Steam or Steam and Motor)

Marine Engineer officer class I (Motor or Steam or Motor and Steam)

Extra-First class engineer (Motor or Steam or Motor and Stcam)

For obtaining the certificate of competency, the candidates are required to pass the relevant examination conducted by MMD.

### 2.2.2 Examinations

For unlimited foreign going motor vessels, the candidates are required to appear in the following examinations. These examinations are conducted at Mumbai, Calcutta, and Madras every month except in May.

Class IV (Motor)

Class II part A and Part B (Motor)

Class I part A and Part B (Motor)

Steam ships are very rare to find in these days, hence the requirements of a steam certificate of competency are not discussed here.

*Marine Engineer Class 4 (Motor)*

This examination is for the certification of officers in charge of an engineering watch in a manned engine room or as designated duty engineers in a periodically unmanned engine room on a vessel powered by propulsion machinery of 750 kilowatt power. It is only an oral an examination. The general requirements are:

- Minimum six months of qualifying sea service on a motorship powered by main propulsion machinery of over 350 kilowatt power, of which at least four months are in watch keeping on main propulsion machinery.
- One month of preparatory course at a recognised institute.
- 3 days simulator training.
- 1 week advance fire fighting course.

*Marine Engineer class II (Motor)*

This examination is for the certification of second engineer officers on motor ships powered by main propulsion machinery of 3000 kilowatt or more power. The examination consists of two parts A and B and subjects in them are given below. As mentioned earlier, Part A is the minimum qualification for joining an unlimited vessel as a junior engineer. Therefore all the marine engineers are required to obtain

part A before proceeding to sea unless exempted from appearing for the examination.

**PART A**

Section 1 Applied Mechanics (One paper of 3 hours)

Section 2 Applied Heat (One paper of 3 hours)

Section 3 Applied Mathematics (One paper of 3 hours)

Section 4 Engineering drawing (One paper of 4 hours)

**PART B**

Section 1 Electrotechnology(One paper of 3 hours)

Section 2 Naval Architecture (One paper of 3 hours)

Section 3 Engineering knowledge(one paper of 3 hours)

Motor (One paper of 3 hours)

Oral examination (Intensive)

The general requirements are:

For part A, there are no requirements and one can undertake the examination at any time.

For part B, the minimum period of qualifying sea service is twenty-one months, of which, at least nine months are in watch keeping on motor vessel powered by main propulsion machinery of over 750 kilowatt registered power. The remaining period is in watchkeeping on either main propulsion machinery or auxiliary machinery or on day work.

*Syllabus*

The syllabus covered under various subjects, of the Class II certificate is quite substantial and relevant to the field. This helps those engineers who have not been to MERI or other engineering college to build up the knowledge in the subjects related to marine engineering. Attending a preparatory course conducted by some institutes is not compulsory.

*Exemptions*:

Some candidates are exempted fully or partly from appearing in a Part A examination. They are:

- Engineer officers who have completed a four year course at MERI, Calcutta are exempted from all sections of part A.
- Engineer officers who have obtained Bachelor of Engineering degree in mechanical engineering are exempted from all sections of part A.
- Engineer officers who have obtained initial training as apprentice engineers and passed section A and B of the Institution of Engineers examinations in mechanical engineering are exempted from all sections of part A.
- Engineer officers who have obtained Bachelor of Engineering degree in electrical engineering are exempted from sections 1, 2 and 3 of part A.
- Engineer officers who have obtained initial training as apprentice engineers in recognised marine workshops and passed section part "A" examination of the Institution of Engineers in mechanical engineering, are exempted from sections 1, 2, and 3 of part A.

No candidate is exempted from taking the Part B of class II certificate examination.

*Marine engineer class I*

This examination is conducted for certification of chief engineer officers on motor ships powered by propulsion machinery of 3000 or more kilowatt power. The examination has two parts A and B and subjects covered under them are given below

**Part A**

Section 1-Applied Mechanics (one paper of 3 hours)

Section 2-Applied Heat (one paper of 3 hours)

**Part B**

Section 1-Electrotechnology (one pare of 3 hours)

Section 2-Naval Architecture (one paper of 3 hours)

Section 3-Engineering knowledge (3 hours)

Engineering motor (one paper of 3 hours)

Oral examinations (intensive)

The general requirements are:

For part A, there are no requirements and one can appear for it at any time.

For appearing in part B, an engineer officer is required to have a class II-certificate of competency and also must have 21 months qualifying sea service, of which at least 9 months are in watch keeping on main propulsion machinery of power greater than 3000 kilowatt and the balance watch keeping either on main propulsion or auxiliary machinery, or on day work. In addition, he is also required to have a Part A certificate unless exempted.

*Syllabus*:

The syllabus covered under the above subjects gives in depth knowledge in the marine engineering subjects and is of great help to those who have not had any formal education before going to sea.

*Exemption:*

The following candidates are provided exemptions from appearing in part A examination

- Engineer officers who have obtained initial education at MERI, Calcutta.
- Engineers who have a degree in mechanical engineering from a recognised institute.
- Engineer officers who have obtained initial training as apprentice engineers and have passed both sections A and B of Institution of Engineers examination in mechanical engineering.

*Qualifying sea service*:

Qualifying sea service means service on articles of agreement as engineer officer. The computation of qualifying sea service depends upon power of main propulsion engine, type of voyage, type of water (lake or sea) and type service (home trade or foreign trade). When a ship is idle for a considerable amount of time, then only part of the actual sea service is taken for the qualifying sea service for the examinations.

### 2.2.3 Examiners

The following persons will conduct examinations and examine written papers for all classes of certificate of competency.

- Chief surveyors with the government of India
- Principal officers-engineering branch
- Deputy chief surveyors-engineering branch
- Engineer and ship surveyors

The above are well qualified and most of them also have Extra class I certificate of competency.

### 2.2.4 Delivery of Certificates

The engineer officer is required to obtain 50% marks in each written examination and 60% marks in the oral examination. When the candidate has passed in all parts of the examination, the examiner will issue a letter of authority to the candidate authorising the principal officer of the Mercantile Marine Department to deliver the certificate of competency. The examiner also intimates the results of the examination to the chief examiner. The chief examiner after due verification gives approval to the results of the examination and prepares the certificate of competency, which is later forwarded to the principal officer to be delivered to the candidate in exchange for the examiner's letter of authority. The examiners letter of authority will have the same effect as that of the certificate of competency for a period of 2 years or until the candidate receives the certificate of competency.

### 2.2.5 Endorsement

A marine engineer sailing on oil tankers, chemical tankers and gas carriers is required to have his certificate of competency endorsed by the chief examiner. For the endorsement he has to have six months sea service and satisfactory completion of approved training course in the field for which he seeking an endorsement.

### 2.2.6 Revalidation of Certificates

Every certificate of competency is valid for only 5 years and is required to be revalidated before the expiry of five years from the date of issue of a certificate. The chief examiner requires the following to revalidate the certificate.

- Medical fitness certificate
- Sea service as an engineer officer for a period of at least one year during the preceding five years or shore service equivalent to the grade of certificate held or
- Passing of an oral examination conducted by an examiner or
- Three months approved sea service in a rank lower than for which one holds the certificate.

The MET and structure in India for certificates of competency for unlimited motor vessels is shown in fig 1-1

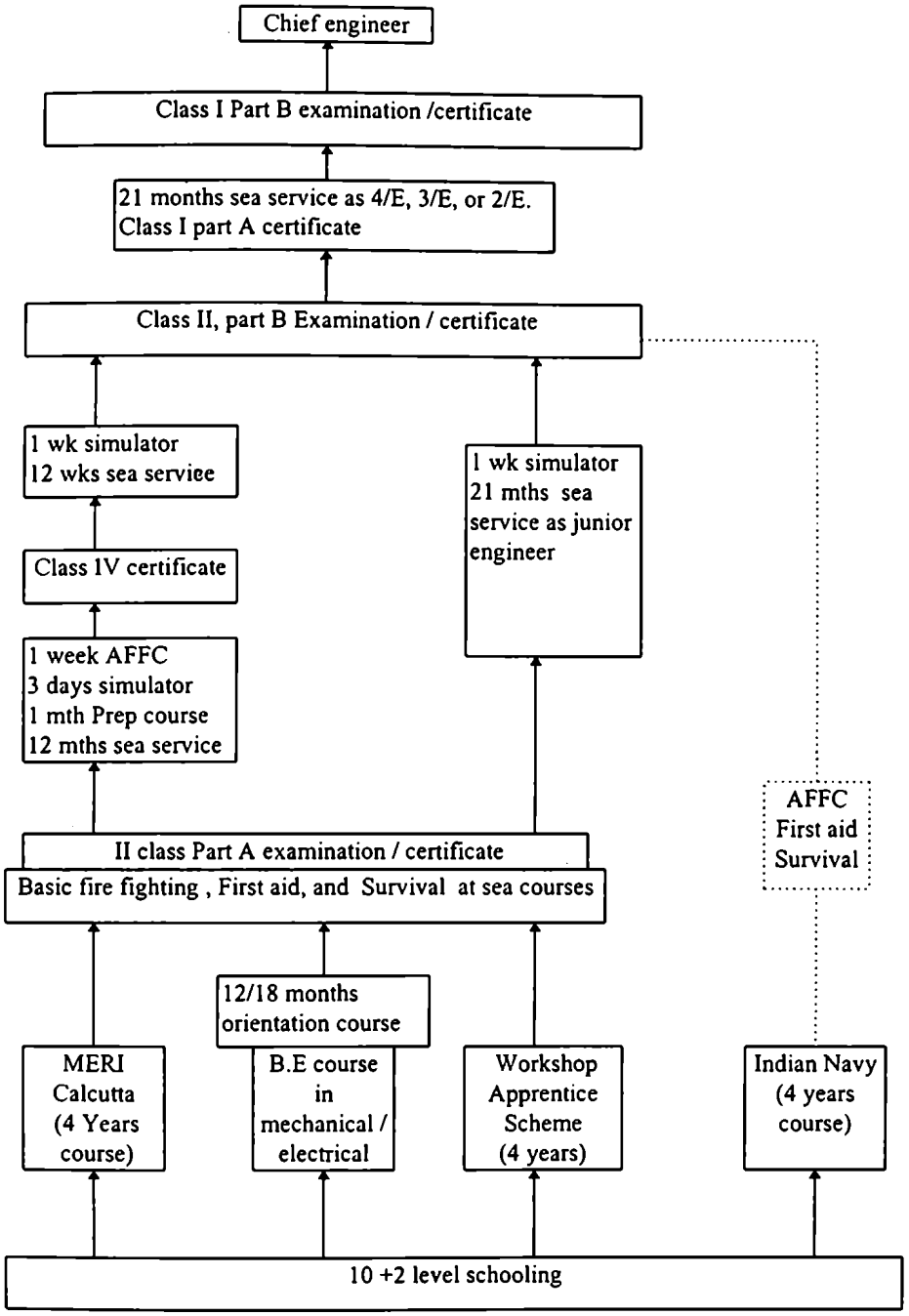


Fig: 1-1 MET and licence system in India

## 2.3 Summary

The Marine engineering training in India can be regarded as follows:
The marine engineers from MERI, Calcutta have a comprehensive education and training which is adequate to function in the whole maritime industry. However their contribution is only 17% in total of the number of engineers required by the industry every year.

Above 50 percent of marine engineers have a degree in mechanical engineering. Though they undergo marine orientation training, i.e. workshop training, it does not provide them with enough hands-on experience on shipboard machinery as it is not conducted properly in the workshops. The main drawback of this practical training is that the engineers are not given any practical or project work to carry out with their own hands in any department.

Others, mainly apprentice engineers, consists of about 20 %, are not provided with any class room lectures in maritime or engineering subjects in the entire 4 year training programme. As they spend most of the time in the different departments of workshops, they acquire reasonably a high level hands-on experience on shipboard machinery.

# CHAPTER 3

## The STCW Convention

### 3.1 OVERVIEW of STCW 1978

To safeguard maritime safety, it is not sufficient to have ships with the highest standard of construction and equipment but it also requires highly trained personnel to operate them. Investigations of maritime accidents have revealed that human error had contributed in most of the cases in spite of having best equipment on board ships. The main reasons for human error are: lack of knowledge, inexperience, incompetence, inadequate training and qualification. The maritime education and training was not uniform from the beginning and standards varied from country to country though shipping business has been of a true international nature in every aspect. Since its inception in 1959, IMO has been endeavouring not only to improve the safety of life but also the standards of seafarers who are sailing on ships. It prescribed minimum standards of training, certification, and watchkeeping for officers and ratings in the 1978 Convention, which came into force in April 1984. The Convention consisted of articles, annex and resolutions.

**Articles**

The articles contained the legal provisions of the convention and dealt with provisions of entry into force, amendment procedures, denunciation, certification, dispensation and various other matters.

**Annex**

The regulations in the annex contained the technical provision of mandatory requirements for the personnel sailing on board. It was divided into six chapters that dealt with the following subjects.

- Chapter I - General Provisions
- Chapter II - Master and deck department
- Chapter III -Engine department
- Chapter IV-Radio department

- Chapter V- Special requirements for tankers.
- Chapter VI-Proficiency in survival crafts.

*Chapter I* basically dealt with definitions of various terms used in the Convention, contents of certificates and the endorsement form required to be placed on the certificate. Some relaxation in the requirements was provided for seafarers on ships engaged on coastal voyages. It also defined the duty of port state control though it was limited to checking the validity of certificates and assessing the abilities of officers to perform in certain eventualities such as grounding or collision. Port State inspectors had been empowered to detain the ship for not having valid certificate or dispensation by the watch keeping officers or other officers.

*Chapter II and III* dealt with minimum mandatory requirements for certification of navigating and engineer officers sailing on board ship. The requirements of deck officers varied according to the tonnage of a ship but for engineer officers it varied as per the power of the main propulsion engine. The requirements of deck and engine officers were relaxed when sailing on vessels in coastal waters.

The knowledge requirement for master or chief mate in the deck department and chief engineer or second engineer in engine department was of the same level, as the chief mate or second engineer was expected to take over as master or chief engineer at any time during the service. These chapters also included the minimum requirements for revalidation of certificates to ensure the continued proficiency and updating of knowledge for deck and engineer officers. Apart from prescribing minimum level of knowledge requirements for certification of officers, chapters II & III provided the principles to be observed by the watchkeeping officers on deck and in the engine room when the vessel is underway, at anchorage, in port and when carrying dangerous goods. The requirements of deck and engine room ratings forming part of a watch were included here.

*Chapter IV* dealt with requirements of radio officers and radio telephone operators' certification, their revalidation of certificates and also the additional minimum knowledge concerned with safety and emergencies.

*Chapter V* dealt with additional special requirements for the officers and ratings sailing on special type of vessels, namely, oil tankers, chemical tankers, and liquefied gas tankers. The requirements are more stringent for senior officers than other officers. Attention was paid not only to safety but also to preventing environment pollution. The inclusion of this chapter was essential considering the service on tankers was much different and critical from other ships.

*Chapter VI* dealt with requirements of issuing certificates of proficiency in survival crafts.

**Resolutions**

There were 23 resolutions in the Convention. Some of the regulations in the Convention specified requirements in a general form and hence guidance to implement some of them in detail was incorporated in the annex of resolutions. The resolutions were not mandatory like regulations but were meant to be used partly or wholly by any government if required. However the resolutions adopted by the STCW conference were linked to the convention and were designed to back up the Convention.

*Resolutions 1-6* specified the principles and operational guidance for deck, engine and radio personnel in charge of watch at sea and in port in compliance with the Convention.

*Resolution 7* dealt with recommendations regarding the minimum requirements for certification of radio operators, training of radio operators, revalidation of proficiency of certificates and principles to be observed relating to safety radio watch keeping.

*Resolutions 8 and 9* stipulated training requirements of deck and engine ratings who are forming part of either a deck or an engine watch

*Resolutions* 10, 11, 12 and 13 specified guidelines regarding special training and qualification for personnel who are sailing on oil tankers, chemical tankers, LPG tankers and ships carrying dangerous goods.

*Resolution 14 and 15* provided the guidelines for training radio officers and radio telephone operators

*Resolution 16* provided the additional technical assistance for the training and qualifications of masters and other responsible personnel who are sailing on oil, chemical and liquefied gas tankers.

*The remaining resolutions* recommended guidelines regarding radar simulator training and training in the use of collision avoidance aids to deck officers, training all seafarers in personal survival techniques, additional training for masters and chief mates for handling large ships and finally technical co-operation among parties.

### 3.2 Need for Revision of STCW Convention

The STCW 78 Convention was the first international treaty regarding seafarers training certification and watchkeeping arrangements and subsequently formed the basis of national standards world-wide. When the Convention entered into force, it was expected that its requirements would ensure the competence of officers and ratings of all sea going ships and their safe operation through efficient watchkeeping. A series of high profile maritime casualities in the eighties drew attention to incompetence, ignorance and inexperience of personnel employed on board. Then it was realised that the STCW 78 Convention was not achieving its objectives despite its broad acceptance in the world. In fact, as its acceptance was being widened it was loosing credibility in the shipping industry. This was very surprising as IMO had worked over decades for its realisation. The following reasons, as summarised by the International Shipping Federation 1996, caused the need for the revision of the STCW 78 Convention:

- It did not contain precise standards of competence relating to the abilities needed to perform shipboard functions safely and effectively. It only stipulated the minimum requirements of knowledge for the issue of certificates. The evidence of required knowledge absorbed by candidates for certification was left entirely to

the satisfaction of the administration as the Convention did not prescribe any assessment criteria for the certification. Therefore it resulted in different interpretation of standards by different parties and thus failed to establish a uniform minimum level of competence internationally.

- There was no guarantee of compliance with STCW requirements by any party as IMO had no role in the enforcement of the Convention. Neither the processes of ratification nor the provisions of the convention were sufficient to implement STCW requirements word-wide. Thus the reliability of STCW certificates for the competence could not be assured.
- For acquiring seafaring skills and competence the Convention had prescribed only the minimum periods of on board sea training or appropriate service without defining skills and competence. But on board sea training was ineffective and did not help officers to acquire any skills due to fast turn around of the vessel, reduction in manning, different background of education and training, multinational manning and frequent crew changes on board
- It lacked the flexibility to meet the future requirements of the industry. The convention had been written in terms of conventional shipboard organisation based on the traditional divisions between the deck and the engine departments. It had failed to accommodate modern developments in training and shipboard organisation. It also limited the potential career development of seafarers and redistribution of work load during intensive work periods.
- Economical pressures in the late seventies demanded sharp cut down in crew manning without reduction in shipboard functions. This required officers and crew with multiple skills and higher competency for which existing educational and training systems were inadequate. Moreover the advent of sophisticated and specialised vessels also demanded improved education and training systems for ship officers in order to operate complex vessels safely and efficiently.

### 3.3 An Outline View of STCW 95

The articles of the STCW -78 Convention were not changed but the entire annex was amended. This helped to implement the Convention early by means of 'tacit

acceptance procedure'. The annex contains basic legal requirements in regulations organised into eight chapters. Dividing regulations in this way makes present administration and future amendments simpler and quicker. The amendments to the annex and the STCW Code which elabotrate them are divided into 8 chapters as follows:

- Chapter 1 General provisions
- Chapter II Master and deck department
- Chapter III Engine department
- Chapter IV Radio communication and radio personnel
- Chapter V Special training requirements for personnel on certain ships
- Chapter VI Emergency, occupational safety, medical care, and survival functions
- Chapter VII Alternative certification
- ChapterVIII Watchkeeping

The legal requirements are supplemented by technical requirements and guidance in STCW code. The code has two parts. Part A of the code is mandatory and specifies the minimum standards of competence required for sea-going personnel in detail in a series of tables. Part B of the code is non mandatory and contains recommended guidance in order to achieve uniform application of all provisions of the STCW. The sections of part A and part B are arranged in exactly the same manner as the regulations in the annex. One of the important features of the convention is that it applies to ships of non-party states when visiting ports of the Parties.

*General Provisions*

One of the important amendments is that IMO itself is given authority to assess and evaluate individual capacity for effective implementation of the convention. The Parties now will be required to provide detailed information concerning measures taken to ensure compliance with convention requirements. Other important amendments to chapter 1 include:

- Enhanced control procedures concerning the exercise of Port State control.

- The establishment and enforcement of penalties and other disciplinary measures for non -compliance with regulation 1/5.
- The establishment of training and assessment procedures in accordance with reg 1/6
- The establishment of quality assurance systems to continuously monitor training, certification, and other procedures.
- Recognition of the use of simulators in training and assessment purposes. Simulator radar and automatic radar plotting aids training courses have been made compulsory.
- To establish procedures to revalidate certificates not exceeding five years to meet the fitness standards and the levels of professional competence.

*Master and Deck department*

The watchkeeping provisions contained in the chapter II have been transferred to a new chapter VIII. The tonnage thresholds applying to the standards in the deck department have been changed to 500 GRT and 3000 GRT instead of the current sizes of 200 GRT and 1600 GRT.

*Engine Department.*

The watchkeeping provisions previously contained in chapter III has been transferred to new chapter VIII. The thresholds of main propulsion machinery power applying to standards in the engine department have not been changed.

*Radio Communication and Radio Personnel*

Every person performing radio duties on a ship under the Global Maritime Distress and safety system are required to have an appropriate GMDSS certificate as mandated by the ITU Radio Regulations

*Special Training Requirement for Personnel on Certain Types of Ships*

Previously only the crew sailing on tankers were required to undertake special training and now this has been extended to ro-ro ferries and passenger ships. In

addition to the familiarisation course, the crew are required to undertake training in crowd and crisis management and human factors.

*Emergency, Occupational Safety, Medical Care and Survival Functions*

New provisions have been added with regard to familiarisation and basic safety training, training in fast rescue boats, advanced fire fighting, medical first aid, and medical care on board ship.

*Alternative Certification*

This enables crew to gain training and certification in various departments of seafaring rather than being confined to one branch (such as deck or engine room) for their entire career.

*Watch keeping*

Measures have been introduced for watchkeeping personnel to prevent fatigue. According to the revised Convention it is necessary to provide for all watchkeeping personnel a minimum 10 hours of rest in any 24 hour period, with exceptions being made for emergencies and drills.

*Resolutions*

Resolutions adopted by the conference dealt with:

- Promotion of technical co-operation at an inter-governmental level to assist those states not having adequate facilitates or expertise for providing training in accordance with the revised STCW Convention.
- Training in crisis management and human behaviour for personal on board ro-ro passenger ships; training of personnel on passenger ships
- Monitoring the implications of alternative certification
- Development of international standards of medical fitness for seafarers
- Promotion of participation of women in the maritime industry.
- Training of maritime pilots, VTS personnel and personnel employed on offshore industries
- Revision of model courses published by the IMO

## 3.4 Impact of Changes Upon Maritime Education, Training and Certification.

### 3.4.1 Assessment of Competency

The biggest change in the 95 STCW Convention is the introduction of the concept of assessment of competence for certification of sea going officers. A candidate by passing just a written examination and an oral examination conducted by the administration can no longer obtain a certificate of competency. The current method of examination or assessment is only knowledge based; now it has been changed over to both knowledge and competence based assessment.

As per the code, the standard of competence means the level of proficiency to be achieved for the proper and effective performance of tasks, duties and responsibilities on board ship. The revised Convention prescribes a minimum level of standard of competence for each function to be carried out on board. Therefore for obtaining a certificate of competency a candidate needs to demonstrate acquisition of required competence during his training. In practice it is a process of comparing evidence of competence against a set standard. Depending on the particular competence, the method of its demonstration will vary and only an appropriate method is required to be chosen. The different methods used for demonstrating competence are:

- Approved workshop training
- Approved in service training
- Approved training ship experience
- Approved laboratory experiment training
- Approved simulator training
- Approved special training course

During the above training it is required to give candidates project work, assignments and physical tasks to perform for developing skills that are essential to carry out ship board functions properly and safely. The mere evidence of completion of workshop training or certain period sea service does not prove acquisition of

requisite competency by a candidate. The criteria prescribed in the Convention for evaluation of competence has to incorporated in either workshop training or sea training or simulator training and same to be indicated in the training certificate documented in a training record book. The persons responsible for the assessment of competence need to have full understanding of assessment methods, practices and must follow prescribed criteria while undertaking the same. If simulators are used for the assessment of competence, then the assessors need to have practical assessment experience on the type of simulator used for the assessment.

Now it is the responsibility of the administration to check that the necessary steps have been taken during assessment to meet the criteria specified in the codes before accepting the evidence from such performance measurements for competency purposes. This new method of assessment is going to be a considerable task to most of the countries as the existing system needs to be drastically changed.

### 3.4.2 Approval of MET Programmes

Another big change in the STCW Convention is the requirement of mandatory education and training courses for certification for all sea going officers. Therefore, the current system of allowing direct entry to competency examinations to both deck and engine without attending an approved education and training course will come to an end by 1st February 2002 unless candidates have commenced approved sea going service before 1st, August 1998. As per the new requirement, a government or a party needs to approve all education and training courses that are leading to the certification process of sea going officers. Such approval also extends to sea going training, including training record books that are required to be kept for each trainee. While approving the education and training programs of institutes, the administration is required to consider the elements of regulation 1/6 in chapter 1 of annex. Each training programme is required to be documented which should include course structure, defined goals, objectives, learning curriculum details, syllabus, methods and media of delivery, entry standards, examination methods and details of

supporting resources. In addition, documentation must indicate the qualification and experience of instructors and assessors and also clearly identify in which areas of the syllabus they are teaching or assessing. The typical elements in such documentation for approval of a MET programme are shown in the following table.

| |
|---|
| **Methods and Media Delivery:** |
| Instructional methods: Break up of lecture hours, tutorials, practical work, field studies, training vessel, simulator time. |
| Teaching programs: use of appropriately qualified and experienced teaching staff in units/subjects and available supporting resources |
| Assessment schedule: Measures to achieve the course objectives through evaluation of students levels of knowledge, understanding and proficiency and demonstrations of ability to perform tasks as per code A tables of competence. |
| **Procedures** |
| Checks on teaching programs against written course objectives and syllabus |
| Appraisal of examination of papers and practical tests for reliability and validity |
| check on practical demonstrations of skill and assessment criteria for relevance to the required tables of competencies |
| Checks on qualifications and experiences of lectures and instructors |
| Checks on the training, qualifications and experiences of assessors |
| Monitor effective use of simulators against required performance standards |
| **Course Materials** |
| Course lectures, texts, notes ,workshops manuals and reports, simulator exercise material, audio visual aids are appropriate for achieving overall objectives. |

Source: P.Muirhead (1997) WMU

### 3.4.3 New Technology and Simulators

The use of simulators for training and assessment purposes has now been recognised. One of the most frequently mentioned reasons for the poor state of affairs of ships is the lack of experience of present seafarers. No ship is the same in any respect and hence the practical experience gained by sailing on ships is not the same, it varies from ship to ship. If one sails always on a modern new ship, one may not get the true picture of the problems encountered on old ships. The lack of practical seafaring experience needs to be compensated for by using other means of training. So the best equipment available today are the simulators that are increasingly being used in maritime education and training. The simulator training is very effective, efficient and time saving and has many advantages over the conventional method of training. The biggest advantage is that all on board operational requirements can be practised and the required skill or competence can be achieved without any actual risk or

serious damage to the equipment or environment. This method of training provides hands on training in realistic imitation of the real world. It allows students to acquire valuable experience in a short period of time and exercises can be repeated innumerable times if required. It can also be used during pre-sea training but can not be treated equivalent to practical training as it can never provide a realistic situation but it can speed up the acquisition of knowledge and skill and ability to perform the needed task to the level that is required. Thus simulators are increasingly becoming valuable tools in developing a comprehensive training program in order to develop skill and knowledge in seafarers to function on board safely and efficiently. The general performance of simulators used for training should be as follows:

- Be suitable for the selected objectives and training tasks.
- Be capable of simulating the realistic operating capabilities of shipboard equipment so as to allow a trainee to acquire the skills appropriate to the training objectives
- Be capable of providing a variety of controlled operating environments, including emergencies, hazardous or unusual situations relevant to the training objectives.
- Be capable of providing an interface through which a trainee can interact with equipment, the simulating environment.
- Be able to permit an instructor to control, monitor, and record exercises for the debriefing of trainees.

Mainly there are three types of simulators,

1. Ship handling (navigation and manoeuvring) - for providing skill in navigation in narrow dangerous waters, anchoring, arrival and departure in harbours.
2. An engine room simulator- for providing skill in handling emergency procedures,
3. Cargo handling simulator- for providing skill in cargo handling equipment, Loading and unloading of liquid cargo.

These simulators are classified into four major categories,

- Full mission- Capable of simulating total environment
- Multi task- Capable of simulating near total environment

- Limited task- Capable of simulating only limited task
- Special task- Capable of simulating only special operations

From 1 February 1997 the use of radar and automatic radar plotting aids simulator for training has become mandatory for navigating officers. If simulator training contributes towards the issue of certificates of competency, then it will become mandatory as well.

### 3.4.4 Quality Standard System

In regard to MET, quality assurance is interpreted as "fitness for purpose". As per the revised Convention, national administrations should have quality standard systems in all their organisations engaged in MET activities. Each organisation should develop, establish, document, implement, and maintain a quality system. It is about having specific processes and procedures in place that are actively used to accomplish objectives.

The requirements for Quality Standards Systems under Regulation 1/8 apply to all STCW education, training, assessment, certification, endorsement, and revalidation activities, including qualifications and experiences of instructors and assessors in both governmental and non-governmental areas. Part B 1/8 of the code provides clear guidelines on the development of quality standards, the establishment of internal quality assurance evaluations involving self- study of the programs. The quality standards system generally includes four particular elements, namely:

- Documentation process
- Compliance with processes and procedures
- Internal quality review
- External evaluation.

*Documentation Process*

The requirements and provisions contained in the quality system are defined and documented as a part of the organisation's overall document which include,

- An organisation's policies and objectives and its structure
- Each course programme in detail, which should include course objective, syllabus, duration, student and instructor ratio and training facilities. All STCW course programs are required to be approved by the maritime administration.
- Qualification and experience of instructors and assessors
- The description of the quality system structure including the main organisation.

*Compliance with processes and procedures*

All activities of education, training, assessment, certification, endorsement and revalidation are required to be executed as per the documentation.

*Internal evaluation*

The internal quality evaluation should be planned, performed and recorded as per the procedures in the documentation. The task should be executed by competent personnel independent of the area being evaluated. A record of compliance or non compliance is required to be documented and submitted to the management by the evaluation team. The management should ensure that all necessary and appropriate corrective actions are taken in respect of the evaluation report

*External evaluation*

Evaluation is to provide an independent assessment of the effectiveness of the quality standard arrangements at all levels. This independent evaluation of the whole MET system is required to be conducted at least once in every five years and before the inspection they should be given advance information pertaining to functions of the organisation.

The external or independent evaluators need to find out whether the functions, procedures and processes are conducted in accordance with the requirements of the revised convention. They have to identify flaws or weakness in the system and bring these to the notice of departmental heads for taking remedial action.

The external evaluators are required to be well qualified in MET system and should carry out the evaluation in accordance with documented procedures. The results of

each evaluation are documented and given to the heads of the area evaluated. The result of each independent evaluation is required to be reported to IMO by each party within six months of completing the evaluation. The quality standards links and interactions is shown in the following figure.

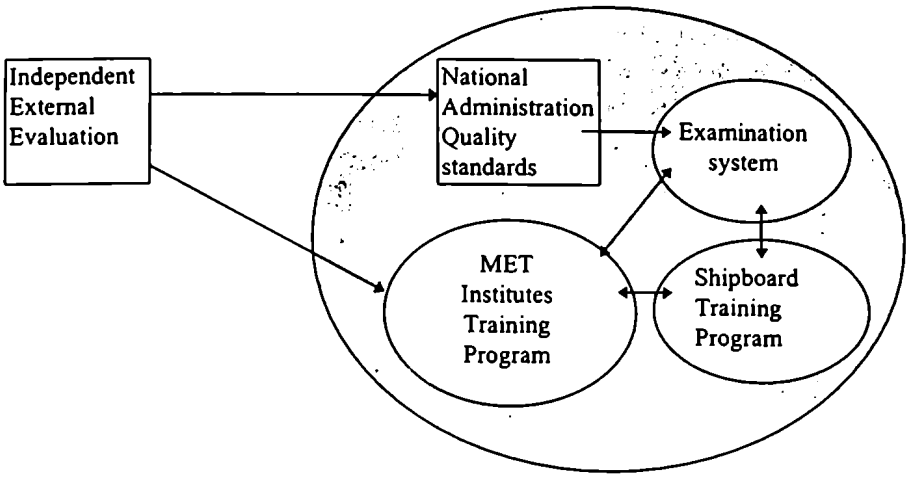


Fig 3-1 Quality Standard System.

Source: P Muirhead (1997) WMU

### 3.5 Summary

A fresh new STCW Convention has not been written in 1995 but only substantial revision to the 1978 Convention has been made. The officers' functions and competence are well defined in the revised Convention and hence it is no longer left to the interpretation of the Administrations of Parties. For the first time IMO has been empowered to ensure the uniform world-wide implementation of the Convention. Hence it has been hoped that the Convention will bring in revolutionary changes in shipping industries particularly in training institutes and examination/certification departments of marine administration.

# CHAPTER 4

## MET in Some of the Developed Countries

### 4.1 Objective

This chapter deals with the marine engineering education and training currently adopted in some of the developed maritime countries. The objective is to highlight how these countries have developed their marine engineering education programmes to suit their specific requirements in the context of changing circumstances created by technological innovation, social and economic needs, safety and international regulations. It will also give an opportunity to examine whether the current MET system in India is at par with the standard of the developed countries.

Most of the developed countries have both "hawse pipe" and "front ended" education and training programmes for sea going officers.

In the former type, a trainee gets a few months of practical training ashore and then joins as a engine rating at the lowest grade. After certain period of sea service, if interested, he joins a maritime institute to gain theoretical knowledge on subjects related to marine engineering and appears for the licence examination conducted by the national board to become an engineer officer on ocean going vessels.

In the latter type, a trainee engineer undergoes a complete education and training programme at institutes and on training ships before joining a vessel as a watchkeeping officer. However he is required to pass the corresponding licence examination before proceeding to sea.

### 4.2 Maritime Education Training system in Japan

Both "hawse pipe" and "front ended " systems are currently adopted in Japan.

In Japan, two levels of schooling are compulsory for all. This consists of six years elementary school and three years in junior high school. After graduating from a junior high school one can seek admission to a Mercantile Marine College for a maritime education instead of continuing general studies at a senior high school.

In Japan admission to all marine institutes is based on the result of a written entrance examination and a health examination.

Those who have failed to get admission to a Mercantile Marine College and are still interested to go to sea can apply for admission to ratings training schools. To become an engineer at sea, the ratings have to take up admission at a Marine Technical College after a few years of qualifying sea service to acquire knowledge in maritime subjects. After completion of the course at the Marine Technical College, they need to clear the officers' licence examination before proceeding to sea.

After passing out from a senior high school, if one wants to go to sea, he can seek admission at a University of Mercantile Marine or rating school for the special course. In the former, one becomes an officer and in the latter, one becomes a rating.

All students at the Mercantile Marine College, the Mercantile Marine University and at rating schools must undergo on board training before they graduate from their respective institutes. This training to the trainees is given at the Institute of Sea Training, the duration of which varies from course to course.

All officers working at sea must have a maritime licence issued by the National Examination Board which is the sole authority in Japan in conducting licence examination. Those who have trained at Mercantile Marine Colleges, and at Mercantile Marine Universities are exempted from appearing for the written examination of third grade level of licence for either engineering or navigation or both but need to pass an oral examination before qualifying as a watch officer on board a foreign going vessel.

**Maritime Education Training Institutes**

There are a number of government and private institutes engaged in imparting maritime education and training in Japan, namely: universities, colleges, re-education institutes, rating schools and training ships. Universities and colleges come under the jurisdiction of the Ministry of Education and re-education schools and institutes for

sea training fall under Ministry of Transport. All the institutes under the Ministry of Education emphasise both vocational training and general education and at the end award to the graduates a recognised degree, which gives them better opportunity of employment in shipping and allied industry rather than providing job opportunity only at sea.

**Mercantile Marine Universities**

There are two of these universities, one is in Tokyo and the other one is in Kobe. Mercantile Marine Universities are the highest educational institutes for marine engineers in Japan. Each university offers 4 years academic course in marine engineering. Those who aim at a career at sea have to undergo 6 months additional on board sea training at the Institute of Sea Training after graduating from the universities. (undergraduates undergo six month sea training). This course provides not only ample scope for research work in the respective field but also gives expert knowledge in maritime affairs, thus promoting development of the whole shipping business activities. Both universities also offer a 2 years post graduate course in maritime studies.

**Mercantile Marine Colleges**

There are five mercantile marine colleges in Japan. Each college offers 5 1/2 years engineering course offering studies in both general and technical subjects.. These colleges do not emphasise research work like universities but stress on skill acquisition for shipboard operations. The subjects covered in the curricula of the 4 years course are shown in appendix "A".

**Institute for Sea Training**

It is located in Tokyo with a branch office in Kobe. It has two large sailing ships, two turbine ships and two diesel ships. It offers 1 year onboard training to students of Mercantile Marine Universities, Merchant Marine Colleges and 6 months training to students of rating schools. The engineering course offers 4 months training on turbine ships, five month on diesel ships and three months on a sailing ship. The

course is designed in such away that a student acquires sufficient knowledge and skill for keeping watch in both departments and competency in his own department.

**Marine Technical Colleges ( Re-educational Institutes)**

The institute imparts further knowledge and skill to the experienced seafarers for the operation of high technology vessels and also provides additional facilities for learning. It offers the following courses:

- Education and training to seamen who are interested in obtaining certificates of competency as marine officers.
- Refresher and revalidation for officers
- Correspondence courses for officers and ratings.
- Dual qualification for existing officers or ratings to work as watch officers and dual purpose crew on highly modernised ships.

**Marine Technical Schools**

There are eight schools and these are located in different parts of Japan, whose main purpose is to train ratings of ocean going vessel. They offer the following courses,

*Regular course*: This course is aimed at recruiting officers for the home trade or dual purpose crew of ocean going vessels. Those who have graduated from the regular course, after having acquired two years service aboard ship, are exempted from the written examination of fourth grade maritime officer (nav or eng) but qualify for the corresponding oral examination. Those who have completed the regular course are treated on a par with the graduates of senior high school and thus qualify for university or college admission.

*Special course*: This course is aimed at recruiting engineers for foreign trade or home trade. Those who graduate from the special course are exempted from written examination of fourth grade Maritime officer (nav or engine)

*Catering course*: The course is aimed to prepare one for the catering department.

*Sea training course*: This course is designed to give those who intend to apply for fourth grade competency necessary practical training on board.

**License System**

The maritime engineer officers' licenses are divided into 6 grades, the highest is the first grade and the lowest is the sixth grade. For each grade the examination is conducted by the Ministry of Transport. The main purpose of these examinations is to determine whether maritime officers have gained the knowledge and skill to carry out the job on board. All examinations consist of a physical and written examination with an oral examination. For the written examination of any grade one does not require minimum sea service but for orals of each grade one does require minimum qualifying sea service. The applicability of each licence varies from ship to ship according to the output of Main Engine and type of navigable water. For example, on a conventional ship with engine power 6000 kW a chief engineer must have a grade 1 licence where as on vessel with 20 kW power engine a person with a third grade licence can become a chief engineer.

With the introduction of the dual class license in 1983, an engineer officer can have a licence of third grade in one department (engine) and a licence to third grade watch keeping in the other department (bridge). With this, manning of ocean going vessels has been considerably reduced.

With the new system the vertical split between engine and deck department has been avoided and there is improved co-ordination, co-operation and team work between the deck and engine department.

The current MET system of Japan is shown in figure 4.1 and the procedure for competency certificates are shown in figure 4.2.

**Summary**

The most visible features of MET Japan can be summarised as follows:

- They have a large number of institutes up to university level for training Japanese seafarers. The MET system is very flexible and gives ample chance at every level for engine ratings who want to seek a career path of an engineer officer.
- The onboard training is carefully designed and is provided on a different kind of training vessel. A minimum one year period onboard training is made compulsory

though the mandatory requirement is only six months for certification of watchkeeping engineers

- It offers dual-oriented education to its officers up to watchkeeping level. Education in Japan is commensurate with requirements of industry and hence is subjected to continuous change in order to provide its seafarers with appropriate training.
- It offers a wide range of studies in the maritime subjects up to post graduation level. It offers an ample facility for carrying out research work.

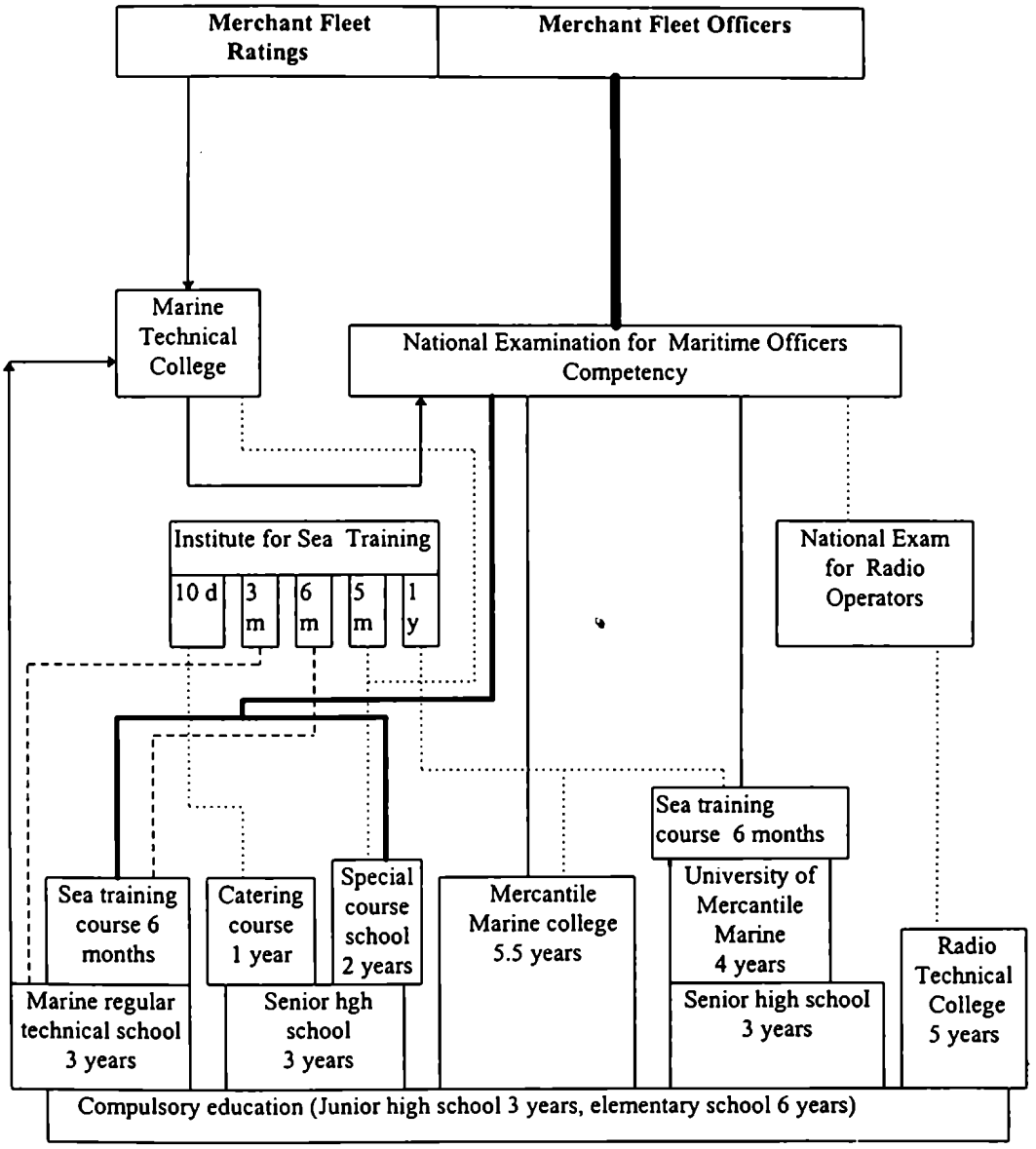


Fig 4.1: Schematic diagram of pathways for ships' personnel training in Japan

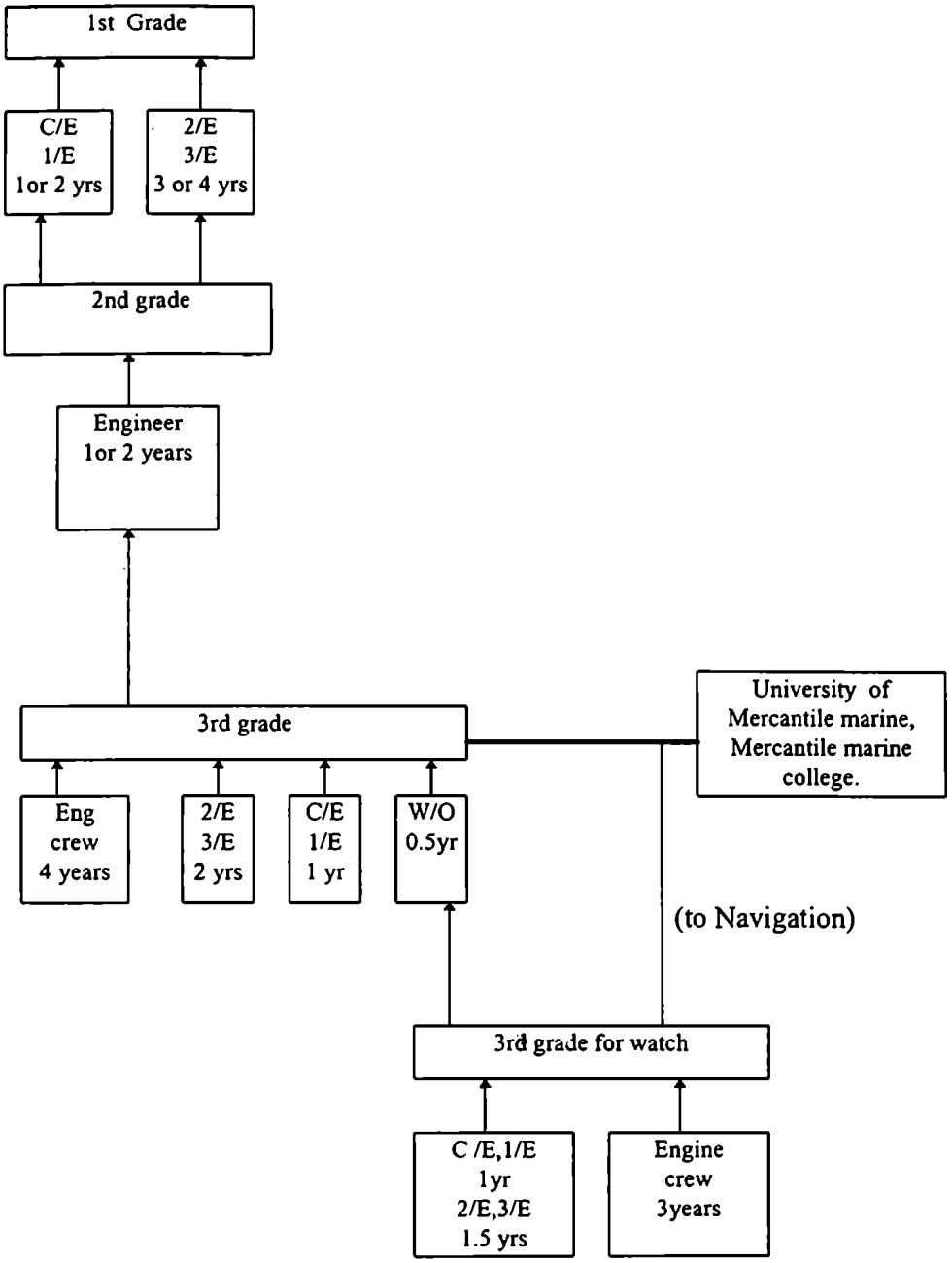


Figure 4.2: Procedure for Engineering Competency

### 4.3 MET Systems in the USA

Maritime education and training in the USA was based on the license examinations requirements of the Coast Guard which is solely responsible for maritime safety in American Merchant Marine. With the advent of high tech specialised vessels, the MET programs have gone beyond the requirements of license examinations. Thus in the USA, like Japan, both 'hawse pipe' and 'front ended' education and training systems are currently in use. The Hawse Pipe educational program is conducted through the following institutes.

*Maritime schools*: Operated by the International Seafarers' Union these schools offer specialised courses and coaching to students for upgrading their licence.

*City colleges*: They provide sufficient knowledge to undergraduates to work safely and effectively on board.

*Preparatory schools*: Operated by master mariners, these private schools offer coaching exclusively for the US Coast Guard license examinations.

In the 'Hawse pipe' system an ordinary seaman presents himself for an AB license examination after one year of sea service. After obtaining the license, the AB seaman sails for two years to qualify for an officers, license examination.

The 'front ended' educational training is undertaken by the Merchant Marine Academies of both the Federal Government and the State Governments. These academies offer a four years course leading to a nationally recognised under graduate Bachelor of Science degree and a licence to sail as an officer in the American Merchant Marine either as third mate or third assistant engineer. For obtaining a higher licence of the Merchant Navy, the marine officer needs to appear for licence examinations conducted by the Coast Guard.

**Merchant Marine Academy (Federal Government)**

There are five service based academies in the USA but this one is exclusively for merchant marine officers' education and training and is located at King's Point in New York state. Other academies are for the USA Navy, Army, Coast Guard and Airforce. All these academies are totally funded by the Federal Government and

trainees need not spend any money during their training period. The academy offers four main undergraduate courses of 4 years duration each, namely:

- Marine transportation: For the preparation of Deck officers.
- Marine engineering: For the preparation of engineer officers.
- Marine engineering system: This curriculum gives in depth knowledge in mathematics and in engineering design.
- Dual license program: The dual program gives a common core of studies and training to both deck and engineering up to third mate and third assistant engineer level.

In addition to completing the required core curriculum in marine engineering, every trainee is also required to complete a number of elective courses.

All students are also required to take a Naval Sciences course prescribed by the Department of the Navy as they are required to be commissioned as ensigns in the United States Naval Reserve after graduation.

The four years programme includes one year on board sea training on a commercial ship. The marine engineering course provides study in marine engineering, naval architecture, the engineering sciences, (mechanics, fluid mechanics, thermodynamics and strength of materials), electrical engineering, and diesel and steam engineering.

The graduates of the Merchant Marine Academy find excellent job opportunities in the wide spectrum of the maritime industry. After completion of the course if a person is not interested in a sea career, he can take up a job as naval architect, maritime lawyer, or port engineer in the marine industry.

**Admission Requirements**

Graduates of high school between the age of 17 and 25 are eligible for admission. Admission mainly depends on competitive standing of the Scholastic Aptitude Test, high school rank, academic record, physical health but is granted on the nomination of a US congress member or other nominating authorities. Therefore high school graduates with all their certificates must approach their respective nominating authority (Congressmen, Governor) for nomination to get admission to the Merchant Marine Academy.

**Shipboard Training**

The shipboard training gives everyone an opportunity to use the ship as a sea going laboratory. As far as possible the on board training is provided on different class of vessels and on different routes. Thus it familiarises a trainee with the performance and operating characteristics of various class of ships under different situations while acquiring practical training on shipboard functions.

Trainees are given a study guide called the sea project which includes both written and practical assignments to be performed during shipboard duties. The sea project is so designed that a trainee needs to apply his knowledge and skill learnt in the class rooms while performing duties on board and also acquires a firm foundation for future studies in the Academy. Marine transportation majors are assigned deck duties and engineering majors are assigned engine duties. Deck and engineering majors are also required to complete additional assignments in the opposite department to ensure basic familiarity with all aspects of ship operation. Dual license majors spend half of their time at sea in each department and their study programme is so designed that it helps to acquire intensive experience in both disciplines.

Though it is a one year programme it is given in two parts of 5 months each. During the second sailing period, a trainee can choose 30 days sailing aboard US navy ships. The sea year concludes with a two week assignment ashore for the internship training in a maritime related activity. Depending upon the field of interest, a trainee can chose a shipyard, surveyor firm, shipping company, port or similar enterprise. Each trainee is required to submit a written report on experiences for evaluation and grading. The subjects covered in the four years course at the Academy are shown in appendix 'B'.

**Merchant Marine Academies (State Government)**

There are six state academies located in different parts of the USA. All these academies with the exception of the one in Michigan offer a 4 year residential course in maritime subjects and award a recognised undergraduate Bachelor of

Science degree and Coast Guard third grade license either in engineering or navigation or both. In the 4 year course, the first two years course curricula are common to all engineering branches and from the third year onwards trainees take a specialised course relevant to the degree provided. The trainee gets one year sea training during his four year course in the academy. The trainees with nautical option, while preparing for third mates' license, can con-currently study for a degree in any of the following subjects:

Bachelor of Engineering (Electrical)

Bachelor of Science (Computer)

Bachelor of Science (Marine Transportation)

The Bachelor of Engineering for navigation officers is specially designed taking into account the sophisticated electronic equipment being used on modern ships.

The graduates from these institutes also have a wide range of options in choosing a carrier within the marine industry.

The Merchant Marine Academy of Michigan which is specially meant for the Great Lakes and river licenses offers a 3 year course with an associate degree of Arts.

The Merchant Marine Academy of NewYork state also offers a 1 year graduate level course for undergraduate merchant marine officers.

**Licence System**

The Coast Guard is the sole authority in US for issuing licences to deck and engineering officers for serving on US flagged commercial ships. For any licence one needs to pass a comprehensive written examination in professional subjects conducted by the Coast Guard after meeting the minimum education, training, and sea experience requirements. The period of sea experience may vary if one has not served the minimum period in the respective rank. For example for the 1 St engineer licence one must have 12 months sea experience services as 2nd engineer, otherwise it is more than 12 months. Other requirements of licence examination are,

- One must have attained 21 years of age
- One must have good health condition

The licence structure of US Merchant Marine is shown in the figure 4.3

**Summary**

The most striking feature of maritime training at the USA particularly at King's Point, New York, is that it trains its students for working not only in the maritime industry but also in the navy. Therefore the training programme is too demanding and comprehensive in all respects. Vigorous physical education has been incorporated in the training as all students are required to take every year the physical fitness test of the navy. The whole training programme is well planned and centres on a regimental system that instils its students with the traits of leadership, discipline, self reliance, initiative, teamwork, and dedication required for a career. The other important aspects of the training are:

- All laboratories have the most modern equipment and instrumentation. Each cadet is provided with a personnel computer and all rooms in the dormitories are connected to the computer network
- Students not only study Naval Science but also undergo training on naval ships.
- Admission to the course is open without any distinction between men and women, which is very uncommon in most training institutes.
- Assessment system is continuous and appropriate and does not depend only on the results of final examination at the end of year.

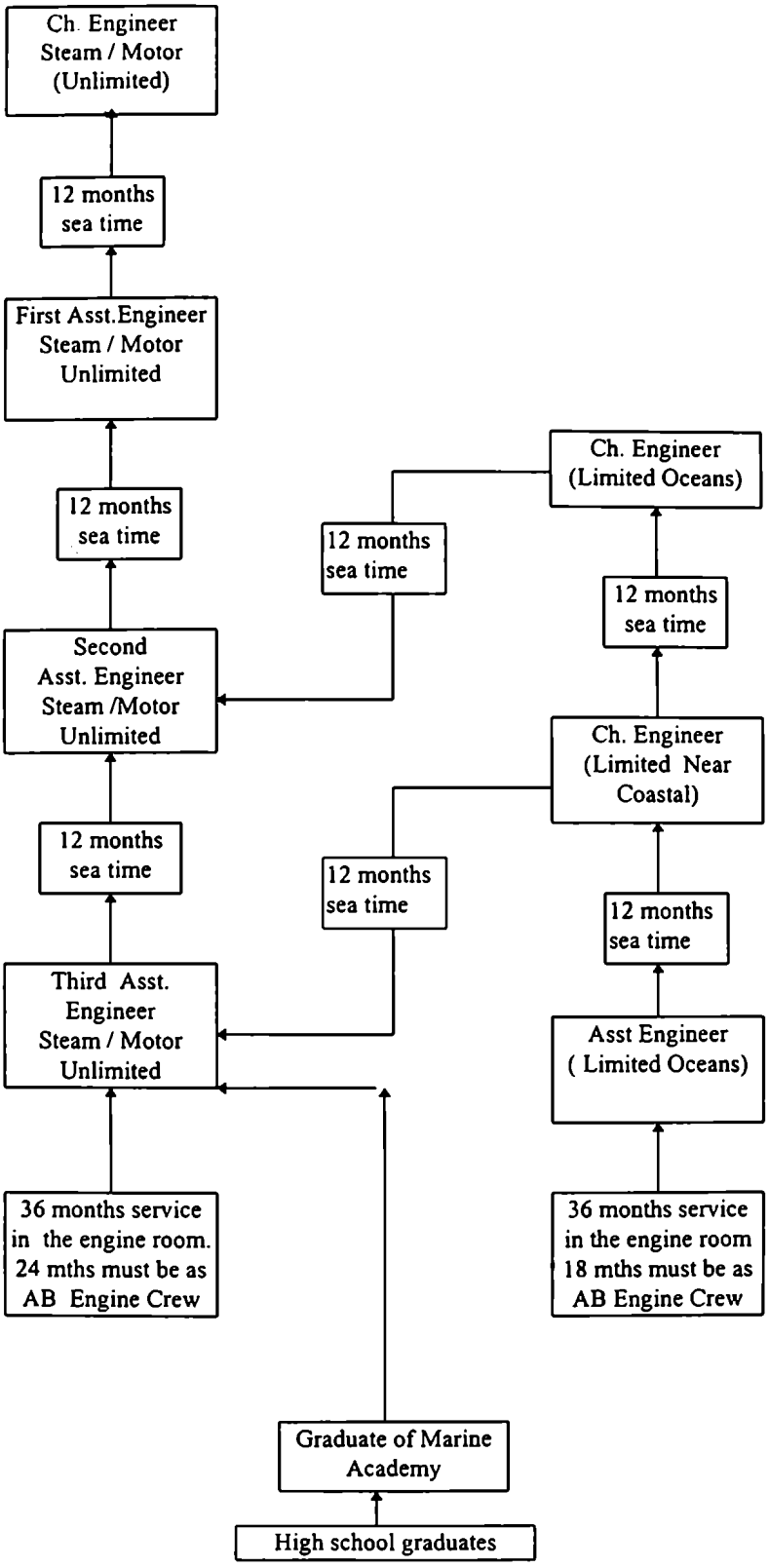


Fig 4.3 Marine engineering training and license structure, US.

### 4.4 MET System in Australia

Australia follows both "front ended" and "sandwich" type education and training programmes for training marine engineers. Comprehensive education programmes were not available in Australia to train maritime industry personnel till late seventies. The rapid technological change and introduction of specialised vessels in the shipping industry in the seventies initiated the need to upgrade the maritime education in the country. This led to the establishment of the Australian Maritime College in Tasmania in 1978 for training not only shipping industry personnel but also the personnel of fishing industry. The training in AMC is structured in such a way that it provides a common integrated ratings training programme whether officer or crew. Those who are desirous of becoming an officer have to continue further studies at the college. It is considered that this pattern of training is the best way to improve relationship between officers and crew on board.

Besides AMC, there are seven more marine institutes located in different parts of the country, which are offering mainly short term STCW courses, specialised courses and certificate courses.

**Australian Maritime College**

This national level autonomous college offers a wide range of accredited courses of both degree and post graduate level in engineering, nautical science and fisheries. In addition, it also offers a substantial number of short, special purpose courses required for training the personnel engaged in highly specialised complex fields.

Apart from regular courses, new courses are also constantly being developed to meet the challenges of future technological developments in the industry.

The courses in AMC are very flexible and that makes it equally suitable for school leavers and for experienced persons wishing to upgrade their qualifications. For engineer officers in the Merchant Service it offers the following courses:

- Bachelor of Technology
- Advanced Certificate of Technology
- Associate Diploma of Technology
- Integrated Training Course

**Bachelor of Technology**

This course provides all the practical, academic and managerial skills needed by an engineer officer in modern ships. The degree is also a qualification for careers at the same professional level in shore organisations. The course provides an advanced knowledge of marine engineering systems, their operation, maintenance and management. The course covers all knowledge requirements of the Australian Maritime Safety Administration(AMSA) certificate of competence examination requirements for class II and class I engineer. After successful completion of the course together with sufficient sea time gained on a training ship, the student qualifies for the oral examination conducted by AMSA for the issuance of a certificate of competency as engineer watch keeper.

The duration of the course is 4 years. The first year is common to all who wish to pursue a sea going career. The following three years education programme is supplemented by on board training and practical training. The subjects covered in the 4 years course are given in appendix 'C'.

*Admission requirements*

Those who seek admission to the Bachelor of Technology course must have a passing out certificate from an Australian high school with good grade in mathematics, physics and chemistry. Experienced candidates with suitable qualifications are given advanced standing but must complete one third of the total subjects of the course.

**Associate Diploma of Marine Engineering**

Associate Diploma in Engineering course incorporates the advanced certificate of technology course and covers the fundamental knowledge requirement of professional certificates of competency of class II & I for engineer officers. It is also designed to meet the need of students seeking professional qualifications as well as career path for integrated ratings who have completed the certificate of marine operators.

**Advanced Certificate of Technology**

It is designed for those who wish to gain a certificate of competency as engineer watch keeper.

**Integrated Training Course (Ratings)**

All new entrants to a sea career have had to follow a common course of training so that trained ratings can undertake duties in both engine room and on deck. These ratings are known as integrated ratings. The integrated ratings can later seek a career path as an officer for which they have to enrol themselves in a maritime college for further studies.

The integrated ratings course comprises:

3 weeks safety training at AMC

16 weeks vocational training at AMC

20 weeks sea service during which a programme of task and guided study is undertaken.

Those who have successfully completed 10 years of schooling in an Australian high school are eligible to enrol for the integrated course but are required to be sponsored by a shipping company. Therefore anyone wishing to take up a seagoing career should approach a shipping company for the sponsorship and employment after the training.

As mentioned before, this course also forms the first year for those who have enrolled in a Diploma in engineering or a Bachelor of Technology.

After successful completion of the integrated training course, trainees are issued a certificate in marine operations.

**Certificate of Competency**

The certificate of competency for merchant service officers is issued by the Australian Maritime Safety Authority AMSA). AMSA does not conduct any written examinations but only oral examinations for issuance of certificates of competency. The written examinations are conducted at colleges or similar institutes which offers courses for training personnel in MET. All candidates must attend approved courses at a college or similar institute before appearing for the certificate of competency

examinations. The education and training requirement for the Merchant Service for those who wish take up a career at sea is divided into 3 levels.

Certificate of Marine Operations (1st year)

Advanced Certificate of Technology (2 nd year)

Associate Diploma of Technology (3 rd year)

To appear for watch keeping engineer oral examinations the candidates must have sufficient qualifying sea service together with Advanced Certificate of Technology. Similarly, to appear for class II or class I certificate of competency oral examination, the candidates must have watch keeping engineer certificate of competency, an Associate Diploma of Technology and sufficient qualifying sea service.

In the Australian certificate of competency system, a watch keeping engineer can directly (without a class II certificate) present himself for class I oral examination after 36 months of qualifying sea service. The licence structure of the Australian Merchant Marine is shown in fig 4.4

**Summary**

The important feature of Australian maritime education is the one year common programme for their officers and ratings. This common education undoubtedly will help to improve the harmony, co-operation and understanding between officers and ratings on board, which is very much essential in the present situation. AMC has its own training ship which supports the use of commercial ships for onboard training of trainees. They have excellent facilities including fume and towing tanks for carrying out research work in the maritime field. Very few maritime institutes in the world have flume and towing tanks for training seafarers. The other important features are:

- It can respond quickly to the demand of the maritime industry as the institute is maintaining close contact with the industry.
- All learning activities required for the whole maritime industry are located in one place.
- It has a well qualified faculty which also offers a consultancy service to the industry.
- It has developed as a regional centre for maritime studies and a large number of overseas students enrol in the college

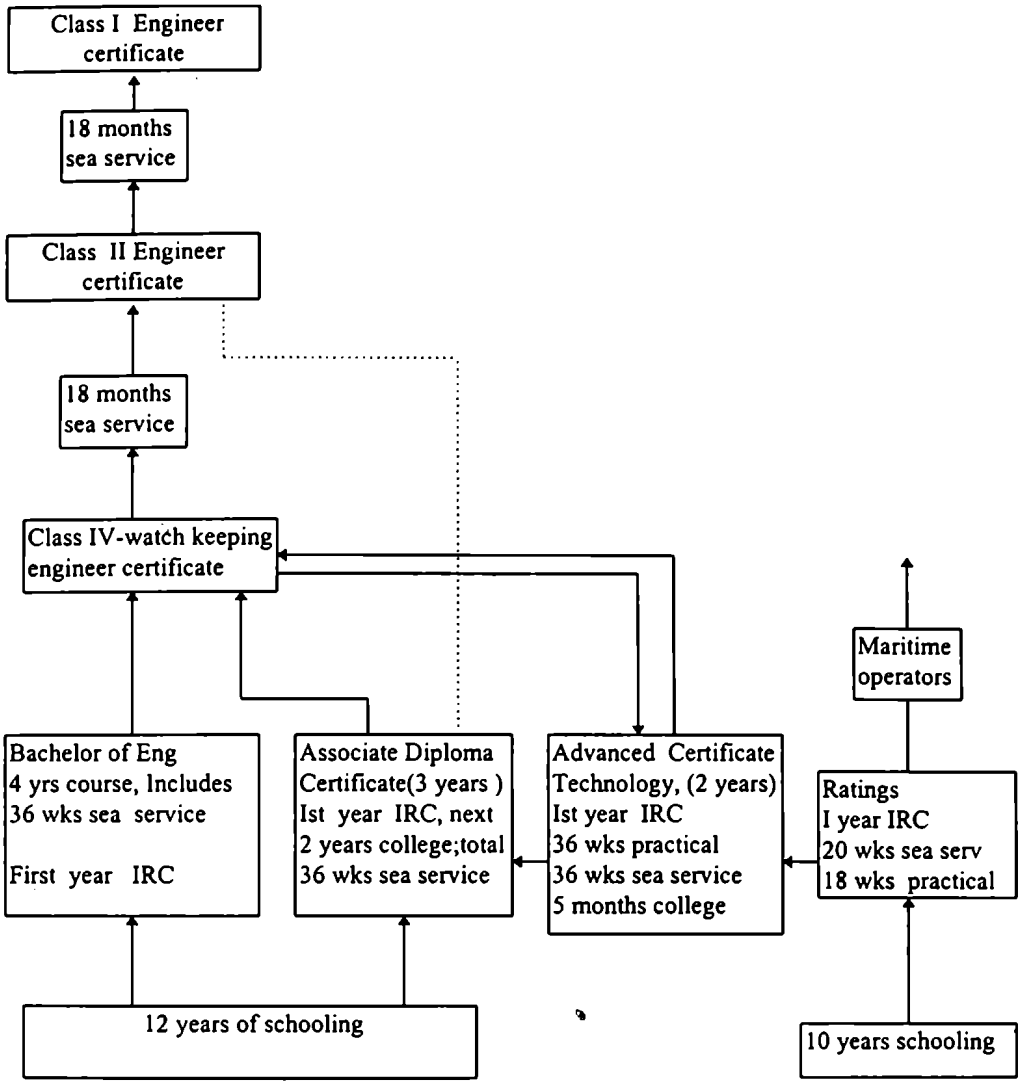


Fig 4.4 Australian MET system and licence structure

### 4.5 MET Systems in the United Kingdom

The United Kingdom follows the 'hawse pipe' and 'sandwich' type education systems for training marine engineers.

In the 'hawse pipe' system, shipping companies select trainees and send them to shipyards or marine workshops where they undergo apprenticeship training. After completion of the training they go on board as uncertified engineer officers. On completion of 18 months sea service, they qualify to appear for the second class engineer certificate of competency examination. As the engineer officers do not have a good academic background, they usually attend a private or public maritime college for about 6 months to prepare themselves for the examination. After obtaining class II certificate of competency, the engineer officer again goes to sea, and on completion of 18 months of sea service qualifies for class I engineer examination. Attending 6 months preparatory course offered by the private institutes is optional.

In this system, the ratings with the aid of a correspondence course (while sailing at sea) and further college modules can seek a certificate as a watch keeping engineer officer.

The education and training provided by the institutes are of general nature and it is not sufficient for serving on specialised vessels. So those who want to sail on specialised vessels must undergo short term training courses meant for the particular vessels.

The most common entry requirement is the completion of secondary or high school education.

**Sandwich Training Program**

The reasons for introducing a sandwich system are,

- Lack of formal education and training in the fundamental science and engineering subjects.
- Increase in technology, automation and sophistication on ships
- Demand for national recognition of maritime education for better employment opportunities

In this system three schemes of training are available to students depending upon their qualification. They are:

Ordinary national diploma.

Higher national diploma.

Degree scheme.

All three schemes involve almost the same degree of practical training but they differ from each other in theoretical contents and standards. These schemes are very flexible so that candidates of a diploma course can enrol in the degree course after a certain period of experience. The duration of all courses is of four years. In general, the ordinary national diploma covers the theoretical requirement of a certificate of competency examination of the UK Safety Administration.

The higher national diploma covers a syllabus more than the requirement of competence examinations. The subjects covered in the course are shown in appendix 'D'

The theoretical content of the degree scheme is considered to have same standard and depth as that of an engineering degree in UK, and hence it provides career opportunities in a wide range of the shipping industry rather than confining one's career to only sea service.

At the end of all training schemes, the candidates appear for class a IV oral examination conducted by the Maritime Safety Administration before proceeding to sea as watch keeping engineer.

In general, in all the three courses the trainees spend the first two yeas in the college then one year at sea and the final year at the institute.

A preparatory course is available for each certificate examination. The duration of the course varies from one week to 12 weeks depending upon the type of certificate examinations.

The UK has now introduced a new system, called National Vocational Qualifications (NVQ), for training and assessment of seafarers. This system helps students to acquire both knowledge and competence for safe and efficient operation of ships. This NVQ system is shown in figure 4.5

**Admission Requirements**

These vary according to the scheme chosen by the candidates.

*Ordinary National Diploma scheme*: Applicants should hold a general certificate of education with four subjects at ordinary level or equivalent to C grade or above, including mathematics, physics and one scientific subject such as general engineering technical drawing.

*Higher National Diploma scheme*: Applicants must have passed five subjects of which mathematics and physics must have been studied at A level.

*Degree scheme*: Applicants must have passed A level with mathematics and physics. Candidates with HND diploma can pursue one more year of academic studies for the award of a degree.

The continuous monitoring of cadets' progress, assessment of their achievement, and formal education have been approved by the UK safety administration.

**Licence Examinations**

The certificate of competency examinations are oriented towards general class of ships rather than to any particular ships. All examinations for a certificate of competency are conducted by the MSA. For marine engineers there are four types of certificate of competency.

Class IV watch keeping engineer (unlimited)

Class III engineer (limited)

Class II engineer unlimited)

Class I engineer (unlimited)

For class IV only the oral examinations are conducted.

Class II examinations have part A and B and are taken up separately. For part B candidates must have completed the necessary sea service and have passed or been exempted from the Part A examination.

Class I examination also has two parts, A & B, and both are taken up separately. To appear for Class 1 part A certificate one must have Class II certificate. For class I, part B, students must have completed their qualifying sea service and have passed or been exempted from the class I part A examination.

Though trainees are required to appear and pass certificate of competency examinations, they are exempted from the theoretical subjects of class II and class I engineer examinations depending upon the training scheme they have followed.

The candidates of OND scheme are exempted from the theoretical subjects of class II examinations.

The candidates of HND and degree scheme are exempted from class II and class I theoretical examinations.

**Summary**

In the UK a large number of institutes offer a wide range of training courses for national and overseas seafarers. However most of them offer only short specialised courses related to the specific needs of personnel working in the industry. It now provides the seafarers with a competence and knowledge based education. The MET course is designed and monitored by a single body, that is by the Merchant Navy Training Board, represented by shipping industries, seafarers' unions, institutes and government, for the development of MET programmes. It continuously improves the training programmes in the light of changing needs of industry, changes in the national and international legislation and the latest technological developments. The manned model centre at the Southampton Institute, one of three such centres in the world, offers one of the best training programmes in ship handling to masters and pilots. The Marine Administration conducts only oral examinations and assessment for officers.

### 4.6 Future Requirements of Indian MET System

The Marine Administration which is responsible for maintaining the standard of marine engineers in India should consider :

- Providing a uniform common training programme
- Providing a common one year training programme for both officers and crew.
- Increasing onboard training period to one year from six months
- Developing training courses for engine room ratings in order to help them to seek the career path of an engineer officer.
- Developing more education and training facility up to post graduation level.

- Introducing dual certificate of competency up to watchkeeping level.

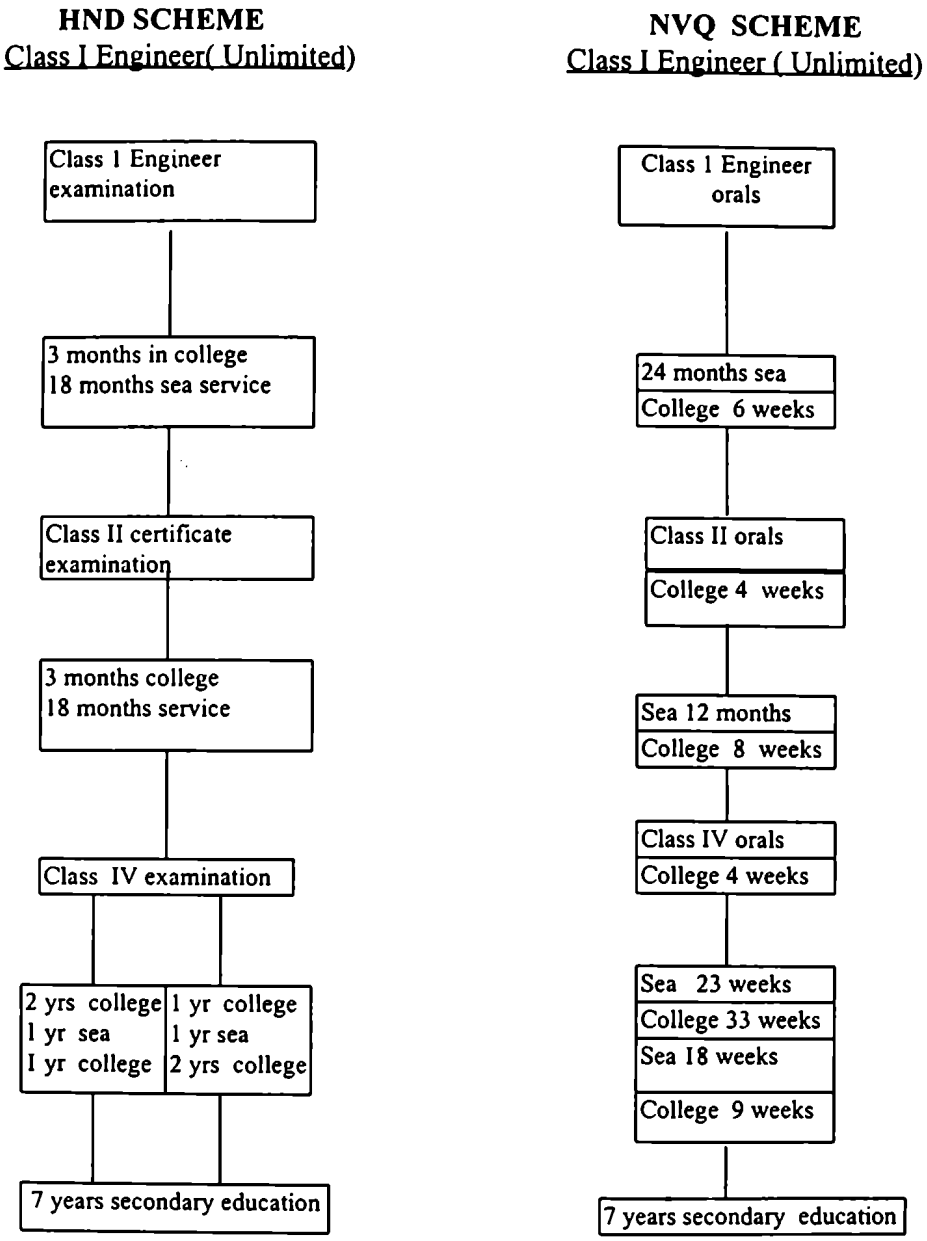


Fig 4.5 UK MET and Licence system

# CHAPTER 5

## Model Course Evaluation

### 5.1 Development of Model Courses

The rapid technological changes in design, construction, cargo handling, communication and increasing awareness of environmental protection in the last three decades have resulted in a greater need for better training for sea going officers and ratings for safe and effective operation of ships. During this period, most of the developing countries had problems in acquiring the latest technical know-how from the traditionally developed maritime countries to develop their own maritime infrastructure.

In recognition of the need for better training, the STCW 78 Convention and a number of recommendations related to the training of seafarers and personnel connected with the maritime sector were adopted under the auspices of IMO. Most of the developing countries were finding it difficult to implement the requirements of the Convention due to lack of technical information, knowledge, facilities, experience, and qualified people in the training institutes. In addition, the STCW Convention did not specify in detail the syllabus for the minimum knowledge requirement for the certification of officers. It had just indicated the broad outline of subjects to be covered in the certification process of officers.

In view of the above, the developing countries in the mid eighties requested IMO to develop a special maritime training programme designed primarily to help them to comply with the international regulations and recommendations and also to have an easy access to information regarding the latest developments in maritime technology. Around the same time, IMO too was concerned about the ineffectiveness of the Convention and hence thought that it would to be prudent to introduce standard model courses to achieve truly world-wide uniform training standards in MET. In 1988 IMO finally took the decision to develop a number of

model courses in order to assist the developing maritime countries not only in maritime education and training ( in compliance with the 1978 STCW Convention) but also in providing the latest technology.

IMO has so far developed 62 model courses in various fields of maritime sector and they are classified into seven major groups as under:

Group I : Basic and modular specialised training courses for all seafarers.

Group II : Advanced specialised training courses for seafarers responsible for operation of the vessel.

Group III : Environmental safety and other courses for the training of maritime administrative personnel and surveyors.

Group IV : Technical courses for the training of port personnel.

Group V : Management courses for the training personnel of shipping companies

Group VI : Training courses necessary for the issuance of competency certificates for seafarers as specified in the 1978 STCW Convention

Group VII : Other courses relevant to the activities of the maritime industry.

Some of these model courses are now being revised in accordance with the requirements of the STCW 1995 Convention.

### 5.2 Objectives of Model Courses

The main objectives of the model courses programme are as follows,

- To provide technical assistance to the developing nations to establish their own training and educational facilities for seagoing officers, ratings and shore personnel of the shipping industry.
- To provide assistance to the staff of Maritime Training Institutes around the world to develop new specialised training courses in their curriculum or to improve the existing training programmes in compliance with the international regulations related to standards of training and watchkeeping and other operational safety requirements.
- To provide assistance in enhancing the teaching skill of lectures and instructors of Maritime Training Institutes in the developing countries.

- To provide latest technology in all areas of shipping to the developing countries in order to develop their own maritime infrastructure and improve their own maritime services.
- To promote the world-wide maritime training network for effective global co-operation in maritime training, technological transfer and in better use of available resources.
- To make developing countries self-sufficient so that they can continue to maintain and develop their own training programmes in the future.
- To provide a framework for the continuous improvement, evaluation and revision of training courses in maritime education and training.
- To reduce the widening technological gap between the developed maritime nations and the developing nations by exchange of important information and knowledge in maritime technology.

## 5.3 Advantages and Disadvantages of Model Courses

5.3.1 *Advantages of model courses*

- They define clearly detailed learning objectives in each module or subject which are very helpful to the course co-ordinator and teaching staff in conducting the course. They are designed to give sufficient depth of knowledge and understanding required for safe operation and maintenance of machinery on board.
- They define clearly the eligibility criteria for the admission to not only each model course but also to the each of the modules if conducted separately.
- They prescribe the number of students to be taken for each course including practical exercises for effective transfer of knowledge from the instructors to the trainees.
- They define the requirement of qualification of instructors for conducting model courses.

- They specifie the requirement of teaching facilities and equipment for conducting each course.
- To assist the instructor for preparation of a lecture, they indicates the text book references and IMO reference against each learning objective.
- They specify the requirement of time for conducting each module in the course
- Learning objectives are useful for the evaluation of the students as they describe what the trainee has to do or is expected from him.
- The recommendation of giving a copy of specific learning objectives of each module to a student before the commencement of the course or on board training is beneficial to students in order to gain full benefit from the course or training.
- Each module contains an instructor's manual that contains guidance notes or teaching aids for teaching of the subject and also indicates the area of importance to be emphasised while teaching the module.
- The courses are flexible and hence implementations are easily achievable at national, regional level and finally at global level.
- They are easily adaptable to the existing resources.
- They place more emphasis on quality than any other criteria in training.

5.3.2 *Disadvantages of model courses:*

- Few learning objectives have been repeated under different modules.
- They do not define clearly the qualifications of instructors other than chief engineer certificate holders. They also do not say anything about the training of instructors or training of officers having chief engineer certificate in teaching pedagogies before being engaged in training activities.
- Some of the modules are repeated in model courses. For example, the module on survival of crafthas been repeated in both watch keeping engineer officer model course and chief engineer / second engineer model course.
- The suggestion to use the latest editions of text books is not feasible always due to financial constraints.

### 5.4 Model Course Implementation at Maritime Training Institute, Mumbai.

This institute belongs to the "Shipping Corporation of India Ltd", for continuous training of its personnel serving both at sea and ashore. It conducts a number of short specialised courses in compliance with the STCW 1978 convention requirements for sea going personnel and a number of short management courses for personnel working in the office.

The courses conducted at MTI on a regular basis for sea going personnel are:

- Basic survival course
- Basic fire fighting course
- Advanced fire fighting course
- Basic first aid course
- Familiarisation course for oil, chemical and LPG tankers.
- Advanced specialised tanker course
- Automation course
- Hydraulic course
- ISM / STCW 95 familiarisation course
- Watch keeping engineer's preparatory course
- Basic familiarisation course for ratings.

Most of the short courses for seagoing personnel are conducted in accordance with the guidelines defined in the respective IMO model course. The standard of some of the courses is maintained at a higher level than that defined in the model courses.

They are:

- Basic fire fighting course.
- Advance fire fighting course.

For both the courses the number of students does not exceed 16 whereas in the model course the limit is set at 24. The number of staff conducting these courses also exceeds the level prescribed in the model course.

While going into the contents of other courses it has been found that the standard of some of the courses is lower than that defined in the model course. The standard of these courses is required to be upgraded at least to the level of the model courses.

They are:

- Basic survival course.
- Basic first aid course.

Most of the staff members are not trained in teaching pedagogies, but are well qualified and experienced in merchant marine and hence meet the minimum requirements defined in the model courses.

### 5.5 Model Course for Watchkeeping Engineer Officers.

This model course 7.04 was based on the requirements of paragraphs 2(c) to (g) of regulation III / 4 and resolutions 2 and 4 of the 1978 STCW Convention and relevant recommendations of section 17, section 20 to section 25 of the "Document for guidance, 1985" of IMO / ILO. It covers all the requirements and recommendations in respect of minimum knowledge, skills and experience for certification of engineer officers in charge of engine room watch at sea or in port on ships powered by main propulsion machinery of 750 kW power or more. The curriculum has been designed in such a way that it would provide sufficient knowledge and understanding of equipment and its operation and safe watchkeeping practice. On successful completion of the course the trainees would be competent to carry out engine room watchkeeping duties safely and efficiently.

It had been designed to cover the mandatory minimum period of 3 years education in the following pattern:

1 ST year (phase 1) at college.

2 ND year (Phase 2) at sea.

3 RD year (Phase 3) at college.

This pattern enables trainees to gain maximum benefit from the real sea going experience and to conduct themselves in a manner that would not place anyone or anything at risk.

The contents of the first year are considered essential before a trainee proceeds to sea. The subjects include not only basic engineering principles but also training in practical skills and safe working practices on board.

It also recommends to undertake study in the following additional subjects.

Computer applications.
English language.
Human relationships.

The marine engineering education and training in India is not undertaken in the pattern described in the model course. All educational and training requirements are provided to students at institutes before sending them to sea. The model course recommends one year on board training, but an engineer officer undergoes approximately 8 to 10 months on board training on commercial ships of the Indian merchant field. This on board training on ships is not conducted in the manner as defined in the training record book and also the trainees do not maintain their record book as prescribed in the model course. Nevertheless trainees do undertake most of the tasks prescribed in the training record book during the on board training.

The Marine Engineering Research Institute, Calcutta covers not only the syllabus of all 26 modules but also the additional subjects stated in the model course in its four years' programme. However the level of theoretical and practical training on maintenance of shipboard machinery (module 9 and 23) is far below the level recommended in those modules. The recommendation to give project work (module 22) to students is excellent but not undertaken at MERI.

The marine engineers from other sources, graduate mechanical and electrical engineers, do not undertake any course in marine engineering subjects as prescribed in the model course during their four years engineering study. Apart from the one year intensive workshop / practical training, they attend only mandatory courses like basic fire fighting, first aid, and survival before proceeding to sea for on board training.

In the second year, trainees are required to be sent on board ship to get practical experience. The students during sea training are required to undertake numerous tasks and assignments as defined in the training record book in order to acquire knowledge and skills required for independent watch keeping in the engine room.

In the third year all unfinished tasks of 1 ST and 2 ND year and additional studies are undertaken. There are a total of 26 modules to be completed in 3 years and they are as under:

**First year:**

*Theory*:
Marine engineering materials
Basic engineering service
Mathematics
Marine engineering drawing and design Part I
Industrial chemistry
Thermodynamics
Mechanical science
Introduction to marine electrotechnology
Introduction to ships and ship routines
Basic fire fighting
Personnel survival
Medical emergency basic training

*Practical:*
Hand power tools
Machine tools
Fabrication and welding
Marine engineering practice
marine plant operation

**2 year** : On board training

**3 year:**

*Theory:*
Marine materials
Marine heat engines
Marine electrotechnology
Marine engineering drawing and design-part II
Marine engineering maintenance-part II
Advanced workshop practice
Operation & maintenance of main and Auxiliary machinery
Medical first aid
Proficiency in survival crafts
Advanced training in fire fighting.

### 5.6 Model Course For Chief /Second Engineer Officer

This model course was based on the requirements of paragraphs 3(a) to 3(i), 4a(i), 4(b) to 4(n), 5 and 6 of the appendix to the regulation III/2 of STCW Convention for certification of chief engineer/second engineer of ships of propulsion power 3000 kW or more and relevant recommendations "Document for guidance, 1985" , jointly prepared by IMO/ILO. The curriculum has been designed to produce competent chief engineer and second engineer officers for carrying out shipboard functions safely and effectively. The subjects covered in the course are given in the following table.

| |
|---|
| Thermodynamics |
| Mechanics and hydrodynamics |
| Operational principles and diesel installations |
| Operation and maintenance of machinery |
| Physical and chemical properties of fuels and lubricants |
| Technology of materials |
| Chemistry and physics of fire & extinguishing properties |
| Marine electrtechnology, electronics and electrical equipment |
| Fundamentals of automation, instrumentation, and control systems |
| Naval architecture and ship construction |
| International maritime law, agreements and conventions |
| Personnel management, organisation & training |
| Medical emergency first aid |
| Life saving appliances. |

The marine engineers of India do not undertake a separate educational programme for chief engineers / second engineers. The complete knowledge requirement for certification of watch keeping engineers and chief / second engineers is provided to students during initial training before sending trainees to sea.

The students of MERI, Calcutta undergo a comprehensive educational programme during the four year course. Their curricula cover more subjects than prescribed in the model course. The following deficiencies are found in MERI programme when compared to the Model course outline.

- They do not undertake any course on maritime law
- They do not undertake any study of on board management training. However their management courses cover a much wider field than specified in the model course, which covers only the maritime sector. The three modules, fire fighting,

first aid and survival are not taught in the institute. For these three modules the students have to go to other institutes where they are conducted in accordance with the model course.

The model courses are not used in other engineering colleges or other training institutes. The marine engineers from these colleges do not undertake any study in maritime subjects like maritime law, naval architecture, etc., before taking up a career at sea.

### 5.7 Summary

Model courses are an excellent tool for most of the maritime institutes of the developing countries in order to develop or improve their existing educational program for personnel working both at sea and ashore. It can be said that they are under utilised in most of the institutes though IMO had put in considerable effort to develop them. They are used in the maritime institutes only for the implementation of mandatory and other specialised courses of the STCW Convention. It is indeed a significant effort of the IMO to meet their overall objective of safer shipping and cleaner oceans through higher standards of education and training of seafarers.

# CHAPTER 6

## Development of Courses

### 6.1 Analysis of MET system in India for watch keeping engineer certification

For the certification of watchkeeping engineer a candidate is now required to undergo an approved marine engineering education and training scheme for a minimum period of 30 months. This education and training should provide him with the minimum desired knowledge as specified in column II of the table A III/1 of the revised Convention. As mentioned in chapter II, there are a number of different training systems offered in India today for training marine engineers. It requires to be seen whether the different systems meet the minimum mandatory requirements of the Convention. In case the standard of the present systems falls below the minimum standard requirements as mentioned in the Convention, then it is necessary to develop and introduce courses in order to bring up the standard. A comparison of the different training systems against the requirements of watchkeeping engineer is made in table 6-1 Since the Marine Engineering Research Institute, Calcutta, is the only institute providing true marine engineering training it is separated from the others while making the comparison. The marine engineers from other systems undertake a marine engineering orientation course, that is an intensive workshop training, before taking up a career at sea. A number of short specialised courses have been developed in India in the last decade in the light of the latest developments in shipping but attending only the relevant mandatory STCW courses has been made compulsory before proceeding to sea and for the certification process of a watchkeeping engineer.

Table 6-1 : Compliance of MET system of India with the knowledge requirements of the revised STCW Convention for watchkeeping engineer certification.

| The revised STCW Convention | MERI | Others |
|---|---|---|
| Engineering materials used in ship construction, equipment, fabrication and repair | Compliance | Partial compliance |
| Interpretation of machinery drawing and hand books | Compliance | Partial compliance |
| Operational characteristics of shipboard equipment and systems | Compliance | partial compliance |

| | | |
|---|---|---|
| Safe working practice in workshops | Compliance | Compliance |
| Construction and operation of electrical systems, DC/AC equipment including measuring and testing instruments. | Compliance | Partial compliance |
| Thorough knowledge of principles of watchkeeping including safety and emergency procedures of all systems. | Compliance | Non-compliance |
| Safety precautions to be observed during watch and actions to be taken in case of fire | Compliance | Compliance |
| Adequate knowledge of English | Compliance | Compliance |
| Principles of operation and trouble shooting of main and auxiliary machinery including boilers | Compliance | Non compliance |
| Basic mechanical knowledge and skill | Compliance | Compliance |
| Pumping systems, bilge, ballast, cargo | Compliance | Partial Compliance |
| Basic operational knowledge of electrical equipment. Alternators-location of faults and action to prevent damage | Compliance | Partial compliance |
| Maintenance and repair of electrical plant equipment including safety and emergency procedures. | Compliance | Partial compliance |
| Prevention of pollution of marine environment-Anti-pollution procedures and all associated equipment | Compliance | Non-compliance |
| Working knowledge of ship stability, water integrity and buoyancy | Compliance | Non-compliance |
| Ship construction-general knowledge of principal structural members of a ship | Compliance | Non-compliance |
| Fire prevention and fire fighting appliances | Compliance | Compliance |
| Knowledge of operation life saving appliances | Partial compliance | Partial compliance |
| Knowledge of medical aid | Partial compliance | Partial compliance |
| Basic knowledge of IMO Conventions | Compliance | Non-compliance |

From the above it can be noted that the trainee marine engineers from Marine Engineering Research Institute, Calcutta, do comply with most of the requirements of the revised STCW Convention. For total compliance they are required to undertake short specialised courses in proficiency in survival crafts and medical emergency instead of the basic survival and basic first aid.

The trainee marine engineers from other sources do not comply with many requirements of the Convention. Therefore, in addition to the proficiency in survival

craft and medical emergency courses, they need to undertake a course in a number of subjects before they are allowed to appear for the examination of watchkeeping engineer certificate conducted by the Administration. This course needs to be conducted only at approved Maritime Training Institutes. While developing this course curriculum the different educational backgrounds are required to be taken into consideration.

From the chapter 2 it can be said that the marine engineers from the Marine Engineering and Research Institute, Calcutta need not undertake this course as subjects in the course have already been incorporated in their curriculum.

The topics to be covered in this course are:

- Safe watchkeeping practice and emergency procedures.
- Main and auxiliary machinery.
- Ship construction.
- Ship stability.
- Fundamentals of marine electricity
- Engineering materials.
- Human relationships
- Engineering knowledge: IMO Conventions; prevention of pollution equipment.

### 6.2 Development of the Course for Watchkeeping Engineers

*Course objectives* :

The main objective of the course is to comply with the minimum knowledge requirement of the revised STCW Convention for the certification of watchkeeping engineer. However, on successful completion of the course, the trainees will:

- be familiar with the watchkeeping principles in the engine room.
- have knowledge of IMO bodies and their functions.
- have sufficient knowledge in ship construction and stability.
- be familiar with safe practices and actions to be taken during emergencies in the engine room.
- have knowledge of dangerous consequences of pollution and procedures of prevention pollution.

- be familiar with the function, the operation and the maintenance of shipboard machinery and systems.
- have basic knowledge of engineering materials and processes used on board.
- acquire better understanding and knowledge of human relationships while working on board.
- have sufficient knowledge to carry out electrical job safely and efficiently.

*Participants:*

The participants of the course are trainee marine engineers from all sources other than MERI, Calcutta. Course attendance should be made compulsory before appearing for the class IV certificate of competency examination. The number of participants in the course should be restricted to 24.

*Duration of the course*

The duration of the course should be around 10 weeks (330 hours). Each week will have 5 1/2 of working days and each day shall have 4 lecture periods of 90 minutes each. Thus each week will have 33 working hours. The approximate time required to teach each subject is shown in the following table.

| Subjects | Duration |
|---|---|
| Safe watchkeeping practice | 18 hours |
| Main and auxiliary machinery. | 66 hours |
| Ship construction | 33 hours |
| Ship stability | 33 hours |
| Fundamentals of marine electricity | 45 hours |
| Engineering materials | 33 hours |
| Human relationships | 18 hours |
| Engineering knowledge | 51 hours |
| Visiting ships, workshops and films | 33 hours |
| Total | 330 hours |

Table 6-2 Course for watchkeeping engineers

*Faculty*

The faculty members should be properly qualified, experienced and trained in teaching pedagogies. All marine engineering subjects should be taught by experienced and trained chief engineers. For engineering and other subjects which can not be taught by chief engineers or master mariners, an outside faculty from reputed institutes should be engaged.

*Teaching methodology*

The course should be conducted mainly by classroom lectures as the participants have already fulfilled the practical requirements during the marine orientation course. Audio and visual aids, demonstration should be used as far as possible to facilitate the learning process. Suitable reading material should be provided to each participant before starting the course, which should comprise the text related to lectures, important information from the books, machinery manuals and articles from periodicals. The evaluation test should be undertaken in each subject during the course to get the direct feed back from the participants. All external faculty should be provided with learning objectives well in advance in order to give them enough time for preparation of the lecture.

**6.3 Detailed Syllabus of Subjects**

The syllabus developed below is based on the IMO model course for training watchkeeping engineer, document of guidance prepared by IMO / ILO and the requirement for certificate of competency examinations for a watchkeeping engineer in India.. Full details will be found in the Appendix "E"

**Safe Watchkeeping Practice and Emergency Procedures**

Watchkeeping is one of the important functions of a marine engineer. However this important function has been neglected or taken lightly on many ships, mainly due to excessive work in the engine room. The other reasons for poor standard of watchkeeping can be attributed to negligence, carelessness, lack of alertness, monotony, boredom, fatigue, illness, stress, and lack of knowledge. A centralised air conditioned control room also contributed some extent to the poor standard of

watchkeeping. A good watchkeeping practice calls for frequent rounds in the machinery space rather than gazing at gauges in the control room. The performance of the watchkeeping engineer plays a vital role in the safe and trouble free operation of machinery and the vessel. Therefore every watchkeeping engineer should have a thorough understanding of tasks, duties and responsibilities to be carried out during the watch, either at sea or in port and in safe anchorage. In order to familiarise him with the principles of watchkeeping, the subject (refer Appendix E) should cover the following topics:

- Criteria for composing the engine room watch
- Requirement for safe watchkeeping practice
- Basic principles to be observed in keeping an engineering watch
- Keeping engineering watch under different situations
- Voyage planning
- Operation requirements of unmanned machinery space
- Minimum requirements for certification of officers and crew
- Safe operating procedures-

This subject should be taught in about 12 lectures of 90 minutes each (18 hours).

**Main and Auxiliary Machinery**

A marine engineer is responsible for the operation, maintenance and repair of machinery fitted on board ship. Full understanding of machinery as a whole is essential to become a competent and self reliant operator. Knowledge of manual operation and performance monitoring of all equipment is a must as automatic control systems can fail at any moment. For efficient and safe economic operation he should have adequate knowledge of working principle, design features, operation, control and maintenance of machinery and plants installed on all types of vessels. Therefore the syllabus ( refer Appendix E) should be comprised of the following topics:

- Main diesel engines: Principles and operation.
- Diesel generators: Principles and operation.
- Auxiliary boilers: Fundamentals, construction, operation and maintenance.

- Main air compressors: Working principles, construction & operation details.
- Refrigeration and air conditioning system.
- Steering system: Principles & operation of steering gear; statutory requirements
- Purifiers: Fuel oil and lubricating oil purification system.
- Pumps: Centrifugal, reciprocating, rotary and screw pumps.
- Evaporator: Principles, operation, drinking water purification
- Heat exchangers: Types and maintenance
- Deck machinery: Winches and windlass, Cargo handling equipment- deck cranes,
- Inert gas plant and cargo pumps
- Principles of maintenance: Planned, breakdown and condition monitoring

This subject should be taught in about 44 lectures of 90 minutes each (66 hours)

**Ship Construction**

Considerable changes have occurred in ship building with the introduction of new technology. The economic factor is of the prime importance in the design of the ship. The design takes into account not only the present economic consideration but also of the future. The construction of merchant ships is considerably influenced by the requirement of classification societies and regulations of the IMO. Ships also requires regular overhaul and maintenance like any other machinery on board in order to maintain seaworthiness. Prevention of corrosion plays a very important role in the upkeep of the vessel. A good percentage of marine engineers in their career become superintendents in shipping companies and their main responsibility is to maintain ships in good condition. Without the fundamental knowledge of basic design and construction of ships a marine engineer will not be able to undertake any structural maintenance and repair effectively. Therefore it is considered essential to provide marine engineers with sufficient knowledge in ship construction covering the following topics. Full details of syllabus will be found in the Appendix E.

- The definitions and the design criteria of ship structure of general cargo and bulk carriers, specialised oil, chemical, gas tankers.

- Stresses in ship structure.
- Bottom and side framing
- Shell and decks.
- Bulk heads and deep tanks.
- Fore and Aft end arrangements.
- Load line rules and classification society rules.
- Corrosion and painting.

This subject should be taught in about 22 lectures of 90 minutes each ( 33 hours ).

**Ship Stability**

Merchant ships exist to carry cargo across the sea speedily, economically, and safely. In order to accomplish this they must float in a stable upright position under all circumstances including heavy weather conditions. Excessive trim and list can affect the operation of machinery in the engine room. Therefore the fundamental knowledge of stability, trim, list, water integrity, and factors affecting them is essential. This knowledge will help the watchkeeping engineer to carry out duties relating to maintenance, ship stability and take measures quickly against flooding of compartments due to collision or grounding. For economic operation of the main engine, one must know the relationship between the fuel consumption, speed, and resistance of the vessel. Therefore it is necessary for marine engineers to have sufficient knowledge in ship stability and in damage control. This subject ( refer Appendix E) should be comprised of the following topics:

- General definitions.
- Draught, trim, heel and buoyancy
- Transverse stability
- Longitudinal stability
- Resistance and propulsion
- Strength of ships

This subject should be taught in about 22 lectures of 90 minutes each (33 hours ).

**Fundamentals of Marine Electricity**

Electric power is vital to all ship board functions, comfort of the crew and to the safety of the ship. A shipboard electrical plant includes: generating plant, switchgear for control of generators and distribution of power, distribution panels and transformers to provide power to electrical loads. A watchkeeping engineer is responsible for power generation, distribution and safe operation of all electrical and electronic equipment. Without sufficient knowledge in the fundamentals of electricity and marine application, he will not be able to operate and handle normal electrical faults of alternators, generators and control systems. For in depth understanding, the syllabus (refer Appendix E) should be comprised of the following topics:

- Electron theory and basic safety.
- Understanding of electrical diagram and symbols.
- Working principle of ammeter, voltmeter and megger.
- Difference between work, energy and power
- Electric power supply on board.
- Testing and measuring insulation and current.
- Working principles of batteries.
- Principles of magnetism and electromagnetism..
- Fundamentals of AC and DC generators and motors and operation.
- Maintenance of generators and circuit breakers.
- Maintenance of motors and starters.
- Production of alternating current, alternators.
- Power distribution and how full protection provided to electrical system.
- Working principles of transformer - Single and 3 phase.
- General description of lighting system on board.
- Safety precaution of electrical system on oil, gas and chemical tankers.

This subject should be taught in about 30 lectures of 90 minutes each (45 hours).

**Engineering Materials**

Marine engineers are required to have sound knowledge of properties of materials used on board and their behaviour, in general, under varying conditions of loading. Materials deteriorate in normal service conditions, sometimes rapidly when conditions are abnormal. Marine engineers should be able to predict such deterioration and take corrective measures against it. As failure of material is very common on board the engineers should also be capable of identifying types of failures by examining the fractured material for ordering new material for the replacement. Improper choice of material can cause machinery breakdown in the engine room. Some of the materials used for repairs require approval of classification society. The health hazardous non-ferrous materials used on board are required to be handled carefully. Knowledge of piping material is essential. In order to provide sound knowledge in engineering materials the subject should be comprised of the following topics. Detailed syllabus will be found in appendix E

- Properties of materials used on board with particular attention to steel, cast iron, cast steel
- Heat treatment of metals
- Non -ferrous metals properties and uses, with particular attention to aluminium, copper, zinc, lead, antimony, brass, white metal
- Non metallic materials, polymers, fillers used on board
- Direct stress and strain, Hook's law
- Shear force and bending moments caused by different types of loads
- Welding and non destructive tests

This subject should be taught in 22 lectures of 90 minutes each (33hours).

**Human Relationships**

Individual differences prevail among people and the environment greatly influences human behaviour. On modern ships crews are getting smaller and increasingly being operated by multinational crews coming from different social, cultural and language backgrounds. The more the size of the crew decreases, the greater the need for officers to communicate directly with crew. Human relations on board are

influenced largely by different attitudes and goals of people, which sometimes conflict and cause deterioration of relationships among people. Unless care is taken, the advantages resulting from the advanced technology, unmanned machinery space and integrated bridge, can be easily denied by personality clashes, lack of communication, carelessness and ignorance. Poor ship management leads to poor team work and low productivity. Co-existence and team spirit should be developed on board by all means to maintain good human relationships among people working together. Therefore this subject is essential for watchkeeping engineers to give them insight into the dynamics of social relationships, behaviour and equip them to be more effective managers. The syllabus (refer Appendix E) of the course should cover the following topics:

- The general aspects and different levels of human relationships.
- The factors affecting human behaviour
- Internal and external human relationships.
- Communication
- Shipboard environment

This subject should be taught in 12 lectures of 90 minutes each (18 hours).

**Engineering Knowledge**

The remaining non-compliance topics are covered in this subject. It should cover mainly environmental pollution, IMO bodies, vibration and engineering drawing.

During the past 25 years the pollution of the world's oceans has become the major concern of the international community. Though most of the pollution has come from land sources, a significant amount of pollution is caused by shipping. A number of measures have been taken to prevent the pollution from ships. So a watchkeeping engineer should have sufficient knowledge of those measures and the operation of pollution prevention equipment on board.

The majority of marine engineers have little knowledge about IMO and its role in the maritime matters and hence it is necessary to include this in the course.

A vibration free ship does not exist. Vibration of one kind or another has an important bearing on operation of machinery and maintenance of the hull structure.

Excess vibration can cause damage to machinery and hull structure. Hence it is essential to have adequate knowledge regarding causes, main sources, effects and necessary steps to reduce the vibration.

As some students have not taken any formal course in engineering drawing, a few classes in this subject should be included. This knowledge will help them to interpret correctly mechanical and electrical drawings.

The syllabus (refer appendix E) should be comprised of following topics:

- Environmental pollution and introduction to MARPOL.
- Bunkering precautions and oil record book.
- International Maritime Organisation and its role and the Conventions
- Vibration: Free, forced, and torsional vibration.
- Engineering drawing

This subject should be taught in about 34 lectures of 90 minutes each ( 51 hours).

### 6.4 Summary

Implementation of above course for watchkeeeping engineers will not pose problem for any training institutes in India. Most of the institutes including the Maritime Training Institute, Mumbai are now conducting a one month preparatory course for a class IV oral examination for watchkeeping certificate. Attending this course has so far not been made compulsory by the Marine Administration (refer fig 1, Chapter 2). The syllabus content of this course, if modified as proposed above, will fulfil the requirement of STCW 95 for watchkeeping certification and a separate course need not be started. However the Administration is required not only to approve the revised course but also to make it compulsory for all engineers. The current practice of appearing directly for class II examination after completion of 21 months sea service should be discontinued.

### 6 .5 Analysis of MET System in India for Second / Chief engineer Certification

For the certification of a chief engineer and second engineer on ships powered by main propulsion machinery of power 3000 kW or above, a candidate must attend an approved education and training scheme in subjects providing minimum knowledge as specified in column 2 of the table III/2 of the revised Convention. An analysis is made in the table 6-2 to know whether the marine engineers comply with these requirements before they appear for a certificate of competence examination. As in the case of watch keeping engineer, the students from MERI are separated from others while carrying out this analysis. Also, the self study undertaken by the students while appearing for licence examination or at any stage is not considered as an approved education programme.

Table 6-3 : Compliance of MET system of India with knowledge requirements of the revised Convention for chief / second engineer certification.

| The revised STCW Convention | MERI | Others |
|---|---|---|
| Thermodynamics and heat transmission | Compliance | Partial compliance |
| Mechanics and hydrodynamics | Compliance | Partial compliance |
| Operating principles of ship power installations | Compliance | Partial compliance |
| Physical and chemical properties of fuels and lubricants | Compliance | Partial compliance |
| Technology of materials | Compliance | Partial compliance |
| Naval architecture and ship construction including damage control | Compliance | Non-compliance |
| Practical knowledge in operation and maintenance of diesel engines | Compliance | Partial compliance |
| Practical knowledge in operation and maintenance of auxiliary machines including auxiliary boiler, steering | Compliance | Compliance |
| Operation, testing and maintenance of control systems | Compliance | Non-compliance |
| Operation and maintenance of cargo handling equipment and deck machinery | Compliance | Non-compliance |
| Operation and maintenance of machinery including pumps piping system | Compliance | Non-compliance |
| Operation of internal communication system on board | Compliance | Non-compliance |

| | | |
|---|---|---|
| Marine electrotechnology, electronics, and electrical equipment | Compliance | Partial compliance |
| Fundamentals of automation, instrumentation and control system | Compliance | Partial compliance |
| Practical knowledge of operation testing and maintenance of electrical and electronic equipment | Compliance | Partial compliance |
| Marine engineering practice | Compliance | Compliance |
| Practical knowledge in Organising and carrying out safe maintenance and repair procedures. | Compliance | Partial compliance |
| Detection of machinery mal-function, location of faults and action to prevent damage | Compliance | Compliance |
| Ship construction and stability and damage control | Total compliance | Non-compliance |
| Knowledge of IMO recommendation concerning ship stability | Compliance | Non-compliance |
| Maritime law- Certificates to be carried on board; International convention on load line, SOLAS, MARPOL, International health regulations | Partial Compliance | Non-compliance |
| Thorough knowledge of life saving appliances, their functions and maintenance | Partial compliance | Partial compliance |
| Organisation of fire drills and maintenance of fire fighting equipment | Compliance | compliance |
| Personnel management, Organisation and training on board ship | Compliance | Non-compliance |
| Knowledge of international maritime conventions, recommendations and related national legislation | Non-compliance | Non-compliance |

From the above, it can be noted that marine engineers from MERI, Calcutta do comply with most of the requirements of the revised Convention. For total compliance their curricula should include a module on maritime law and they need to undertake a course in proficiency in survival craft

Marine engineers from other sources do not comply with many requirements of the Convention. Therefore in compliance with the mandatory requirements, a short course is required to be developed and introduced for all marine engineers other than from MERI, Calcutta. Attending this course should be made compulsory before the chief/ second engineer licence examination. While developing the new course, the subjects included in the watchkeeping engineer course have to be taken into consideration in order to avoid duplication. This course involves only classroom lectures as participants are expected to have good understanding of all shipboard

machinery operation by virtue of their few years of service at sea as a watchkeeping engineer. All non and partial compliance topics are covered in the following subjects.

Thermodynamics and heat engines

Automation

International maritime law

Computers

Operation and maintenance of diesel engines

Ship operations, management, Organisation, training and shipping economics

Marine electrotechnology, electronics and electrical equipment.

Applied mechanics and fluid mechanics.

### 6.6 Development of the Course for Chief / Second engineers

*Objectives:*

The main objective of the course is to comply with minimum knowledge requirement of the revised STCW Convention for the certification of chief / second engineer. However on completion of the course the participants will:

- Have the basic knowledge of computer functioning and operation.
- Have in-depth knowledge in operation and maintenance of main engines.
- Have sufficient knowledge in instrumentation and automation that is required for operation and maintenance of various control systems.
- Be conversant with legal obligations and responsibilities concerning international provisions for the safety of ship, crew, passengers, cargo and for the prevention of pollution from the ship.
- Acquire sufficient theoretical knowledge in thermodynamics and heat transmission appropriate to the responsibility of a chief engineer.
- Be capable of organising and managing the crew and able to draw up a plan for dealing with emergencies.
- Have sufficient knowledge of marine electricity and systems to carry out duties of chief engineer/second engineer in a safe and efficient manner.
- Have adequate knowledge in applied mechanics and fluid mechanics appropriate to the duties of chief engineer.

Participants:
The participants of this course are those marine engineers who have completed 12 months of sea service after obtaining a certificate for keeping independent watch in a engine room on a vessel powered by a engine of power 750 kW or above. The number of participants in a class should be restricted to 24.

*Duration of the course:*
The minimum duration of the course should be around 14 weeks (462 hours). Each week shall have five and half working days with four periods each of 90 minutes programmed each day. In a week there will be 33 working hours. The time utilised for audio and visual aids or for other purposes is included. The time required for teaching each subject is shown in the following table.

| Subjects | Duration |
|---|---|
| Thermodynamics and heat engines | 66 hours |
| Automation | 66 hours |
| International maritime law | 33 hours |
| Computers | 33 hours |
| Operation and maintenance of diesel engines | 66 hours |
| Ship operations and management | 33 hours |
| Marine electrotechnology and electronics | 84 hours |
| Applied mechanics and fluid mechanics | 66hours |
| Audio and visual aids | 15 hours |
| Total | 462 hours |

Table 6-4 Course for second/chief engineers.

*Faculty*:
The faculty should consist of well qualified, and well experienced staff with teaching capabilities. The marine engineering subjects should be taught by senior chief engineers having sound knowledge and wide range of sea experience. For teaching other subjects external faculty should be drawn from leading engineering institutes or the industry.

**6.7 Detailed Syllabus**
The syllabus developed below is based on the IMO model course for chief / second engineer, document of compliance prepared by IMO /ILO and the requirement of competency examination for second / chief engineer. The Full details of the syllabus will be found in the appendix "F".

**Thermodynamics**

Thermodynamics is the science that encompasses the study of energy transformation from one form to another form and the relationship among the various physical quantities of a substance that are affected by the transformation. The fundamental laws of thermodynamics and heat transfer are used in the functioning of internal combustion engines, boilers, gas turbines, main air compressors, refrigeration, and air-conditioning. The designs of condenser, evaporator, compressor and control valves are based on the principle of heat transfer. The core activities of marine engineers relate to the operation and maintenance of the above machinery. Without the adequate knowledge in thermodynamics and heat transfer a marine engineer will not be able to operate the above machinery efficiently economically while carrying out duties in the engine room. For this reason he should undertake study in thermodynamics and heat transfer before the certificate of competency examination of second/chief engineer. The syllabus(refer Appendix F) should be comprised of the following topics.

- Fundamental concepts and definitions of thermodynamics.
- Internal energy and enthalpy of a pure substance.
- First and Second laws of thermodynamics.
- Compression and expansion processes
- Vapour power, Rankine, Carnot, Air standard power and refrigeration cycles
- Fundamentals of heat transfer and combustion in practical systems.

This subject should be taught in about 44 lectures of 90 minutes each (66 hours ).

**Automation**

The field of automation and control is immense. Over the past three decades the automation in the control system has been increasingly used in the engine room on almost all ships. The main advantages of automation in the engine room are: it relieves marine engineers from routine watchkeeping duties, monitors plant performance continuously and reduces the manning requirement in the engine room. In spite of enjoying better working conditions, the automation has been regarded with apprehension by most engineers. They are very sceptical about the reliability

of the automation and often resort to normal watchkeeeping even if the engine room is designed for unmanned operation. It is also true that most engineers do not have the knowledge to rectify the faults, however simple and small maybe, when the control system goes out of order. The deficiency in performance and apprehension is due to inadequate knowledge and understanding of the functioning of automation used in the engine room.. In order to operate a plant safely, reliably and efficiently in the machinery space, a chief engineer is required to have a good understanding of design principles, function and maintenance of instrumentation and automatic control system. The syllabus(Appendix-F) should be comprised of following topics:

- All measuring devices.
- Signal transmitting devices.
- Automatic control theory.
- Automatic controllers.
- Control valves.
- Various control systems in marine application
- Monitoring systems in the machinery space.

The subject should be taught in 44 lectures of 90 minutes each (66 hours)

**International Maritime law**

Generally the master is responsible for all legal aspects related to navigation, the safety of a ship, crew, cargo and for the protection of the marine environment. Even though the chief engineer officer is also responsible for a large part of the ship's performance that involves maritime law he does not undertake any study in the subject. Therefore it is necessary for a chief engineer to have basic knowledge of various International Agreements and Conventions. The syllabus (Appendix F) should be comprised of the following topics:

- Certificates and documents required to be carried on board
- Various international conventions related to SOLAS, MARPOL & STCW
- Arrival / Departure documents and procedures
- Functions and responsibilities of classification societies
- Cargo carrying procedures

- Law of the sea
- Brief introduction to Merchant Shipping Act

This subject should be taught in about 22 lectures of 90 minutes each ( 33 hours).

**Computers**

The development of computers has led to the increasing use of computers on board for many functions namely, spare parts inventory control, machinery planned maintenance system and record keeping. In addition, the computers are increasingly being used in the control system for a monitoring role that will inform the engineer of any fault and location in machinery. Indicator cards to measure the main engine performance is no longer taken on modern ships. Most of the engineers are uncomfortable on modern vessels as they do not have any working knowledge of computers. Nowadays simulator training has become one of the outstanding tool of on-job training. Any simulator training will not be effective without the sufficient knowledge in the operation of computers. Most of the allied industries of shipping namely, shipyards ports and workshops extensively use computers in their working field. Therefore training of an engineer in the computer science is essential. The course syllabus (Appendix F) should cover the following topics :

- Parts and principles of working of computers.
- Introduction to various software packages.
- Application to spreadsheets, word- processing and database programmes.
- Introduction to windows and their advantages over DOS system.
- This subject should be taught in about 22 lectures of 90 minutes each (33 hours)

**Operation and Maintenance of Diesel Installations**

In the highly competitive world of shipping, the condition of the main propulsion engine plays a very important role in providing good service. Improper operation or lack of maintenance of the main propulsion engine and associated equipment might lead to undesirable breakdown of the main propulsion engine and stoppage of a vessel at sea causing considerable danger to the vessel. A chief engineer should be competent to handle all types of problems of the main engine at sea. Broader

knowledge regarding the latest developments in the design and operation of various types of main diesel including the latest requirements of low exhaust emission is essential. Good understanding of manoeuvring systems and fuel timing adjustments for different types of diesel engines is essential. In order to provide an in depth knowledge in the operation and maintenance of a 2 stroke slow speed diesel engine for a second/ chief engineer the syllabus (Appendix F) should be comprised of the following topics:

- Operating principles of diesel engines.
- Measurement of engine performance.
- Fuel oil injection system, fuel pumps, injectors and fuel oil properties.
- Construction and design of various engine components.
- Starting and reversing system.
- Measurement of Crankshaft deflection, and adjustment of main bearings.

The subject should be taught in about 44 lectures of 90 minutes each (66 hours )

**Ship operations and Management, Organisation, Training and Shipping Economics**

In the initial period of sea service an engineer is mostly confined to the engine room dealing with machines all the time. While performing his duties in the engine room, he does not deal with many people and hence does not develop the art of managing people. All that will change when he becomes second/ chief engineer. As a second/ chief engineer he should be capable of organising and managing crew for safe and efficient operation of engine room machinery and be able to draw up an organisation for dealing with emergencies. A chief engineer is also required to deal with ship repairers, surveyors, port agents, and other shore staff. Therefore, an adequate knowledge in management of personnel, ship operations and in the behaviour of an organisation is essential for him. As second/ chief engineer should also be required to be familiar with the training methodology of trainee junior engineers. The basic knowledge of shipping economics and marine insurance is beneficial to understand the shipping business.

The syllabus (Appendix F) for this subject is categorised into six main headings as:

- Principles of personnel management
- Organisation of staff
- On board training procedures
- Ship operations - Planning sailing schedules, voyage estimates
- Brief history of shipping and introduction to economics.
- Brief introduction to marine insurance

This subject should be taught in about 22 lectures of 90 minutes each (33 hours).

**Marine Electrotechnology, Electronics and Electrical Equipment**

Though a chief engineer is entirely responsible for operation and maintenance of electrical equipment it is the electrical engineer officer who carries out all electrical work on board ships. In general, it has been observed that most of the marine engineers including the chief engineer are not confident in carrying out electrical work, leaving aside operation of equipment, in spite of having studied electricity during pre-sea training. As per STCW 95 Convention, a second/ chief engineer should be competent to carry out tests, detect faults and restore electrical and electronic equipment to operating conditions. To achieve this, the knowledge imparted at watchkeeping level is not sufficient as it concentrates only on safe operation of the electrical equipment. In order to gain sufficient competence in handling electrical equipment, a course at this stage providing deep understanding of marine electrical machinery including the use of electronic components will be great beneficial to marine engineers. It should also cover statutory "Regulations" and "Recommended practice" regarding utilisation, inspection and testing of electrical and electronic equipment. The subject (Appendix F) should be comprised of the following topics:

- Principles of magnetism and electromagnetism
- Batteries, emergency system and shore power
- Understanding of electrical circuits
- AC generators- working principle and construction.
- AC switchboards and distribution systems
- AC motors

- DC generators- working principle and construction
- DC switchboards and distribution system
- DC motors
- Safe electrical equipment for hazardous areas
- Inspection and maintenance electrical equipment

This subject should be taught in 56 lectures of 90 minutes each (84 hours).

**Fluid Mechanics and Applied Mechanics**

Over the years shipboard hydraulic machinery has substantially increased in volume, diversity, and complexity. The design and construction of the hydraulic systems depend upon the particular application on board. They are used for cargo handling, ship handling, opening hatch covers and remote operation of ballast and cargo tank valves. The engineers are mainly responsible for operation and maintenance of all hydraulic equipment. Any deficiency in performance of machinery can cause considerable delay in the cargo work. The marine engineers should also have the ability to predict effects of force and motion on machines and performance of machine components under static and dynamic loading. The knowledge of friction in bearings and different types of drives is beneficial. Therefore to understand the proper functioning of the machinery a second/chief engineer should have an adequate knowledge in fluid mechanics and applied mechanics. The syllabus (Appendix F) should be comprised of the following topics:

*Fluid Mechanics:*

- Hydrostatics
- Fluid in motion.
- Flow through pipes
- Fluid friction
- Properties of hydraulic fluids
- Introduction to hydraulic system on board

*Applied mechanics:*

- Statics and Couples
- Friction

- Kinematics
- Circular motion
- Periodic motion
- Drives and brakes
- Governors

This subject should be taught in 44 lectures of 90 minutes each (66 hours).

### 6.8 Summary

The course developed above for second/ chief engineers is just fulfilling the requirements of STCW 95 Convention. The course content is adequate in the present circumstances but may not be sufficient for the future needs of the shipping industry as technology in the maritime field is continuously improving. Short modules on new subjects should be included in this course with the extension of the course period if required in the future. The following institutes are suitable for conducting these courses as they have the infrastructure, faculty and library facility.

- Maritime Training Institute, Mumbai.
- Marine Engineering and Research Institute, Mumbai.
- Institute of Marine Engineers, Mumbai.
- Marine Engineering and Research Institute, Calcutta.

Approval from the Marine Administration must be obtained before conducting the course.

# CHAPTER 7

## Conclusions and Recommendations

### 7.1 Conclusions

From the study the following conclusions can be drawn:

The training facility for marine engineering has not grown in pace with the growth of the shipping industry. Even after fifty years of independence, the country has only one marine engineering training institute, MERI, Calcutta, for pre-sea training of engineers. This institute has adopted "front end" type education like other developed maritime nations. The standard of education and training in this institute is as high as in the developed maritime countries. It even surpasses the knowledge level prescribed in the model courses for watchkeeping engineers and second chief engineers.

Traditional method of training "apprenticeship" at various marine organisations has been continued even after the establishment of MERI, Calcutta. In this scheme, trainees undertake only practical training. Distance education on basic engineering subjects has been made compulsory to them only after implementation of the STCW 78 Convention. Their knowledge level falls short of the standard prescribed in STCW 95.

When the above two schemes could not meet the demand for trained engineers in the seventies, the government introduced a new fast scheme for producing marine engineers instead of establishing more marine engineering institutes. This scheme has allowed a large number graduate mechanical /electrical engineers to take up a marine engineering profession. Though they have a degree in an engineering discipline, their knowledge of marine engineering subjects falls short of STCW 95.

Shipping is a cyclic industry and the demand for trained engineers will always vary in the industry. An accurate prediction of demand and supply is very difficult to

make. For smooth supply of trained engineers to the shipping industry all three schemes for training engineers will continue in India.

The knowledge level of marine engineers varies depending upon the course undertaken by them. Since it is necessary for all marine engineers to have the same level knowledge, the best solution in the present situation would be to introduce the short courses developed in the chapter 6 for all engineers except from MERI, Calcutta before the certificate of competency examination. This will certainly help to bring down disparity in standard among engineers.

It has been observed that many marine engineers with the intention of obtaining certificates of competency quickly sail continuously in only one kind of vessel before they appear for class II and class I examination. This will not provide them with varied sea experience on different kind of vessels in different situations.

In the present education and training system there is no provision for higher studies (Post graduation /PhD course) and research work in the maritime field.

The STCW 78 Convention has substantially been revised in 1995. The amended regulations will have far reaching effect in the training of merchant navy officers. The code gives the details of the convention which had been absent in the past. The greatest changes in the STCW Convention are the introduction of assessment of competence for certification of officers and establishment of quality standard system to monitor MET activities.

The revised Convention emphasises a lot on proper on-board training. Proper on board training on commercial vessel is not possible with current levels of manning. The quality of on board training also depends on the condition of a vessel. For effective on board training sailing on both new and old ships is essential.

The model courses developed by IMO to assist maritime training institutes in developing countries have not been effectively used in many training institutes.

The developed maritime nations have adopted either front end or sandwich type education for their officers. Their courses award a recognised degree to engineers after completion of the course. The shipboard training is well structured and is included in the curriculum of the engineering course.

### 7.2 Recommendations

This paper has looked into only the knowledge requirement for the certification of watchkeeping engineer and second/chief engineer for performing duties in the engine room. Immediate changes are required in the examination system for certificates of competency as the present system has become outdated. In order to implement the STCW 95 convention, the author makes the following recommendations in respect of current marine engineering system in India.

1) The certification and examination system for engineer officers should be restructured and examinations conducted only at two levels, namely, watchkeeping level and management level.
2) Written and oral examinations should be conducted for both levels.
3) Separate examination papers should be conducted for each subject.
4) The written examinations should cover all the knowledge requirements of Code "A"
5) Oral examinations should cover only the safety, environment protection and safe operation aspects of machinery on board.
6) All written examination papers should be sent to the Marine Engineering Institute, Calcutta or Mumbai for assessment.
7) Re-examination should be made necessary only in that particular subject in which a candidate has failed to pass.
8) The sea service certificate issued by the chief engineer to an engineer officer for a higher level examination should indicate whether the engineer officer under him has

demonstrated requisite the competence as specified in the Code during his service on board.

9) Every institute should have a staff development policy. The faculty should be sent to attend various national and international conferences and seminars conducted in the maritime field.

10) The Institute should make arrangements for the faculty (Former - chief engineers) to undertake a short voyage on the latest vessels at least once in every three years.

11) Lecturers should be encouraged to carry out research work in the subjects which they are teaching in the institutes.

12) The practical training of graduate engineers should be restructured and sufficient tasks, and project should be given to each trainee.

13) The courses developed in chapter 6 should be considered for the refresher course for the revalidation of certificates of competency.

14) A maritime university should be established in Mumbai for promoting higher studies and researching activities in the maritime subjects.

15) All maritime pre-sea and post-sea education and training and written examinations should be brought under the purview of the Maritime University in order to ensure uniform standards of all schemes of training.

16) Two months practical training at large ship repairing dry-docks or marine workshops should be made compulsory after onboard training and before the examination for certification of watchkeeping.

17) It should be made mandatory for all engineers to sail on at least three different ships for class II examination and six ships for class I examination. In other words, an engineer should not be allowed to sail more than six months on any ship.

# Bibliography


Australian Maritime College (1997). *Handbook.* Launceston, Australia.

Focus on IMO (1996). *The New STCW Convention.* London :IMO.

Government of India Rules (1990). *Examination Rules for Engineers* . Mumbai: Bhandarkar publications.

IMO ( 1991). *Model Course( 7.04) Engineer Officer in Charge of a Watch.* London: IMO.

IMO ( 1996). *STCW 95 Convention.* London: IMO.

IMO (1990). *Guidance on the implementation of model courses.* London: IMO.

IMO (1990). *Strategy for Maritime Training.* London: IMO.

IMO (1991). *Model Course (7.02) Chief/ Second Engineer Officer.* London: IMO.

IMO (1994). *Maritime Training Activities Under the Auspices of IMO.* London: IMO.

Kyaw Zeya (1996). 'Main changes in the international Convention on Standards of Training, Certification and Watchkeeping for seafarers, 1978, as amended in 1995'. Technical Journal, the World Maritime University, Malmö, Sweden.

Marine Engineering and Research Institute. (1995) *Prospectus.*

Muirhead. P. M.(1997). *STCW 95 and Maritime Academies.* Lecture notes, World Maritime University, Malmö, Sweden.

Nakazawa. T. (1997). *MET systems (Japan).* Lecture notes, World Maritime University, Malmö, Sweden.

Southampton Institute of Higher Education (1993). *Catalogue.* Southampton: SIHE.

The United States Merchant Marine Academy(1993-1994). *Catalog*: New York: USMMA.

# Appendix A

Curriculum of Marine Engineering Course at Mercantile Marine College, Kobe.

Subjects of General Education:

| Subjects | Credits |
|---|---|
| Japanese | 9 |
| Ethics and Social studies | 2 |
| Philosophy | 1 |
| Politics and Economy | 2 |
| Laws | 2 |
| Economics | 2 |
| History | 4 |
| Geography | 2 |
| Mathematics | 16 |
| Physics | 4 |
| Chemistry | 4 |
| Biology | 2 |
| Physical education | 11 |
| Arts | 2 |
| English | 18 |
| German/ French | 4 |
| Total | 85 |

Subjects of Professional Education:

| Subjects | Credits |
|---|---|
| Applied Mathematics | 3 |
| Information Processing | 2 |
| Applied Mechanics | 6 |
| Electric/Electronic Engineering | 6 |
| Instrument and Automatic control | 3 |
| Principles of Merchant Marine | 4 |
| Marine Safety engineering | 2 |
| Maritime Laws | 3 |
| Marine Engineering | 2 |
| Boating and Signalling | 2 |
| Marine Medical practice | 2.5 |
| Total | 35.5 |

| Subjects | Credits |
|---|---|
| Nautical Laws | 2 |
| Seamanship | 3 |
| Navigation | 3 |
| Prime Mover | 10 |
| Technical thermodynamics | 1 |
| Materials of Machines | 2 |
| Design and Drawing | 4 |
| Machine Practice | 2 |
| Experiment and Practice | 6 |
| Graduation Experiments | 4 |
| Total | 37 |

Elective Subjects:

| Subjects | Credits |
|---|---|
| Exercises in Information Control Engineering | 1 |
| Special Lecture on Marine Information Engineering | 1 |
| Special Lecture on Marine Safety Engineering | 1 |
| General oceanography | 1 |
| Port and Harbour | 1 |
| Special Lecture on Electric & Electronic Engineering | 1 |
| Thermomotive Engineering | 2 |
| Refrigeration and Air Conditioning | 1 |
| Total | 10 |
| To be taken | 4 |

| | |
|---|---|
| Total Credits of Professional Subjects | 76.5 |
| Minimum Credit requirement for Graduation | 161.5 |

**School- ship practice**

| Subjects | Hours |
|---|---|
| Ship-board Operation | 10 |
| Watch Keeping | 45 |
| Seamanship | 15 |
| navigation | 15 |
| Engine management | 40 |
| Emergency Procedure | 15 |
| Total | 140 |

Training onboard the training ships of IST for 12 months is essential

# Appendix B

Curriculum of Marine engineering Course at the USA Merchant Marine Academy

| **Plebe Year (Fourth Class)** | |
|---|---|
| | |
| **First quarter** | **Third Quarter** |
| Calculus and Analytic Geometry | Calculus and Analytic Geometry III |
| Chemistry 1 | Physics 1 |
| English 1 | Nautical Science II * |
| Engineering Graphics | Engineering Graphics *** |
| Marine safety 1 | Marine Engineering III *** |
| Nautical Science | Engineering Shop III *** |
| Physical Education | Naval Science Fundamentals |
| | Physical Education |
| **Second Quarter** | Marine Transportation I * |
| Calculus and Analytic Geometry | |
| Chemistry II | **Fourth Quarter** |
| English II | Calculus and Analytic Geometry IV |
| Engineering Graphics | Physics II |
| Marine Engineering I | nautical Science III *** |
| Engineering Shop I | Safety of life at Sea |
| Physical Education | Nautical Science IV **** |
| | Engineering Graphics IV ** |
| | Electrical Engineering *** |
| | Metal Cutting Processes I *** |
| | Metal Joining Processes I ** |
| | English III |
| | Physical Education |
| | |
| **Sophomore Year (Third Class)** | **Junior Year (Second Class)** |
| Introduction to Linear Differential equations | Strength of Materials |
| Physics III, IV | Principles of naval Architecture |
| Safety of Life at Sea I | Fluid Mechanics |
| Introduction to Computer Engineering | Thermodynamics II, III |
| Introduction to Materials Engineering | Electric Circuits I, II |
| Engineering Mechanics I, II | History I |
| Thermodynamics I | Managerial Process |
| Economics I, II | Naval Operations |
| Naval Weapon systems | Physical Education |
| | Elective |
| **Senior Year (First Class)** | |
| Marine Refrigeration | |
| Alternating- Current Machinery | |
| Electronics I | |
| Marine Engineering I, II, III | |
| Internal Combustion Engines I, II | |
| History II, III | |
| Marine Transportation | |
| Naval Operations II | |
| Physical Education | |
| Option: | |
| Humanities or Comparative Culture Sequence | |

# Appendix C

Curriculum of Bachelor of Technology Course at AMC

**1 St year: Integrated Ratings Course**

**2 Nd year (36 weeks)**

| Subjects | Hours |
|---|---|
| Electrical Fundamentals | 90 |
| Environmental Engineering | 30 |
| Engineering Mechanics | 90 |
| Marine Technology | 60 |
| Materials Technology | 90 |
| Mathematics 1 | 90 |
| Physics | 60 |
| Thermofluid Dynamics 1 | 60 |
| Practical training 1 | 180 |
| Practical Training 2A & 2B | 195 |
| Computing | 60 |
| Total hours | 1005 |

**3Rd year (36 weeks)**

| Subject | Hours |
|---|---|
| Engineering Graphics | 90 |
| Sea Service Guide 1* | 90 |
| Engineering Mechanics 2 | 75 |
| Applied hydrostatics | 30 |
| Electrical Engineering | 60 |
| Ship Design & Production | 30 |
| Instrumentation | 60 |
| Marine Electrical Systems 1 | 45 |
| Marie Technology | 75 |
| Mathematics | 60 |
| Thermofluid Dynamics 2 | 90 |
| Practical raining 3A & 3B | 195 |
| Total hours | 900 |

**4 Th. year (36 weeks)**

| Subject | Hours |
|---|---|
| Digital electronics | 60 |
| Control and Instrumentation | 75 |
| Engineering Mechanics 3 | 75 |
| Cargo systems and safety 3 | 60 |
| Machine Design | 60 |
| Marine Electrical Systems 2 | 45 |
| Maritime Engineering Management | 75 |
| Marine Technology 3 | 90 |
| Ship Resistance and Propulsion | 30 |
| Ship Structures | 30 |
| Power Electronics | 30 |
| Thermofluid Dynamics 3 | 60 |
| Sea Service Guide 2* | 90 |
| Practical Training 4 A | 60 |
| Practical Training 4B or 4C | 90 |
| Total hours | 930 |

* Non-sea going students will have Technical Report 1/2

# Appendix D

Curriculum of HND Engineering Course (Southampton Institute)

Mathematics
Computer Studies
Applied Thermodynamics
Applied Mechanics
Electrical and electronic principles
Engineering Drawing
Workshop processes and Materials
Marine Engineering Practice
Instrumentation and Control
Naval Architecture
Marine Electronics
Marine Power Plant technology
Control Engineering
Marine Safety Equipment Practices
Marine Machinery Systems
Marine Electrical Practices
Supervisory and legislative studies
Other activities include boatwork, firefighting, and practical training using the machinery space simulator.

# Appendix E

## Safe Watchkeeping Practice and Emergency Procedures

a) *Criteria for composing the engine room watch* - Types of ships, type and condition of machinery, position of a ship, weather conditions, Master's involvement, rest period for watchkeepers, type of cargo and cargo work (1.5 hours).

b) *Requirement for safe watchkeeping practice* - Knowledge of:

The use of internal communication system.

The escape routes from machinery space.

The engine room alarm system, machinery and safety.

The fire fighting equipment- location and use in machinery space.

Actions to be taken in case of fire in the engine room, flooding and for other emergencies like main engine scavenge fire, high mist level alarm (damage control)

Local, national, and international regulations.

Fitness for duty - Blood alcohol limit.

Prevention of environment pollution.

First aid medicines.

Performance monitoring of main engine, generators, boilers and auxiliaries

Cargo work ( 3.0 hours).

c) Basic principles to be observed in keeping an engineering watch:

Taking over a watch, at sea, in port and in anchorage.

Performance of watch, at sea, in port and in anchorage with particular attention to execution of bridge orders, notification to bridge.

Maintenance of engine room log book, bridge order book and other record book and their purpose.

Handing over a watch, at sea, in port and in anchorage (3.0 hours)

d) *Keeping engineering watch under different situations:*

Navigation in coastal and congested water and during restricted visibility.

On oil, chemical and gas tankers

When carrying hazardous cargo (1.0 hours).

e) *Voyage planning* ( 0.5 hours).

f) *Operation requirements of unmanned machinery space* (1.5 hours)

g) *Introduction to STCW convention* - Minimum requirements for certification of officers and crew, special requirements for engineer officers for oil tankers, chemical tankers and gas tankers (3.0 hours).

h) *Safe operating procedures* - Knowledge of normal operating pressure and temperature of all engine room plants, safe operation of fuel and combustion, procedures to be carried out to prevent damage to machinery from overspeeding, overloading and lack of lubrication (3.0 hours)

Evaluation (1.5 hours)

## Main and Auxiliary Machinery

Main diesel engines - Principles, types, difference between 4 stroke and 2 stroke engines, and engine components; preparation and operation of plant with particular attention lubricating oil system, cooling water system, and fuel oil system; local/remote manoeuvring, emergency overriding conditions; measurement of power. Understanding of mist detector, Viscotherm, mal-function of main engine, scavenge fire, crankcase explosion and air starting line explosion, safety trips (22.5 hours).

*Diesel generators* - Principles and operation. Governors (4.5 hours)

*Auxiliary boilers* - Fundamentals, construction, operation and maintenance. Mountings and fittings, steam pipes; automatic combustion control and the boiler feed water system. Exhaust boiler system (9.0 hours)

*Main air compressors* - Working principles, construction details and operation. Air bottles and air distribution system (3.0 hours)

*Refrigeration and Air conditioning system* - Refrigerants and their properties, plant operation with description of components. Operation problems. Brine and brine system (3.0 hours).

*Steering system* - Principles of steering gear, statutory requirements, basic control system of steering and working knowledge of power units (pumps). Rudder actuator system, electrical steering and emergency steering (3.0 hours)

*Purifiers* - Fuel oil and lubricating oil purification system, Auto desludge operation, working principles of purifiers (3.0 hours)
*Pumps* - Centrifugal, reciprocating, rotary and screw pumps. Pumping system- bilge, ballast, liquid cargo system and fire mains (3.0 hours).
*Evaporators* - principles, operation, drinking water purification.(1.5 hours)
*Heat exchangers* - Types and maintenance (1.5 hours)
*Deck machinery* - Winches and windlass, Cargo handling equipment- deck cranes, electric and hydraulic (4.5 hours)
Inert gas plant and Cargo pumps (1.5 hours)
*Principles of maintenance* - Planned, breakdown and condition monitoring (1.5 hours).
Evaluation (1.5 hours)

## Ship Construction

*Definitions* - Various terminology and materials used in ship construction, use of high tensile steel and aluminium. Common terms used in measurement of modern steel ships (3.0 hours)
*Stresses in ships structure* - Hogging, sagging, racking, pounding and Panting etc. (3.0 hours)
*Bottom and side framing* - Double bottoms, water tight floors, solid and bracket floors, longitudinal framing keels, side framing and tankside brackets (1.5 hours).
*Shell and decks*- Plating system for shell, deck plating and deck girders, discontinuities like hatches and other openings, supporting and closing arrangements (3.0 hours)
*Bulkheads and deep tanks* - Watertight bulkheads, structural fire protection arrangements, arrangements of plating and stiffeners, watertight slide doors, watertight opening through bulkheads for cables (3.0 hours).
*Ventilation* - Arrangements (natural and mechanical) for pump rooms in tankers, for holds and fuel oil tanks (1.5 hours)
*Fore-end arrangements* - Stem construction, arrangements to resist panting, forepeak collision bulkheads, bulbous bows, Anchor and cable arrangements (3.0 hours).
*Afterend arrangements* - Types of sterns, stern frame and rudder. Propellers types of rudders, supporting of rudder, locking pintle and bearing pintle. Pallister bearing and shaft tunnel (4.5 hours).
*Load line* - Common terms, markings and main criteria used in assignment of freeboards. Maintenance of conditions of assignment (1.5 hours).
*Ship type* - Construction details and requirement of bulk and container carriers, LPG and LNG carriers, chemical carriers, lash ships and passenger ships (3.0 hours)
*Classification societies* - Construction standards, surveys, types of survey, Classed and unclassed ships (3.0 hours).
Corrosion and painting - (1.5 hours)
Evaluation (1.5 hours).

## Ship Stability

*General* - Displacement, wetted surface area. Block, midsection, prismatic and waterplane area coefficient. Tonne per centimetre immersion. Application of simpson's rules to areas, moment of area and moment of volumes. Hydrostatic curves shearing force and bending moment of loaded ship in still water (3.0 hours).
*Draught, trim, heel and buoyancy* - Changes due to adding or removing fuel, ballast and cargo. Alteration of mean draught due to change in density water. Buoyancy and reserve buoyancy. Effect of bilging midship compartments. Forces on rudder and stress in rudder stock. Heel when turning (6.0 hours).
*Transverse stability* - Centre of gravity, centre of buoyancy, meta centre. Shift of centre of gravity due to addition and removal of mass, transverse movement of mass. Stability at small angles of heel. The inclining experiment. Free surface effect and sub division of tanks. Management of water and fuel tanks at sea, dangers due to water accumulation during fire fighting (6.0 hours)
*Longitudinal stability* - Longitudinal BM, GM and static stability, centre of floatation, moment to change trim by one centimetre. Change of trim due to adding or reducing weights. Effect of flooding and calculation, loss of stability due to grounding. Dry docking and docking stability, pressure on chocks (6.0 hours).
*Resistance and propulsion* - Comparison of skin frictional resistance of hull with model at different speeds, residual resistance and total resistance. Froude's law of comparison, full scale resistance from

models. Admiralty and fuel coefficients. Relation between speed and fuel consumption with constant displacement. Sea trials data interpretation, effects of fouling. Elementary treatment of propeller and simple problems on pitch, pitch ratio, apparent slip, wake thrust and power. Qualitative treatment of cavitation (6.0 hours).
*Strength of ships* - Curves of buoyancy and weight, curves of load, shearing force, and bending moments, balancing ship on wave. Approximation for maximum shearing force and bending moment, method of estimating BM, deflection and longitudinal strength, Moment of inertia of a section and section modulus. Simple problems of strength of structural members to resist liquid pressure (4.5 hours).
Evaluation (1.5 hours).

## Fundamentals of Marine Electricity

*Electron* theory and basic safety (1.5 hours).
*Understanding* of electrical diagram and symbols (1.5 hours).
*Simple* circuits and ohms law (1.5 hours).
*Series* and parallel circuits (1.5 hours).
*Working* principle of ammeter, voltmeter and megger (1.5 hours).
*Difference* between work, energy and power (1.5 hours).
*Conductors* and variation of resistance in conductors (1.5 hours).
*Electric power* supply on board (1.5 hours).
*Meaning* and purpose of insulation and introduction to cables (1.5 hours).
*Testing* and measuring insulation and current (3.0 hours).
*Working* principles of batteries (1.5 hours).
*Principles* of magnetism and electromagnetism (1.5 hours).
*Principles* of electro magnetic induction (1.5 hours).
*Fundamentals* of AC and DC generators and motors and operation ( 4.5 hours).
*Maintenance* of generators and circuit breakers (3.0 hours)
*Maintenance* of motors and starters (3.0 hours).
*Introduction* to impedance and inductance (1.5 hours).
*Production* of alternating current, alternators (4.5 hours).
*Power* distribution and how full protection provided to electrical system (1.5 hours).
*Working* principles of transformer - Single and 3 phase (1.5 hours).
*General* description of lighting system on board (1.5 hours)
Safety precaution of electrical system on oil, gas and chemical tankers (1.5 hours).
Evaluation (1.5 hours)

## Engineering Materials

*Metallurgy* of steel and cast iron, different grades of steel (3.0 hours).
*Properties* of materials, metals used in ship construction and equipment with particular attention to steel, cast iron, cast steel (3.0 hours).
*Heat* treatment of metals (3.0 hours).
*Alloying* elements in irons and steels and reasons for adding those metals (1.5 hours).
*Non - ferrous* metals properties and uses, with particular attention to aluminium, copper, zinc, lead, antimony, brass, white metal (3.0 hours).
*Non metallic* materials, polymers, fillers used on board (1.5 hours).
*Direct* stress and strain, Hook's law (1.5 hours).
*Strain* energy (1.5 hours).
*Stresses* in pressure vessels (1.5 hours).
*Shear* and torsion (1.5 hours)
*Shear* force and bending moments caused by different types of loads (1.5 hours).
*Bending* of beams, bending moment, second moment of area, combined bending and direct stress (3.0 hours).
*Welding* - Principles, defects, types of welding, Arc and argon welding (3.0 hours)
*Non destructive* tests gauging (1.5 hours).
*Principles* of brazing and soldering (1.5 hours).
Evaluation (1.5 hours).

## Human Relationships

*The general aspects of human relationship*:
Human nature and relationship with others
Organisational behaviour system
Effect of social system on human behaviour
Role of conflict
Status (4.5 hours)
*Human relationship in shipping:*
Management and shipping
Objectives, functions and constraints of ship management
Organising ship management
Human relationship aboard ship (4.5 hours).
*Communication:*
Fundamentals of communication
Methods to improve communication
Communication equipment on board (6.0 hours)
*Shipboard situations:*
Social and work environment
Conformity
Privacy
The use of alcohol and drugs
Discipline
Individual responsibility (1.5 hours).
Evaluation (1.5 hours )

## Engineering Knowledge

*Prevention pollution* - Introduction to MARPOL and various conventions. Pollution prevention equipment- oily water separator working principle, operation and maintenance. Maintenance of oil record book. Incinerator operation and maintenance. sewage plant operation and maintenance (6.0 hours).
*Bunkering* - Safe procedures and precautions (1.5 hours).
*International Maritime Organisation* - purpose of organisation, functions, committees and sub-committees, Conventions and amendments.
Introduction to SOLAS (12 hours). ( MARPOL and STCW has already been covered)
*Vibration*:
Free harmonic vibration, linear motion of an elastic system. Angular motion of elastic system.
Torsional vibrations - Single rotor system, rotor at end and rotor in the middle. Effect of inertia on shaft
Transverse vibrations of beams - Single concentrated load, effects of mass in the beam
Whirling of shafts
Damped vibrations
Forced vibrations (12.0 hours)
*Piping system* - Methods of measuring and replacing of pipes and fittings (3.0 hours)
Engineering drawing - Type of drawing, line work, locking devices and welded connecting (15.0 hours).
Evaluation (1.5 hours).

# Appendix F

## Thermodynamics

*Fundamental concepts and definitions* - Thermodynamic system, state, property, change of state, process, cycle density. Concept of temperature and temperature scales. Heat and work transfer. First law of thermodynamics (6.0 hours)

*Pure substance* - Internal energy and enthalpy of a pure substance, specific heats (Cp and Cv ) and steady flow energy equations (6.0 hours).

*Second law of thermodynamics* - Limitations of 1st law, heat engines, reversed heat engines and their performance, reversible and irreversible process. Carnot cycle (6.0 hours)

*Entropy* - The property entropy principle of increase of entropy. Calculation of entropy change, T-S diagram, h-s diagram. Ideal gases-internal energy, enthalpy and specific heats. Reversible adiabatic and polytropic processes (4.5 hours).

*Real gases* - Properties (3.0 hours)

*Compression and expansion processes* - Definitions, efficiencies, work of compression, single and multistage reciprocating compressors. Vapour power cycles; Rankine cycle, effect of pressure and temperature on Rankine cycle; deviation of actual cycles from ideal cycles (6.0 hours).

*Flow through nozzles* - Isentropic flow of vapours and ideal gases flow through nozzles and diffusers, adiabatic flow through nozzles and diffusers, effect of variation of back pressure in nozzle flow, critical flow, mass rate flow, nozzles and orifices as flow measuring device (6.0 hours).

*Air standard power cycle s*- Carnot, Otto, diesel and dual. Mean effective pressure and air standard efficiencies (6.0 hours).

*Refrigerant cycles* - Reversed Carnot cycles, Vapour compression and vapour absorption cycles. Molliers's charts (3.0 hours)

*Psychometry* - Properties of air-vapour mixture. Psychometric chart. Psychometric process applied to air conditioning (3.0 hours).

*Gas turbine cycles* - Brayton cycle, simple open and closed gas turbine cycles with intercooling, reheating and regeneration (3.0 hours).

*Stoichiometry* - Enthalpy of combustion, first law applied to chemical reactions and chemical equilibrium. Analysis of combustion products from boiler and engine exhaust, calculation of air fuel ratio (6.0 hours)

*Combustion in practical systems* - Combustion process in CI and SI engines, combustion chamber designs. Basic concept of gas turbine combustion chambers (6.0 hours).

*Evaluation* (1.5 hours)

## Automation

*Purpose* and requirement of automation (1.5 hours).

*Different* methods of measuring temperature (1.5 hours).

*Different* methods of measuring pressure (1.5 hours ).

*Different* methods of measuring level (1.5 hours ).

*Different* methods of flow measurement (3.0 hours).

*Other measurements* - Mist detectors, flame detector, oxygen analyser and salinity meter (6.0 hours).

*Transmission of signals* - Transmitters, both pneumatic and electric (4.5 hours ).

*Final controlling elements* - Pneumatic, electric and hydraulic (6.0 hours).

*Control theory* - proportional action, integral action, proportional plus integral action (6.0 hours).

*Proportional* plus integral plus derivative action (6.0 hours).

*Principles* of pneumatic control action (6.0 hours).

*Principles* of operation of electro-pneumatic controller (6.0 hours).

*Different control* circuits used in the engine room (6.0 hours).

*Operation and safety* aspects of remote control of main engine (3.0 hours).

*Instrumentation air* supply system (3.0 hours ).

*Plant monitoring* system ( 3.0 hours ).

*Evaluation* (1.5 hours)

## International Maritime Law

*Certificates* and documents required to be carried on board in accordance with International Conventions and Agreements (1.5 hours).

*Various international conventions* with respect safety construction and operation of a vessel, SOLAS, MARPOL, STCW (17.0 hours).
*Various labour Conventions*, Recommendations concerning, manning, minimum wages to seafarers (0.75 hour).
*Minimum standards* in merchant ships and medical examination of seafarers (0.75 hour).
*Arrival / Departure* documents and procedures (0.75 hour).
*Convention* on facilitation of international maritime traffic (0.75 hour).
*Functions* and responsibilities of classification societies (1.5 hours).
*Cargo carrying procedures* - Type of charter party (3.0 hours).
*Law of the sea* (3.0 hours)
*Brief introduction to Merchant Shipping Act* - Registration of a ship, pilotage, duties regarding pollution, collision, explosion, fire etc. vessel in distress; shipping causalities, penalties under Merchant Shipping Act (3.0 hours).
*Evaluation* (1.0 hour)

## Computers

A brief introduction to the introduction to the principles of operation of computer, the basic anatomy of the computer, the arithmetic and logic unit, memory devices, control unit, input and out put devices, data representation with computer ,computer languages, DBMS and word processors, compilers and interpreters (3.0 hours).
*A brief introduction to DOS* - Components and versions. Description of a diskette, files and directories, disk operations, file operations. Formatting discs:

*Internal DOS commands*- Dir., Type, CD, MD, RD, Copy, Del, Ren, Date, Time, CLS, VER, VOL and Copy CON.
*External DOS Commands*- Diskcopy, CHKDISK, DISKCOMP, Format and Label.
Introduction to batchfiling programming - ECHO, PAUSE, FOR LOOP; SHIFT, GOTO and IF commands.
*Redirection*, pipes and filters, redirecting input and output, DOS filters, More, Sort and Find.
*Configuring the system* - Configuring, System file, Auto exec, Bat file
Setting up print queue and print command (6.0 hours).

*Introduction* to software packages, including word processing, spread sheet, and database programs (6.0 hours).
*Application* of spread sheets and databases in connection with ship's accounts, crew records, planned maintenance and inventory control (3.0 hours).
*An introduction* to windows (3.0 hours).
Computer practice (12 .0 hours)

## Operation and Maintenance of Diesel Engines

Operating principles of diesel engines (3.0 hours)
*Measurement* of engine performance - Indicator cards, specific fuel consumption, brake thermal efficiency (3.0 hours).
*Lubricating oil* system - Principles of lubrication and properties of lubricating oils oils (3.0 hours).
*Fuel oil* injection system, fuel pumps, injectors; fuel oil properties (6.0 hours).
*Different types of scavenging*, supercharging and exhaust system (3.0 hours).
*Various engine* components - Bed plates, tie bolts, cylinder covers, cylinder liners, columns, exhaust valves, cylinder lubricators, turbochargers, pistons, bearings and crankshaft (27.0 hours).
*Starting and Reversing system* - Manoeuvring, reversing servomotor (3.0 hours).
*Diesel engine cooling* water system - Care of cooling water and system (1.5 hours).
*Starting air system* - Safety devices (3.0 hours).
*Multi engine* propulsion arrangements - Fluid coupling , reducing gear (3.0 hours).
*Crankshaft deflection*, unbalanced forces, and balancing (3.0 hours).
Diesel engine control - Engine governor, overspeed trip (6.0 hours).
Evaluation (1.5 hours).

## Ship Operations and Management, Organisation and Training Shipping Economics

1) *personnel management:*
Principles involved for controlling and maintaining good relationship with subordinates (1.5 hours).
Attitude of person to work (1.5 hours ).
Reasons for exercising authority (1.5 hours).
Group behaviour of a person (1.5 hours).
Conditions of employment (1.5 hours).
2) *Organistion of staff:*
Factors affecting the manning arrangement of a vessel (1.0 hour ).
Analysis of duty carried out on board (0.5 hour).
Allocation of staff for work (0.5 hour).
Organising staff for safety and emergencies (0.5 hour).
Organising for staff duties (0.5 hour).
Organising for maintenance of on board equipment (0.5 hour).
Maintenance of various ship records (0.5 hour).
Organising communication on the ship (0.5 hour).
Group holding techniques (1.5 hours).
3) *Training on board ships* - On board training methodology and needs of training.
Training in safety on board (1.0 hour).
Training in ship operations (1.0 hour).
Training in maintenance (1.0 hour).
Training in conducting emergency drills (1.0 hour).
Evaluation of training (0.5 hour).
4) *Ship operations* - Planning sailing schedules, voyage estimates (1.5 hours).
5) *Brief history of shipping* - Liner & tramp services. Chartering and charter parties. Theory of freight rates and fares. Bill of lading ,cargo survey and protests, introduction to economics (9.0 hours).
6) *Brief introduction to marine insurance* - Under writing and loss adjusting principles applied to marine cargo insurance. Hull policy, particular average, general average and P & I clubs (3.0 hours).
Evaluation (1.5 hour).

## Marine Eectrotechnology, Electronics and Electrical Equipment

*Introduction* to general requirements of electrical requirements of electrical equipment used on board and its design (1.0 hour).
*Application* of Ohm's law, Kirchoff's law to solve problems of simple electrical circuits (3.0 hours).
*Insulation* and temperature ratings of electrical machines (1.5 hours).
*Description* of *DC* generators (1.5 hours).
*Description* of types and functions of switch gear (1.5 hours).
*Electro- magnetism* principle (1.5 hours).
*Explanation* of *AC* circuit theory, solve problems on pure resistance, inductance and capacitance and their combination. Power calculations (9.0 hours).
*Solving* simple problems in parallel circuits (3.0 hours).
*Electronics:*
Properties of crystals and semiconductor crystals
Intrinsic conduction in semiconductor crystals
Impurity conduction in a semiconductor crystals
Pn junction
Passive components and active components
Diodes; Rectifiers; Zenar diodes.
Light emitting diodes; Transistors
UNI junction transistors; Field effect transistors
Thyristors; Heat sinks; Integrate circuits
*Solving* problems related to semi conductor devices (Total 18.0 hours).
*Demonstration* of power factor improvement (1.5 hours).
*Principles* of poly phase supplies, star and delta connection (1.5 hours).
*Principles* of construction of *AC* generator (1.5 hours).
*Function* of Automatic Voltage Regulator and their parts (I.5 hours).

*AC switch board* and its additional fittings (1.5 hours).
*Generator protection devices* (1.5 hours).
*Single and parallel* operation of a generator (1.5 hours).
*Description* of simple single phase transformer (1.5 hours).
*Rectification* - Conversion of AC into DC (3.0 hours).
Principles *power distribution* (1.5 hours).
*Starter circuits* and circuit protection (3.0 hours).
Types of *cables* and their materials (1.5 hours).
*Essential* difference and use of AC and DC motors (1.5 hours).
*Control, protection* and maintenance of AC and DC motors (3.0 hours).
*Description* of cells, batteries and their maintenance (3.0 hours).
*General* requirements of lighting on board (1.5 hours).
*Operation* and maintenance of electrical *winches* on deck (6.0 hours).
*Precautions* and requirement of electrical equipment on *tankers* (1.5 hours).
*Description* of type of equipment susceptible to interference (1.5 hours)
*Principles* of measuring and recording insulation (1.0 hour).
*Identification* of graphical symbols in a circuit (1.0 hour).
*Effect* of AC and DC electrical shock (1.5 hours)
*Evaluation* (1.5 hours).

## Applied Mechanics and Fluid Mechanics

Applied mechanics

*Statics* - Force as a vector, equilibrium of non coplanar forces, Rapson's slide (3.0 hours)
*Couples* - Moments of areas and volumes, centroids and centre of gravity, second moment of areas (3.0 hours).
*Friction* - Coefficient of friction, energy and power lost due to friction in simple bearings and collar bearings. Friction clutches, work done against friction (3.0 hours)
*Kinematics* - Linear motion, equations for displacement, speed, velocity and uniform acceleration (3.0 hours).
*Circular motion* - Forces due to circular motion, D' Alambert's principle, static balancing, dynamic balancing at the bearings (3.0 hours).
*Periodic motion* - Simple harmonic motion, application of simple harmonic motion, work & power - problems with constant force or force with liner variation. Potential & kinetic energy, centrifugal force & its application; dynamics of rotation of particle and rotating bodies, Torque equation (7.5 hours).
*Drives and brakes* - Belt and rope drives, open and cross belt drive- Belt dimensions. Power of belt drives and maximum power transmitted ; Dynamometers and their working principle, different types of dynamometer (3.0 hours).
*Governors* - Function of a governor, comparison between a governor and a flywheel. various types of governors. Sensitiveness, hunting of governors, Governor effort and power (3.0 hours).
*Impulse* and momentum (4.5 hours).

Fluid Mechanics:

*Hydrostatics* - Equilibrium of floating bodies, variation of fluid pressure with depth centre of pressure on vertical rectangular vertical plane (3.0 hours).
*Fluid in motion*, energy of flowing fluid, energy. Bernoulli's equation for steady motion. Venturimeter. Discharge through a small orifice (6.0 hours).
*Flow through pipes* - Loss of energy in pipe lines-Friction losses. Transmission of power by pipe line (3.0 hours)
*Fluid friction* - Viscous, laminar and turbulent flow, resistance coefficient, Reynolds' number-viscous flow in pipes (6.0 hours)
*Vortex motion and Radial flow*- Real, ideal, steady and unsteady flow. Two dimensional flow theory (3.0 hours)
*Introduction to hydraulic system on board* - Hydraulic circuits, hydraulic cranes, deck winches, hatch cover operations, cargo tank valves (7.5 hours)
*Hydraulic fluids* - Types of fluid, application, quality requirements, additives and effect of temperature, deterioration of oil (3.0 hours)
*Evaluation* (1.5 hours)