Transport Canada Transports Canada
Marine Safety

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Marine Engineer Cadet Training Program

Responsible Authority	Approval
The Director, Marine Personnel Standards and Pilotage, is responsible for this document, including any change, correction, or update.	Director, Marine Personnel Standards and Pilotage Marine Safety **Date signed: March 14, 2005**

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REVISION CHART

Last Review

Next Review

Revision No.	Date of Issue	Affected Pages	Author(s)	Brief Description of Change
1	October 2000		Paul Mannion	From original 1997 edition to Quality format
2	September 2003		Paul Mannion	Total revision of TP dated September 2003
3	March 2005		Alain Giguère	Update of Paragraph 4.5 and clarification of *Program* vs *Course* throughout the document

Important Notices and Disclaimers

Également disponible en français.

Table of Contents

Scope and Application

1.1 Purpose

(1) To provide information to marine stakeholders with respect to programme content and the general conditions associated with the training of marine engineers while enrolled at Marine Safety approved cadet training, conducted at Canadian schools and colleges.

(2) To provide information to marine schools and colleges outlining the requirements of the program, before approval can be granted by Marine Safety

1.2 Scope

(1) Entry level training of marine engineers at marine schools and colleges leading to certification at the watchkeeping level.

(2) Compliance with the Marine Certification Regulations of the *Canada Shipping Act* and the Seafarers' Training , Certification and Watchkeeping (STCW) Code A of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995, to which Canada is a party.

1.3 Effective date

(1) This document enters into force on September 1st, 2004.

1.4 Authority

(1) The Marine Certification Regulations (SOR/2002/150), made pursuant to the *Canada Shipping Act* (R.S.C. 1985, c.s-9) as amended.

2

General

2.1 Overview

(1) This full time program provides the basic education and training required for a student to be able to pursue a rewarding career as a seagoing Marine Engineer Officer. The core curricula comply with the requirements of the *Marine Certification Regulations* and the STCW 78 Convention as amended in 1995.

2.2 Objectives of the Program

(1) To provide a Diploma program which is acceptable to both Transport Canada, Marine Safety and the shipping industry in general.

(2) To provide a source of well trained individuals, capable of starting a career as a marine engineer at the watchkeeping level, and

(3) Provide successful students with qualifications, which will be accepted by Marine Safety for exemption from certain subjects towards the 2nd Class Marine Engineer certification levels.

2.3 Admission qualifications

(1) Qualifications for entry to the program is at the discretion of college principals, but should be based on the extent to which the level of pre - program education will enable students to cope with the standard of technology inherent within the program. In general a high school diploma with a math/science background should be considered as a minimum requirement for entry into the program.

3

Requirements

3.1 Marine Certification Regulations

(1) Provisions are made in the Marine Certification Regulations to allow for approved marine engineering cadet programs that lead towards certification as a marine engineer under the *Canada Shipping Act*. This publication outlines the requirements of such a program. Graduates of approved cadet programs are entitled to certain credits and exemptions beyond the basic 4th Class engineering certificate, based on the content and duration of the specific program attended.

(2) Previous TP versions of this document, indicated the requirement for Marine Emergency Duties (MED) and 1st Aid training to be contained within the program. As MED and Marine 1st Aid training are identified in separate Transport Canada Publications, the course contents are not listed in this document. However, candidates applying for 4th Class Engineer Certificates will have to show, in addition to a graduation diploma, training certificates for the applicable MED, 1st Aid and propulsive plant simulator courses. As the Skills Training and Training Record Book requirements are included in the cadet program, candidates applying for marine engineering certificates will not be required to show separate training certificates for either of these two requirements.

(3) Marine schools with Transport Canada approved engine room simulators may choose to integrate the mandatory simulator training in their program, however the schools will have to arrange for any Marine Safety examinations and provide the applicable training certificates for the engine room simulator in addition to the graduation diploma.

(4) Marine schools choosing to integrate MED and Marine 1st Aid in their program, will need to provide the training certificates for both these courses in addition to the graduation diploma.

4

Program Approval Conditions

4.1 Access to program location and suitable accommodations

(1) In order to be considered for approval, the college/institution has to be serviced by public transport and have suitable student accommodations within commuting distance from all program delivery sites.

(2) Alternately, the college/institution shall have on-site student accommodation and meal facilities within walking distance of the main delivery site.

4.2 Transport Canada approved instructors

(1) All instructors teaching marine engineering specific subjects should hold a Canadian 1st Class Certificate of Competence issued under the *Marine Certification Regulations*, that is valid for use at sea (medical restrictions may apply). Instructors holding 2nd Class Canadian engineering certificates have to be approved by Transport Canada Marine Safety (AMSP), Ottawa, on an annual basis.

(2) All instructors teaching the non-specific engineering subjects can either be qualified as above or hold provincially recognized qualifications for the subject being taught.

(3) Subjects within the program that are of a more general nature should be taught by teachers/instructors that have an expertise in those areas, but in all cases must hold suitable qualification in that subject.

(4) All instructional staff and teachers shall hold teaching qualifications and/or relevant experience recognized by Transport Canada, Marine Safety (AMSP), Ottawa.

4.3 Suitable Teaching environment and facilities

(1) At a minimum, any institution wishing approval of it's program must provide the following services/facilities to their students:

(a) Classrooms, lecture and study rooms suitable for the delivery of technical subjects.

(b) Workshops with sufficient modern equipment to deliver the practical portions of the program.

(c) A learning resource centre and library with sufficient marine texts to allow independent study on marine engineering subjects.

(d) Recreational facilities at or close by the facility to allow students the opportunity to relax between or after classes.

(e) Routine access to vessels and ships sufficient to cement the practical aspects of the program and course material.

4.4 Compliance with the detailed program content outlined in this publication

(1) Colleges and institutions that wish approval from Transport Canada, Marine Safety for their marine engineering cadet program are to view the program content as the minimum standard required in so far as the number of hours and the various subject areas. However while many of the program objectives will remain a regulatory requirement, colleges and institutions should look at the contents of each course as being a guide and use the process of continuous improvement and client feedback to keep the various courses up to date.

4.5 Pass/Fail Criteria

(1) All courses within the program shall have sufficient evaluation of each student. As a minimum standard, an aggregate pass mark of 60% shall be required to successfully complete each course.

(2) Final examinations shall be held in the following subjects:

(a) Applied mechanics

(b) Thermodynamics

(c) Electrotechnology

(d) Naval Architecture

(e) Blueprint interpretation and sketching, or drawing

(3) For the examinations identified in (2) above, the pass/fail mark shall be 60%. Students not achieving the 60 % pass mark or higher in each final examination shall not be awarded a graduation diploma.

4.6 Course attendance

(1) The college or institution shall have a strict policy with respect to the amount of time the student must attend classes. Normally this policy should expect that students to attend all classes, lectures and workshops to a rate of 90% attendance in the program. Students with attendance levels less than indicated will not be considered for examination at the 4th Class level by Marine Safety. Additional time at college/institution or at sea maybe assigned by Marine Safety before being allowed to sit the 4th Class examinations.

4.7 Quality System

(1) The College or institution shall operate under a quality system that conforms to the standards identified in Section A-I/8 of the STCW Code Part A of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995.

5

Graduate Credits/Exemptions

5.1 Graduate credits/exemptions

(1) Diploma graduates will be given exemption from academic subjects of Transport Canada Marine Safety examinations up to second class level, and with completion of six months of sea service and after meeting the other requirements of the *Marine Certification Regulations*, graduates may attempt the examination for a 4th Class Engineer certificate.

(2) Diploma graduates will also be allowed, when set to graduate (and up to three months after the date of graduation,) one attempt at certain Marine Safety examinations (applied mechanics, thermodynamics, electro technology and naval architecture) at the 1st Class level. A pass in any subject will be considered an exemption and will not expire.

6

Miscellaneous Issues

6.1 Propulsion Plant Simulator Training

(1) Colleges or institutions that integrate the use of a Transport Canada, Marine Safety approved engine room simulators in their programs are subject to the following conditions:

(a) Students in their 3rd year may be subject to evaluation by a Marine Safety Examiner. The Marine Safety evaluation will be at the watchkeeping level. Any training certificates issued by the college or institution to the successful student shall only be at PPS level 1.

6.2 Other requirements of the Marine Certification Regulations

(1) While not covered specifically in this TP, the following are requirements before an engineering certificate can be issued to any candidate for Canadian certification.

(a) Proof of Canadian Citizenship or permanent resident status as defined in subsection 2(1) of the *Immigration Act*.

(b) A valid medical certificate issued in accordance with the *Crewing Regulations*

(c) Successful completion of the other applicable safety training courses, such as marine emergency duties and marine advanced first aid.

(d) For institutions that do not have a marine safety approved engine room simulator, successful completion of the watchkeeper level of propulsion plant simulator (PPS1) and any examination at that level by Marine Safety.

6.3 Programs greater than 36 months

(1) Upon application, colleges or institutions that have engineering cadet programs of a duration greater than the 36 months, may be granted additional levels of exemption or service credits for their program.

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Program Outline and Minimum Course Hours

7.1 Marine engineer program - minimum instructional hours

SUBJECT	MINIMUM INSTRUCTIONAL HOURS	
Skills Training	600	
Materials	90	
Mathematics	180	
Applied Mechanics	300	
Refrigeration & Air Conditioning	45	
Naval Architecture including stability and ship construction	165	
Chemistry	70	
Electrotechnology	250	
Automation, Control and Instrumentation	120	(see note 1)
Marine Computer Science and Networks	100	(see note 1)
Marine Law and Ships' Business	70	
Thermodynamics	180	
Blue Print Interpretation and sketching, or Drawing	150	
Engineering knowledge, motor, steam and general	300	
Communication	100	
M.E.D.(A1, B1, B2 & C) and Advanced First Aid	119	(see note 2)
PPS Training	60	(see note 2)
Total hours	**2720**	

Note 1: Institutions may chose to combine the Automation, Control and Instrumentation course and the Marine Computer Science and Networks course. A suitable reduction of instructional hours may be achieved.

Note 2: As MED and PPS training can be taken as stand alone courses, the hours listed are for reference purpose only and these hours are not required in the program. However, colleges or institutions that include this training as an integral part of their program should see a corresponding increase in the total hours for their programs.

7.2 Sea Training experience on vessels

(1) In order to be accepted for examination for the 4th Class certificate of competence candidates must show 6 months of supervised experience in the engine room of a vessel of a sufficient power and have completed the program's Sea Training Manual.

8

Skills Training

8.1 Introduction

(1) The skills course is intended to teach the marine engineering student practical skills which will correspond to his overall professional training. The supporting experience at sea which is an integral component of all marine engineering training programs, should be employed to consolidate the basic skills taught during the academic periods.

8.2 Marine engineering basic skills 200 hrs

(1) Fitting

- **(a)** Safety
  - **(i)** Accident Prevention and Shop Safety
  - **(ii)** Hazards
  - **(iii)** First Aid
- **(b)** Hand Tools
  - **(i)** Files
  - **(ii)** Pliers
  - **(iii)** Screwdrivers
  - **(iv)** Hacksaws
  - **(v)** Chisels
  - **(vi)** Punches
  - **(vii)** Drills (bits, press)
  - **(viii)** Cutting Tools
  - **(ix)** Hammers
  - **(x)** Calipers
  - **(xi)** Grinder
  - **(xii)** Wrenches
  - **(xiii)** Reamers
  - **(xiv)** Taps and Dies
  - **(xv)** Countersink
  - **(xvi)** Layout Tools:
    - **(A)** Surface plate
    - **(B)** Scriber
    - **(C)** Dividers

(D) Square and Combination Set

(E) Parallels

(F) Angle Plate

(G) Surface gauge

(H) Vernier height gauge

(I) Vernier Calipers

(J) Bevel protractor

(K) Inside and outside micrometer including various dial gauges

(c) Power Tools

(i) Drill Press and sharpening of drill bits

(ii) Grinder and selection of stones

(d) Metal Fasteners

(i) Clamp

(ii) Bolt

(iii) Turnbuckle

(iv) Sheet metal screw

(v) Self Tapping screw

(vi) Taper pin

(vii) Rivets

(viii) Woodruff key

(ix) Cotter pin

(x) Screws

(xi) Carriage bolt head

(xii) Stud

(xiii) Nuts

(xiv) Washers

(e) Adhesives and bonding

(i) Methods for temporary repair

(f) Project.

(i) The fitting phase will comprise completion by the student of a fitting shop manufacturing project, which utilizes all the skills covered by the classroom instructions. The development of the project in the shop should parallel classroom instruction in the various fitting tools. For example, a hand screw

clamp can be produced in the fitting shop within the 40 hours allocated.

(2) Shipboard Maintenance

(a) Torque Wrench

(b) Grease Gun and Fittings

(i) Types of grease

(ii) Fittings

(c) Tube Fittings

(i) Compression

(ii) Flare

(d) Valve Repairs and Gaskets

(i) Packing

(ii) Seat

(iii) Flange Faces

(iv) Testing

(v) Gaskets

(vi) Spindle

(vii) Disc

(e) Project

(i) Students should be required to overhaul a series of defective marine valves incorporating common shipboard maintenance procedures. Similar short projects to provide practical skill training with tube fittings should be developed.

(f) Basic shipboard electrical skills

(i) Paralleling and parallel operation of A/C and D/C generators

(ii) Lighting - test, repair and replacement of all shipboard fluorescent and incandescent lighting

(iii) Test Equipment - shipboard use of following meters

(A) Voltmeter (digital)

(B) Multimeter

(C) Tong tester

(D) Bridge megger

(E) Wee megger

(F) Stroboscope

(G) Growler

(3) Welding

(a) Gas Welding

(i) Principles

(A) Fundamentals

(B) Equipment

(C) Techniques

(D) Faults

(ii) Practices

(A) Welding

(B) Cutting

(C) Brazing

(D) Soldering

(b) Arc (Electrical) Welding

(i) Processes

(A) Shielded metal

(B) Electrode selection

(ii) Practices

(A) Pre-heating and post-heating

(B) Ferrous metals

(C) Pipes

NOTE: Emphasis should be placed on shipboard welding safety practices such as pertinent regulations, gas freeing, ventilation, heat transfer and grounding considerations. These welding courses are primarily shop instruction with minimal practical consolidations. Training facilities should encourage students to take every opportunity to consolidate their welding skills during practical sea phases.

8.3 Machine shop and minor overhaul 200 hrs

(1) Machine Shop

(a) Machine Shop Practices

(b) Principles of Machining

(c) Layout Work and Shop Safety

(d) Set-up Tools and Measurement

(e) Safe Working Practices

(2) Lathe Operations

(a) Safety

(b) Tool Bit Grinding

(c) Facing

(d) Short Turning

(e) Long Turning

(f) Turning Between Centres

(g) Taper Turning

(h) Drilling

(i) Boring

(j) Parting

(k) Tapering

(l) Reaming

(m) External Threading

(n) Internal Threading

(o) Sharpening of various tool bits and drills etc..

(3) Machine Shop Projects: Lathe operations phase to be consolidated by student manufacturing two practical projects incorporating diversified lathe operations.

(a) Manufacturing a lathe project consisting of 1 threaded spindle, 2 tapered sleeves, 3 knurled nuts and one spacer. Total time allocated - 35 hours; and

(b) Manufacture of following valve spindles:

(i) Steel spindle with two different thread types

(ii) Brass spindle with ACME thread

(iii) Steel spindle with right hand double start square thread

Total time allocated: 40 hours

(4) Minor Overhaul

(a) Bearings

(i) Removal

(A) Shaft fitted tapered roller bearing

(B) Shaft fitted ball bearing

(C) Housing fitted ball bearing

(D) Journal bearing

(ii) Fit

(A) Tapered roller bearing

(B) Ball Bearing

(C) Journal bearing

(D) Methods of fitting - heating, pressing

(b) Valve Repair

(i) Removal

(ii) Disassembly

(iii) Component inspection

(iv) Manufacture (spindle, gland, ...)

(v) Machine (disc, seat, flange faces, ...)

(vi) Assemble

(vii) Test hydrostatically

(c) Pumps

(i) Identification

(ii) Strip and overhaul

(A) bearing clearances and tolerances

(B) wear rings

(C) impellers

(D) pistons and rings

(E) shaft wear

(F) alignment and balance

(iii) Assemble and Test

(d) Heat Exchangers

(i) Strip and inspect

(ii) test for leaks

(iii) Plugging and tube end packing

(iv) Assemble and Test

(e) Gauges

(i) Calibration (manometer, dead-weight tester,...)

(ii) Gauge glasses

(A) removal

(B) fitting

(C) testing

(f) Internal Combustion Engine

(i) Strip small I.C.E. for practical exposure to all engine components such as:

(A) injectors

(B) pumps

(C) cylinder heads

(D) pistons and rings

(E) crankshaft

(ii) Assemble small I.C.E. noting:

(A) clearances

(B) tolerances

(C) assembly procedures

(g) Overhaul Projects: The following projects are used to consolidate the above-noted overhaul maintenance skills.

(i) Manufacture a fitting project consisting of:

(A) A shaped metal block with drilled, reamed and tapped holes

(B) A round plug, drilled, tapped, countersunk and counterbored

(ii) Remove 4 broken studs from metal block using

(A) drilling

(B) Ez-out

(C) Chisel

(iii) Machine following components of a low pressure globe valve

(A) Disc

(B) Seat

(C) Flange faces

(iv) Manufacture a high pressure face to face joint

(A) Machine

(B) Hand fit

(C) Assemble

(v) Fuel Injector Overhaul

(A) Disassembly

(B) Overhaul and replacement of matched parts

(C) Re-assembly

(D) Calibration and final testing

(h) Electrical systems and distribution

(i) Cabling and Wiring. Locating and isolating electrical earths. Removing and replacing shipboard electrical wiring

(ii) Power Generation and Distribution. Minor overhaul and repair of electrical contacts, switches, fuses and circuit breakers

(5) Shipboard maintenance and machine shop

(a) Machine Shop Shaping

(i) Milling Operations

(A) Machine capabilities

(B) Set-up

(C) Cutting Operations

(D) Vertical and horizontal

(ii) Shaping

(A) Machine capabilities

(B) Set-up

(C) Cutting Operations

(D) Tools

(iii) Surface Grinding

(A) Machine Capabilities

(B) Types

(C) Dressing and truing

(iv) Power Sawing

(A) Hacksaws

(B) Blade selection

(C) Band saws

(D) Band saw blades

NOTE: Skills training for this equipment should be limited to exposure only, as this equipment is not normal shipboard maintenance equipment. Projects should be limited to illustrating machine capabilities as opposed to manufacturing a specific marine engineering related project.

8.4 Shipboard maintenance 200 hrs

(1) Maintenance procedures and practices stressing dismantling, examination, repair, tolerances, fits, clearances, reassembly and testing of shipboard equipment and systems including:

- **(a)** Reciprocating machines – Air compressors, pumps etc….
- **(b)** Gear pumps
- **(c)** Turbines
- **(d)** Gearing
- **(e)** Purifiers
- **(f)** Telemotor systems
- **(g)** Alternators
- **(h)** Refrigeration systems
- **(i)** Diesels (I.C.E.)
- **(j)** Evaporators
- **(k)** Auxiliary drives – belts, shaft, chain…
- **(l)** Hydraulic machinery
- **(m)** Deck machinery – davits, winches, windlass, cranes
- **(n)** Air vessel mountings
- **(o)** Machinery piping systems – welded, flanged, jointed…
- **(p)** Propulsion shafting
- **(q)** Watertight doors and hatch closing equipment
- **(r)** Oily water separators, holding facilities and monitors
- **(s)** Sewage treatment systems, holding facilities and monitors

(2) Boiler Maintenance

- **(a)** Internal and external cleaning
- **(b)** Mountings
  - **(i)** Soot blowers
  - **(ii)** Superheater
  - **(iii)** Valves – safety, boiler feed…
    - **(A)** Valve testing
  - **(iv)** Gauges and monitoring devices
- **(c)** Brickwork
- **(d)** Boiler openings (handholes etc.)
- **(e)** Boiler inspections

(f) Pressure testing of boilers

(3) Electrical shipboard maintenance skills

(a) A/C Motors. Students are to disassemble/assemble a small AC motor for practical exposure to the following components:

(i) Stator

(ii) Rotor

(iii) Bearings

(iv) End Bells

(b) DC Motor/Generator. Students are to disassemble / assemble a DC motor/generator for practical exposure to the following components:

(i) Enclosures

(ii) Armature

(iii) Field coils

(iv) Commutator

(v) Brushes

(vi) Brush assembly

(c) Overhaul. Student practical projects should attempt to stress the following electrical maintenance skills:

(i) Electrical fault identification (system, unit and component level)

(ii) Electrically connect/disconnect motors and generators

(iii) Check security and condition of bonding and grounding straps

(iv) Change brushes (motors and generators)

(v) Bed in brushes

(vi) Check and adjust carbon brush tension

(vii) Check and adjust carbon brush holder clearances

(viii) Inspect, clean and resurface commutator

(d) Miscellaneous electrical and electronic maintenance

(i) Disassembly and reassembly of motor control centres with special consideration given to low voltage starting of electric motors

(ii) General maintenance of components contained in electrical distribution panels such as:

(A) Gauges

(B) High and low voltage trips

(C) Reverse power trips

(D) Synchronization gauges

(E) Auto-synchronization devices

(F) Self-charging breakers

(G) Ground fault indicators

(iii) Circuit board replacement and repair

(A) Handling of circuit boards – static damage

(B) Removal and replacement procedures

(C) Strapping, DIP switch and component adjustment

(D) Soldering techniques and the use of heat sinks

(4) Rigging

(a) Knots

(b) Splicing of ropes and wires

(c) Shackles and clamps

(d) Use of slings

(e) Chain blocks and "come-alongs"

(f) SWL of lifting gear and lifting points

(g) Jacks and blocks

(h) Staging

(i) Fall arrest equipment

(j) Manual lifting techniques

(5) Machinery alignment

(a) Alignment methods for various types of couplings

(i) Pulley/belt

(ii) Chain

(iii) Flange

(iv) Mountings – use of shims and resilient mounts

(6) Insulation materials and use

(a) Pipe insulation

(b) Exhaust shielding

(c) Asbestos awareness and disposal

(7) Confined Space Entry

(a) Safe working practices – Labour Code

(8) Tank Cleaning, Inspection and Testing

9

Materials

9.1 Introduction

(1) Materials used on board ships

(2) Service, fabrication, and economic requirements

(3) Basic manufacturing processes

9.2 Manufacture of ferrous and non-ferrous metals

(1) Extraction of iron ore

(2) Production of pig iron - the blast furnace

(3) Production of steel – electric arc and converter processes

(4) Refining of Alumina

(5) Production of aluminium

9.3 Structure of metals

(1) Atomic structure, periodic table, bonding

(2) Properties of the metallic bond

(3) Crystal lattice structure

(4) Solidification - dendritic growth, crystal formation

(5) Formation of dislocations

(6) The role of dislocations in plastic deformation

(7) Slip planes - miller indices

(8) Interstitial and substitutional atoms in crystal structures

9.4 Equilibrium diagrams

(1) Cooling curves

(2) Equilibrium Diagrams - basic binary systems

(3) Iron - iron carbide diagram

(4) Aluminium – copper diagram

9.5 Cast iron

(1) Types of cast-iron

(2) Effect of alloys on cast-iron

9.6 Heat Treatment of Steel

(1) Temperature and cooling rate - T.T.T. curves

(2) Hardening and tempering

(3) Annealing, normalizing, stress relieving

(4) Surface hardening

(5) Practical heat treating procedures

9.7 Alloys and Their Effect on Steels

(1) Chromium, cobalt, manganese, molybdenum, silicon, nickel, phosphorus, tungsten, titanium, vanadium, aluminium

9.8 Classification of Steels

(1) The United Numbering System (UNS)

(2) How different systems compare to UNS

9.9 Non-ferrous Light Metals

(1) Solution heat-treatment, age hardening, recrystallization

(2) Aluminium alloys

(3) Magnesium - production, alloys

(4) Titanium

9.10 Non-ferrous Heavy Metals

(1) Copper - production, properties

(2) Copper alloys - brass, bronze, etc.

(3) Nickel

(4) Lead

(5) Zinc

(6) Tin

(7) The precious metals

9.11 Plastics

(1) The chemical structure of polymers

(2) Thermo plastic and thermo set resins

(3) General chemical and mechanical properties of plastics

(4) Properties of polyethylene, polyvinyl chloride, acrylics, polyesters, silicones

9.12 Inspection and Testing of Metals

(1) Testing standards and procedures - A.S.T.M., CSA, etc.

(2) Physical properties of metals

(3) Photomicrographic examination

(4) Physical testing - tensile test, hardness, impact

(5) Non-destructive testing - dye penetrants, magnaflux, ultra-sonic, x-ray

9.13 Corrosion

(1) Types of corrosion

(2) Corrosion resistant metals

(3) Oxidation and reduction reactions

(4) The electromotive series

(5) Corrosion protection

- **(a)** Cathodic protection
- **(b)** Protective finishes (paints, coatings)

9.14 Industrial Processes

(1) Casting

- **(a)** Sand casting
- **(b)** Die Casting
- **(c)** Investment casting

(2) Hot-working

- **(a)** Forging
- **(b)** Rolling
- **(c)** Drawing

(3) Cold working

(4) Cold rolling

(5) Stamping

TOTAL: 65 hours

The course content will include 65 instructional hours plus 25 laboratory hours to make up a total of 90 hours.

9.15 Suggested Laboratory Exercises

(1) Tensile Test to Destruction

(2) Impact Test - Izod and Charpy Tests

(3) Hardness Test - Rockwell, Brinell

(4) Preparation of Photomicrographic Specimens

(5) Examination of Grain Structures of

- **(a)** Steels of various carbon content
- **(b)** Steels after tempering at various temperatures
- **(c)** Copper alloys

(6) Corrosion of Steel

(7) Annealing, Hardening and Tempering of Steel

(8) Heat Treatment of Aluminium Alloy

(9) Cold Working of Copper

(Average time 2-3 hours each -- Total 25 hours)

10

Mathematics

10.1 Computation

(1) Powers of 10 and scientific notation

(2) Approximate solution for complex products and quotients

10.2 Fundamental concepts and operations

(1) Fundamental laws of algebra

(2) Addition, subtraction, multiplication and division of algebraic expressions

(3) Equations and formulas

10.3 Functions and graphs

(1) Functions

(2) Rectangular co-ordinate system

(3) The graph of a function

(4) Solving equations graphically

10.4 Trigonometry

(1) Trigonometric functions

- **(a)** Introduction; angles
- **(b)** Defining the trigonometric functions
- **(c)** Values of trigonometric functions
- **(d)** The right triangle with applications

(2) Trigonometric functions of any angle

- **(a)** Sign of trigonometric functions
- **(b)** Trigonometric functions of any angle
- **(c)** Radians
- **(d)** Applications of the use of radian measure

(3) Vectors and oblique triangles

- **(a)** Vectors
- **(b)** Application of vectors
- **(c)** Oblique triangles, the Law of Sines
- **(d)** The Law of Cosines

(4) Graphs of Trigonometric Functions

(a) $y = a \sin x$, $y = a \cos x$

(b) $y = a \sin bx$, $y = a \cos bx$

(c) $y = a \sin (bx + c)$, $y = \cos (bx + c)$

(d) Graphs of other functions

(e) Applications of the trigonometric graphs

(f) Composite trigonometric curves

10.5 Complex numbers

(1) Imaginary and complex numbers

(2) Basic operations with complex numbers

(3) Graphical representation of complex numbers

(4) Polar form of a complex numbers

(5) Exponential form of complex numbers

(6) Products, quotients and powers of complex numbers

(7) Applications to AC circuits

10.6 Determinants and matrices

(1) Determinant; expansion by minors

(2) Some properties of determinants

(3) Matrices; definitions and basic operations

10.7 Ratio, proportion and variation

(1) Ratio

(2) Proportion

(3) Variation

10.8 Exponents and radicals

(1) Integral exponents

(2) Fractional exponents

(3) Simplest radical form

(4) Addition and subtraction of radicals

(5) Multiplication of radicals

(6) Division of radicals

10.9 Logarithms

(1) Definition of a logarithm

(2) Graph of $y - b^x$ and $y - \log_b x$

(3) Properties of logarithms

(4) Logarithms to base 10

(5) Computation using logarithms

(6) Natural logarithms

(7) Relation of natural logarithms to common logarithms

10.10 Permutations and combinations

(1) Basic concepts

10.11 Plane analytic geometry

(1) Basic definitions

(2) The straight line

(3) The circle

(4) The parabola

(5) The ellipse

(6) The hyperbola

(7) The second degree equation

10.12 Progression

(1) Arithmetic progression

(2) Geometric progression

(3) Geometric progression with infinitely many terms

10.13 The binomial theorem

(1) The Binomial Theorem

(2) Expansion of a positive integral power of a binomial

(3) The general term

(4) Computation of powers and roots

10.14 Functions

(1) Variables and constants

(2) Meaning of a function

(3) Explicit and implicit functions

(4) Domain and range

(5) Evaluation of functions

(6) Summation notation

10.15 Limits

(1) A basis for differentiation

(2) Meaning of a limit

(3) Limit of a function

(4) Rules for evaluating limits

Optional - topics (16 to 26)

10.16 Differentiation - introduction

(1) Slope of a line - $\Delta y/\Delta x$ notation

(2) Slope of a curve - derivative

(3) Graphical meaning - 1st principle

(4) Differentiation of simple polynomials using 1st principle

(5) Simple applications

(6) Differentiation of simple polynomials of form u^n, u a function of x

(7) Product Rule

(8) Quotient Rule

(9) Successive differentiation

10.17 Differentials

(1) A basis for integration

(2) Definition

(3) Differential of a function

(4) Approximations and small errors

10.18 Integration - introduction

(1) Integration as the inverse of differentiation

(2) Evaluation of $\int u^n du$, u a function of x

(3) Constant of integration

(4) The definite integral $\int_a^b u^n du$

(5) Graphical meaning

(6) Numerical methods of integration

(7) Fundamental Theorem of Integral Calculus

(8) Simple applications - area under curves

10.19 Partial differentiation

(1) Meaning of a partial derivative

(2) Graphical significance

(3) Total derivatives

(4) Total differential

(5) Related rate problems

(6) Small errors

10.20 Differentiations - continued

(1) Simple inverse functions

(2) Chain rule

(3) Differentiation of trigonometric functions and their inverses

(4) Differentiation of exponential functions

(5) Differentiation of logarithmic functions

10.21 Maxima and minima

(1) Turning (critical) points

(2) Maximum and minimum points

(3) Inflection points

(4) Curve sketching using maxima and minima theory

(5) Maximum and minimum problems

10.22 Integration - continued

(1) Integration of logarithmic and exponential functions

(2) Integration of trigonometric functions and their inverses

(3) Evaluating indefinite and definite integrals

10.23 Applications of differentiation

(1) Simple rates of change

(2) Rotary and rectilinear motion

(3) Mention of differential equations

(4) Newton's method for finding roots of an equation

10.24 Areas and volumes by integration

10.25 Methods of integration

(1) integration by Parts § udv - uv-§ vdu

(2) Integration by substitution

- **(a)** algebraic substitution
- **(b)** trigonometric substitutions

(3) Integration using partial fractions

10.26 Differential equations

(1) Definitions

(2) Classification - order, degree

(3) General and particular solutions

(4) Separation of variables

(5) Homogeneous differential equations

(6) Exact differential equations

(7) First-order linear equations

(8) Second-order-linear equations

- **(a)** R.H.S. = 0
- **(a)** R.H.S. = f(x)
- **(b)** Real, equal, and complex roots

(9) Applications to elastic curves of beams

11

Applied Mechanics

11.1 Course content list

(1) PART 1 Statics

(2) PART 2 Dynamics

(3) PART 3 Friction and anti-friction devices

(4) PART 4 Strength of materials

(5) PART 5 Applied strength of materials

(6) PART 6 Hydraulics

(7) PART 7 Pneumatics

11.2 Part 1 - Statics

(1) Fundamental Force Concepts and Principles

- **(a)** Force types, characteristics and units, resultants by graphical methods - triangle and polygon of forces. Equilibrants
- **(b)** Components of a force, resultants by components method
- **(c)** Moments and couples, units
- **(d)** Equilibrium conditions
- **(e)** Equilibrium of 3 coplanar forces (3 force principle)
- **(f)** Rapson's slide
- **(g)** Comparison of Rapson's slide and link type steering gears

(2) Force Analysis for Simple Static Structures

- **(a)** Free body diagrams, two force members, three force members, cables and pulleys, roller and frictionless supports
- **(b)** Simple coplanar concurrent force systems
- **(c)** Coplanar parallel force systems, point loads, uniform and non-uniform distributed loads
- **(d)** Simple coplanar non-concurrent force systems

(3) Force Analysis for more Complex Static Structures and Members

- **(a)** Method of Joints
- **(b)** Method of Sections

11.3 Part 2 - Dynamics

(1) Fundamental motion concepts and principles

(a) Displacement, velocity, acceleration and their interrelationship expressed analytically and graphically. Speed

(b) Angular rotation, angular velocity, angular acceleration. Units

(c) Conversions from angular to linear motion

(d) Cams

(e) Relative velocity in one plane

(f) Relative velocity and acceleration - effect of current on velocity and course of a ship, relative velocity between bodies moving in different planes

(g) Linear motion with constant acceleration

(h) Centrifugal acceleration

(i) Gravitational acceleration

(j) Angular motion with constant angular acceleration

(2) Force and motion analysis of moving structures, bodies and machine elements

(a) Newton's laws of motion, momentum and its conservation

(b) Moment of inertia and the angular form of Newton's third law (Torque equation)

(c) Inertial force and torque, application to structural analysis

(d) Acceleration of connected bodies

(e) Effect of simple air resistance on motion under the effect of gravity

(f) Centrifugal force and its use in Watt governor mechanisms

(g) Stress in a thin rim due to centrifugal action

(h) Porter Governor with sleeve friction

(i) Dynamic balancing of masses moving in a single place

(j) Separators and other applications

(k) Basic dynamics of the engine mechanism

(l) Use of piston velocity and acceleration formulae

(m) Derivation of piston displacement formulae

(3) Work, power and energy

(a) Definitions and relations between work, power and energy, Units

(b) Translational kinetic energy

(c) Potential energy

(d) Conservation of energy

(e) Rotational kinetic energy, flywheels

(f) Effect of flywheels or torque variation

(4) Periodic forces and vibration

(a) Simple harmonic motion, simple pendulum, simple vibrations

(b) The simple harmonic oscillator, amplitude versus frequency characteristic, resonance, effect of damping

(c) Vibration amplitude, velocity and acceleration

(d) Torsional and translational vibration modes for beams and cantilever, whirling of shafts, interference diagrams and critical speeds

(5) Power transmission and matching

(a) Power transmission methods (mechanical, hydraulic, electric) and the power equations

(b) Mechanical advantage, velocity ratio, efficiency

(c) MA, VR and efficiency for various force amplifying machines (per 2nd class syllabus)

(d) Force amplifying power transmissions

(e) Power matching transmissions; belt and pulley, chain and sprocket, reduction gearing, bearing loads induced by these transmissions

(f) Inertia calculations

11.4 Part 3 - Friction and anti-friction devices

(1) Friction

(a) Friction force, coefficient of friction, typical values, work done against friction, friction angle

(b) Friction on inclined plane

(c) Thread friction

(d) Effect of lubrication and sliding velocity on friction force - boundary layer, mixed film and full film lubrication

(2) Friction devices

(a) Friction clutches

(b) Band and disc brakes

(c) Flat belt and v-belt drives

(3) Anti-friction devices - rolling element bearings

(a) Radial and thrust bearing types, identification and terminology

(b) Alignment capabilities and requirements, separability, relative load carrying capabilities

(c) Statically determinant bearing arrangements, ring fits and installation rules

(d) Static load rating, dynamic load rating, statistical nature of bearing life, B_{90} and B_{50} life, load/life relation

(e) Equivalent radial loads, bearing selection

(f) Lubrication selection

(g) Sleeve Type Bearings

(h) Osborne Reynolds experiments, viscosity, pressure distribution, design parameters and charts, grooving and oil feeding. Pressure developed within oil film

(i) Michell and Kingsberry thrust bearings

11.5 Part 4 - Strength of materials

(1) Stress and Strain

(a) Direct stress and strain and modulus of elasticity, shear stress and strain and modulus of rigidity

(b) Stress on oblique planes (simple tension only)

(c) Elastic limit, yield stress, proof stress, ultimate tensile strength, percent elongation

(d) Fatigue stress, SN curve, endurance limit

(e) Relation between design load, safety factor and margin of safety

(f) Stiffness, compliance

(g) Stress concentrations

(h) Temperate stresses in constrained bars

(i) Effect of direct loading and temperatures changes on composite bars

(j) Strain energy and resilience, stress due to suddenly applied loads (Simple tension only)

(2) Shearing forces and bending moments

(a) Shearing force and bending moment diagrams for cantilevers and simply supported beams with concentrated or uniformly distributed loads

(3) Centroids and second moments of areas

(a) Centroid position for simple cross-sections

(b) Calculation of centroid position for more complex sections

(c) Second moment of area for simple cross-sections

(d) Use of parallel axis theorem to calculate second moment of area for more complex sections

(e) Polar second moment of area

(4) Beams and Bending

(a) Deflection of beams

(b) Deflection criteria

(c) Shear stresses in beams

(d) Stress due to bending, neutral axis, section modulus

(e) Use of Roark's "Formulae for Stress and Strain"

(5) Shafts and Torsion

(a) Stress due to torsional load (including power transmission) in solid and hollow shafting, torsional stiffness

(b) Torsion of shaft fitted with liner

(c) Stiffness of close coiled helical spring

(6) Struts

(a) Buckling of struts, use of Euler formulae

11.6 Part 5 - Applied strength of materials

(1) Pressure Vessels

(a) Circumferential and longitudinal stress in thin cylindrical shells subject to internal pressure

(b) Riveted joint design, use of boiler shell design formulae

(2) Bolted Joints

(a) Allowable stresses in bolts, stresses induced in bolts by torquing, recommended bolt tightening stress, elastic analysis of bolted joint, metal to metal and gasketed joints, composite gaskets, bolt load due to external load, opening condition and importance of initial bolt tension. Methods used to pretension bolts (temperature, hydraulic, stretch gauge)

(3) Welded joints

(a) Revision of weld and joint, types, symbols and terminology

(b) Full strength groove welds and their characteristics

(c) Pre-heating

(d) Fillet weld sizing methods

(e) General rules for welding design

11.7 Part 6 - Hydraulics

(1) Hydrostatics

(a) Variation of fluid pressure with depth, Archimedes principle, dry weight, wet weight, equilibrium of floating bodies

(b) Flotation in two liquids of different specific gravities

(c) Force on immersed vertical and horizontal plane surfaces, centre of pressure for vertical rectangular and triangular plane surfaces with one edge in contact with surface of liquid

(d) Force and centre of pressure calculations for tank sides and bulkheads

(e) Pascal's Law, force due to pressure on curved surfaces, Barlow's Formula, applications (e.g. piston forces in rack and pinion actuators, forces on spools in hydraulic valves)

(f) Applications including pressure balancing of variable pitch propeller return lines, stern tube shaft seals, submerged motors and drives

(2) Hydrodynamics

(a) Full bore flow of fluid through pipes under constant head, flow through orifice, coefficient of velocity, coefficient of discharge

(b) Bernoulli's equation, flow through metering orifices, venturi meter

(c) Force exerted by a jet on a flat surface perpendicular to jet, blade angle diagrams for a centrifugal Pump

(d) Laminar and turbulent flow, Reynolds no., friction factor variation with Reynolds no

(e) Absolute and kinematic viscosity viscometers, Redwood No. SAE No, SUS No, viscosity index, leakage flow rates

(f) Use of pitot-static tube for duct air flow and fan P-V characteristic measurement

(g) Loss calculations for ducting systems

(h) Fan P-V characteristics, fan power characteristics, pump characteristics, affinity laws, pump system matching

(i) Hydraulic pump inlet conditions, cavitation

(3) Hydraulics

(a) Hydraulic fluids

(b) Petroleum based and fire resistant fluids, properties, compatibility, additives

(c) Seals - leakage, static and dynamic sealing, seal and packing shapes and materials, compatibility, causes and cures for extrusion and spiral failures. Carbon face seals. Labyrinth seals

(d) Distribution

(e) Hose, pipe and tube uses and materials, pickling procedures for pipe

(f) Internal diameter sizing, hose reinforcement and pipe/tube wall thickness sizing, service severity factor

(g) Fittings, conductor installation procedures

(h) Computation of conductor pressure drops, including corrections for temperature, flow regimes by system application

(i) Thermal conditioning

(j) Reservoir features and maintenance

(k) Heat exchangers

(l) Heat generated by flow across relief valve, effect of reservoir size on temperature build-up, factors affecting stabilisation temperature, active and passive methods for reducing stabilisation temperature

(m) Contamination control

(n) Methods of contamination control, system installation and maintenance procedures, use of filters

(o) Contamination levels, allowable levels by system type, measurement techniques, filter element rating criteria, filter location and function

(p) Filter element and housing types, bypass and differential pressure indicator features, maintenance

(q) Hydraulic pumps and motors

(r) Fixed and variable displacement pump and motor types; construction characteristics (including porting techniques and drain connections)

(s) Volumetric, mechanical and overall efficiency of pumps and motors

(t) Control valves

(u) Pressure control valves, construction and operation of direct and pilot operated types - relief, sequence, unloading, motion control (overcentre, counter balance and motion control and lock), reducing

(v) Directional control valve types, porting, actuation methods

(w) Flow control valve types and construction, restrictors, pressure compensated types

(x) Integrated valve package designs

(y) Actuators and miscellaneous components

(z) Linear and rotary actuator types and characteristics, cushioning

(aa) Actuator mountings

(bb) Linear and rotary intensifiers

(cc) Marine hydraulic systems

(dd) Propeller pitch controls

(ee) Hopper gate actuators and vibrators

(ff) Hydraulic mooring winches

(gg) Unloader boom actuators

(hh) Hydraulic steering gears

(ii) Accumulators

(jj) Reading hydraulic schematics

(kk) Trouble shooting procedures

11.8 Part 7 - Pneumatics

(1) Comparison of pneumatic and hydraulic systems

(a) Pressure levels, component size fluid compressibility, energy storage capabilities and safety, cleanliness, self-lubrication, use in explosive environments, flow through pipes

(2) Basic principles

(a) Properties of air, SCGM, the gas laws, work done during adiabatic and isothermal compression

(3) Compressors

(a) Single and multi-stage compressors

(b) Receivers

(c) Pipe pressure drop calculations

(4) Distribution

(a) Filters, regulators, lubricators, driers, piping runs, moisture traps, fittings

(b) Valve capacity coefficient CV, terminal capacity

(5) Control of pneumatic power

(a) Control valve types, construction and maintenance

(b) Precautions and safeguards necessary to prevent fire and explosions

(6) Marine pneumatic systems

(a) Ships compressed air system, compressors and receivers, start air, control air, tank pressurization, level indicators

12

Refrigeration and Air Conditioning

Note: Course to be delivered after thermodynamics course

12.1 General

(1) Reasons

(2) Classification

(3) Physical notion recall

- **(a)** Temperature
- **(b)** Heat
- **(c)** Refrigeration power
- **(d)** Refrigeration efficiency
- **(e)** Gas law
- **(f)** Expansion and compression
- **(g)** Enthalpy
- **(h)** Entropy
- **(i)** Quality of saturated vapour

(4) Modern refrigerants

12.2 Principle of operation of a refrigeration system

(1) Theoretical vapour compression cycle

(2) Actual vapour compression cycle

(3) Representation of a refrigeration cycle

(4) Diagrams

(5) Performance characteristics

12.3 Refrigeration agent

(1) Classification

(2) Codification

(3) Identification

(4) Leak detection

(5) Safety

(6) Environmental considerations

12.4 Lubricating oil for refrigeration compressors

(1) Selection of lubricating oil

(2) Care to be given to the refrigeration installation due to the oil present within the circuit

12.5 Installation on board ships

(1) Indirect expansion system

(2) Brine

(3) Direct expansion system

(4) Refrigerated food

(5) Refrigerated cargo

(6) Notions of gas liquefaction on board ships

12.6 Description of the main components

(1) Compressors

- **(a)** Reciprocating type
- **(b)** Screw type
- **(c)** Centrifugal type

(2) Expansion valves

(3) Condensers

(4) Evaporators

12.7 Pieces of equipment

(1) Separators

(2) Dryers

(3) Filters

(4) Indicators

(5) Heat exchangers

(6) Valves and piping

12.8 Control and regulation components

(1) Pressure switches

(2) Thermostats

(3) Magnetic valves

(4) Flow-restriction valves

(5) Non return valves

12.9 Utilisation installation

(1) Cold room

(2) Cargo hold

(3) Insulation

(4) Insulation material

(5) Defrosting

12.10 Air conditioning systems

(1) General

- **(a)** Atmospheric air
- **(b)** Air characteristics
- **(c)** Air qualities

(2) Psychrometric chart

- **(a)** Realization
- **(b)** Humidity
- **(c)** Temperatures
- **(d)** Dew point
- **(e)** Humidity calculation from a saturation diagram

(3) Humidity measurement

- **(a)** Instruments used

(4) Numerical applications of the calculus

(5) Air conditioning installation on board ships

- **(a)** Individual and collective system
- **(b)** Air re-circulation installation
- **(c)** Installation with central control of temperature and humidity
- **(d)** Installations with individual temperature and humidity control

12.11 Running and maintenance

(1) Running and maintenance of refrigeration systems

(2) Running and maintenance of air conditioning systems

13

Naval Architecture (Stability)

13.1 Objective

(1) At the end of the term, the Cadet must be able to describe the conditions of flotation and stability in the transverse and longitudinal modes as they pertain to ships. The Cadet must be able to estimate the power required for various ships and the effects of rudder action and external influences on the ships. The Cadet must also be able to describe the various types of propellers and be able to estimate the losses pertaining to each type.

Total 84 hrs.

13.2 Basic hydrostatics

(1) Density and Specific Gravity

(2) Loss of flotation

- **(a)** Archimede's Principle
- **(b)** Hydrometers

(3) Tonnes per centimetre immersion

(4) Reserve Buoyancy

(5) Pressure exerted by a liquid

(6) Load on an immersed plane

(7) Centres of pressure

(8) Load diagrams

(9) Drafts, displacement, freeboard

(10) International Load line marks

13.3 Areas, volumes, forces and moments

(1) Form coefficients

- **(a)** Block
- **(b)** Prismatic
- **(c)** Waterplane
- **(d)** Midship section area
- **(e)** Vertical prismatic

(2) Wetted surface areas

(3) Simpson's Rules applied to Area calculations

- **(a)** First Rule

(b) Second Rule

(c) Combination of Rules

(d) Use of intermediate ordinates

(4) Simpson's Rules applied to Volume calculations

(a) First Rule

(b) Second Rule

(5) Simpson's Rules applied to First Moments

(a) First Rule

(b) Second Rule

(c) Determination of the centre of flotation

(d) Determination of the centre of buoyancy

(6) Simpson's Rules applied to Moments of Inertia

(a) Determination of BM and BMT

(b) Centres of Pressure

(7) Simpson's Third Rule

(a) Area

(b) Volume

(c) 3, 10, 1 Moment Rule

(8) Other methods for Area, Moments and Volume

(a) Trapezoidal Rule

(b) Mean ordinate rule

(c) Tchebycheff's rule

(d) Mechanical integration

13.4 Centre of gravity of ships

(1) Definition

(2) Shift of G

(3) Determination of KG

(4) Real and virtual centres of gravity

(5) Free surface effects

13.5 Centres of buoyancy and flotation

(1) Vertical centre of buoyancy, KB or VCB

(2) Shift of B

(3) Longitudinal centre of buoyancy, LCB

(4) Longitudinal centre of flotation, LCF

13.6 Transverse statical stability

(1) Heel and List

(2) Equilibrium of Ships

(3) Righting Lever

(4) Metacentre and metacentric height

(5) Moment of Statical Stability

(6) Relationship between GM and GZ

(7) Initial stability and range of stability

(8) Calculation of BM

(9) Inclining Experiment

(10) Loll or List due to

- **(a)** displacement of G
- **(b)** negative GM

(11) Effect of suspended weights

(12) Factors affecting stability

- **(a)** Beam
- **(b)** Freeboard
- **(c)** Vertical centre of gravity

(13) Dry-docking

(14) Grounding

13.7 Longitudinal stability

(1) Terms used G, B, F, M_L, GL

(2) Longitudinal metacentric height

(3) Calculations for BM_L

(4) Trim

- **(a)** Moment to change trim by 1 cm
- **(b)** Change to draft due to change of trim
- **(c)** Layer correction

(d) Effect of loading or unloading weights

(e) Special trims or drafts

(5) Change in mean draft due to change in density

(6) Change in trim due to change in density

13.8 Damaged Stability

(1) Bilging and permeability

(2) List due to damaged compartments

(3) Trim due to damaged compartments

13.9 Stability curves and scales

(1) General usage

(2) Information supplied to ships and how to use it

(a) Hydrostatic curves

(b) Cross curves

(3) Effect of beam and freeboard on curves

13.10 Dynamical stability

(1) Drawing curves of statical stability

(2) Assessment criteria for large angle stability

(3) Calculating areas under the GZ curve

(4) IMO Standards for stability

13.11 Waves and rolling

(1) Waves

(a) Formation

(b) Periods of waves

(2) Rolling

(a) Periods of ships

(b) Unresisted rolling

(c) Resistance to Rolling

(d) Curves for heavy rolling

13.12 Resistance

(1) Total resistance (Rt)

(2) Frictional Resistance (Rf)

(3) Residuary resistance (Rr)

(4) Laws of comparison

- **(a)** Models – ships
- **(b)** Effective power
- **(c)** Ship correlation factor
- **(d)** Naked effective power

(5) Admiralty coefficient

(6) Fuel coefficient and fuel consumption

13.13 Rudder theory

(1) Forces on rudders

(2) Torque on rudder stock

(3) Angle of heel due to force on rudder

(4) Angle of heel when turning

13.14 Propellers theory

(1) Definitions

- **(a)** Diameter
- **(b)** Pitch
- **(c)** Pitch Angle
- **(d)** Pitch ratio
- **(e)** Blade area
- **(f)** Projected area
- **(g)** Developed area
- **(h)** Blade area ratio
- **(i)** Disc area ratio
- **(j)** Blade thickness
- **(k)** Boss dimension
- **(l)** Number of blades

(2) Theoretical speed

(3) Apparent slip

(4) Wake and wake fraction

(5) Real or true slip

(6) Relationship between speeds

(7) Thrust

(8) Relationship between powers

- **(a)** ip
- **(b)** bp
- **(c)** sp
- **(d)** dp
- **(e)** ep
- **(f)** tp

(9) QPC

(10) Thrust Deduction factor

(11) Relationship between mean power and speed

(12) Diameter and pitch measurement

(13) Cavitation

13.15 Propellers - Practical

(1) Built propellers

(2) Solid propellers

(3) C.P. propellers

- **(a)** Operation
- **(b)** Systems

(4) Diameter and Pitch determination

(5) Materials

(6) Maintenance

- **(a)** Inspections
- **(b)** Damage
- **(c)** Corrosion
- **(d)** Erosion
- **(e)** Methods of repair
- **(f)** Propeller mounting
  - **(i)** Keyed

(ii) Keyless

(g) Procedures for removing propellers

14

Naval Architecture (Ship Construction)

14.1 Ships terms

(1) Ships structural parts

(2) Various ship configurations. Examples:

- **(a)** Flush deck ship
- **(b)** Three-island ship
- **(c)** Long bridge ship
- **(d)** Shelter deck ship
- **(e)** Ships with raised quarter-deck
- **(f)** Superstructure aft

14.2 Ships dimensions and forms

(1) Base line

(2) Bending moment

(3) Camber

(4) Centreline

(5) Dead-weight

(6) Depth extreme

(7) Depth moulded

(8) Draught extreme

(9) Draught moulded

(10) Displacement

(11) Entrance

(12) Flare

(13) Freeboard

(14) Freeboard deck

(15) Half-length amidship

(16) Length overall

(17) Length between perpendiculars

(18) Rake

(19) Rise of floor

(20) Run

(21) Sheer

(22) Tumblehome

14.3 Stresses in ships structure

(1) Static Stresses

- **(a)** Stresses due to water pressure
- **(b)** Stresses due to weight
- **(c)** Bending
  - **(i)** Hogging
  - **(ii)** Sagging, shear, thermal effects
- **(d)** Forces during dry-docking

(2) Dynamic Stresses

- **(a)** Bending
  - **(i)** Hogging
  - **(ii)** Sagging
  - **(iii)** Racking
- **(b)** Panting
- **(c)** Pounding

14.4 Steel profiles and plates used in shipbuilding

(1) Angles

- **(a)** Equal
- **(b)** Unequal
- **(c)** Bulb angles

(2) Bulb plates

(3) Channel bar

(4) I or H beams

(5) Tee bar

(6) Flat Bar

(7) Round bar

(8) Half round

(9) Tyzack moulding

14.5 Aluminium used in shipbuilding

(1) General uses

(2) Aluminium alloys

14.6 Structural Fire protection

(1) International Regulations (IMO)

(2) Canadian Regulations and Standards

(3) Bulkheads and decks rating

(4) Fire zones

(5) Penetrations

14.7 Riveting (Historical reference)

(1) Rivet strength (descriptive)

(2) Rivet types

(3) Rivet Heads

(4) Rivet points

(5) Riveting and spacing

14.8 Welding and cutting processes

(1) Welding

- **(a)** Equipment
- **(b)** Procedures

(2) Electric arc welding

- **(a)** Slag shielded processes
  - **(i)** Manual electrode
  - **(ii)** Gravity welding
  - **(iii)** Fusarc
  - **(iv)** Submerged arc
  - **(v)** Stud welding
- **(b)** Gas shielded processes
  - **(i)** Tungsten-Inert Gas (T.I.G.)
  - **(ii)** Metal Inert Gas (M.I.G.)
- **(c)** Other welding processes
  - **(i)** Electro-slag

(ii) Consumable guide

(iii) Electro - gas

(iv) Thermit welding

(3) Cutting processes

(a) Gas cutting

(b) Plasma arc cutting

(c) Gouging

(d) Lancing

(4) Testing welds

(a) General

(b) Weld faults

(c) Non destructive testing

(i) Visual

(ii) Dye penetrant

(iii) Magnetic particles

(iv) Radiographic

(v) Ulrasonic

(vi) Weld tests

14.9 Keels

(1) Bar keels

(2) Flat plate

(3) Duct keel

(4) Bilge keels

14.10 Systems of construction

(1) Transverse system

(2) Longitudinal system

(3) Combined syatem

14.11 Single bottom construction

(1) Transverse framing

(2) Longitudinal framing

14.12 Double bottoms

(1) Transverse framing

(2) Longitudinal framing

(3) Inner bottom plating

(4) Margin plates and tank side brackets

(5) Precautions against pounding

(6) Cofferdams

(7) Testing

14.13 Side structures

(1) Frames and framing systems

(2) Types of frames

- **(a)** Welded
- **(b)** Web frames
- **(c)** Deep frames

(3) Frame spacing

(4) Framing in tween decks

(5) Numbering of frames

(6) Portholes and windows

14.14 Deck structures

(1) Beams

- **(a)** Functions
- **(b)** Sections used
- **(c)** Systems
  - **(i)** Transverse
  - **(ii)** Longitudinal
- **(d)** Deep beams
- **(e)** Half beams
- **(f)** Hatch end beams
- **(g)** Brackets

(2) Pillaring

- **(a)** Functions

(b) Ordinary pillars

(c) Massed pillaring

(d) Longitudinal bulkheads

(e) Construction and fitting

(3) Deck girders

(a) Functions

(b) Fitting

(c) Construction

(d) Hatch side girders

14.15 Shell and deck plating

(1) General

(2) Stresses on plating

(3) Shell expansion diagrams

(a) Identifying plates

(b) Special plates

(i) Stealer plate

(ii) Shoe plate

(iii) Coffin plate

(iv) Boss plate

(v) Oxter plate

(4) Plating systems

(a) Joggled plating, straight frames

(b) In and out plating, straight frames

(c) Clinker plating, joggled frames

(d) Flush welded

(5) Plating at sheerstrake

(a) Openings

(b) Connection of deck stringer to sheerstrake

(6) Crack arrestors

(7) Shift of butts

(8) Tween deck at ships side

(9) Openings in plating

- **(a)** Deck
- **(b)** Shell

(10) Lloyds classification of plating

- **(a)** Width
- **(b)** Thickness

(11) Sheathing

(12) Hatchways

- **(a)** Deck openings
- **(b)** Height of coamings
- **(c)** Coamings
- **(d)** Hatch end beams
- **(e)** Half beams
- **(f)** Longitudinal at coamings

(13) Hatches in oil tankers

(14) Bulwarks and freeing ports

(15) Scuppers and sluices

14.16 Hatch covers

(1) Single pull hatch covers

(2) Hinged hatch covers

(3) Direct lift hatch covers

(4) Sealing and fastening methods

(5) Maintenance of mechanical hatch covers

14.17 Bulkheads

(1) Watertight Bulkheads

- **(a)** Uses
- **(b)** Number and location
- **(c)** Height
- **(d)** Fitting
- **(e)** Plating
- **(f)** Stiffeners
- **(g)** Corrugated Types

(h) Passages for pipes, cables and ventilation

(i) Boundary connections

(j) Testing

(2) Non-watertight bulkheads

(3) Watertight doors

(a) Vertical type

(b) Horizontal

(c) Clip and hinge doors

14.18 Deep tanks

(1) Purpose

(2) Construction

(a) Ordinary deep tanks

(b) Deep tanks used as oil fuel bunkers

(c) Deep tanks used for carrying oil as a cargo

(3) Use of cofferdams

(4) Testing

14.19 Peaks and panting arrangements

(1) General

(2) Peak tanks

(3) Testing

(4) Fore peak

(a) Construction

(b) Panting Arrangements - Forward of the collision bulkhead

(c) Arrangements aft of the collision bulkhead

(5) After peak

(a) Construction

(b) Panting arrangements

14.20 Stems

(1) Bar Stem

(2) Plate stem

(3) Composite stems

(4) Bulbous bow

14.21 Chain lockers and anchoring arrangements

(1) General

(2) Construction

(3) Hawse pipes

(4) Spurling pipes

(5) Mooring and anchoring arrangements

14.22 Sterns

(1) General

(2) Ordinary sterns - counter or elliptical

(3) Cruiser

(4) Transom

(5) Rudder trunks

14.23 Rudders and sternframes

(1) General

(2) Rudders

- **(a)** Single plate
- **(b)** Double plate
- **(c)** Balanced
- **(d)** Construction of rudders

(3) Gudgeons

(4) Pintles

- **(a)** Ordinary
- **(b)** Locking
- **(c)** Bearing

(5) Couplings

(6) Sternframes

- **(a)** Single screw
- **(b)** Double screw

(c) Transom floor

(d) A-Brackets

(e) Bossing

14.24 Stern Tubes

(1) Water lubricated

(2) Oil lubricated

(3) Fitting of stern tubes and shafting

(a) Light method

(b) Laser method

(c) Piano wire

(d) Checking

(4) Strengthening around Stern Tubes

14.25 Ducted propellers

(1) General

(2) Fixed

(3) Active

14.26 Engine and boiler rooms

(1) General arrangements

(2) Engine and boiler seating

(3) Shaft tunnels

(4) Casings

14.27 Superstructures and deckhouses

(1) Definitions

(2) Forecastles

(3) Poops

(4) Bridges

(a) Long and short bridges

(b) Plating

(c) Bulkhead construction

(5) Deckhouses

(6) Raised quarterdecks

14.28 Miscellaneous details

(1) Ventilators

(2) Air pipes

(3) Sounding pipes

(4) Overboard discharges

14.29 Strengthening for navigation in ice

(1) Canadian Arctic Pollution Regulations

(2) Ice Class notations

14.30 Ship types requiring special considerations

(1) Icebreakers

(2) Buoy tenders

(3) LPG and LNG

(4) VLCC and double hull tankers

(5) High speed craft

(6) Ro-Ro ferries

14.31 Classification societies and vessel regulatory authorities

(1) General

(2) Lloyds, American Bureau of Shipping and other classification societies

(3) Transport Canada Marine Safety

(4) International Maritime Organisation (IMO)

(5) Inspection and Surveys

- **(a)** Annual
- **(b)** Docking
- **(c)** Special Surveys
- **(d)** Continuous Surveys
- **(e)** Damage and Repairs

14.32 Shipyard practice

(1) Shipyard Layout

(2) Drawing office activities

(3) Plate preparation and machining

(4) Prefabrication and unit construction

(5) Launching

(6) Dry Docking

15

Chemistry

15.1 Theory of universe formation

15.2 Chemistry method

(1) Scientific method

(2) Material and energy

(3) Heat - temperature

15.3 Material constitution

(1) Mass conservation law

(2) Determined proportion law

(3) Multiple proportion law

(4) Atomic theory

(5) Atomic weight

(6) Atom - gram

(7) Avogadro's number

15.4 The atoms

(1) Experimental analysis

- **(a)** Faraday's experience
- **(b)** Discharge tube experience
- **(c)** Milikan’s experience

(2) Isotopes

(3) Radioactivity

(4) Atomic nuclear

(5) Periodic law

(6) Electronic energy levels

(7) Energy levels and periodic classification

(8) Electronic symbols

(9) Atomic sizes

(10) Ionisation potential

(11) Electronic affinity

15.5 Chemical bonding

(1) The electrons in the molecules

(2) Ionic bonding

(3) Covalent bonding

(4) Polarity bonding

(5) Electronegativity

(6) Bonding energy and electronegativity scale

(7) Valence saturation

15.6 Stoechiometry

(1) Approximative formulas

(2) Molecular formulas

(3) Mass of formula and moles

(4) Chemical reactions

(5) Oxydation number

(6) Oxydo - reduction

(7) Chemical equation

(8) Gram - equivalents

(9) Heat of reaction

N.B.: This section completes the first chemistry course.

15.7 Water

(1) What is water

- **(a)** Chemical composition and physical structure

(2) Chemical characteristics of water

- **(a)** Water as solvent
- **(b)** Solution containing water and reactions

15.8 Important characteristics of solutions

(1) Acids, bases and salts

(2) Acidity and alkalinity

(3) pH

(4) Conductivity

(5) Hardness

(6) Types of solids found in water

- **(a)** Dissolved solids
- **(b)** Suspended solids
- **(c)** Total solids

15.9 Water chemistry (brief description of the topic)

(1) What is chemistry

(2) What fundamentals of chemistry are important in the application of water treatment

(3) How can we visualise chemical reactions

- **(a)** Impurities
  - **(i)** Sodium
  - **(ii)** Magnesium
  - **(iii)** Calcium
  - **(iv)** Potassium
  - **(v)** Chloride
  - **(vi)** Sulphate
  - **(vii)** Bicarbonate
  - **(viii)** Silicate
  - **(ix)** Hydrogen
  - **(x)** Hydroxide
- **(b)** Ions resulting from corrosion
- **(c)** Ferrous iron
- **(d)** Ferric iron
- **(e)** Cuprous copper
- **(f)** Cupric copper

(4) Gasses

- **(a)** Oxygen
- **(b)** Carbon dioxide

(5) Other compounds

- **(a)** Sodium chloride
- **(b)** Magnesium chloride

(c) Potassium chloride

(d) Calcium chloride

(e) Magnesium sulfate

(f) Calcium bicarbonate

(g) Silicic acid

(h) Carbon dioxide

(i) Oxygen

(6) Chemical reactions

(a) Reactions resulting in scale

(i) Calcium carbonate formation

(ii) Calcium silicate formation

(iii) Magnesium hydroxide formation

(iv) Magnesium silicate formation

(v) Calcium sulphafite formation

(b) Reactions resulting in corrosion

(i) Steel corrosion

(ii) Copper corrosion

(c) Reactions associated with water treatment

(7) Chemical reaction calculations

16

Marine Electrical Technology

Marine engineers must be fed a balanced diet of the practical and theoretical in their training because they work closely with some of the most complex equipment in use. Their theoretical knowledge must be adequate to interpret the written, verbal, mathematical and symbolic language of the electrical engineer, and to analyze problems.

It is impossible to acquire a thorough understanding of electrical principles without working out a large number of numerical problems; and while doing so the student should make a habit of writing the solutions in an orderly manner attaching the name of the unit wherever possible, when students tackle problems in examinations or in industry, it is important that they express their solutions in a way that is readily intelligible to others and this facility can only be acquired by experience.

Engineering terminology and symbols approved by international agreement should only be used. The units are SI (MKSA). The use of correct terminology should be stressed to the students because this is the means through which they will communicate to those who work in the industry. We adopt the attitude that most people who will study marine electrical technology do so for very practical reasons and with this in mind many practical applications should be demonstrated during lectures to reinforce theory while holding the interest of the students.

This course is covered in 3 years:

MET year 1 Introductory to the terminology then leading on to circuits and theorems while including electrostatics.

MET year 2 Is devoted to AC circuits including Power factor phasors and energy measurement. Construction and use of DC machines and control. Testing of DC machines.

MET year 3 Deals with AC machines including alternators, synchronous machines and voltage control. Introduction to electronic devices and circuit theory biasing of transistors and simple amplifying circuits and the use of Zener diodes and rectification. A treatment of logic circuits is also included.

No attempt will be made to suggest to instructors how they should schedule material. Many factors will determine the sections to be selected; the order of presentation and the timing will be chosen to suit the purposes of the complete learning program.

Reference

"Introductory Circuit Analysis"	R. L. Boylestad
Electric Circuits - Schaum's	J. A. Edminster
Electronic Devices and Circuit Theory	R. Boylestad L. Hashelsky
Electrical Machines DC & AC	D. S. Siskind
Basic Electro Technology Reeds	E. Kraal

Advanced Electro Technology Reeds E. Kraa1

MET I

16.1 Electric Circuit

(1) Voltage potential difference

(2) Current flow ampere - Nature of electric current

(3) Resistance ohm's Law: V = R I

(4) Power watts. Units of energy Joule

(5) Specific resistance

(6) Insulation resistance of cables

(7) Effect of temperature on resistance

(8) Temperature coefficient

(9) Characteristics of series circuits

(10) Characteristics of parallel circuits

(11) Commercial resistors - Colour coding of fixed resistors

(12) American wire gauge

16.2 Circuit Analysis

(1) Kirchoffs voltage Law

(2) Voltage divider rule

(3) Parallel circuits

(4) Kirchoffs current law

(5) Current divider rule

(6) Short circuits

16.3 Methods of analysis

(1) Series Circuits

(2) Current sources in parallel

(3) Current sources in series

(4) Bridge networks

16.4 Electrical meters

(1) The shunt

(2) Ammeter shunt

(3) Conversion of ammeter to voltmeter

16.5 Electrolysis

(1) Electrolysis of water

(2) Quantitative laws of electrolysis (Faraday's Law)

(3) Electrochemical equivalent (ECE)

(4) Conduction of current in solids, liquids and gasses

16.6 Batteries

(1) Primary and secondary cells - shelf life etc

(2) Dry cells, Mercury cells, alkaline and seawater cells

(3) Cells in series

(4) Cells in parallel

(5) Grouping of cells - Internal resistance of cells

(6) Detailed construction of lead acid and alkaline battery; characteristics and application

(7) Charging accumulators

(8) Ship Safety Standards - Battery room aboard ship

(9) Battery maintenance

(10) Electrolyte spill clean up and first aid

16.7 Electromagnetism

(1) Magnetic fields

(2) Flux density

(3) Force on current carrying conductor

(4) Permeability

(5) Reluctance

(6) Ohm's law for magnetic circuits

(7) Magnetising force

(8) Hystresis

(9) The flux

(10) Flemings right-hand rule

(11) Lenz's law

(12) Magnetic field strength

(13) Magnetic leakage and fringing

(14) Magnetic pull and solenoids

16.8 Electrostatics

(1) Structure of the atom

(2) Electric charges

(3) Movements of electrons in a conductor

(4) Electro static units

(5) Capacitors in series

(6) Capacitors in parallel

(7) Force on isolated charge in electric field

(8) Deflection of electron moving through an electric field

(9) Energy in charged capacitor

(10) Charging and discharging capacitor R C circuits

(11) Transients in an R C circuit - steady state

16.9 Inductance

(1) Self inductance

(2) Inductance of toroid

(3) Iron-cored inductor

(4) Energy in inductor

(5) Mutual inductance

(6) Transients in an R L circuit - steady state

MET II

16.10 Introductory to A.C. circuits

(1) Sinusoidal alternating current

- **(a)** Sinusoidal AC voltage generation
- **(b)** Waveforms, their magnitude and value
- **(c)** Cycles, periods, frequency and wavelength
- **(d)** Sine wave and sine wave values
- **(e)** Generation of alternating E.M.F.

(f) Average and RMS values

(g) Representation of an alternating quantity by a phasor

(h) Addition, subtraction, multiplication and division of phases, phase angles graphical representation

(i) Circuits with inductance capacitance and resistance in series and parallel configurations

(j) Resonance circuits

(k) Power and power factor, methods of improving power factor

(l) Apparent power

(m) Reactive power

(n) Power triangle

(2) Poly-phase Systems

(a) Three phase system

(b) Three phase system voltages

(c) Balanced three phase loads

(d) Unbalanced delta - connected loads

(e) Unbalanced 4 wire, wye connected loads

(f) Unbalanced 3 wire wye connected loads

(g) Power in balanced three phase loads

(h) Wattmeters and four - wire wye loads

(i) Two watt meter method

(j) Two watt meter method applied to balanced loads

(3) Transformers

(a) Principle of action

(b) E.M.F. equation

(c) Useful and leakage fluxes

(d) Reactance

(e) Voltage regulation

(f) Losses and efficiency

(g) Three phase transformer

(h) Instrument transformer

(i) Marine application of open, delta, 3-phase transformer and auto transformer

(4) Direct Current Machines

(a) Ring - wound armature

(b) Commutator

(c) Lap and wave winding

(d) E.M.F. equation

(e) Armature reaction

(f) Commutation

(g) Main fields DC machines

(5) Direct Current Generators

(a) Methods of excitation

(b) Load and no load characteristics of shunt, series compound and separately excited generators

(c) Operation of generators in parallel

(6) Direct Current Motors

(a) Speed and torque characteristics

(b) Starting methods

(c) Speed control by rheostats and thyristors

Met III

16.11 AC machines - Electrical measurement - Electronics

(1) AC Machines

(a) Construction of salient - Pole and cylindrical rotor types

(b) Stator windings

(c) E.M.F. equation

(2) Production of a Rotating Magnetic Field

(a) Resultant magnetic flux due to two-phase and three-phase currents

(b) Synchronous speed

(c) Reversal of direction of rotation of magnetic flux

(3) Characteristics of synchronous generators and motors

(a) Armature reaction in synchronous generator

(b) Voltage regulation

(c) Synchronizing and parallel operation of synchronous generators

(d) Effects of varying load and excitation, starting synchronous and induction motors

(e) Discussion of AVR'S

(f) Introduction to self regulating alternators

(g) Static excitation systems

(4) Three phase induction motor

(a) Principle of operation

(b) Relationship between slip and rotor I^2R loss

(c) Torque/slip characteristics

(d) Speed control of motor having slipring rotor

(e) Starting methods - star delta - auto transformer resistance

(f) Fault operation, e.g. single phasing

(g) Starter wiring line diagrams

(h) Single phase motors, types and torque speeds characteristics and theory of operation

(5) Electrical Measurement

(a) Moving coil - application

(b) Moving iron - application

(c) Electrodynamics and rectifier ammeters and voltmeters

(d) Thermocouple and its applications

(e) Ohmmeter

(f) Megger - its applications

(g) Impedance bridge

(6) Shipboard distribution systems (Typical)

(7) High Voltage Propulsion Systems

(8) Earth/Ground Fault Detection systems

(9) Intrinsically safe Equipment

(10) Switchboards

(a) Motor starters

(b) Preference tripping

(11) Uninterrupted Power Supply (UPS) Systems

17

Automation, Control and Instrumentation

17.1 Binary system and Boolean algebra

(1) Number systems

- **(a)** Decimal system
- **(b)** Binary system
- **(c)** Binary to decimal conversion
- **(d)** Decimal to binary conversion
- **(e)** Natural binary system table and formation rule
- **(f)** Binary addition and addition table
- **(g)** Binary subtraction and subtraction table
- **(h)** Binary multiplication and multiplication table
- **(i)** Binary division
- **(j)** Logical advantages of the binary system

(2) Binary logical function and Boolean Algebra

- **(a)** Binary variable
- **(b)** Basic logical function and truth table
  - **(i)** Equality or affirmation
  - **(ii)** Complement or negation
  - **(iii)** OR function or logical sum
  - **(iv)** AND function or logical product
- **(c)** Logical function properties and Boolean Algebra operation properties
  - **(i)** Idempotance
  - **(ii)** Commutativity
  - **(iii)** Associativity
  - **(iv)** Distributivity
  - **(v)** Morgan theorem
  - **(vi)** Remarkable equations
- **(d)** Obtainment of logical equations and simplification using Boolean Algebra
- **(e)** Simplification of logical equations using the Karnaugh matrix

17.2 Automatic systems and control system elements

(1) Constitutive elements of an automatic control system

(a) Electrical switches

(b) Electrical push button contacts

(c) Controlled electrical switches and contacts

(d) Electromagnetic relays and relay contacts

(e) Pneumatic and hydraulic distributor

(f) Pneumatic jacks and single acting and double acting hydraulic jacks

(g) Machine states

(2) Practical realization of the logical functions

(a) Electrical

(b) Pneumatic or hydraulic

(3) Setting a diagram in equation and diagram realization of a logical equation

(4) Study of combinatory logical automation

(5) Study of sequential logical automation

17.3 Electronic of logic circuits

(1) Electronic logic circuits

(a) Constitutive elements

(i) Resistance

(ii) Diod

(iii) Transistor

(b) Fundamental circuits and their practical realization

(i) NON circuit

(ii) OR circuit

(iii) AND circuit

(c) Complementary circuits and their practical realization

(i) NOR circuit

(ii) NAND circuit

(d) Logigrams

17.4 General conclusion and system analysis

(1) This section is constituted by the analysis of real automatic system diagrams.
NOTE: This section completes the first automation and control course.

17.5 Fundamental notions

(a) Terminology

(i) Controlled variable

(ii) Controlled medium

(iii) Manipulated variable

(iv) Control agent

(b) Types of control systems

(i) Self operating system

(ii) Relay operating system

(2) Fundamental measuring concepts

(a) Time element

(i) Lag

(b) Dynamic error and lag

(c) Static error

(d) Reproduction error

17.6 Sensing elements

(1) Pressure

(a) Fundamental notions

(b) Manometers

(c) Pressure gauges

(2) Temperature

(a) Temperature measurement theory

(b) Lag coefficient

(c) Factors influencing the answer of bulb thermometers and thermocouple

(d) Transmission delay

(e) Protection well and answer speed

(f) Bulb thermometers

(g) Bi-metallic thermometer

(h) Thermocouple thermometer

(i) Resistance thermometer

(3) Flow

(a) General considerations

(b) Flow measurement by pressure difference

(i) Primary element function

(ii) Primary element types

(iii) Measuring element types

(iv) Electric flow transmitter

(c) Mechanical flow measuring instrument

17.7 Automatic control principles

(1) Uncontrolled system

(a) Feed disturbances

(b) Consumption disturbances

(c) External disturbances

(2) Air/fuel ratio opened loop control

(a) Feed

(b) Consumption

(3) Closed loop temperature control

(4) Closed loop control, free from some disturbances

(5) Cascade type control

(6) Air/fuel ratio control

(7) Compensation for consumption request

17.8 Non-automatic control elements

(1) Pneumatic and hydraulic elements

(a) ON-OFF valves

(b) 2-way valves

(c) Pressure reducing valve

(d) Double check valve

(e) Solenoid valve

(f) Relay valve

(g) Filters

(h) Multiple way control valve

(2) Study of a main engine control from bridge and control room

(a) Control possibilities

(b) Operation of the various valves

(c) Detailed study of the various control possibilities

17.9 Control modes

(1) ON-OFF action

(a) Application

(2) Continuous action controls

(a) Comparisons

(i) Proportional action

(ii) Integral action

(iii) Derivative action

(3) Proportional action control

(a) Proportional band

(4) Integral action control

(5) Derivative action control

(6) Possible combination

(a) P + I control

(b) P + I + D control

(7) Practical realization of pneumatic controls

(a) ON-OFF control

(b) Continuous action controls

(i) Proportional action control

(ii) P + I control

(iii) P + I + D control

(8) Selection of a control

(a) ON-OFF control

(b) Proportional control

(c) P + I control

(d) P + I + D control

17.10 Level measurement

(1) Visual indicators

(a) Level indicators

(b) Remote reading indicators

(2) Float indicators

(3) Displacement indicators

(a) Torsion tube

(4) Level measurement using pressure

(a) Closed tank

(i) Manometer

(ii) Torsion tube

(iii) Bellows

(b) Opened tank

(i) Box with diaphragms

(ii) System with trapped air

(iii) Simple pressure gauge

(iv) Bubble indicator

(v) Pneumercator system

(5) Electric measurement

(a) ON-OFF systems

(b) Continuous systems

(c) Ultrasonic level measurement

17.11 Final control element

(1) General

(a) Control loop

(b) Parts of a control valve

(2) Control valve types

(a) Alternative spindle valve

(b) Rotative spindle valve

(3) Actuators

(a) Selection

(b) Pneumatic actuators

(c) Hydraulic actuators

(d) Electric actuators

17.12 Steam turbine control

(1) Manual control

(2) Remote and/or automatic control

(3) Typical turbine control system

(a) Control possibilities

(b) Bridge control

(c) Engine room control

(4) Instrumentation

(5) Emergency stop circuits

17.13 Gas Turbine control

(1) Overview

(2) Automatic and manual control options

(3) Typical gas turbine control applications

(4) Instrumentation

(5) Shutdowns and emergency controls

17.14 Diesel engine control

(1) Directly reversing engine

(a) Security systems

(2) Bridge control of engine

(a) Supplementary security systems

(b) Operation

(3) Typical diesel engine control

(4) Instrumentation

17.15 Speed governors

(1) Recall on fuel pumps

(a) Regulation

(b) Fuel pump realization

(2) Fuel lever

(3) Mechanical governors

(a) Construction

(b) Operation

(c) Installation examples

(d) Interconnection with safety devices

(4) Hydraulic governors

(a) Principle

(b) Comparison

(c) Speed droop mechanism

(d) Woodward SG governor

(e) Woodward PSG governor

(f) Woodward UG8 governor

(5) Electronic governors

(a) Power supplies

(b) Speed pick-ups

(c) Actuators

(d) Electronic components

17.16 Steam plant automatic control

(1) General

(2) Combustion control

(a) Qualities requested from a combustion control

(b) Combustion control classification

(c) Series control logical study

(d) Parallel control logical study

(i) Control with air flow corrections

(ii) Fuel control with delay for air

(e) Detailed study of a parallel combustion control

(i) General

(ii) Operation principle

(iii) Operation conditions

(iv) Operation modes

(3) Feed water control

(a) Water level

(b) Recall on mechanical feed control

(c) Thermo-hydraulic control

(d) Thermo-mechanic control

(e) Two element control

(4) Logical study of modern system

(a) One element control

(b) Two element control

(c) Three element control

(5) Detailed study of a two element control

(a) Detection

(b) Analysis

(c) Control

(d) Operation mode

(e) Construction of some elements

(6) Soot blower automation

(a) Retractable soot blower

17.17 Integrated Monitoring and Alarm Systems

(1) Unmanned Machinery Space (UMS) systems and practice

18

Marine Computer Science and Networks

18.1 General

(1) The introduction of computer based control systems is replacing many of the traditional tasks carried out by engine room personnel. Modern vessels are being equipped with a range of such control systems - from propulsion systems that are reliant on microprocessor based controls, through alarm and monitoring functions down to complex control circuitry that operate cranes and other deck machinery. Engineers today, need to be fully conversant with the principles of this labour saving technology and also have the knowledge and ability to troubleshoot and carry out repairs to these types of systems.

(2) While listed as a separate course, the marine computer science and networks course may be integrated with the automation, control and instrumentation course as many of the topics cover the same basic elements. Substantial savings in time may be obtained by integrating these two courses.

18.2 Subject areas

The following subject areas are to be included.

(1) Computer and other microprocessor based applications on board vessels - general

(2) Computer internal and external hardware

- **(a)** Power supplies
- **(b)** Process cards
- **(c)** Input – output cards
- **(d)** Monitors
- **(e)** Input devices

(3) Operating systems and computer languages

- **(a)** Common languages and their usages
  - **(i)** Typical commands

(4) Networks

- **(a)** Purpose
- **(b)** Types
- **(c)** Hardware
- **(d)** Communication protocols

(5) Trouble shooting of hardware and software faults

- **(a)** Theoretical
- **(b)** Practical

18.3 Common applications

(1) Ships' internal communication systems using microprocessor based systems

(2) Fire detection systems using micro processor based systems

(3) Alarm, monitoring and activation systems using microprocessor based systems and networks.

(4) Vessel propulsion control systems

- **(a)** Multiple control locations
- **(b)** Dynamic positioning control
- **(c)** "Joystick" control.

(5) Remote control systems for deck machinery, cranes and other miscellaneous shipboard applications.

19

Marine Law and Ship's Business

19.1 General

(1) While there are references to certain regulations and the enabling legislation in the other courses that make up the cadet program, this course should give a broad overview of the regulatory regime under which vessels operate in Canada and worldwide. The course is to concentrate on how the various Acts, Regulations and international conventions affect the operation of the engine room, it's staff, and vessels in general.

19.2 Canadian marine law and ship operations

(1) *Canada Shipping Act* and its Regulations, with specific reference to the following:

- **(a)** *Canada Shipping Act*, the powers of the Governor in Council and the Minister of Transport
  - **(i)** Registration of ships and the various parts of the act
- **(b)** Marine Certification Regulations
  - **(i)** Certification of Masters, Mates, Engineers and Ratings
- **(c)** Crewing Regulations
  - **(i)** Manning scales, training requirements, medicals
- **(d)** Hull Construction, Inspection Regulations
  - **(i)** General overview
- **(e)** Marine Machinery Regulations
  - **(i)** General overview
- **(f)** Boat and Fire Drill Regulations
- **(g)** Crew Accommodation Regulation
- **(h)** Fire Detection and Extinguishing Equipment Regulations
- **(i)** Garbage Pollution Prevention Regulations
- **(j)** General Load Line Rules and the various Load line Regulations
- **(k)** Non-Pleasure Craft Sewage Pollution Prevention Regulations
- **(l)** Great Lakes Sewage Pollution Prevention Regulations
- **(m)** Home Trade, Inland and Minor Waters Voyages Regulations
- **(n)** Life Saving Equipment Regulations
- **(o)** Oil Pollution Prevention Regulations
- **(p)** Air Pollution Regulations
- **(q)** Safe Working Practice Regulations
- **(r)** Ships' Crews Food and Catering Regulations

(s) Steering Appliances and Equipment Regulations

(t) Towboat Crew Accommodation Regulations

(2) Canada Labour Code

(a) Occupational Health and Safety Regulations, General and Marine

(3) Criminal Code as it relates to the operation of a ship

19.3 Ship's Business

(1) Marine Insurance

(a) A general knowledge of marine insurance and its interrelationship with charter parties, bills of lading and the various Acts, Regulations and International Conventions that deal with marine commerce as it relates to vessels

(b) Statutory and contractual requirements as to sea worthiness

(2) International Maritime Organization (IMO), International Labour Organization (ILO), Safety of Life at Sea convention (SOLAS) and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995.(STCW 95)

(a) A general knowledge of the international conventions and agreements that affect world shipping

(b) Specific knowledge of the various parts of the international conventions that effect the operation of the engine room of the vessel
As an example: Chapter VIII of the STCW Code part A that refers to the standards regarding watchkeeping.

(3) Pollution Prevention and the Protection of the Environment.

(a) A knowledge of the methods and aids to prevent pollution of the environment by ships

(i) Canadian regulations and international conventions (MARPOL) to be observed to prevent pollution to the marine environment

(ii) Effects of marine pollution on the environment

(4) International Safety Management Code (ISM)

(a) Knowledge of the requirements of the code and the impact on engine room operations

(b) Case study of a ISM system in operation.

(5) Purchasing, contracting and accounting methods

(a) Controlling budgets and finance

(b) Project management – planning and running of vessel refits/drydocks

(c) Supervision of trades and contractors

(d) Dealing with Reps', shore suppliers, and agencies

(i) Transport Canada inspectors

(ii) Classification surveyors

(iii) Shore superintendents

(6) Miscellaneous

(a) Crew welfare and training – company appraisal systems etc

(b) Interdepartmental relationships on a ship

(c) Crew representation and rights under the CSA

(d) Official Log Books

(e) Communication methods Ship – shore

20

Thermodynamics

20.1 Course

(1) Course Duration - 180 hours

20.2 Recommended texts

Basic Thermodynamics by Bernhardt G. A. Skrotzki - McGraw Hill.

Thermodynamics and Heat Power by I. Granet - Reston.

Engineering Thermodynamics with Applications by M.D. Burghardt Harper Row.

Reeds Heat and Heat Engines for Engineers.

Part I - 90 Hours

20.3 General objectives

(1) Thermodynamics is that branch of the physical sciences that treats the various phenomena of energy and the related properties of matter, especially the laws of transformation of heat into other forms of energy and vice versa. The science of thermodynamics covers such fields as:

- **(a)** Steam propulsion plants
- **(b)** Internal Combustion engines
- **(c)** Air compressors
- **(d)** Gas turbines
- **(e)** Jet propulsion
- **(f)** Refrigeration
- **(g)** Air conditioning
- **(h)** Heating systems (steam, oil, gas)

(2) From the above list one can readily appreciate the vastness of the field of thermodynamics and to attempt to cover in any depth the entire above list in one course is impossible. Therefore the students will be introduced to the basic principles of thermodynamics and later apply their principles in solving practical problems in such areas as steam cycle and Internal Combustion engine cycle analysis, air compressors and refrigeration.

20.4 Specific objectives

(1) Energy and Work

- **(a)** Forms of energy
- **(b)** Convertibility of energy to work
- **(c)** Law of conservation of energy

(2) Heat and Gasses

- **(a)** Heat and heat transfer
- **(b)** Energy changes
- **(c)** Boyle's law
- **(d)** Charles' Law

(3) The Perfect Gasses

- **(a)** The perfect gas equation
- **(b)** Avogadro's law
- **(c)** Principal specific heat capacities and Joules' law

(4) Measurement of Energy

- **(a)** Mechanical equivalent
- **(b)** Heat equivalent
- **(c)** Electrical equivalent
- **(d)** Calorimetry
- **(e)** First law of thermodynamics
- **(f)** Specific heats and their relationships
- **(g)** Thermal-Mechanical conversions

(5) Energy Equation of Gasses

- **(a)** Use of the PV diagram
- **(b)** Reversibility of processes
- **(c)** Joule's experiment
- **(d)** The gas processes
  - **(i)** Constant volume
  - **(ii)** Constant pressure
  - **(iii)** Constant temperature
  - **(iv)** Adiabatic
  - **(v)** Polytropic

(6) The Energy Cycle

- **(a)** Carnot cycle
- **(b)** Thermal reversibility
- **(c)** Cycle processes
- **(d)** Carnot efficiency

(7) Heat Flow

- **(a)** Second law of thermodynamics
- **(b)** Enthalpy and enthalpy change
- **(c)** Adiabatic enthalpy change
- **(d)** Polytropic enthalpy change
- **(e)** The TS diagram

(8) Process Irreversibility
(Cross reference to Refrigeration and Air Conditioning subject)

- **(a)** Internal and external irreversibility
- **(b)** Pressure variations
- **(c)** Disorder of gasses
- **(d)** Entropy of energy
- **(e)** Irreversible processes
- **(f)** Irreversible cycles

(9) Basic Engine Cycles

- **(a)** Stirling cycle
- **(b)** Ericson cycle
- **(c)** Regenerative heating
- **(d)** Joule cycle

(10) Compressed Air Cycles

- **(a)** The air compressor
- **(b)** Air processes
- **(c)** Work inputs
- **(d)** Effects of clearance volume
- **(e)** Varying output
- **(f)** Multi staging
- **(g)** Intercooling
- **(h)** Compressed air engines
- **(i)** Energy flow through the system
- **(j)** Performance factors

(11) Internal Combustion Engine Cycles

- **(a)** The Otto Cycle

(i) Cycle performance

(ii) Temperature effects

(iii) Work variation

(iv) Performance and efficiency factors

(v) Cycle analysis

(b) The Diesel Cycle

(i) The processes

(ii) Diesel efficiency

(iii) Performance characteristics

(iv) Cycle analysis

(12) Actual Engine Cycles

(a) Actual P-V diagrams

(b) Work output

(c) 2 stroke cycles

(d) 4 stroke cycles

(e) Cycle comparisons

(13) Steady Flow Energy

(a) Energy forms

(b) Mass flow

(c) Steady flow energy equation

(d) Enthalpy

(e) Steady flow devices

(i) nozzle

(ii) turbine

(iii) fan, induction devices

(f) Vortex flow

(g) Heat Exchanges

(h) Flow analysis

(14) Gas Turbine Cycles

(a) Brayton cycle

(b) Cycle analysis

(c) Cycle efficiency

(d) Regenerative cycle

(e) Reheating and Intercooling

(15) Nozzle Gas Flow

(a) Energy transfer

(b) Types of nozzles

(c) Stagnation states

(d) Nozzle pressures

(e) Nozzle flow

(f) Performance factors

(g) Sonic velocity

(h) Throat properties

(i) Static and critical pressures

(j) Nozzle efficiencies

(16) Vapour and Liquid Properties

(a) States of matter

(b) Fusion

(c) Evaporation and condensation

(d) Sublimation

(e) Critical point

(f) Volume changes

(g) Heat transfers

(h) Temperature - Saturation relationships

(i) Latent and sensible enthalpies

(j) Temperature - Heat value relationships

(k) Mollier diagram (H-S relationships)

(l) Steam tables

(m) Wet mixtures and quality

(n) Compressed liquid

(o) Superheating

(17) Steam Processes

(a) Constant pressure relationships

(b) Constant volume relationships

(c) Constant temperature relationships

(d) Constant Entropy relationships

(e) Adiabatic relationships

(f) Throttling

(18) Basic Steam Cycles

(a) The Rankin cycle

(b) Cycle components

(c) Component efficiencies

(d) Cycle efficiency (theoretical)

(e) Engine efficiency

(f) Factors affecting efficiency

(i) line loss

(ii) throttling

(iii) condenser pressure and temperature

(g) Reheat cycle

(h) Regenerative cycle

(i) Bleed cycle

(j) Cycle combinations

(k) Cycle analysis

Part II - 90 Hours

20.5 General objectives

(1) The aim of this phase is to prepare the student to apply the basic concepts of Thermodynamics covered in Phase I to the generation of Marine propulsion and auxiliary power by Steam, Internal Combustion and Gas Turbine systems. It also includes the application of fundamental Thermodynamic principles to Refrigeration and Air Conditioning systems, Heat Pumps and the continuing requirements for Energy Conservation.

20.6 Course outline

(1) The Steam Cycle

(a) Properties of steam

(b) Steam tables and diagrams

(c) Saturated and Superheated steam

(d) Ideal processes Rankin

(e) Steam generation

(i) Boiler types and principles

(ii) Feed water considerations

(iii) Combustion principles

(f) Boiler efficiencies

(g) Cycle efficiencies

(i) Deviations from ideal

(ii) Line losses

(iii) Throttling

(iv) Heat losses

(v) Condensate temperatures

(vi) Feed and air preheating

(2) Fuel Technology

(a) Calorimetry

(b) Combustion process

(i) Air requirements

(ii) Fire triangle

(iii) Products of combustion

(iv) Calorific values

(c) Fuel components

(d) Comparisons of various fuels

(e) Combustion efficiencies

(f) Flue gas analysis

(g) Stack losses

(3) Steam Engines (Reciprocating)

(a) Reciprocating Engine principles

(b) Valves and timing

(c) Indicator diagrams

(d) Power calculations

(i) Effects of cut-off

(ii) Back pressure, condensing and non condensing

(e) Staging

(f) Single and double acting

(g) Referred pressures

(h) Ideal, thermal and mechanical efficiency

(i) Indicated and brake power

(4) Steam Turbines

(a) Reaction and impulse

(b) Staging

(c) Velocity calculations

(d) Significant design considerations

(e) Ideal, thermal and mechanical efficiency

(f) Nozzle flow characteristics

(g) Factors affecting efficiency

(h) Condensing arrangements

(5) Diesel Power

(a) Cycle characteristics

(b) PV diagrams

(c) Pressure - time diagrams

(d) Combustion theory and diesel detonation

(e) 2 Stroke and 4 Stroke cycle efficiencies

(f) Factors affecting efficiency

(i) Timing calculations

(ii) Scavenging principles

(iii) Compression ratio

(iv) Expansion and cut-off ratios

(g) Air standard analysis

(h) Supercharging effects

(i) Exhaust gas analysis

(j) Heat exchanger calculations

(k) Waste heat conversion

(6) Internal Combustion Engine Power (Otto)

(a) The practical Otto Cycle

(b) PV diagrams

(c) Pressure-time diagrams

(d) Combustion theory

(i) fuel air ratio

(ii) carburetion

(iii) timing considerations

(e) Factors affecting efficiency

(f) 2 Stroke and 4 Stroke cycle efficiencies

(g) Air standard cycle analysis

(h) Cycle limitations

(i) Exhaust gas analysis

(7) Gas Turbine Power

(a) Steady flow analysis

(b) Joule-Brayton Cycle analysis

(c) The Compression process

(i) Axial flow compression

(ii) Radial or centrifugal compression

(d) Pressure ratios

(e) Factors affecting efficiency

(i) Compression limitations

(ii) Mass flow

(iii) Temperature limitations

(f) Open cycle system

(g) Closed cycle system

(h) Shaft power and Indicated power calculations

(i) Specific fuel consumption

(j) Gas velocities

(k) Cycle limitations

(l) Regenerative cycle

(8) Refrigeration and Air Conditioning

(a) Reversed Carnot cycle

(b) Coefficient of performance

(c) Vapour compression cycle

(d) Refrigerants and their properties

(e) Cycle analysis

(f) Plant output calculations

(g) Factors affecting cycle efficiency

- **(i)** Compression procedures
- **(ii)** Intercooling
- **(iii)** Sub cooling
- **(iv)** Cascade staging

(h) Selection of refrigerants

(i) Expansion characteristics

(j) Brine system calculations

(k) Types of compression

(l) Absorption refrigeration systems

- **(i)** C.o.p. calculations
- **(ii)** Energy equations and heat balance
- **(iii)** Cycle limitations

(m) Steam jet system

(n) The heat pump

- **(i)** C.o.p. heating
- **(ii)** C.o.p. cooling

(o) Psychrometric chart

(p) Partial pressures/humidity

(q) Comfort zone

(r) Heat balance calculations

(9) Heat Exchangers and Insulation

(a) Modes of heat transfer

(b) Laws of heat transfer

(c) Conductive resistivity (R factor)

(d) Black body absorption

(e) Composite material calculations

(f) Critical thickness calculations (insulation)

(g) Heat exchangers

(i) Effectiveness

(ii) Parallel flow vs. counter flow calculations

(iii) Differential lengths

(iv) Differential areas

(h) Steady flow analysis

(10) Laboratory Experiments

(a) The laboratory experiments run parallel to and complement the theory lectures by the use of actual equipment under laboratory conditions to provide practical instruction, demonstration, and operation experience with Steam Reciprocating, Steam Turbine, Gasoline (Otto), Diesel, and Rotary Engines. Additional practice and experience is provided by experimentation in Calorimetry, Heat Transfer and Insulation Methods, Flue Gas Analysis, Feedwater Testing, Nozzle Flow and Refrigeration/Heat, and Pump Cycles.

(b) Each student is required to submit an account of each experiment in the form of a comprehensive Technical Report outlining the aim of the experiment, equipment used, procedures followed, results obtained, calculations and computations, observations noted, conclusions drawn, and possible sources of error; Results obtained will normally be in the form of instrument readings and will be presented in the form of a neat and logical table. Calculations will be neat, accurate and in all cases, explanatory in every detail. Calculations will be complemented by the use of graphs where appropriate, and equipment descriptions will be complemented by the use of neat and representative line diagrams or sketches in all cases. Observations will be meaningful and pertinent to the aim of the experiment and conclusions, and sources of error will be fully explained and justified.

(c) The laboratory experiments will cover

(i) Operation of Steam Power Plant

(A) Lighting up and raising pressure of a boiler

(B) Draining and warming through all lines of the system;

(C) Draining and warming through the engines

(D) Putting engines on load

(E) Shutting down engines

(F) Securing the system lines, valves, drains, traps and separators

(G) Shutting down and securing the boiler

(ii) Calculation of boiler output (HP)

(iii) Calculation of boiler efficiency

(iv) Operation of turbine at various loads and calculations of engine efficiencies at various conditions of load, steam inlet, condenser or exhaust pressure and

steam rates

(v) Operation of steam reciprocating engine at various loads and calculations of IHP by indicator diagram and BHP by Prony brake; calculation of thermal and mechanical efficiencies at various conditions of load

(vi) Starting and stopping and operating procedures of a gasoline and diesel engine; application of various loads by a water torque converter, dynamometer and power brake; calculation of energy by measurement of air and fuel flow, power out and heat rejected to exhaust and computation of engine efficiencies, fuel air ratios and "best operating" conditions

(vii) Demonstration of the operation of a Wankel Engine

(viii) Calculation of heat transfer by use of parallel and counter flow heat exchange methods

(ix) Calculation of the insulation properties of various thicknesses of steam pipe lagging

(x) Calculation of nozzle flow characteristics using various types and sizes of nozzles and various inlet and back (outlet) pressures

(xi) The use of a Bomb Calorimeter for calculating higher calorific values of fuels

(xii) The use of Orsat Apparatus for investigation of flue gas components and proportions

(xiii) The procedures for testing of boiler feedwater for the presence and amounts of alkaline, salinity and phosphates and the methods of treatment to eliminate or control their reactions

(xiv) Vapour compression refrigeration cycle and heat dump analysis (York Trainer)

(11) In all laboratory experiments, the use of proper operating procedures, safety precautions and the recognition of conditions dangerous to personnel and equipment are stressed.

21

Blueprint interpretation and sketching, or Drawing

21.1 General

(1) The Blue Print Reading and Free Hand Sketching course will allow the student to read and interpret blueprints and technical drawings by:

(a) locating specific features of objects described on a blueprint or drawings;

(b) extracting dimensions, identifying fabrication tolerances, and processes as indicated on the blueprint or drawing in the manufacture or maintenance of components;

(c) explaining the location of specific items on the blueprint or drawing, and their relationship to the whole system or machine indicated on the blueprint or drawing having auxiliary or sectional views;

(d) obtaining required information from blueprint or drawing, using graphic symbology, title blocks, material lists, drawing notes, callouts, change systems;

(e) describing conventional screw tread forms, bearings, fillets, rounds, holes, fasteners, keys, gears, springs, splines and serration's to ensure understanding of these conventions;

(f) making freehand technical sketches using multi-view orthographic, one and two point perspective, and isometric projections. The subject to be drawn may be either an item included on a blueprint or a machinery part viewed and measured by the candidate. The completed drawing must be accurately proportioned at the scale chosen by the candidate, lettered and dimensioned, using only pencils, eraser and graph or squared paper.

(2) The candidate at the time of examination will be given blueprints, objects or drawings selected from the following: detail drawings, assembly drawings, schematics, block diagrams, exploded pictorial drawings as used for machinery drawings; graphic piping diagrams and symbols, ship's electrical distribution drawings, component schematics, wiring connections, power panels, instrumentation and control diagrams, fluid power drawings (hydraulic and pneumatic), welding blueprints, sheet metal blueprints and special drawings - hydrostatic curves, stability curves, shell expansions and general arrangements.

(3) Autocad and similar drafting programs

(a) Computer based drafting may be integrated into the program and it's use should be encouraged. However, the course must not focus solely on this type of computer based system.

(4) Traditional drafting course

(a) Institutions and programs retaining the traditional drafting course should ensure that sufficient Blueprint interpretation is covered in this course or is integrated in the other courses of the program.

22

Engineering Knowledge - General

22.1 Pumps

(1) Reciprocating Pumps

(2) Centrifugal Pumps

(3) Screw-displacement and Gear Pumps

(4) Injectors and Ejectors

22.2 Systems

(1) Bilge system including vacuum priming

(2) Fire main system

(3) General service System

(4) Fuel Oil Transfer System

(5) Lubrication System

(6) Feed System

(7) Hydraulic Systems

(8) Potable Water System

(9) Domestic water system

(10) Ballast System

(11) Cargo Pumping System

(12) Cargo and bunker heating systems

- **(a)** Steam and hot water types
- **(b)** Electric heating
- **(c)** Thermal oil heating plants

22.3 Piping & associated hardware

(1) Various types of valves and fittings

(2) Safe Operating Procedures

22.4 Power transmission

(1) Thrust, Intermediate and Propeller Shafts

(2) Main, Thrust, Intermediate and Propeller Shaft Bearings

(3) Alignment and Couplings

(4) Gear Types and Systems

22.5 Steering gear

(1) Types of Steering gears and Testing of Emergency Steering Gear

(2) Variable pitch propeller

(3) Voith Schneider propellers

22.6 Under water fittings

(1) Rudders, Propellers, Stern Glands, Sea Suctions

22.7 Fuels

(1) Types of Fuel

(2) The storage, transfer, heating, filtration and purification of fuel

(3) Cleaning of tanks and precaution before entering

(4) Source and Treatment of crude oil

- **(a)** Refinery Processes - Breaking Distillation, Atmospheric Pressure Distillation, Vacuum Distillation, cracking of crude oil

(5) Source and treatment of Gas and Gas oil

- **(a)** Important characteristics of Gas and Gas oil for its use in engines
- **(b)** Ignition delay, Cetane no., Detonation and Octane indices
- **(c)** Volatility, Viscosity, Density, Carbon indice, Ash content, Water and sediment, Sulphur Content, Flash point
- **(d)** Additives for Gas and Gas oil

(6) Source and treatment of Bunker Oil

- **(a)** Important characteristics for the use of Bunker Oil in boilers and motors
- **(b)** Viscosity, Density, Flash point, Ash content, Asphalt Content, Sulphur Content, Calorific value, etc.

22.8 Lubricating oils

(1) Lubrication objectives and essential characteristics of lubricating oils - Paraffinic, Naphtenic, Aromatic

(2) Types of Lubrication - Perfect, hydrodynamic and unctuous

(3) Lubricating oil refining - Asphalt and paraffin removal, oil re-distillation, earth filtration

(4) Additives and dopes and their effects

(5) Synthetic oils

(6) Lubricating greases - essential characteristics and uses

(7) Lubricating oil classification and appropriate selection for each type of machinery

(8) Lubricating oil selection for standard journal bearing, roller and ball bearings, steam reciprocating engine, steam turbine, Diesel engine, gas engine, air compressors, steering gears etc

(9) Lubricating oil special analysis - saponification index, anti-emulsion value, carbon residue, etc

(10) On board simple test kits for lubricating oils

(a) Spectrometric analysis of lube oil

(11) Lubricating oils contamination and pollutants

22.9 Experiments on liquid fuels and lubricating oils

(1) Laboratory tests to determine density, viscosity, solidification and melting, flash point, firing point, self ignition point and calorific values etc

(a) Effect of temperature and pressure on viscosity, viscosity index and blending of oils

22.10 Combustion

(1) Fuel composition and chemical reactions due to combustion process

(2) Qualitative and Quantitative analysis of complete combustion

(3) Combustion control - Flame, smoke

(4) Effects of temperature variations in fuel combustion

(5) Measurement and temperature control of exhaust gases

22.11 Pneumatic systems

(1) Compressors, Air receivers, Heat exchangers, Filters, Piping Fittings and Control devices

(2) Precautions and Safe Guard necessary to prevent fires and explosions

22.12 Pollution

(1) A knowledge of pollution prevention procedures, oil-water separators, bilge and ballast water, bunkering operations

22.13 Instruments & control

(Cross reference to Automation, Control and Instrumentation Subject)

(1) The principles, construction, operation of instruments employed for the control and operation of ships' machinery

(2) Bridge control of engines, cargo control, valve positioners

(3) Tank gauges, temperature measuring devices

(4) Fire detection and Carbon Dioxide flooding

22.14 Refrigeration

(Cross Reference to Refrigeration and Air Conditioning Subject)

(1) Construction and operation of refrigeration systems

(2) Types of refrigerants and hazards

(3) Vapour compression systems

(4) Brine, Cold air, Direct expansion cooling

(5) Food storage temperature

22.15 Fire fighting systems

(1) $C0_2$ system

(2) Halon system

(3) Foam generator system

(4) Inert gas system

(5) Steam smothering system

(6) Sprinkler system

22.16 Potable water treatment

(1) Chlorination, Water softener, Ionization

(2) U.V. Sterilizers

22.17 Sewage treatment

(1) Sewage treatment systems

23

Engineering Knowledge - Steam

23.1 Boilers

(1) Boiler types - Fire tube and water tube

(2) Boiler construction

(a) Boiler parts and methods of joining them by riveting, welding, threading, bolting and staying

(3) Boiler insulation - brick work, plastic and refractory

(4) Boiler mountings including water gauges, safety valves

(5) Boiler steam and water regulating devices

(6) Soot blowers

(7) Air pre-heaters types, construction, operation and maintenance

(8) Economisers - types, construction, operation and maintenance

(9) Superheaters - types, construction, operation and maintenance

(10) Operation and maintenance of boilers - standing watch, raising steam, steaming, blow down and shut down and emergency shut down of boilers

(11) Water gauges and testing for accuracy

(12) Water level controls

(13) Priming and foaming of boilers

(14) Combustion controls

(15) Safety precautions in boilers operation

(16) Boiler survey - preparation

(17) Boiler shut down procedures - short period, long period and winter lay up

23.2 Steam plant ancillary equipment

(1) Construction, operation and maintenance of oil fuel systems, air fans/blowers, steam separators and steam traps and injectors

(2) Types of feed water pumps

(3) Feed water heaters and filters

(4) Closed feed and open feed systems

(5) Air ejectors and deaerators

(6) Evaporators and distillers

(7) Chemical treatment system

23.3 Reciprocating engines

(1) Types, construction, operation and maintenance of the different types of engines including uniflow engine

23.4 Turbines

(1) Types, construction, operation and maintenance of turbines

(2) Types, construction, operation and maintenance of gearing, flexible couplings

(3) Construction, operation and maintenance of Turbo-Electric installations

(4) Expansion provisions and measurement of turbine casing, rotor etc

(5) Turbine lubrication system including purification system

(6) Various types of Governors

(7) Safety cut out devices

(8) Safety precautions in operation and maintenance of turbines

23.5 Boiler water chemistry

(1) Boiler water contaminants

(2) Corrosion and deposits in boilers and piping

(3) Types of corrosion and wastage

(4) Electrolytic corrosion, caustic embrittlement, and corrosion due to oxydation

(5) Boiler water treatment - use of phosphates, carbonates, etc.

23.6 Impurities found in water on board ship

(1) Sea water

(2) Distilled water from evaporator

(3) Feed water

(4) Condensate

Engineering Knowledge - Motor

24.1 General

(1) General principles of construction and operation of two-stroke and four-stroke cycle engines

(2) Slow speed, medium speed and high speed diesels

(3) Methods of supercharging, turbo charging and scavenging

(4) Methods of starting and reversing

(5) Transmission systems, couplings, clutches and gearing

(6) Applications of single, multiple and diesel electric installations

(7) Effects of vibrations, TV Dampers

24.2 Lubrication systems

(1) Types and lubricants used

(2) Purifiers, their construction and maintenance

(3) Types of pumps, filters, heat exchangers

24.3 Cooling systems

(1) Air and liquid cooling

(2) Types of pumps, piping and heat exchangers

(3) Temperature Control and Expansion Arrangements

(4) Engine cooling water treatment - corrosion inhibitors, etc

(5) Engine corrosion

24.4 Governors

(1) Construction, operation and maintenance of hydraulic, pneumatic and electronic Governors (Cross Reference to Automation and Control subject)

24.5 Gas turbines

(1) General

(2) Applications

(3) Construction

(4) Operation and Control

(5) Maintenance

24.6 Watch-keeping duties

(1) Tests and precautions pertaining to:

(a) Boilers and related indicators/gauges

(b) Engine room propulsion machinery

(c) All auxiliaries including steering gear and machinery outside the engine-room

(d) Safety shutdowns and isolating devices (dampers, WT doors, remote valves)

(e) Control Station/Room auto/manual operation of machinery

25

Communication Skills

25.1 Objectives

(1) To develop further the communication skills (reading, writing, listening and speaking), especially in the areas of Report Writing, Remedial Grammar and Public Speaking. The use of computer based word processing applications is encouraged.

25.2 Part one - Report writing

Time: 10 Hours **Value: 40%**

(1 hour)	1. Steps in writing a report after choosing the topic (Research, take notes, list of ideas from memory; Related ideas in the list become the sections of the report; Distribute both note and bibliography cards; Recall of all previous ideas covered)
(3 hours)	2. Introduction to Library (Librarian's lecture; choose title and library books; Begin use of card catalogue and begin readings)
(3 hours)	3. Write rough draft with instructor present; Books signed out and officer cadet expected to work on report outside of class hours; Rough draft corrected in complete detail by the instructor
(1 hour)	4. Writing of final draft with instructor present; Pass in rough draft with the final draft
(2 hours)	5. Writing informal reports, short reports, resumes, memoranda, progress reports, inspection reports and investigation reports

25.3 Part two - Grammar review for technical communication

Time: 20 Hours **Value: 20%**

1. Sentences by form; exercise
2. Sentences by structure; exercise
3. Definitions and types of phrases; exercise
4. Definitions and types of clauses; exercise
5. Explanation demonstrating relationships between words, phrases, clauses, sentences, paragraphs and the total report; Conjunctions; The combinations of sentence structures to form good paragraphs; exercises
6. Verb forms and tenses; exercises
7. Pronouns; exercices
8. Punctuation; exercises
9. Spelling; exercises
10. How to write a description; exercise
11. How to write a narration; exercise
12. How to write an exposition; exercise
13. Chronological description of an event; exercise
14. Functional description of an event; exercise
15. Business letter; exercise
16. Personal letter; exercise
17. Letter of Application; exercise
18. Letter of Request; exercise
19. Purchasing letter; exercise
20. Fleet Reports:
    Exercises concerning Boiler Explosions,
    Master's reports, etc., and forms used in the f1eet

25.4 Part three - Public speaking

Time: 20 Hours **Value: 40%**

1. Components of the communication process
2. Identifying effective listening skills
3. Identifying principles of effective delivery
4. Identifying components of the oral report
5. Impromptu talk; exercises
6. Two-minute and five-minute presentations; exercises
7. Demonstration talk; exercise
8. Formal, oral presentation using correct audio-visual aids
9. Conducting a business meeting; exercise
10. Panel discussions and debates: exercises

25.5 Shipboard Radio and Telephone Communications

(1) Internal communication systems

(a) Correct usage of typical internal communication systems used on vessels

(b) Best practices, standard phrases and communication protocols between E/R, Bridge and other departments

(2) Internal and external ship radio communication

(a) Engine Room use of VHF radios and similar communication tools for use during re-fueling and emergency drills etc…

(b) General knowledge of external ship radio communication

(i) VHF

(ii) GMDSS

(iii) Satellite and Cellular phone

25.6 Examination

(1) The course mark is based on marks given for written reports, grammar exercises and oral reports and presentations

25.7 Course texts

(1) Turabian, Kate L. A Manual for Writers of Term Papers, Thesis and Dissertations. Toronto: The University of Toronto Press, 1973.

(2) McGraw-Hill Handbook of English, Second Canadian Edition. 1970.

25.8 Reference text

(1) American Psychological Association, Publication Manual, Second Edition, 1974.

(2) Eriquas "English Drills and Exercises".

26

Sea Training

26.1 General

(1) Sea training and experience at sea, is an integral component of programs that develop a person for a career as a marine engineer. Training programs that attempt to equip a young person for a career at sea, cannot disregard the necessary “On the Job Training” that is a requirement of the *Marine Certification Regulations* and the STCW Convention.

26.2 Requirements

(1) Approval of sea training manual by TC, Marine Safety

(a) The Sea Training Manual or Training Record Book to be used by the engineering cadets while at sea shall be included in the program documentation and is subject to Transport Canada, Marine Safety approval.

(2) Officer of primary interest (OPI)

(a) Colleges or institutions shall have an OPI that is responsible for the sea training portions of the program.

(b) Individual sea training manuals have to be signed off by the OPI as satisfactory before Marine Safety will accept the manual as a part of the mandatory six months of experience.

(3) Integration with classroom portions

(a) Experience at sea shall where practical, be matched to the classroom portions of the program.

(4) Minimum sea service is set by regulation at 6 months.

(a) Applicants for certification as a 4th Class Engineers will be required to show discharge books and testimonials together with a sea training book or training manual that clearly shows that they have 6 months experience in the engine room of a ship.

(b) It is not necessary to have the total period "at sea," however the service has to be on operational vessels that will expose the candidate to a normal range of watchkeeping engineer and engine room duties. Service on laid up vessels will not be accepted, however service on vessels with a few days either loading or unloading or under repair will be accepted as normal vessel operation.

(c) A graduate from an approved program that wishes to be examined for a 4th Class Steam Certificate at the same time as the 4th Class Motor Certificate, will be required to have obtained a minimum of 2 months of service on steam powered vessels. This 2 months service can be within the 6 months mandatory service (i.e. 2 months steam, 4 months motor.)

26.3 Content

(1) The content of the sea training manual or training record book shall conform to the "Model Training Record Book for Candidates as Officers in Charge of an Engineering Watch or Designated Duty Engineers" published by the International Maritime Organization STCW.7/Circ.3, December 1, 1996.