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マレイシア船舶機関士養成計画
エバリュエーション調査報告書

（別冊資料）

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国際協力事業団

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Ⅵ 別 冊 資 料

Ⅵ－1. "Regulations for the Examination of Engineer in the Merchant Navy"

DEPARTMENT OF TRADE

Regulations for the Examination of Engineers in the Merchant Navy

Revised (1958) *Edition*

LONDON

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CHAPTER 1

General

Authority for regulations. These regulations are issued in pursuance of the Merchant Shipping Acts 1894 to 1967. In accordance with section 92 of the Merchant Shipping Act 1894 as amended:

> Every British foreign-going ship* and every British home trade passenger ship, when going to sea from any place in the United Kingdom, every ship registered in the United Kingdom, being a foreign-going ship or a home trade passenger ship, when going to sea from a place outside the United Kingdom, and every foreign steamship carrying passengers between places in the United Kingdom, shall be provided with officers duly certificated under this Act according to the following scale:
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>
> (*d*) If the ship is a foreign-going steamship of one hundred nominal horse-power† or upwards, with at least two engineers, one of whom shall be a first-class and the other a first-class or second-class engineer duly certificated.
>
> (*e*) If the ship is a foreign-going steamship of less than one hundred nominal horse-power, or a sea-going home trade passenger steamship, with at least one engineer who is a first-class or second-class engineer duly certificated.

2. An officer is not deemed duly certificated unless he is the holder for the time being of a valid certificate under the Merchant Shipping Acts of a class appropriate to his station in the ship, or of a higher class. A valid certificate means a certificate of competency granted by the Department of Trade *or* a certificate of competency granted by the Government of a Commonwealth country or British Colony or by the Government of the Irish Republic and declared by Order in Council in pursuance of

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* Section 742 of the Merchant Shipping Act 1894 gives the following definitions:

'Foreign-going ship' includes every ship employed in trading or going between some place or places in the United Kingdom, and some place or places situate beyond the following limits; that is to say, the coasts of the United Kingdom, the Channel Islands, and Isle of Man, and the continent of Europe between the River Elbe and Brest inclusive;

'Home trade ship' includes every ship employed in trading or going within the following limits; that is to say, the United Kingdom, the Channel Islands, and Isle of Man, and the continent of Europe between the River Elbe and Brest inclusive; 'Home trade passenger ship' means every home trade ship employed in carrying passengers.

(The term 'United Kingdom' in the above definitions should be interpreted to include the Irish Republic.)

† The nominal horse-power of a British steamship may be taken from the Certificate of Registry.

section 102 of the Merchant Shipping Act 1894 to have the same force as a certificate of competency granted under the Merchant Shipping Acts, *or* a certificate of service granted by the Department (*see* paragraph 12). A list of authorities entitled to issue certificates of competency declared to have the same force as those granted under the Merchant Shipping Acts is at Appendix F.

3. Section 743 of the Merchant Shipping Act 1894 prescribes that any provisions of the Act applying to steamers or steamships shall apply to ships propelled by electricity or other mechanical power (*e.g.* internal combustion engines), with such modifications as the Department may prescribe for the purpose of adaptation.

4. Section 92 of the Act provides that if any person having been engaged as one of the above-mentioned officers goes to sea as such officer without being duly certificated, or if any person employs a person as an officer, in contravention of that section, without ascertaining that the person so serving is duly certificated, that person shall be liable for each offence to a fine not exceeding fifty pounds.

5. Section 104 of the Act provides that any person who makes, assists in making, or procures to be made any false representation for the purpose of procuring either for himself or for any other person a certificate of competency, shall in respect of each offence be guilty of a misdemeanour, which is punishable, on summary conviction, with imprisonment for a term not exceeding six months, or with a fine not exceeding one hundred pounds.

6. **Examinations.** In section 96 of the Act, provision is made for holding examinations for the grant of certificates of competency; and power is given to the Department to regulate the conduct of the examinations and the qualifications of the applicants.

7. **Aliens.** No alien may be examined for the issue of a certificate of competency as Extra First Class Engineer or First Class Engineer.

CHAPTER 2

Certificates

8. **Classes of certificates.** The term 'certificate' in these Regulations means a certificate as described in paragraph 2 above. The following classes of certificates are granted by the Department.

9. Certificates of competency (First and Second Class) are granted as follows:

(i) Steam Certificates qualifying the holders to serve as engineers in the class certified in steamships.

(ii) Motor Certificates qualifying the holders to serve as engineers in the class certified in motor ships, *i.e.* ships propelled by diesel (internal combustion) engines.

(iii) **Combined Steam and Motor Certificates** qualifying the holders to serve as engineers in the class certified in both steam and motor ships.

10. **Endorsement of certificates.** Holders of First or Second Class Certificates, Steam or Motor, will, after serving the necessary period of qualifying sea time in the other type of ship and passing the endorsement examination in the same class as for the certificate which they hold, be furnished with a combined Steam and Motor Certificate, entitling them to serve in either type of ship. Candidates holding a First Class Certificate who have passed the Second Class examination only for the other type of ship will have their First Class Certificate endorsed accordingly.

11. **Certificates as Extra First Class Engineer.** (*See* paragraphs 50 and 78.) The examination for an Extra First Class Engineer's Certificate of Competency is voluntary and intended for officers who wish to prove their superior qualifications and to have certificates of the highest class granted by the Department. These certificates are qualifications for some governmental and professional appointments.

12. **Certificates of service.** Officers of the Royal Navy who have specialised in marine engineering (ME) may apply to be granted a certificate of service without examination. Officers on the General list who have attained the substantive rank of lieutenant and above who have taken the full marine engineering course at the Royal Navy Engineering College and who have performed not less than twenty-one months qualifying sea service* as Watch-keeping Engineer Officer or Senior Engineer Officer or Engineer Officer since attaining that rank (acting rank, if any, to count) may be granted a certificate of service as First Class Engineer.

Officers on the Special Duties list who have attained the substantive rank of Engineer Sub-lieutenant (ME) or Engineer Lieutenant (ME) and who have performed not less than twenty-one months' qualifying sea service* as Watch-keeping Engineer Officer, Senior Engineer Officer or Engineer Officer since attaining that rank may be granted a certificate of service as Second Class Engineer. Officers who hold additional qualifications will have these taken into account as provided for in paragraph 70 of these Regulations.

Supplementary List Officers will have their applications considered in relation to their training, qualifications and

* Service other than that concerned with ship's main boilers, propelling machinery and auxiliary machinery connected therewith (*e.g.* as flight engineer or on servicing of aircraft) is not accepted.

experience both before and since entering the Royal Navy, provided that they have met the sea service requirement* set out above.

Regarding the eligibility of Royal Navy personnel to sit the examinations for certificates of competency please see paragraph 59 of these Regulations.

Temporary and Reserve Officers are not eligible for the grant of certificates of service.

Engineer Officers of a Commonwealth Navy who have similar qualifications to those of Officers of the Royal Navy, may also apply to be granted certificates of service.

Certificates of service qualify the holders to go to sea, in the classes certified, as engineers of any ships in the British Merchant Navy, however propelled.

Applications for certificates of service should be made on a printed form (Exn. 18) obtainable free of charge from the Registrar General of Shipping and Seamen, Llantrisant Road, Llandaff, Cardiff, CF5 2YS, or from the Superintendent of a Mercantile Marine Office, and forwarded as directed on the back of the form. The fee for a certificate of service is detailed at paragraph 60 (*b*).

CHAPTER 3

Classes of Certificates of Competency

SECOND CLASS CERTIFICATES AND ENDORSEMENTS

13. A candidate for a Second Class Certificate must:

(a) be not less than twenty-two years of age. Candidates may attempt Part A on completion of a satisfactory apprenticeship,

(b) satisfy one or other of the requirements as regards workshop service or other training set out in paragraphs 14 to 18, subject to the provisions as to compensatory sea service set out in paragraph 21, and

(c) have attended a four-day fire-fighting course approved by the Department, and

(d) have performed the requisite sea service set out in paragraph 22. He will be required to pass the examination as set out in paragraph 72.

No workshop training or time devoted to apprenticeship before the age of sixteen years can be accepted.

A candidate for the endorsement of a certificate must have performed the extra sea service set out in paragraph 23 and will be required to pass the examination as set out in paragraph 76.

* Service other than that concerned with ship's main boilers, propelling machinery and auxiliary machinery connected therewith (*e.g.* as flight engineer or on servicing of aircraft) is not accepted.

(A) Workshop Service

14. **Service as apprentice engineer or journeyman.** Except as provided for in paragraphs 15–17, a candidate must have performed satisfactory service for not less than four years as apprentice engineer or journeyman on work suitable for the training of a marine engineer in the manufacture or maintenance of machinery. Not less than nine months of this workshop service required should have been devoted to fitting, erecting or repairing machinery of a suitable size and description (*e.g.* work on marine propelling machinery, substantial auxiliary machinery of a type fitted in ships, or on motive power machinery which has a similar value in the training of marine engineers) either in the works or outside; the remaining period may have been spent on work of this nature or on other suitable work, subject to a time allowance for each type of work, examples of which are specified below:

Metal turning . .	Full time up to a maximum of two years.
Brass finishing . .	Full time up to a maximum of one year.
Boiler making or repairing of boilers .	Full time up to a maximum of one year.
Pattern making . .	Full time up to a maximum of one year.
Planing, slotting, shaping and milling .	Full time up to a maximum of one year.
Tool room . . .	Full time up to a maximum of one year.
Approved schemes of training in the use of hand and small machine tools . .	Full time up to a maximum of one year.
Smith work . . .	Full time up to a maximum of six months.
Coppersmith work .	Full time up to a maximum of six months.
Welding	Full time up to a maximum of six months.
Work in drawing office as draughtsman or engineer engaged on arrangement, detail or design.	Full time up to one year. When more than one year has been spent in the drawing office, only half the additional time will count.
Electrical work of a substantial nature.	Full time up to a maximum of eighteen months.
Instrument and distant control gear fitting.	Full time up to a maximum of six months.

In the case of candidates who have obtained the City and Guilds of London Institute Final Certificate in Machine Shop Engineering; the Mechanical Engineering Technician's Certificate,

Part II Courses No. 255; the City and Guilds of London Institute Second Class Certificate in Mechanical Engineering Craft Studies (Courses No. 205) Part II, or any other similar qualifications approved by the Department, the period of four years will be reduced by six months.

15. **Student or technical apprenticeships.** As an alternative to the requirements in paragraph 14, the Department will consider a candidate who has performed satisfactory service for not less than four years in an organised student or technical apprenticeship accepted by the Department, provided that the candidate has obtained one of the technical qualifications referred to in paragraph 70 by part-time study and, in addition to having received basic craft training, has devoted not less than nine months to fitting, erecting or repairing machinery of a suitable size or description. The Department will be prepared to advise on the acceptability of any such apprenticeship for this purpose.

16. **Full-time technical college or university courses.** As a further alternative, the Department will consider a candidate who has satisfactorily completed a full-time course of study of at least the standard of a Higher National Diploma in Mechanical Engineering approved or recognised under paragraph 70 for a period of not less than three years at a technical college or university. The candidate should have served for not less than twenty-four months in workshops on work suitable for the training of a marine engineer as prescribed in paragraph 14 or otherwise to the satisfaction of the Department. Not less than six consecutive months of this period should have been devoted to fitting, erecting or repairing machinery of a suitable size as required in that paragraph.

Suitable workshop training carried out during technical college or university vacations and periods totalling not more than six months spent in works' apprentice training schemes for fitters and turners or on similar training in technical college or university workshops will be allowed to count towards the required twenty-four months' service up to an overall maximum of nine months. Separate periods of training must be of not less than one month's duration.

17. **Marine engineer cadet training scheme.** The Department has also approved an alternative scheme for training engineer officers, which is accepted in place of the four-year apprenticeship in an industrial workshop. Each candidate accepted for training under this scheme will, depending upon his qualifications at entry, follow one of three possible courses of training and education. One of these courses leads to the City and Guilds of London Institute Marine Engineering Technicians' Certificate (Courses No. 291), one leads to the Ordinary National Diploma in Engineering for marine engineer cadets, and one leads to the Higher National Diploma in Mechanical Engineering (Marine).

The first two of these courses are each of four years' duration and normally consist of twenty-four months at an approved technical college, twelve months at sea as a cadet engineer, and a further twelve months at a technical college having a specially approved Phase III training centre. The Higher National Diploma course is of three and a half years' duration and normally consists of eighteen months at an approved technical college, six months at sea as a cadet engineer, and a further twelve months at an approved technical college. On all three courses practical work is done in addition to academic work during the college terms and is also done during college vacations.

Candidates who satisfactorily complete a course of training approved by another Commonwealth country or the Republic of Ireland, and by the Department, will be accepted for examination. No workshop training or time devoted to apprenticeship before the age of sixteen years can be accepted.

18. Details of this scheme, and a list of shipping companies participating in it, may be obtained from the British Shipping Federation, 146–150 Minories, London, EC3N 1ND.

19. **Testimonials.** All candidates will be required to produce testimonials as to their workshop service. These testimonials must be signed by the employer or his representative and must testify to the candidate's conduct and ability and state the kind of work on which he was engaged and the period of time spent in each branch, *e.g.* fitting, erecting, turning, machine work, etc. Testimonials will be returned to candidates when the examination is completed.

A specimen copy of the form of testimonial recommended is shown in Appendix D. This form of testimonial is not applicable in the case of apprentices trained under one or other of the schemes set out in paragraph 17.

20. **Training outside the United Kingdom.** Courses of study and apprenticeships served in the Commonwealth or in the Republic of Ireland will be considered (*see* also paragraph 70), but time spent in technical training establishments in foreign countries will not be accepted except in special circumstances.

21. **Compensatory service.** Where candidates perform workshop service for the period of time prescribed in one of paragraphs 14, 15 or 16, deficiencies in any of the types of service, which will be assessed in each case by the Department, must be made up by further workshop service of a suitable character or by compensatory service on regular watch or on day work at sea. Time spent, not on articles, whilst standing by a ship undergoing repair or during the construction of a new ship may be accepted at full rate towards workshop service deficiencies up to a maximum period of six months.

Compensatory sea service must be performed either (*a*) on day work as engineer on board foreign-going or home trade steamships of not less than 66 nominal horse-power and/or motor ships of not less than 373 brake horse-power, or (*b*) on regular watch on such ships. Time so spent on foreign-going ships will be accepted as having two-thirds of the value of suitable workshop service and on home trade ships as having four-ninths of that value. No day work at sea performed before the age of twenty will be accepted.

(B) Sea Service

22. Candidates for a Second Class Certificate of Competency must, in addition to the above requirements, have completed the following period of sea service:

(*a*) For a **Steam Certificate, 21 months,** of which at least nine months must have been spent on the boilers and main propelling machinery of a steamship.

This period of at least nine months must have included at least six months' service on the boilers and six months' service on the main propelling machinery, but the service on the boilers and on the main propelling machinery may have been simultaneous.

The remaining twelve months (or balance of twelve months) may have been spent on the boilers of a steamship, *or* on the main propelling machinery of a steam or motor ship, *or* on suitable auxiliaries of a steam or motor ship (*see* paragraph 33), *or* on day work (*see* paragraph 24 (*a*)).

(*b*) For a **Motor Certificate, 21 months,** of which at least six months must have been spent on the main propelling machinery of a motor ship.

The remaining fifteen months (or balance of fifteen months) may have been spent on the main propelling machinery of a steam or motor ship, *or* on suitable auxiliaries of a steam or motor ship (*see* paragraph 33), *or* to the extent of not more than six months on the boilers of a steamship, *or* on day work (*see* paragraph 24 (*a*)).

(*c*) For a combined **Steam and Motor Certificate, 24 months,** of which at least:

(i) nine months must have been spent on the boilers and main propelling machinery of a steamship.

This period must have included at least six months' service on the boilers and six months' service on the main propelling machinery, but the service on the boilers and main propelling machinery may have been simultaneous; and

(ii) six months must have been spent on the main propelling machinery of a motor ship.

The remaining nine months (or balance of nine months) may have been spent on the boilers of a steamship *or* on the main propelling machinery of a steam or motor ship *or* on suitable auxiliaries of a steam or motor ship (*see* paragraph 33), *or* on day work (*see* paragraph 24 (*a*)).

(*d*) Service performed by engineer officers employed in work practices in ships operated on other than the traditional eight hour watch routine may be accepted if the Department is satisfied that such work practices provide a reasonably balanced system of service. Service falling within the scope of this sub-paragraph will be assessed according to the following general principles:

(i) **Watchkeeping service by reference to part-time unattended machinery space operation**

An engineer officer nominated as being in sole charge of the machinery spaces for a twenty-four hour period may assess the time spent on such on-call watchkeeping at one and a half rate, the remainder of the time on articles being daywork allowed towards qualifying sea service as detailed in paragraph 24 (*a*). Qualifying sea service will be that computed in accordance with this paragraph or the time actually spent on articles, whichever is the less.

(ii) **Regular daily six-hour watches coupled with regular daywork**

Where four watchkeeping officers each perform six hours a day for seven days per week on regular watch (forty-two hours) with a total number of working hours per week of fifty-six (the balance of fourteen hours being carried out between Mondays and Fridays inclusive on maintenance and/or other essential work giving approximately a nine-hour working day during the week) such service will be accepted in full as qualifying sea service.

(iii) **Combined certificates**

Eligibility for the examination for a combined certificate will be conditional upon:

(*a*) performance of the service specified in paragraph 22 (*c*)

OR

(*b*) the performance of a minimum calendar period of twenty-four months, which when considered under

the above arrangements gives an assessed time of not less than twenty-four months, providing not less than one-third of the period has been spent on steam ships and not less than one-third of the period has been spent on motor ships

OR

(*c*) a suitable combination of service under (*a*) and (*b*) totalling not less than twenty-four calendar months and giving an assessed time of twenty-four months.

(iv) **Endorsement of a certificate**

Eligibility for the examination for an endorsement of a certificate will be conditional upon:

(*a*) performance of service as specified in paragraph 23

OR

(*b*) the performance of a minimum period of nine months in an operational system wherein the ratio of daywork to the period 'nominated charge of machinery' (sub-paragraph (*d*) (i) above) is not greater than two to one

OR

(*c*) a suitable combination of (*a*) and (*b*) totalling not less than nine months overall service.

23. Candidates for the endorsement of a Second Class *Certificate of Competency must have completed*:

(*a*) for the **Motor Endorsement of a Steam Certificate**, a further period of three months additional to that required for the Certificate held, provided that not less than six months' service in all shall have been service on the main propelling machinery of a motor ship.

(*b*) for the **Steam Endorsement of a Motor Certificate**, a further period of six months additional to that required for the Certificate held, provided that not less than nine months' service in all shall have been service on the boilers and main propelling machinery of a steamship.

This period of at least nine months must have included at least six months' service on the boilers and six months' service on the main propelling machinery, but the service on the boilers and on the main propelling machinery may have been simultaneous.

The Department may issue a temporary permit to enable the holder of either a Steam or Motor Certificate to complete the necessary sea service in a motor ship or steam ship to qualify for examination for the relevant endorsement.

(*c*) the conditions under which service in ships operated on other than the traditional eight-hour watch routine is allowed to count are set out in paragraph 22 (*d*).

24. Service required under paragraphs 22 and 23 must have been performed in foreign-going steamships of not less than 66 nominal horse-power and/or motor ships of not less than 373 brake horse-power, as an engineer at sea on regular watch, *i.e.* on watch for not less than eight out of each twenty-four hours' service claimed, except that:

(*a*) day work, by which is meant engineering work carried out within the engine and boiler spaces of a steam or motor ship at sea, other than that performed on regular watch, will be counted towards the qualifying period of sea service as follows: up to eight months at full rate and any further periods at half rate, the service so calculated is subject to a maximum acceptable limit of twelve months;

(*b*) the conditions under which service performed in ships other than foreign-going ships is allowed to count are set out in paragraphs 34 to 40.

25. [Remission] Candidates who have passed Part A of the examination for a Second Class Certificate or who have obtained a certificate, diploma or degree recognised by the Department as conferring full or partial exemption from Part A of a Second Class Certificate of Competency (*see* paragraphs 69 and 70) may be granted a remission of qualifying sea service not exceeding three months as follows:

(i) those who pass or gain exemption before completing three months' qualifying sea service: three months;

(ii) those who pass or gain exemption before completing nine months' qualifying sea service: two months;

(iii) those who pass or gain exemption before completing fifteen months' qualifying sea service: one month.

FIRST CLASS CERTIFICATES AND ENDORSEMENTS

26. Candidates for a First Class Certificate of Competency must hold a Second Class Certificate, and, whilst holding it, must have completed the same period of sea service as that required in paragraph 22 for the Second Class Certificate for Steam, Motor or Combined, as appropriate.

27. Candidates for the endorsement of a First Class Certificate of Competency must have completed the same period of sea service subsequent to obtaining the Second Class Certificate as that required in paragraph 23 for the endorsement of a Second

Class Certificate for Steam or Motor, as appropriate. Permits for endorsements of certificates may be issued as described in paragraph 23.

28. Service required under paragraphs 26 and 27 must have been performed in foreign-going steamships of not less than 99 nominal horse-power and/or motor ships of not less than 560 brake horse-power as an engineer at sea either:

(i) on regular watch, *i.e.* on watch for not less than eight out of each twenty-four hours' service claimed. This service should have been performed as senior engineer in charge of the entire watch, but service as second in seniority on ships propelled by two or more sets of engines, or in large single-screw ships where there are three or more engineers on regular watch at the same time, will also be accepted at full time value. Service below this rank on such ships will count at half rate

OR

(ii) in work practices in ships operated on other than the traditional eight-hour watch routine falling within the scope of paragraph 22 (*d*).

Daywork will be accepted under the conditions stated in paragraph 24 (*a*).

The conditions under which service performed in ships other than foreign-going is allowed to count are set out in paragraphs 34 to 40.

29. **Remission.** Candidates who pass Part A of the examination for a First Class Certificate or who obtain a certificate, diploma or degree recognised by the Department as conferring full or partial exemption from Part A of the examination for a First Class Certificate of Competency (*see* paragraphs 69 and 70), may be granted a remission on the same scale as that shown in paragraphs 25 (i), (ii) and (iii).

30. A candidate for the endorsement of a First Class Certificate of Competency who fails to pass the examination but shows that he has reached the standard required for a Second Class Certificate may be granted a Second Class Endorsement but no part of the fee will be returned.

GENERAL PROVISIONS AS TO ELIGIBILITY

31. Sea service means service on Articles as engineer in ships with propelling machinery in full use. When part or the whole of the qualifying service has been performed in ships which for considerable periods have not been at sea, a statement or certificate from the owners of the ship must be produced showing

the time in days actually spent at sea. Qualifying sea service may be reckoned as one and a half times the number of days actually spent at sea, but in no case can it exceed the time spent on Articles during the period concerned. If this time amounts to not less than two-thirds of the service required to qualify for the examination, the service will be accepted in full, but where the actual service at sea falls below this proportion, the deficiency must be made up by additional service actually spent at sea.

32. Service in ships cannot be accepted as qualifying where a watch-keeping engineer is, as part of his regular duties, required to do work not usually performed by a watch-keeping engineer in the Merchant Navy.

33. **Service on auxiliary machinery.** Time served on auxiliary machinery run in conjunction with the main propelling machinery and which is essential to the running of the main propelling machinery will, subject to the conditions as regards the minimum service on boilers and main engines, be allowed to count in full towards the qualifying period of sea service. Time served on suitable auxiliaries run independently of the main propelling machinery will be allowed to count at half rate, provided that the minimum service on boilers and main engines has been served.

34. **Home trade ships.** Service in home trade ships* will be allowed to count at two-thirds rate, provided that the class of service and the horse-power of the ship render the service acceptable in all other respects.

35. **Sea service in ships trading entirely abroad.** Service in ships trading entirely abroad will be accepted as equivalent to service in foreign-going ships, provided that the distance between any two adjacent ports visited during the course of the voyage is at least 500 miles. If the distance is less than 500 miles, the service will be accepted as equivalent to service in the home trade, and will only be allowed to count at two-thirds rate.

36. **Lake or river service.** Service as watch-keeping engineer in lake or river vessels will be accepted under the following conditions for a Steam or Motor Certificate, or a combined Steam and Motor Certificate, and will be counted at half rate (*i.e.* two months of lake or river service will be regarded as equivalent to one month's foreign-going sea service) provided that:

(*a*) in the case of a candidate for a Second Class Certificate, the service has been performed in lake or river steam vessels of not less than 66 nominal horse-power and/or motor vessels of not less than 373 brake horse-power, and the candidate has had, in addition to his lake or river service,

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* See definition on page 1.

at least three months' qualifying service* at sea in a foreign-going ship *or* the equivalent service in the home trade; or

(*b*) in the case of a candidate for a First Class Certificate, the service has been performed in lake or river steam vessels of not less than 99 nominal horse-power and/or motor vessels of not less than 560 brake horse-power, and the candidate has had, in addition to his lake or river service, at least six months' qualifying service* at sea in a foreign-going ship *or* the equivalent service in the home trade.

37. **Service in tugs, dredgers, fishing vessels, or pilot vessels.** Service as engineer in sea-going tugs, dredgers or fishing vessels, and in pilot vessels when on their stations or when going to or returning from their stations, will be accepted towards the qualifying period of sea service at half rate.

38. Candidates for Second Class Certificates may perform all their qualifying sea service on regular watch in sea-going tugs, dredgers, fishing vessels or pilot vessels of not less than 66 nominal horse-power, if steam, or 373 brake horse-power, if motor. Candidates for First Class Certificates must, however, in addition to their service in charge of the watch in sea-going tugs, dredgers, fishing vessels or pilot vessels of not less than 99 nominal horse-power, if steam, or 560 brake horse-power, if motor, have served in a qualifying capacity (*see* paragraph 28) for not less than six months in a foreign-going ship *or* have performed equivalent service in the home trade.

39. **Service in yachts.** Service as watch-keeping engineer at sea performed in yachts of the horse-power referred to in paragraphs 24 and 28 will be accepted at two-thirds rate, provided the service satisfies the requirements set out in those paragraphs and the candidate's name is entered on the ship's Articles with his rank shown as engineer.

40. A candidate for a First Class Certificate must, however, in addition to his service in yachts, have had at least three months' service in a qualifying capacity on board a foreign-going passenger or cargo ship, or the equivalent service in the home trade, unless he has served for twenty-seven months as First Engineer or for three years as a Second Engineer in a steam yacht of not less than 99 nominal horse-power and/or a motor yacht of not less than 560 brake horse-power.

41. **Testimonials.** Every candidate must produce testimonials in respect of the qualifying period of his service signed, in each case, by the Chief Engineer under whom his service has been

* The conditions under which sea service must be performed in order to count towards the qualifying periods for Second and First Class Certificates are set out in paragraphs 22 *et seq.*

performed, stating his actual rank on watch, the number of engineers simultaneously on watch on the boilers and/or the main propelling machinery, and the nature of the duties performed by him. When the candidate is a Chief Engineer, he should produce testimonials signed by the Engineer Superintendent, or by the Managing Owner or Secretary of the company. The whole of the candidate's sea service should be covered by testimonials certifying to his sobriety, experience, ability and general good conduct.

42. It is desirable that testimonials signed by Chief Engineers should be endorsed by the Engineer Superintendent or by the Master or other representative of the owner. Testimonials signed only by the company's Superintendent or other officials will not, as a rule, be regarded as sufficient.

43. A specimen copy of the form of testimonial recommended is shown in Appendix D. Testimonials will be returned to candidates when the examination is completed.

44. **Physical defects.** When a candidate is somewhat hard of hearing or suffers from any physical or mental defects of such a nature as might interfere with the proper performance of his duties as an engineer, the signatories of his testimonials should state whether such defect did in fact interfere in any way with the efficient discharge of the candidate's duties.

45. **Verification of sea service.** Service which cannot be verified by proper entries in the Articles of Agreement of the ships in which the candidate has served cannot be counted. In all cases, the candidate's name must have been duly entered on the ship's Articles as engineer in the rank in which he actually served.

46. As discharges and testimonials may have to be forwarded to the Registrar General of Shipping and Seamen for verification, they must be handed in, together with the form of application, not less than one month before the commencement of the week of the examination which the candidate desires to attend. In the absence of the necessary verification, the candidate cannot be examined.

47. Where, as in the case of the service of engineers in foreign ships, the length of service cannot be verified by the Registrar General of Shipping and Seamen, the testimonial of service must be confirmed either by the Consul of the country to which the ship in which the candidate served belonged, or by some other recognised official authority of that country, or by some responsible person having personal knowledge of the facts required to be established. Where the testimonial is not confirmed by a Consul or other official authority of the country referred to, it should be endorsed by a British Consular official.

48. **Calculation of service.** The candidate's service, as shown on his discharges, will be reckoned by the calendar month, *i.e.* the time included between any given day in any month and the preceding day of the following month, both inclusive. The number of complete months from the commencement of the period, ascertained in this way, should be computed, after which the number of odd days should be counted. The day on which the agreement commences, as well as that on which it terminates, should both be included, all leave of absence excluded and all odd days added together and reckoned at 30 to the month.

49. **Penalty for misconduct.** Candidates who have neglected to join their ships after having signed Articles, or who have deserted their ships after having joined, or who have been found guilty of gross misconduct, will be required to produce satisfactory proofs of two years' subsequent service and good conduct at sea before being admitted to any of the Department's engineer examinations, unless the Department, after having investigated the matter, should see fit to reduce the time.

EXTRA FIRST CLASS ENGINEER'S CERTIFICATE

50. A candidate for this certificate must possess a First Class combined Steam and Motor Certificate, or a First Class Engineer's Certificate for the one motive power with a First Class Endorsement for the other, or a First Class Certificate of Service, but is not required to have performed any additional sea service.

STUDIES FOR CERTIFICATES

51. Certain places of higher education provide special intensive courses in the theoretical aspects of marine engineering which are specially designed for candidates who, possessing the necessary workshop and sea experience, wish to consolidate and refresh their knowledge before sitting for either the Second or First Class Certificates of Competency. A list of colleges which at present provide such courses to the satisfaction of the Department is at Appendix E.

52. Candidates are advised to consult the Principals of their local technical colleges or schools, or the Seafarers' Education Service, regarding the choice of text books from which they should study. They should also read technical journals and the *Transactions* of their professional institutions. Marine engineers should also be familiar with the contents of Merchant Shipping Notices issued from time to time by the Department of Trade. The most important of these are:

Notice No. M.407, Arrangements for preventing oil fuel from leaking or draining from machinery spaces into bilges;

Notice No. M.439, Prevention of fire in cargo ships using oil fuel;

Notice No. M.467, Precautions to be taken before entering tanks and enclosed spaces;

Notice No. M.474, Explosions in diesel engined vessels;

Notice No. M.533, Bilge pumping and injection system;

Notice No. M.576, Carriage of dangerous chemicals in bulk;

Notice No. M.603, Use of L.P.G. in domestic installations and appliances on ships.

Copies of these may be obtained free of charge from Mercantile Marine Offices.

Candidates should also study the Department's manual on the avoidance of pollution of the sea by oil (HMSO, 19p, postage extra), and the Engineer Officers' section of the "Code of safe working practices for the safety of merchant seamen" (HMSO, price £2 for complete code).

53. The Department has issued sets of specimen examination papers. These are published in a series entitled *Examinations for certificates of competency in the Merchant Navy. Specimen papers.* Separate sets are available for:

Second class engineer (*price* 23½p)

First class engineer (23½p)

Extra first class engineer (34p)

These are obtainable from HMSO (or through any bookseller).

CHAPTER 4

Admission to Examinations and Award of Certificates

54. **Application for examination.** Candidates who wish to take the examination for a certificate of competency should fill up a form of application (*Exn. 3*) and pay the appropriate fee (*see* paragraph 60 (*a*)) at a Mercantile Marine Office, signing the declaration on the form of application in the presence of the Superintendent. The completed form, together with the candidate's certificate of apprenticeship, testimonials, discharges, certificate of competency or service, if any, etc., must be lodged with the Superintendent at least one month before the commencement of the week during which the examination is to be held.

A candidate may, however, if he prefers, submit his application and papers by post to the Superintendent of the Mercantile Marine Office at the port at which he desires to be examined; he should remit the fee at the same time. Candidates will be informed as soon as possible whether or not their applications have been accepted; if they are accepted, candidates will be supplied with a copy of the rules to be observed during the examination.

55. **Proof of nationality.** Every candidate for a certificate of competency of any grade will be required to produce proof of nationality.

Proof of British nationality will in general involve the production of a birth certificate or of a certificate of naturalisation. Failing this, the applicant should furnish all possible documentary evidence of nationality or of the birth and nationality of his parents. If the applicant is not a British subject, he should produce an official document testifying to his nationality.

56. **Knowledge of English essential.** All candidates must prove to the satisfaction of the Examiner that they can speak, write and understand the English language sufficiently well to perform the duties required of them on board a British vessel.

57. **Age.** Every candidate for a certificate of competency will be required to produce a birth certificate or otherwise as proof of age (in the same manner as required for proof of nationality in paragraph 55).

58. **Penalty for offering gratuity.** If a candidate offers a gratuity to any officer of the Department, he will not be allowed to be examined for twelve months.*

59. **Examination of Royal Navy personnel.** Engineer Officers, Officers of the Engineering Specialisation, Marine Engineering Artificers (Propulsion) and Mechanicians who have served or are serving in the Royal Navy may be examined for certificates of competency on the same conditions as engineers in the Merchant Navy. Applications to be examined should be made in accordance with paragraph 54, except that naval officers should furnish a statement of service (form *DNA 902*) together with testimonials (form *S.450*) in respect of all sea-going appointments and of the last active appointment. Ratings should furnish their Naval Service Certificates.

60. **Fees.**

(*a*) A candidate for examination will be required to pay the following fee on each occasion on which he applies for an

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* This penalty is additional to any penalty to which the candidate may be liable under the criminal law.

examination either for a certificate of competency or for the endorsement of a certificate of competency:

	£ p
SECOND CLASS EXAMINATION (Steam or Motor or combined Steam and Motor)	
(i) upon an application to sit the full examination at one time	9·50
(ii) upon an application either for Part A or Part B or a portion of either Part or for exemption from all of Part A	4·50
(iii) the endorsement (Steam or Motor) examination	4·50
FIRST CLASS EXAMINATION (Steam or Motor or combined Steam and Motor)	
(i) upon an application to sit the full examination at one time	16·50
(ii) upon an application either for Part A or Part B or a portion of either Part or for exemption from all of Part A	8·00
(iii) the endorsement (Steam or Motor) examination	7·00
EXTRA FIRST CLASS EXAMINATION	
(i) upon an application to sit the full examination at one time	19·00
(ii) upon an application either for Part A or Part B	9·50

No part of the fee will be returned to a candidate who takes the examination or any part of it, or is credited with full exemption from Part A.

(*b*) Certificate of service as Second Class Engineer . .	5·00
Certificate of service as First Class Engineer . . .	5·00

61. A person enquiring as to his eligibility for examination will be required to pay the appropriate fee before any step is taken to enquire into his service or to test his qualifications. If a candidate or prospective candidate is found not to be qualified, the fee will either be returned to him or placed to his credit until he is qualified.

62. **Issue of certificate.** When the candidate has successfully completed all parts of his examination, he will receive a form authorising the Superintendent of the Mercantile Marine Office to whom it is addressed to issue the certificate. Certificates of competency, certificates of service, or certificates of competency granted by other governments but declared to have the same force as those granted under the Merchant Shipping Acts, of a lower class, will not be returned to successful candidates. A candidate who has not successfully completed all parts of his examination will receive a record of his examination results on

form *Exn. 45.* This form must be produced to the Examiner when a candidate next presents himself for examination.

63. **Service found to be insufficient.** If, after a candidate has passed the examination, it is discovered on further investigation that his service is insufficient to entitle him to receive a certificate, the certificate will not be granted until the candidate has performed the amount of service in which he was deficient, and has been re-examined, unless the Department sees fit to dispense with the re-examination.

64. **Copy of lost certificate.** An applicant for a certified copy of a lost certificate, either of competency or service, should fill in a form of application (*Exn. 23*), giving the necessary particulars, and hand it to a Superintendent of a Mercantile Marine Office, paying at the same time the appropriate fee. A declaration as to the circumstances in which the certificate was lost must be made by the applicant before the Superintendent. No fee is chargeable if the applicant can prove that the certificate was lost through shipwreck or fire.

65. **Re-examination.** A candidate who fails in any part of the examination may present himself for re-examination at any subsequent examination.

66. **Penalties for failure in examinations or breach of examination rules.** It is evident that ignorance of those subjects which form a vital part of a marine engineer's daily work, such as the manipulation and reading of the water-gauge, the danger of fire and explosion in steam and motor vessels, can easily cause acts or omissions which would seriously endanger a ship. In particular, candidates should be very familiar with the water-gauge (*see* Appendix G). A failure in one of these subjects, either in the Engineering Knowledge paper or the oral test in Part B of the examination, will be regarded as failure in practical knowledge, and any candidate so failing will not be allowed to present himself for re-examination until he can produce proof of further service at sea in a qualifying capacity. The period of the further service which will be required will be assessed in each individual case by the Department, but will not exceed six months.

Should a candidate fail through ignorance of fundamental principles, or on account of general defectiveness in the examination, he will not be allowed to present himself for re-examination until a period of time to be fixed by the Department has elapsed. Such period will not usually exceed three months, but in the case of a subsequent failure on account of general defectiveness, the penalty may, in exceptional circumstances, be increased to a maximum of six months.

67. Breach of examination rules may incur a penalty.

CHAPTER 5

Examinations and Exemptions

68. **Place and day of examination.** The Department have examination centres at the ports of Aberdeen, Belfast, Cardiff, Glasgow, Hull, Leith, Liverpool, London, Newcastle upon Tyne and Southampton. The addresses of the examination centres are given in Appendix A1. The dates upon which the respective examinations will be held are available from the Examination Centres given in Appendix A1 or from the Mercantile Marine Offices given in Appendix H.

The time tables of the different examinations are given in Appendix A2.

The examination for Extra First Class Certificates will commence on the third Monday in January and July of each year.

69. **Exemptions.** Candidates who have attended approved courses of instruction during their apprenticeship and have obtained certificates showing that they have passed the appropriate examination at the termination of the course to the standard required by the Department will be granted exemption from the whole or part of Part A on completion of apprenticeship and as shown in paragraphs 73 and 75.

70. Approved courses. The Department have approved certain courses of instruction as follows:

(*a*) courses recognised by the Joint Committee of the Institution of Mechanical Engineers and the Education Departments of the United Kingdom as leading to the Higher National Diploma or Higher National Certificate in Mechanical Engineering in the United Kingdom for the purposes of examinations for both the First and Second Class Certificates of Competency;

(*b*) the course leading to the Special Technological Certificate of the Republic of Ireland Department of Education and the courses specified in paragraph 17 of these Regulations;

(*c*) courses in the United Kingdom leading to the Ordinary National Diploma in Engineering* and to the Ordinary

* Formerly the Ordinary National Diploma in Mechanical Engineering.

National Certificate in Engineering for the purposes of the examinations for the Second Class Certificate of Competency only;

(*d*) special courses leading to an Ordinary National Diploma in Engineering* together with supplementary certificates covering studies of an advanced nature which form part of the Department's scheme specified in paragraph 17 for the purposes of the examination for the Second and First Class Certificates of Competency. Courses leading to the City and Guilds of London Institute Marine Engineering Technicians and Advanced Technicians Certificates (Courses No. 291) which form part of the Department's scheme specified in paragraph 17 for the purposes of the examination for the Second Class Certificate only;

(*e*) the Department will also recognise university degrees and university college diplomas in engineering awarded in England and Wales, Scotland and Northern Ireland, provided that candidates who submit such degrees or diplomas produce evidence that the course of study has satisfied the Department as to its suitability. Candidates will similarly be allowed either complete or partial exemption from Part A of the Department's examinations for the First and Second Class Certificates of Competency if they satisfy the Department that they have obtained suitable degrees or similar qualifications in appropriate subjects at a university or place of higher education within the Commonwealth.

71. (*a*) Candidates, for either the Second or First Class Certificates of Competency, who have satisfactorily completed the Ordinary National Diploma marine engineer cadet training scheme described in paragraph 17 of these Regulations, have passed the subject *Electrical Engineering* in the Diploma examination and have, after the completion of twelve months' sea service required in the second phase of that scheme, to the satisfaction of the Department attended part-time instruction during their workshop service and obtained the group endorsement in Naval Architecture, Electrotechnology and Power Plant Operation and Management may be exempted from Section I of Part B of the examination.

(*b*) A candidate who passes the Marine Technicians Advanced Certificate examination may be exempted from Section 1 of Part B of the Second Class Certificate examination if he passes both of the subjects Naval Architecture and Electrotechnology.

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* Formerly the Ordinary National Diploma in Mechanical Engineering.

72. **Examination for Second Class Certificate.** The syllabuses for this examination are given in Appendix B. The examination is divided into two Parts as follows:

PART A

(i) Applied Mechanics (one paper of three hours)
(ii) Heat and Heat Engines (one paper of three hours)
(iii) Mathematics (one paper of three hours)
(iv) Drawing (one paper of six hours)

PART B

(i) (*a*) Electrotechnology (one paper of three hours)
(*b*) Naval Architecture (one paper of three hours)
(ii) (*a*) Engineering Knowledge (two papers, each of three hours*)
(*b*) Oral.

73. *Candidates may be exempted from Part A or some portion* of it and may take the examination in separate parts as follows:

(*a*) A candidate who has attended an approved course of instruction (*see* paragraphs 69 and 70) covering not less than two of four subjects included in Part A and has obtained the terminal certificate stating that he passed the appropriate examination at the termination of the course, will be granted exemption from the subjects in Part A covered by the certificate. (*See* paragraphs 73 (*b*), (*c*), (*d*) for exemptions granted to holders of certificates or diplomas under the scheme specified in paragraph 17.)

(*b*) A candidate who obtains a Higher National Diploma in Mechanical Engineering (Marine) under the scheme specified in paragraph 17 will be granted exemptions from Part A on a subject for subject basis.

(*c*) A candidate who obtains an Ordinary National Diploma in Engineering under the scheme specified in paragraph 17 will be granted exemption from the whole of Part A provided he obtains not less than 40 per cent of the marks in each of the papers in Applied Heat, Mechanics, Mathematics and Engineering Drawing in the final examination for the Diploma. A candidate who fails to obtain 40 per cent of the marks in one of these papers will be required to sit the corresponding paper in the Part A examination but will be granted exemption from the remaining subjects in Part A.

(*d*) A candidate trained under the City and Guilds of London Institute scheme specified in paragraph 17 who passes the Marine Technicians' Certificate examination at a standard satisfactory to the Department will be afforded exemption

* In the examination for a combined Steam and Motor Certificate, a third three-hour paper in Engineering Knowledge is set.

from the subjects Mathematics and Engineering Drawing in Part A.

A candidate who passes the Marine Technicians' Advanced Certificate examination at a standard satisfactory to the Department may be exempted from Part A on a subject for subject basis.

(*e*) A candidate may present himself either for the whole of Part A of the examination, or, if exempted under (*a*), (*b*), (*c*) or (*d*) above from certain subjects of the examination, for the remaining subject or subjects at any time after he has completed the necessary workshop service required by paragraph 14, or, in the case of candidates trained under the scheme specified in paragraph 17, as soon as he has completed his cadetship.

(*f*) A candidate who has not been exempted under (*a*), (*b*) or (*c*) above from Part A or a part of it, and who, when taking Part A of the examination, passes in one subject only, must sit for the whole Part on re-examination. If he passes in two or three subjects, he will not be required to take those subjects again and may present himself for re-examination in the remaining subject or subjects.

(*g*) A candidate may take Part B or that part of it from which he is not exempted at any time after he has completed the necessary periods of qualifying workshop and sea service, provided he also takes at the same time the whole of Part A of the examination or such subjects, if any, in that Part, in which he has not already passed or from which he has not been exempted under (*a*), (*b*) or (*c*) above.

(*h*) A candidate will not be given a pass in Part B or in either Section of Part B unless he completes Part A at the same time as Part B or has previously completed it or has been exempted from it.

(*i*) A candidate who when taking Part B passes in Section (i) (Electrotechnology and Naval Architecture), but fails in Section (ii) (Engineering Knowledge and Oral), will be given a pass in Section (i) and may sit for re-examination in Section (ii).

(*j*) A candidate who when taking Part B passes in Section (ii), but fails in Section (i), will be given a pass in Section (ii) and may sit for re-examination in Section (i).

74. **Examination for First Class Certificate.** The syllabuses for this examination are given in Appendix B. The examination is divided into two Parts as follows:

PART A

(i) Applied Mechanics (one paper of three hours)
(ii) Heat and Heat Engines (one paper of three hours).

PART B

(i) (*a*) Electrotechnology (one paper of three hours)

(*b*) Naval Architecture (one paper of three hours)

(ii) (*a*) Engineering Knowledge (two papers, each of three hours*)

(*b*) Oral.

75. Candidates may be exempted from Part A or a part of it and may take the examination in separate parts as follows:

(*a*) A candidate who holds a certificate, degree or diploma approved by the Department as stated in paragraph 70 of these Regulations for the purposes of the First Class Certificate of Competency will be exempted from this examination on a subject for subject basis.

A candidate holding an Ordinary National Diploma, trained under the scheme specified in paragraph 17, who passes the supplementary examination in Mechanical Technology (Applied Mechanics and Heat Engines) at a standard satisfactory to the Department may be exempted from any subject of Part A provided he has passed the corresponding subject at the Diploma level.

(*b*) A candidate possessing a Second Class Certificate is allowed to take either the whole of Part A or, if exempted under (*a*) above from one subject, the remaining subject.

(*c*) A candidate who has not been exempted under (*a*) above from Part A or part of it and who, when taking Part A, passes in one subject only, will not be required to take that subject again and may sit for the remaining subject.

(*d*) A candidate may take Part B or that part of it from which he has not already been exempted at any time provided he holds a Second Class Certificate and has completed the necessary period of qualifying sea service, and provided also that he takes at the same time either the whole of Part A of the examination or such subject, if any, in that Part, in which he has not already passed or from which he has not been exempted under (*a*) above.

(*e*) A candidate will not be given a pass in Part B or in either Section of Part B unless he completes Part A at the same time as Part B or has previously completed it or has been exempted from it.

(*f*) A candidate who when taking Part B passes in Section (i) (Electrotechnology and Naval Architecture), but fails in

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* In the examination for a combined Steam and Motor Certificate a third three-hour paper in Engineering Knowledge is set.

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Section (ii) (Engineering Knowledge and Oral) will be given a pass in Section (i) and may sit for re-examination in Section (ii).

(g) A candidate who when taking Part B passes in Section (ii), but fails in Section (i), will be given a pass in Section (ii) and may sit for re-examination in Section (i).

76. Examination for endorsement of Second and First Class Certificates. The examination consists of:

(a) One written paper of three hours in Engineering Knowledge,
(b) Oral.

The syllabuses for these examinations are given in the sections of Appendix B relating to these subjects.

77. **Marks required for pass.** Candidates will be expected to obtain a minimum number of marks in each subject in the written examinations and not less than one-half of the total number of marks to secure a pass. In the oral examination a somewhat higher standard will be required. The result of the examination will be communicated to the candidate by the Examiner.

78. **Examination for Extra First Class Certificate.** This examination covers the syllabuses for the First Class and Second Class examinations, and also that given in Appendix C. This examination is divided into two separate parts, A and B. No exemption from any of the subjects covered by the examination is granted.

Candidates will be permitted either to take the whole of the examination at one time, or to take the two Parts at separate examinations, in which case a candidate must first pass in Part A to qualify for entrance to Part B. On the other hand, a candidate who chooses to take the whole examination at one time and passes only in Part B will be eligible to sit for Part A at any future examination and will be exempt from further examination in Part B. No certificate will be issued until the candidate has passed both Parts of the examination.

APPENDIX A 1

Examination Centres for Engineers

		Telephone
Aberdeen	41½ Union Street Aberdeen AB1 2BN	0224–51341
Belfast	Custom House Belfast BT1 3ET	0232–34466
Cardiff	3 Bute Place Cardiff CF1 6ND	0222–29556
Glasgow	15 Muir House Street Glasgow S1	041–423 6677
Hull	Victoria Chambers Trinity House Yard Princes Dock Street Hull HU1 2LN	0482–223066
Leith	1 John's Place Leith Edinburgh 6	031–554 5488/9
Liverpool	Graeme House Derby Square Liverpool L2 7SQ	051–236 6901
London	Dock Street London E1 8LJ	01–480 6501
Newcastle	Government Buildings Broadway West, Gosforth Newcastle upon Tyne NE3 2JL	0632–85717
Southampton	South Western House Canute Road Southampton SO9 1NP	0703–23061 0703–20917

APPENDIX A 2

Timetables of Examinations

SECOND CLASS

Day	Part of examination	Morning session	Afternoon session
Monday	B	Engineering Knowledge (One paper—3 hours) NOTE: *Candidates for Endorsement do not take this paper.*	Engineering Knowledge (One paper—3 hours) NOTE: *Separate papers are set for Steam and Motor candidates.*
Tuesday	B	Electrotechnology (One paper—3 hours)	Naval Architecture (One paper—3 hours)
Wednesday	A	Applied Mechanics (One paper—3 hours)	Heat and Heat Engines (One paper—3 hours)
Thursday	A and B	A Mathematics (One paper—3 hours)	B Engineering Knowledge (One paper—3 hours) NOTE: *To be taken by candidates for combined Steam and Motor certificates only.*
Friday	A	Engineering Drawing (One paper—6 hours) NOTE: *An interval of half an hour may be allowed.*	

NOTE: *The oral examination will be taken on completion of the written papers at a time fixed by the Examiner.*

FIRST CLASS

Day	Part of examination	Morning session	Afternoon session
Monday	B	Engineering Knowledge (One paper—3 hours) NOTE: *Candidates for Endorsement do not take this paper.*	Engineering Knowledge (One paper—3 hours) NOTE: *Separate papers are set for Steam and Motor candidates.*
Tuesday	B	Electrotechnology (One paper—3 hours)	Naval Architecture (One paper—3 hours)
Wednesday	A	Applied Mechanics (One paper—3 hours)	Heat and Heat Engines (One paper—3 hours)
Thursday	B	Engineering Knowledge (One paper—3 hours) NOTE: *To be taken by candidates for combined Steam and Motor certificates only.*	

NOTE: *The oral examination will be taken on completion of the written papers at a time fixed by the examiner.*

Appendix A 2

EXTRA FIRST CLASS

First Week

Day	Part of examination	Morning session	Afternoon session
Monday	A		Marine Heat Engines (One paper—3 hours)
Tuesday	A	Applied Thermodynamics (One paper—3 hours)	
Wednesday	A	Strength and Properties of Materials (One paper—3 hours)	
Thursday	A		Theory of Machines (Mechanics of Fluids) (One paper—3 hours)

Second Week

Monday	B	Engineering Knowledge (One paper—3 hours)	
Tuesday	B	Essay (One paper—3 hours)	
Wednesday	B	Electrotechnology (One paper—3 hours)	
	B		Naval Architecture (One paper—3 hours)
Thursday	B	Machine Design (Drawing) (One paper—6 hours) NOTE: *An interval of half an hour may be allowed.*	

APPENDIX B

Syllabuses for the First and Second Class Examinations

Fundamental Knowledge Subjects. Part A

NOTES:

1. The problems will require a knowledge of the SI system.

2. The problems at Second Class level will be such as can be solved by the knowledge of elementary algebra, geometry, and plane trigonometry.

3. Formulae that require for their development the use of mathematics beyond the syllabus and constants will be given.

4. Graphical solutions will be acceptable where the analytical solution is not expressly stated to be required.

5. Candidates may, if they wish, use slide rules for their calculations, but in each case a full statement of the steps leading to the calculations must be shown.

SECOND CLASS MATHEMATICS

(One paper of three hours. Six questions only out of nine to be attempted.)

Arithmetic. Ratio and proportion. Percentages. Variation, direct and inverse.

Algebra. Indices, including fractional and negative types. Use of common logarithms for multiplication, division, powers and roots. Use of Naperian logarithms. Simplification of algebraic expressions. Addition, subtraction, multiplication and division of algebraic functions. Re-arrangement of formulae. Factorisation. Algebraic fractions. Squares and cubes of polynomials such as $(a \pm b)^2$ and $(a \pm b)^3$. Simple equations. Quadratic equations and solution by factorisation or by completing the square, proof of general formula for solution. Simultaneous equations.

Graphical work. Simple graphs of statistics. The graph $y = ax + b$ either from calculated values or from experimental results. Calculation of constants from graphs. Graphical solution of simple simultaneous equations involving two unknowns. Graph of $y = ax^2 + bx + c$ and graphical solution of equation $ax^2 + bx + c = 0$.

Trigonometry. Measurement of angles in degrees and radians. Complementary and supplementary angles. Sine, cosine and tangent of angles up to 360°. Proof of sine and cosine rules. Solution of triangles. Solution of simple trigonometric equations. Expansion of $\sin (A \pm B)$ and $\cos (A \pm B)$.

Geometry. Properties of triangles. Sum of the angles. Relation between exterior and interior angles. Isosceles and equilateral triangles. Similar and congruent triangles.

The circle. Properties of chords and tangents. Angles in the same segment. Angles at centre and circumference.

Mensuration. Areas of triangle, polygon, parallelogram, trapezium, circle, sector and segment of a circle and ellipse. Areas of oblique sections of regular solids of uniform cross-section. Area and mean height by mid-ordinate rule and by Simpson's rules. Ratio of areas of similar figures. Volumes and surface areas of prisms, pyramids, frustums, spheres, cylinders and cones. Ratio of masses, weights and volumes of similar solids. Solids of revolution.

Appendix B

SECOND CLASS APPLIED MECHANICS

(One paper of three hours. Six questions only out of nine to be attempted.)

Statics. Force as a vector. Triangle and polygon of forces. Resultant and equilibrant of a system of concurrent coplanar forces. Equilibrium of three coplanar forces. Moment of a force. Couples. Moments of areas and volumes. Centroids and centres of gravity (limited to geometrical shapes). Conditions of equilibrium of solids. Necessary force applied parallel to an inclined plane to pull body up or down the plane or to hold it stationary (including effect of friction). Work done at uniform speed up the plane.

Friction. Laws of friction for dry surfaces. Coefficient of friction. Friction angle. Energy and power lost due to friction in simple bearings.

Kinematics. Linear motion. Graphs and equations for displacement, speed, velocity and uniform acceleration. Simple cases of vector change of velocity and the acceleration produced. Relative velocities in one plane only. Angular motion. Equations for displacement, velocity and uniform acceleration.

Dynamics. Work and power. Problems with constant force or force with linear variation. Energy. Conservation of energy. Potential energy. Kinetic energy of translation. Newton's laws of motion. Momentum and rate of change of momentum. Centrifugal force and its application to conical pendulum, unloaded governor, curved tracks and machine parts. Stress in thin rim due to centrifugal action.

Machines. Simple lifting machine. Graphs of load-effort and load-efficiency. Linear law. Velocity ratio, mechanical advantage and efficiency of the following machines:—wheel and axle, differential wheel and axle, rope pulley blocks, differential pulley blocks, screw jack, Warwick screw, hydraulic jack, worm-driven chain blocks and single and double purchase crab winches. Reduction gearing.

Stress and strain. Direct stress and strain. Shear stress. Hooke's law. Modulus of elasticity. Ultimate tensile stress. Yield stress. Limit of proportionality. Percentage elongation and reduction of area. Working stress. Factor of safety. Stress due to restricted expansion or contraction of single members.

Beams. Cantilevers and simply supported beams with concentrated or uniformly distributed loads. Shearing force and bending moment diagrams. Stress due to bending.

Torsion. Twisting moment due to engine crank mechanism. Strength and stiffness of solid or hollow shafts of circular cross-section. Stress due to torsion. Power transmitted by shafts. Coupling bolts.

Thin shells. Circumferential and longitudinal stress in thin cylindrical and spherical shells subject to internal pressure.

Hydrostatics. Equilibrium of floating bodies. Variation of fluid pressure with depth. Level control. Total force due to liquid pressure on immersed plane surfaces horizontal or vertical. Centre of pressure on a rectangular vertical plane surface or triangular plane surface, both with one edge parallel to the surface of the liquid.

Hydraulics. Full bore flow of liquid through pipes under constant head. Flow through orifice. Coefficients of velocity, contraction of area and discharge.

FIRST CLASS APPLIED MECHANICS

(One paper of three hours. Six questions only out of nine to be attempted.)

Statics. Laws of equilibrium. Moments and couples. Polygon of forces. Rapson's slide.

Friction. Law of dry friction. Friction angle. Friction clutches. Friction on inclined plane. Friction on threads. Work done against friction.

Kinematics. Linear and angular motion with acceleration. Cams. Velocity-time and acceleration-time graphs.

Relative velocity and acceleration. Relative motion between bodies moving in different planes.

Dynamics. Newton's laws of motion. The force equation. Atwood's machine. Acceleration of connected bodies. Effect of simple air resistance on motion under the effect of gravity. The torque equation. Conservation of momentum. Kinetic energy of translation and of rotation. Flywheels. Potential energy. Conservation of energy. Impulsive forces. Centrifugal force. Governors including sleeve friction. Simple harmonic motion. Simple pendulum. Simple vibrations. Dynamic balancing of masses rotating in one plane. Basic dynamics of the engine mechanism. Use of piston velocity and acceleration formulae. Derivation of piston displacement formula.

Stress and strain. Direct stress and strain and modulus of elasticity. Shear stress and strain and modulus of rigidity. Stresses on oblique planes. Strength of simple connections such as cottered or screwed joints. Resilience due to direct stress. Suddenly applied loads.

Compound bars. Effect of direct loading and of temperature changes.

Beams. SF and BM diagrams for cantilevers and simply supported beams. Stresses in beams of simple section. Use of deflection formulae.

Torsion. Torsion equations for solid and hollow round shafts. Torsion of shaft fitted with liner. Power transmitted. Close coiled helical spring.

Struts. Eccentric loading of short columns. Use of strut formulae.

Hydrostatics. Flotation in two liquids of different densities. Total force and centre of pressure on immersed surfaces such as tanks and bulkheads.

Hydraulics. Bernoulli's equation and applications. Venturi meter. Flow through orifices under constant head. Force exerted by a jet. Blade angle diagrams for a centrifugal pump.

Control. Simple flow and control problems.

SECOND CLASS HEAT AND HEAT ENGINES

(One paper of three hours. Six questions only out of nine to be attempted.)

Basic thermodynamic principles. Properties, energy, the First Law of Thermodynamics, flow and non-flow processes.

Elements. Temperature and its measurement. Linear, superficial and volumetric expansion due to temperature changes. Coefficients and the relationship between them. Specific heat.

Heat transfer. Qualitative treatment of heat transfer by conduction, convection and radiation. Laws of conduction and thermal conductance and applications to problems.

Mixtures. Heat and temperature problems involving change of phase and not more than three substances.

Gases. Boyle's and Charles' laws for perfect gases. Absolute temperature. Characteristic equation. Constant R and its use in simple problems. Isothermal and adiabatic expansion and compression. Relation between P, V and T when pV^n = constant. Specific heats c_p and c_v and the relationship between them.

Air compressors. Elementary principles and cycles of operation. Calculation of work done. Indicator diagrams.

I.C. engines. Elementary principles and cycles of operation. Actual indicator diagrams. Work done and power developed. Fuel consumption.

Properties of steam. Change of enthalpy with and without change of phase. Specific volume of steam under various conditions. Throttling. Separating and throttling calorimeters. Boiler efficiency. Use of steam tables in problems referring to steam plant. Effect of air leakage into condensers.

Reciprocating steam auxiliary machinery. Mean effective pressure and work done. Advantages of using steam expansively. Steam consumption per hour and per power-hour. Thermal, mechanical and overall efficiencies of engines.

Boilers and engines. Boiler efficiency. Heat balance for engine and boiler trials.

Steam turbine. Elementary principles. Simple velocity diagrams. Thermal mechanical and overall efficiency. Steam consumption per hour and output.

Combustion. Solid and liquid fuels. Higher calorific value. Chemical equations for complete combustion. Theoretical minimum air required. Excess air.

Refrigeration. Vapour-compression cycle. Refrigerating effect. Cooling load. Use of tables of properties of refrigerants.

Boilers and evaporators. Change in dissolved solids due to contaminated feed. Blowing down.

FIRST CLASS HEAT AND HEAT ENGINES

(One paper of three hours. Six questions only out of nine to be attempted.)

Elements. First and second laws of thermodynamics and applications. Work done associated with the formula $pV^n = C$.

Heat transfer. Conduction and thermal conductance (excluding log mean temperature difference). Radiation.

Properties of steam. Calculation of change of enthalpy, internal energy and entropy with and without change of phase. Use of steam tables and entropy. Throttling and separating calorimeter.

Mixtures of gases and vapours. Applications of Dalton's law of partial pressure.

Gases. Boyle's law. Charles' law. Characteristic equation. Relations between p, V and T when $pV^n = C$. Determination of n from graph connecting p and V. Proof of the formula $c_p - c_v = \frac{R}{J}$. Calculations for expansions and compressions on air compressors, internal combustion engines, air pumps and air storage.

Gas cycles. Use of entropy charts. Constant volume cycle. Diesel cycle. Dual cycle. Open and closed cycles for gas turbines. Indicated and brake thermal efficiencies. Mechanical efficiency. Overall efficiency.

Expansion of steam. Throttling, expansion, work done and heat transfer.

Steam cycle. Use of entropy charts. Isentropic efficiency. Basic Rankine cycle. Heat drop in turbines. Effect on thermal efficiency of such modifications as superheating, reheating and regenerative feed heating.

Boilers and evaporators. Basic calculations on the effect of condenser leakage and impure feed on the dissolved solids and scale in boilers. Basic calculations on evaporator and boiler performance.

Turbines. Basic cycle and its modifications. Flow through nozzles (excluding proof of critical pressure ratio). Blade diagrams for impulse and reaction turbines. Force on blades. Work done on blades. Use of enthalpy-entropy charts to determine steam condition at various stages.

Combustion. Combustion equations. Calculation of theoretical air required. Determination of calorific value. Avogadro's hypothesis. Basic analysis of exhaust gases. Relation between volumetric and mass analysis of a gas mixture. CO_2 content of exhaust gases.

Refrigeration. Reversed Carnot cycle. Vapour compression cycle. Use of vapour tables. Coefficient of performance.

DRAWING

(This subject is to be taken by candidates for Second Class Certificates only.)

(One paper of six hours. A choice of two drawings will be given.)

The Drawing paper will consist of a test of the ability to apply the principles of projection and candidates will be asked to draw a plan, elevation or section or a combination of these views of a piece of marine machinery from information supplied. All the required information for the completion of the drawing will be given in the question paper.

Practical Knowledge Subjects. Part B

N.B. The notes under 'Fundamental Knowledge Subjects', Part A, apply equally to Part B.

Appendix B

SECOND CLASS ELECTROTECHNOLOGY

(One paper of three hours. Six questions only to be attempted.)

General. Effects of electric current—chemical, magnetic, thermal. Production of light. Electric shock. Production of e.m.f. by chemical, magnetic, thermal and light means. Electrical safety.

The electric circuit. Units—ampere, ohm and volt. Ohm's law. Series and parallel circuits of sources of e.m.f. and of resistances. Current distribution in simple circuits. Non linear resistors in parallel with constant value resistors. Difference between e.m.f. and p.d. Power and energy. Relationships between heating, mechanical and electrical units. Conductor resistance, effect of length, area, material and temperature. Specific resistance. Temperature coefficient of resistance. Types of insulation. Wheatstone network bridge, slide wire bridge. Applications to steering gears, resistance pyrometers, strain gauges, etc.

Electrolytic action. Theory of electrolytic dissociation applied to common solutions, etc., acidulated water, copper sulphate and salt water. Uses of electrolysis. Faraday's laws. Electro-chemical equivalent.

Cells. Primary (wet or dry Leclanché) and secondary (acid or alkaline) types. Construction and principles. Maintenance, charging. Watt-hour and ampere-hour efficiencies.

Magnetism and electromagnetism. Simple magnetic theory. Magnetic field. Lines of force. Field strength. Field intensity. Magnetic fields due to current in straight conductors, loops, coils and solenoids. Relative directions of current and field. Effect of iron. Flux density. Total flux. Reluctance. Permeability. Typical B/H and μ/B curves.

Electro-magnetic induction. Faraday's and Lenz's laws. Magnitude and direction of induced e.m.f. Force produced on a current carrying conductor.

Electronics. Knowledge of terms used in electronic circuits. Thermionic emission. Conduction in vacuum, gases, insulators, semi-conductors and conductors. Rectification.

Alternating current theory. The sinusoidal wave, frequency, maximum, r.m.s. and average values. Phasor representation of a.c. quantities. Phase difference. The a.c. circuit. The inductor. Inductance and its effect on the circuit. The capacitor. Capacitance and its effect on the circuit. The general series circuit. Relationship between resistance, reactance and impedance. Simple treatment of power factor.

Instruments. Principles and function of a.c. and d.c. switchboard indicating instruments. Moving-coil, moving iron and dynamometer types. Uses of shunts and series resistances to increase the range. The current transformer and potential transformer for instrument work (description and simple explanation). Rectifiers and transducers.

Testing methods and measurements. Resistance measured by ammeter-voltmeter, by bridge and by instrument. Simple ohmmeter and insulation testing. General insulation, continuity and millivolt-drop testing. Fault tracing. Temperature measurement by resistance and thermo-electric effects.

Circuits. Distribution systems for a.c. and d.c. installations. Use of fuses and circuit-breakers. Use of earth lamps.

Electrical machines. Construction, general and details. Maintenance and protection. *D.c.* machines—field circuits (separate, shunt, series and compound). Commutating poles. Commutation. Simple approach to lap and wave windings.

A.C. generators. Protection. Simple explanation of the alternator as a generating unit. Parallel running and synchronising procedure.

D.C. generators. Protection. E.m.f. and load voltage equation. Brief treatment of theory of self-excitation. Load characteristics. Methods of voltage control. Parallel operation procedure.

D.C. motors. Need for starters. Types of starter. Speed and torque equations. Load characteristics. Speed control.

FIRST CLASS ELECTROTECHNOLOGY

(*One paper of three hours. Six questions only to be attempted.*)

The magnetic circuit. *B-H* and *B*-At/m curves. Their effect on the design of simple magnetic circuits involving an air gap. Hysteresis.

Electromagnetism and electrostatics. Mutual inductance. Energy stored in an electric field and in a capacitor. Generation of static electricity. Descriptive treatment of voltage and current changes in an electric circuit involving inductance, capacitance and resistance. Time constants.

The electric circuit. Kirchoff's laws. Network problems. Circuits involving non-linear elements.

A.C. circuit. Phasor representation of alternating quantities. Resistance, inductance and impedance. Current and voltage relationships. Power, apparent power (VA) reactive volt-amp and power factor applied to RLC circuits. The impedance triangle. Reactive and active components of current. Capacitance and the application of capacitors to power factor improvement. The desirability of high power factors.

Distribution problems. Volt-drop. Single and double fed distributors.

Distribution systems. D.c. 2-wire and 3-wire. A.c. single-phase and three-phase 3-wire and 4-wire.

D.C. machines. Parallel operation of shunt and compound generators. Equalising bar. Load sharing treated quantitatively. Applications of Ward Leonard systems. Steering gear. Suitability of d.c. motors for the various types of work.

Faults and maintenance of machines. Overheating due to mechanical and electrical defects. Sparking at brushes. Loss of residual magnetism, etc. Testing machines—use of the megger.

Motor starters. Automatic types—reference to time and current control. The drum controller for series motors. Calculations on starters.

General A.C. Production of an alternating waveform. Rectification. The sine law. Frequency; amplitude, instantaneous and maximum values. Relation between frequency, number of poles and speed of a machine. R.m.s. average values and form factor.

Phasor representation of an alternating quantity to give instantaneous and r.m.s. values.

Electronics. Characteristics of electronic valves and transistors. Photo electric effect. Effect of voltage feedback on amplifier gain, input and output impedances. Equivalent circuits.

Three-phase systems. Star and delta (mesh) connections for supplies and loads. Phase and line relationships. Power. Three-phase 4-wire distributor. The production of rotating magnetic fields.

Alternators. Construction of salient pole, cylindrical rotor and brushless machines. E.m.f. equation. Synchronising and load sharing. Automatic voltage regulators.

Induction motors. Construction. Slip. Reference to rotor e.m.f. and frequency. Typical torque-speed curves. Wound, slip ring and cage types. Description of double wound type. Starting methods.

Synchronous motors. Construction. Starting methods. Reference to use for power factor correction.

Propulsion. Types using d.c. and a.c. machines. Turbo-electric drives; starting methods; speed changing. Advantages and disadvantages of electrical propulsion.

Single-phase motors. Description of general common types. Starting.

Transformers. Elementary principles and general description.

Instruments. Qualitative treatment of, e.g. dynamometer, wattmeter, frequency meter, power factor meter, rotary synchroscope, reverse power relay, salinometer, telegraph.

SECOND CLASS NAVAL ARCHITECTURE

(One paper of three hours. Six questions only out of nine to be attempted.)

General. Displacement. Wetted surface. Block, mid-section, prismatic and water-plane area coefficients. Tonne per centimetre immersion. Application of Simpson's First Rule to areas and volume.

Draught and buoyancy. Alteration of mean draught due to change in density of water. Buoyancy and reserve buoyancy. Effect of bilging amidship compartments.

Transverse stability. Shift of centre of gravity due to addition or removal of ballast, fuel or cargo. Stability at small angles of heel (given the second moment of area of the waterplane or formulae). The inclining experiment.

Resistance and propulsion. Comparison of skin frictional resistance of hull with model at different speeds. $R_f = f.S.V^n$ and residual resistance. Admiralty and fuel coefficients. Relation between speed of vessel and fuel consumption with constant displacement and assuming that resistance varies as $(\text{speed})^n$. Elementary treatment of propeller. Pitch, apparent slip, real slip, wake, thrust and power.

Structural strength. Simple problems on strength of structural members to resist liquid pressure. Loading due to head of liquid.

Ship construction. Common terms used in the measurement of steel ships, e.g. length between perpendiculars, breadth overall, moulded depth, draught and freeboard. Definitions of shipbuilding terms in general use. Descriptions and sketches of structural members in ordinary types of steel ships. Machinery seating arrangements. Watertight doors. Hatches. Rudders. Bow thrusters. Propellers. Stern tubes. Watertight bulkheads. Double bottoms. Anchors and cables. Precautions necessary before entering empty oil fuel or ballast tanks. Descriptive treatment of the effect of free surface of liquids on stability.

The preservation in good condition of the ship's structure, in particular the bilges, bunkers, tanks under boilers and watertight doors.

Ventilation arrangements (natural and mechanical) for pump rooms in tankers and for holds and oil fuel tanks.

Arrangements for the carriage of dangerous goods in bulk.

Fire detection and extinction arrangements for passenger and cargo spaces. Fire precautions in port and dry dock.

Fore and aft peak tanks, double bottom and deep tank filling and pumping arrangements. Compartmental drainage. Levelling arrangements for damaged side compartments.

Dry docking and maintenance of underwater fittings.

FIRST CLASS NAVAL ARCHITECTURE

(One paper of three hours. Six questions only out of nine to be attempted.)

General. Form coefficients. Wetted surface formulae. Simpson's rules applied to areas, moment of areas, second moments of areas, volumes, moments of volumes, centroids and centres of pressure.

Transverse stability. Centre of gravity. Centre of buoyancy. Metacentre. Moment of statical stability. *GZ* curves. Cross curves of stability. Hydrostatic curves commonly supplied to ship. Effect of free liquid surface and subdivision of tanks. Dangers due to water accumulation during fire-fighting. Effect of suspended weights. Practical requirements to ensure stability at sea. Management of water and fuel tanks. Filling and emptying tanks at sea.

Longitudinal stability. Longitudinal *BM* and *GM* and statical stability. Centre of flotation and its calculation. Moment to change trim by one centimetre.

Draught, trim and heel. Changes due to adding or removing fuel ballast or cargo. Changes due to alteration in density of sea water. Changes due to bilging of compartments, using the lost buoyancy and added mass methods. Forces on rudder and stress in rudder stock. Heel when turning, including effect of centrifugal force and of rudder.

Resistance and propulsion. Derivation of Admiralty and fuel coefficients. The law of corresponding speeds. Froude's law of comparison. Simple problems on the prediction of full-scale resistance from model experiments. Simple problems involving the use of ep, dp, and QPC. Simple problems on propellers. Pitch ratio. Wake factor. True slip. Apparent slip. Thrust and power. Cavitation.

Ship construction. Forces on ship under various conditions, including the effect of panting and pounding. Construction of all parts of steel ships. Use of high tensile steel and aluminium. Structural fire protection arrangements. Fire detection and extinction arrangements. Fire precautions in port and in dry dock. Arrangements for the carriage of dangerous goods in bulk. Bilge and ballast arrangements. Levelling arrangements for damaged side compartments. Dry docking. Ventilation of holds and oil fuel tanks. Design features of ships for general and specialised trades.

Ship measurement and classification. Meaning of 'classed' and 'unclassed' ships. Common terms used in measurement of modern steel ships. Common terms used in tonnage measurements, *e.g.* gross tonnage, nett tonnage, propelling power allowance.

ENGINEERING KNOWLEDGE

(Second Class and First Class)

Candidates for a combined Steam and Motor Second Class Certificate must be prepared to be examined in all the items (a) to (x) but those for a Steam Certificate or the Steam Endorsement of a Motor Certificate will not be examined in items (t) to (x) and those for a Motor Certificate or the Motor Endorsement of a Steam Certificate will not be examined in items (m) to (s).

Candidates for First Class Certificates or First Class Endorsements will be expected to display a fuller knowledge of the different items in the Syllabus than candidates for a Second Class Certificate or Second Class Endorsement and will also be liable to be examined in items (y) and (z)

NOTES:

1. The engineering knowledge to be shown by candidates is that which is required for the use, operation and maintenance of the machinery, equipment and ship structure usually in the charge of the engineer. A knowledge of the managerial responsibilities of a certificated engineer will be required.

2. Candidates for certificates and endorsements are required to take a written examination followed by an oral examination.

3. The written examination for a Steam or Motor Certificate consists of two papers of three hours each—six questions only to be attempted out of nine in each paper. One question in the morning paper will be compulsory for First Class candidates.

4. The written examination for a combined Steam and Motor Certificate consists of three papers of three hours each—six questions only to be attempted out of nine in each paper. One question in each morning paper will be compulsory for First Class candidates.

5. The written examination for a Steam or Motor Endorsement consists of one paper of three hours—six questions only to be attempted out of nine in the paper.

6. Candidates may be required to illustrate their answers by means of freehand sketches.

(a) A knowledge of the methods of manufacture of the various components, the general effects of various treatments on the physical properties of materials commonly used in the construction of marine engines and boilers and the mechanical tests to which these materials are normally subjected.

(b) The natural and desirable properties of steam, fuel, lubricants and other liquids, gases and vapours used in machinery on board ship.

(c) The use, constructional details and principles involved in the action of the pressure gauge, thermometer, pyrometer, barometer, salinometer, hydrometer and other meters commonly used by engineers on board ship.

(d) Dissolved solids, scale formation and feedwater treatment. Corrosion inhibition.

(e) The methods of dealing with wear and tear of machinery and boilers. The alignment of machinery parts. The correction of defects due to flaws in material or accident. Temporary or permanent repairs in the event of derangement or total breakdown.

(f) Constructional details and principles of action of pumps and oily water separators fitted in ships. The general requirements concerning feed, fuel, bilge ballast and fire pumping systems.

(g) The constructional arrangement, details and working of steering machinery, refrigerating machinery, hydraulic and other auxiliary machinery and such steam and internal combustion engines as are used for emergency and auxiliary machinery on board ship.

(h) (1) Application of the indicator. Fluctuation of pressure in the cylinder as shown by indicator diagrams. Interpretation of normal conditions. Candidates for First Class Motor Certificates and Endorsements will be expected to illustrate, by means of sketches, the changes produced in the diagram due to an alteration in the setting or working of the valves or any other factors.

(2) Methods of determining engine shaft power. The principles of working and methods of calibration of dynamometers and torsion meters.

(i) Safe working practices, overhauling machinery, mechanical safety in workshops, protective equipment, lifting tackle.

(j) Knowledge of the appropriate statutes that concern marine engineers (*e.g.* those dealing with oil pollution and clean air) is required.

(k) (1) Precautions against fire or explosion. Flash point. Explosive mixtures of air and gas or vapour given off by fuel or lubricating oils. The danger of leakage from oil tanks, pipes, gas producers and vaporisers, particularly in bilges and other unventilated spaces; sources of ignition. The action of wire gauze diaphragms and the places in which such devices should be fitted.

(2) Toxic and other dangerous properties of substances used in marine practice. Maintenance of plant associated with the carriage of dangerous cargoes.

(3) Fire detection. Methods of dealing with fire. Action and maintenance of mechanical and chemical fire extinguishers and other fire-fighting appliances, respirators and safety lamps.

(l) Control systems, automation and instrumentation. Periodically unmanned machinery spaces. Bridge control arrangements, alarm systems, operational techniques and work practices.

(m) The methods of constructing marine steam turbines, gearing and boilers, the processes to which the several parts are submitted, or which are incidental to their manufacture, and the methods employed in fitting the machinery on board ship.

(n) The various types of propelling and auxiliary machinery now in use, the functions of each important part and the attention required by the different parts of the machinery on board ship.

(o) The methods of testing and altering the setting of the steam admission and exhaust valves of auxiliary machinery and the effect produced in the working of the engine by definite alterations in the settings of the valves.

(p) The constructional details and working of evaporators, feed water heaters and feed water filters.

(q) Marine boilers of various modern designs, their construction and manner of attachment to ship.

(r) The use and management of boiler fittings and mountings, with special reference to water-gauges and safety valves. Precautions necessary when raising steam and operating stop valves with particular reference to the danger arising from water-hammer action.

(s) Constructional details, operation and maintenance of installations generally employed for assisting draught, superheating steam and burning fuel.

(t) The principles underlying the working of internal combustion engines. The differences between various types of engines. Constructional details of internal combustion engines, gearing and clutches in general use. The processes to which the several parts are submitted or which are incidental to their manufacture and the methods employed in fitting the machinery on board ship.

(u) The nature and properties of the fuel and lubricating oils generally used in internal combustion engines. The supply of air and fuels to cylinders of engines of different types. The means of cooling the cylinders and pistons. Constructional details and working of air compressors.

(v) Starting and reversing arrangements and the various operations connected therewith.

(w) The attention required for the operation and maintenance of the various parts of machinery. The use and management of valves, pipes, connections and safety devices employed.

(x) Constructional details and management of auxiliary steam boilers, their fittings and mountings, with special reference to water-gauges and safety valves. Constructional details and management of auxiliary machinery. Draught, combustion equipment, oil fuel equipment.

Candidates for First Class Certificates and Endorsements only

(y) The administrative duties of a Chief Engineer: organisation of his staff for emergency duties and the use of safety equipment: organisation of repairs and surveys. Reports to owners. Training marine engineer cadets.

(z) The recognition of irregularity in the performance of machinery. Analysis and interpretation of monitoring equipment and instrument readings to determine machinery condition and future availability. Diagnostic techniques to forestall breakdown.

ORAL EXAMINATION

The oral examination will be largely based upon the Practical Knowledge subjects of the examination and will include questions on the management of engines and boilers, electrical machinery, prevention of fire and methods of fighting fires at sea, the duties of the supervising engineer, the work to be done to engines, boilers and auxiliary machinery in port and the periodical examination of the working parts.

Candidates should also be well acquainted with machinery and boiler casualties which may occur at sea and be able to state how these may be prevented and remedied.

APPENDIX C

Syllabus for the Extra First Class Examination

Candidates are expected to show a more extensive knowledge of all the items in the syllabuses for First and Second Class candidates.

ENGINEERING KNOWLEDGE

Questions will be set to test the candidate's knowledge of technological investigations which have influenced engineering practice and important developments arising therefrom free from the limitations of the Second and First Class examination syllabuses.

THEORY OF MACHINES (MECHANICS OF FLUIDS)

Plane kinematics of mechanisms. Instantaneous centres of rotation. Relative velocity of machine parts by calculation and graphic methods. Displacement, velocity and acceleration diagrams. Calculation of displacement, velocity and acceleration of slider crank mechanisms. Cams. Theory of shape and action of gear teeth. Helical, bevel worm, spur gearing and gear trains. Inertia forces on engine mechanisms. Balancing of rotating masses, primary balancing of reciprocating parts, secondary balancing of engines. Turning moment diagrams. Flywheels. Governors. Vibrations of mechanical systems including forced vibration and the effect of viscous damping. Torsional oscillations of shafting. Whirling of shafts.

Gyroscopic theory and action.

Friction and chain drives, clutches.

Lubrication, theory of boundary film lubrication, ball and roller bearings.

Automatic Control: Analysis of control systems with feedback which can be represented by first and second order differential equations. Examples from marine practice of servo mechanisms and regulators.
Transfer functions. Combination of non inter-acting elements; open and closed loop transfer functions.

System response. Transient and steady state response of systems with step and ramp changes of desired value and load; time constant, natural frequencies, damping ratio, logarithmic decrement, steady state deviation. The principle of superposition. Harmonic response: vectorial representation of input and output; amplitude ratio, phase displacement, resonance, performance improvement: feedback and feedforward methods; derivative and integral action, three term controllers.

Stability. The characteristic equation, determination of roots.

Hydrostatics: Fundamental properties of fluids. Viscosity, surface tension. Resultant pressure on plane and curved surfaces, centre of pressure. Vertical stability of the atmosphere.

Hydrodynamics: Streamline, laminar and turbulent flow, influence of solid boundaries on fluid motion. Bernoulli's principle, continuity of flow. Distribution of pressure and velocity in free and forced vortices. Resistance of viscous fluid in streamline or turbulent motion. Use of coefficients to correct for

resistance and streamline contraction. Measurement of velocity of incompressible flow by Pitot and static pressure tubes, orifices, notches and Venturi meter. Loss of head due to bends, sudden enlargements and contractions—hydraulic gradient. Dynamical similarity. Flow between parallel surfaces and in circular pipes. Critical velocities for flow in pipes. Reynolds' number, Rayleigh's formulae. Water-hammer. Impact and reaction of jets. The theory of centrifugal pumps, reciprocating pumps, accumulators and other hydraulic machines with a marine application.

STRENGTH AND PROPERTIES OF MATERIALS

Structure of the atom; electrons, protons, neutrons (simple Bohr atom); electron shells, energy levels, ionisation potentials.

Arrangement of atoms in materials; types of atomic bond; crystalline and amorphous materials; nature of metallic, organic (highpolymer) and ceramic materials; crystal structure of metals; setting of resins.

Imperfections in materials and influence on mechanical properties; deformation in single crystals; polycrystalline metals, recrystallisation of deformed metals, basic strengthening mechanisms in metallic materials (strain hardening, solid-solution-hardening and dispersion hardening); deformation of polymers, methods of forming and working.

Mechanical properties of metals, polymers and other engineering materials (*i.e.* strength, elasticity, hardness, creep, fatigue, resistance to impact, wear, ductile and brittle behaviour including effect of temperature and strain rate). Effects of stress concentrations.

The structure and properties of cast metals and alloys; typical defects in castings—shrinkage and gas unsoundness, residual stresses. Structural and mechanical property changes resulting from cold working, annealing and hot working of metals; comparison of mechanical properties of cast and raw products. The joining of metals; shrinkage, oxidation, residual stresses and cracking associated with welding. The effect of welding on structure and properties of parent metal. Elements of binary phase diagrams applied to the strengthening of metals; the formation of solid solutions and dispersed phases; precipation—hardening, quench-hardening and tempering. The influence of alloy structure on strength, ductility, fracture and creep characteristics.

Introduction to TTT diagrams for steels, the hardenability of carbon and medium alloy steels, and the influence of hardenability on welding behaviour.

Oxidation and corrosion of metals and alloys; stress-corrosion cracking, corrosion fatigue; protection against corrosion. Destructive and non-destructive testing of materials (strength, ductility, shear, impact,. fatigue, hardness, X-ray, gamma ray, ultra sonic). Methods of forming and working metals.

Simple stress and strains; elastic constants. Compound stresses and strains; normal and shear stresses; complementary shear stresses; Poisson's ratio; relation between elastic constants; principal stresses and planes; principal strains; strain energy due to complex stress; theories of elastic failure. Stresses and strains in thin wall and thick wall cylinders under fluid pressure; compound cylinders. Bending moments, slope and deflection in freely supported and built-in beams and cantilevers. Distribution of stress in beams. Leaf and flat spiral springs. Strain energy due to bending. Struts subjected to axial and eccentric loadings; torsion of shafts, transmission of power by shafting. Close coiled and open coiled helical springs. Stress and deflection in frame work treated analytically and graphically.

APPLIED THERMODYNAMICS

Processes, flow and non-flow, application of the Thermodynamic Laws for perfect and imperfect fluids.

Ideal cycles, steam or gas, mixtures of gases.

Systems, available energy, availability in cyclic processes and in non-cyclic closed system processes. Entropy.

Heat transfer involving slender fins (fin efficiency), composite sections, flat and mathematically curved surfaces and with internal heat generation.

Derivation and solution of fundamental equations for steady two dimensional and unsteady one dimensional conduction problems. Transient heat flow.

Mixtures of gases and vapours, hygrometry, use of psychometric chart. Humidification and de-humidification. Direct contact water and gas cooling.

Application to air conditioning and non-marine plant.

Descriptive knowledge of laminar flame propagation, minimum spark ignition energy, quenching distance, spontaneous ignition, flammability limits. Fuels.

Combustion efficiency, effect of air/fuel ratio. First Law of Thermodynamics applied to combustion processes.

Frictionless one dimensional flow through ducts of varying cross sectional area, heat addition and external work, critical pressure ratio. Mach number.

Stagnation properties (temperature, pressure) at a point in the fluid stream. Wind tunnel testing.

Adiabatic one dimensional flow of imperfect gases in nozzles.

Application of fundamental principles to existing and proposed plant and equipment. Cycle analysis of specified hybrid plant both marine and non-marine.

MARINE HEAT ENGINES

Gas turbines, effect of intercooling, reheating and heat exchangers. Influence of component efficiencies, losses, pressure ratio and maximum cycle temperature on performance. Calculation of performance of specified plant.

Desirable characteristics of refrigerants. Vapour compression cycles: single and multiple stage expansion and compression. Heat pump applications.

Cycle analysis of steam plant including effects of superheating, reheating, regenerative feed heating with specified arrangement of feed heaters, drain coolers, pumps. Steady flow analysis of single and multiple effect evaporators.

Axial flow steam turbines. Performance, impulse, reaction, blading efficiency, stage and overall isentropic efficiencies, condition curve, reheat factor. Compounding.

Descriptive knowledge of ignition and flame propagation in internal combustion engines; types of combustion chambers and their influence on ignition delay, fuel air mixing, specific fuel consumption. Cetane number as an index of fuel rating. Dissociation.

Practical internal combustion engine cycles. Supercharging.

Operation of compressors; radial flow, axial flow, reciprocating. Blading in rotary machines. Steady flow analysis. Performance characteristics.

Heat transfer in marine plant. Parallel and counterflow heat exchangers involving fluids of constant specific heat. Surface and overall cofficient, use of dimensionless parameters in convection heat transfer.

The testing and performance of marine heat engines.

Appendix C

ESSAY

The purpose of the Essay is to test the candidates' ability to compose and write good grammatical English and to express their opinions, conclusions and suggestions in essays on subjects connected with the engineer in society or on topics of current interest.

Two subjects will be given; one only is to be attempted.

ENGINEERING DRAWING AND DESIGN

To produce a working drawing of any part of marine machinery, boilers, mechanical equipment or parts of ship structure involving the arrangement of constituent members from given particulars and the design calculations asked for. Two subjects will be given; one only is to be attempted.

ELECTROTECHNOLOGY

Network theorems and their application to linear passive and active networks. Networks with mutual inductance. Two port networks. Electrical measurement circuits. Strain gauge circuits. Transients and oscillations in R.L.C. circuits. Switchgear and distribution systems. Short circuit protection.

Composite magnetic circuit calculations, energy stored in a magnetic field, self and mutual inductance, effect of inductance or capacitance on d.c. circuits.

General principles of electrostatics. Intensity and strength of electric fields. Theorems of Gauss and Coulomb. Potential and capacitance, potential gradient. Charge and discharge of capacitors including oscillatory charge and discharge.

Generation of sinusoidal e.m.f. waveform, values of current and voltage. A.c. circuits involving resistance, capacitance, inductance and resonance. Phasor representation. Power factor. Single and three-phase circuits with star and delta connections. Power and energy measurement in three-phase balanced and unbalanced circuits. Harmonics in single-phase circuits.

Vacuum and gas-filled valves and tubes, semi-conductor diodes, thyristors and transistors. Photo-electric effects and applications. Amplifiers and rectifiers. Feedback effects on amplifiers.

Construction of d.c. machines. Windings including multiple windings. Equaliser rings. Commutation. Armature reaction interpoles. Characteristics of d.c. motors and generators used in marine practice. Motor speed, torque, starting and control. Application of amplidyne and metadyne to control of speed, current and voltage. Operation of d.c. generators in parallel. Testing of d.c. machines direct and indirect methods—separation of losses, retardation and regeneration methods of testing.

Construction of a.c. machines. Flux distribution in salient pole and non-salient pole fields. E.m.f. generated in coils and distributed windings. Armature reaction. Alternators and their use as synchronous motors. Voltage regulation. Parallel operation of alternators. Static and rotary voltage regulators. Instruments. Transformers—phasor diagrams, equivalent circuit, voltage regulation and efficiency. Polyphase induction motors—theory, characteristics and starting arrangements. Synchronous machines—equivalent circuit, synchronous impedance, voltage regulation.

Automatic control, simulation, use of analogues. Generation of integral and derivative action by passive and active electrical circuits. Analysis of control systems with feedback. *Input and output characteristics.* Transient, steady state and harmonic response of systems. Instruments—indicating, recording, integrating, detection, conversion and data transmission. Matching of components.

NAVAL ARCHITECTURE

Derivation of Simpson's and Tchebycheff's rules.

Stability. Hydrostatic curves, statical curves and cross curves of stability. Dynamical stability. Free surface problems. Grounding.

Subdivision of passenger ships. Floodable length curves and their use.

The strength of ships. The trochoidal wave theory. Local and longitudinal strength calculations. Statical strength treated graphically and by calculation. Dynamical effects. Oscillation, rolling and pitching of ships. Qualitative treatment of vibrations.

Resistance and propulsion of ships. Model experiments and laws of comparison. Dynamical similarity. Viscosity and its effects on fluid friction. Dimensional analysis and the non-dimensional factor approach to Reynolds' and Froude's numbers Other methods of estimating power, *e.g.* Admiralty coefficient formula, Taylor's curves. Circular constants and their use.

Propellers, geometry of the helix, typical triangle of velocities introducing slip and angle of incidence. Thrust, torque and efficiency. Blade element theory—lift and drag on aerofoil section. Axial momentum. Propeller coefficients and their use. Cavitation. Interaction between screw and ship. Hull efficiency and its factors. Overall propulsion coefficient.

Ship construction and materials used in ship building. Modern developments in structural design. Use of high tensile steels, mild steel, aluminium and other materials. Discontinuities. Welding. Corrosion and fouling.

General principles of load line assignment and tonnage measurements.

APPENDIX D

Specimen Forms of Testimonials

(A) WORKSHOP SERVICE

Name and address of engineering works.....

.....

I certify that the following is a full and true statement of the workshop service performed by.....under my supervision at the above works.

Period of service. (Dates)		Total period	Nature of duties. (For appropriate description see below)	Particulars of weekly release periods to permit apprentice to pursue technical studies
From	To			

Report as to ability.....

Report as to conduct.....

Remarks (if any).....

Signature of employer or his representative.....

Description of duties

I. (*a*) Installation or repair of substantial machinery in the machinery spaces of new and existing ships (nature of duties must be specified).

I. (*b*) Fitting, erecting or maintenance of machinery other than the above suitable for the training of marine engineers (nature of duties must be specified).

II. Fitting on machinery other than I.

III. Metal turning.

IV. Machine work (other than lathe).

V. Work in drawing office, as draughtsman or engineer.

VI. Other work, the nature of which should be specified.

The use of the appropriate numerals is sufficient except in cases I. (*a*), I. (*b*) and VI.

(B) SEA SERVICE

{Name and address of shipowner or company.

I certify that the following is a full and true statement of the sea service performed by Mr.....under my supervision on board the*.....O.N.....

Period of service (*Dates*)		Rank of officer and actual seniority on watch	Type of main *engines and boilers* (Single or twin-screw)	Nature of duties (*For appropriate* description see below)
From	To			

During the whole period stated above, Mr.
(*a*) was granted no leave of absence.
(*b*) was granted days leave of absence whilst still on articles.

Report as to ability.....

Report as to conduct.....

Report as to sobriety.....

Signature of Chief Engineer.....

Remarks (if any).....

Signature of {*Engineer Superintendent*..... or Master or other representative of owners .....

Description of duties

I. On fitters' work either by day or regular watch.†
   (*a*) Within main engine and boiler spaces.
   (*b*) Outside main engine and boiler spaces.

II. (*a*) On refrigerating or other machinery not essential to the propulsion of the vessel.
   (*b*) On auxiliary engines separated from main propelling units but worked in conjunction therewith.

* Steam or motor ship. Name of ship and official number.
† On regular watch means eight hours in every twenty-four hours.

[contd. overleaf]

III. On regular watch* on main engines as
  (*a*) First Engine Room Assistant under the Senior in full charge.
  (*b*) Second Engine Room Assistant.
  (*c*) Junior Engine Room Assistant.

IV. On regular watch* on main boilers.
  (*a*) In charge of all stokeholds.
  (*b*) In charge of a section or one stokehold only.
  (*c*) As Boiler Room Assistant.

V. On regular watch* on main engines and boilers simultaneously.
  (*a*) In full charge of the entire watch.
  (*b*) As First Assistant to the Senior in full charge.
  (*c*) As Junior Assistant.

In ships where watches are kept on other than the traditional system of not less than eight out of each twenty-four hours, a brief description of the duration and frequency of the watches should be given. Mention of periods on day work or on fitters' work by watch should be made. This is particularly applicable to vessels that:—

1. have a centralised control room;
2. are fully or partly automated;
3. have arrangements such that the engine room is unmanned for some part of the twenty-four hours.

Note: It is recommended that this form should be used when the engineer reported on, or when the Chief Engineer leaves a ship.

On regular watch means eight hours in every twenty-four hours.

APPENDIX E

Colleges which run Courses for Marine Engineers*

Aberdeen: Technical College, Gallowgate, Aberdeen

Belfast: Ulster College, The Northern Ireland Polytechnic, Jordanstown, Newtownabbey

Cardiff: Llandaff College of Technology, Western Avenue, Cardiff

Dundee: Kingsway Technical College, Old Glamis Road, Dundee

Glasgow: College of Nautical Studies, Thistle Street, Glasgow C5

Hull: College of Technology, Queen's Gardens, Kingston-upon-Hull, HU1 3DG

Leith: Nautical College, Commercial Street, Leith, Edinburgh EH6 6NM

Liverpool: Liverpool Polytechnic, Byrom Street, Liverpool L3 3AS

London: Poplar Technical College, High Street, London E14

Southampton: College of Technology, East Park Terrace, Southampton

South Shields: Marine and Technical College, St. George's Avenue, South Shields

* See paragraph 51.

APPENDIX F

Certificates as First and Second Class Engineer, and First and Second Class Motor Engineer, granted by Governments outside the United Kingdom which are recognised as having the same force as those granted by the Department of Trade

Under the provisions of the Order in Council dated 9th May 1891 as amended by No. 810 of 1906:

Canada

Hong Kong

Malaysia, Singapore — Equivalent certificates were formerly issued by the Straits Settlements and later by the Federation of Malaya and the State of Singapore.

New Zealand

Under the provisions of the Order in Council No. 1288 of 1923 as amended by No. 692 of 1931:

Australia. Equivalent certificates were formerly issued by the States of New South Wales, Queensland, South Australia, Tasmania and Victoria.

Under the provision of the Order in Council No. 1100 of 1931:

India. Equivalent certificates were formerly issued by the Provinces of Bombay and Bengal.

Pakistan. Consequent upon the withdrawal of Pakistan from the Commonwealth recognition is only given to certificates granted before 1st September 1973.

Under the provisions of the Order in Council No. 740 of 1954:

Republic of Ireland

Under the provisions of section 6 (1) of the Third Schedule to the South Africa Act 1962:

South Africa. Recognition is only given to certificates granted before 31st May 1962.

APPENDIX G

Reading the Water-Gauge

Notwithstanding that the reading of the water-gauge is made a special feature in the examination of engineers, many boiler casualties result from the Engineer of the watch either not understanding the construction of the water-gauge fittings or not satisfying himself by actual trial that the cocks, pipes, etc., are clear.

Unless a candidate under examination is able to prove that he understands how to verify the indications of the water-gauge, he will not be passed in practical knowledge. Failure in practical knowledge involves a candidate going to sea for further experience before re-examination.

The sketches, Figures 1, 2, 3 and 4, Plate 1, represent the usual methods of attaching water-gauge mountings to marine boilers, the smoke boxes being omitted, for convenience, from Figures 3, 4 and 5. The important features in each gauge and the method of verifying its indications are dealt with separately in the following notes.

Referring to Figure 1 only

In this case the water-gauge cocks are attached direct to the boiler, and the accuracy of the gauge when the boiler is under steam can be tested as follows:

First. Let B remain open, then close cock D and open cock E, and if steam issues it proves that cock B and the passage through the top fitting and gauge glass are clear. If no steam or water issues, either cock B or the passage through the top fitting and gauge glass is choked and the gauge cannot act properly until the obstruction is removed.

Second. Close cock B and open D and E, and if water issues, cock D is clear. If no water or steam issues, either cock D or the passage from the boiler through the lower fitting is choked and must be cleared before the gauge can act properly.

Referring to Figure 2 only

In this case the gauge cocks are attached to a bent pipe of comparatively large diameter (at least 3 inches in the bore), the upper end of which communicates with the steam space, and the lower end with the water space of the boiler. Owing to the bore of the pipe being large, it is not likely to become choked or stopped under the ordinary conditions of working. The water-gauge is, therefore, in practically the same condition as if it were attached direct to the boiler, as in Figure 1. This gauge, when at work, is tested in precisely the same manner as the one shown in Figure 1.

Screw plugs are inserted at P.P. and Q.Q., by the removal of which the apertures in the pipe can be cleared, if necessary, by the insertion of a wire or rod when steam is down.

Referring to Figure 3 only

In this gauge there is an open communication from A to C through the column Y, and in order to 'blow through the *glass*' it is only necessary to shut cocks D and B alternately, keeping E open. But to 'blow through the *water-gauge*', including the pipes H and I, it is necessary, after blowing through the glass as described above to shut A and C alternately, at the same time keeping B, D and E open for such time as will ensure the complete discharge of the contents of the

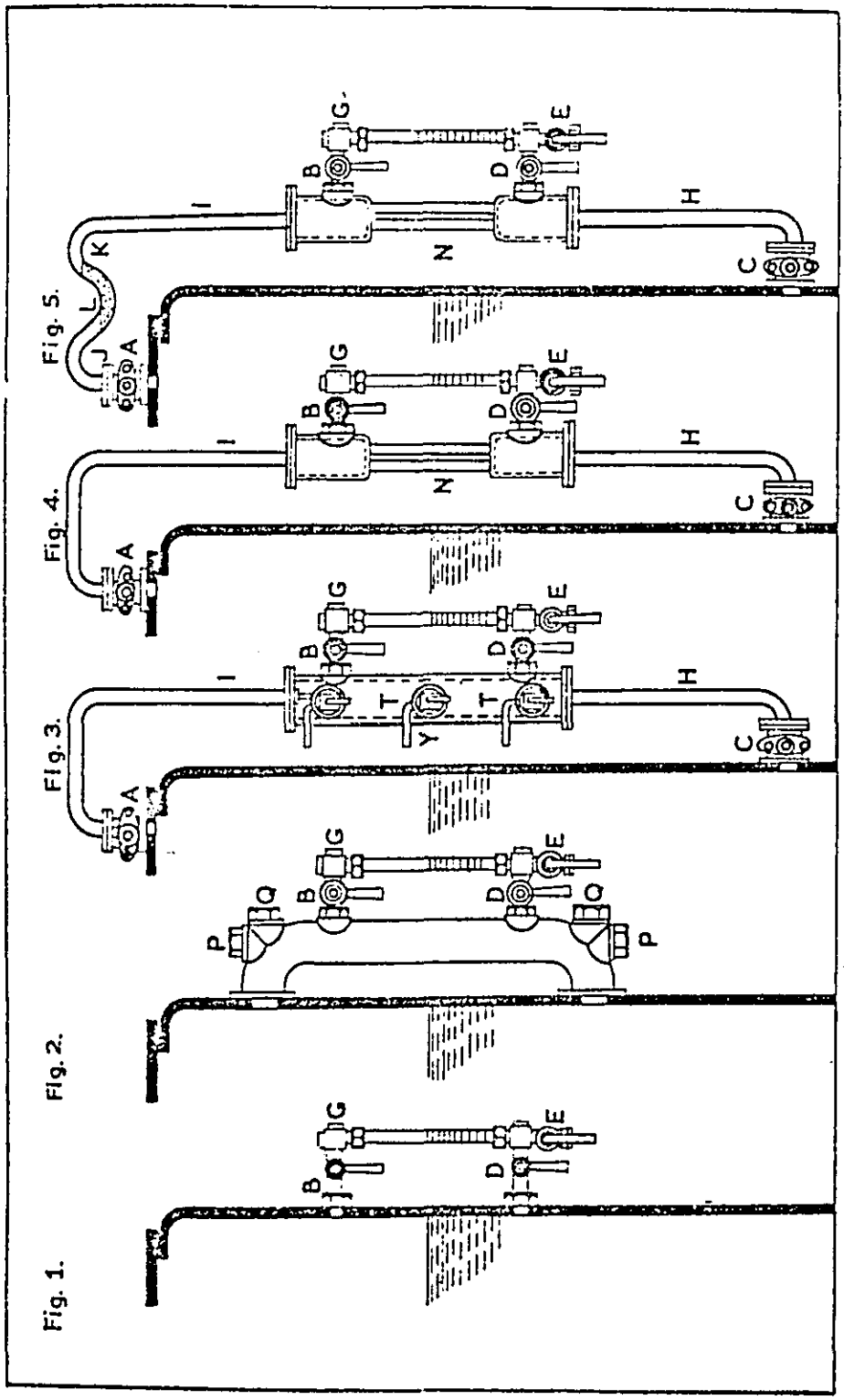


Fig. 5.
Fig. 4.
Fig. 3.
Fig. 2.
Fig. 1.
A
B
C
D
E
G
H
I
J
K
L
N
P
Q
T
Y

gauge and its connections. When B, D and C are clear and A choked the steam lodging in the glass and in the pipe I leading from column Y to A becomes condensed and the water flowing through C to take its place rises in column Y and in the glass to a level above that of the water in the boiler. In other words, the gauge shows a false level. If now E be opened and water is blown out, then on E being again closed the water in the gauge will rise higher than before and be still further misleading. On the other hand, when B, D and A are clear and C choked, the water, if any, in the glass is trapped and no longer rises and falls with the water in the boiler or with the motion of the vessel; it, however, slowly rises in the glass owing to the condensation of the steam in the upper part of the gauge until such time as E is opened, when the whole of the water in the glass is blown out; and on E being closed, the glass does not show any water, notwithstanding that the water in the boiler may be at the proper level. When the test cocks T. T. T. are attached to column Y, as shown in Figure 3, they cease to be reliable when either cock A or C or the pipe in connection therewith is choked, or nearly choked; hence it is desirable that such test cocks should be fitted direct to the boiler and not the column as shown.

Referring to Figure 4 only

Sometimes the water-gauge fittings are arranged as shown in Figures 4 and 5, with no passage up the column, the central portion (N) of the column being simply a pillar or connecting piece of any convenient section between the upper and lower portions to which the cocks B and D are attached.

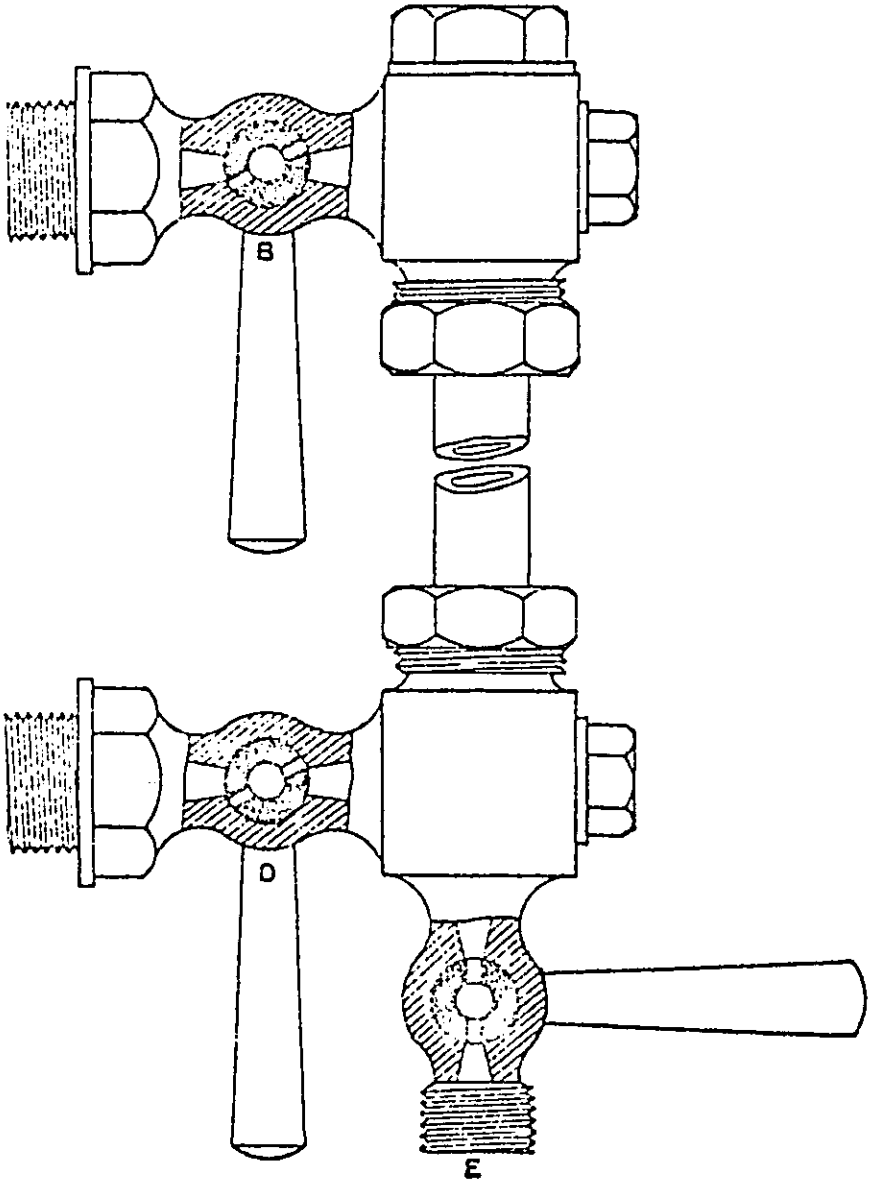
By this arrangement double communications are obviated and there is no need for what is known as 'double shut off' in testing the accuracy of the gauge. When, however, the gauges are constructed in this manner, the cocks B and D are unreliable as test cocks in the event of there being no glass in the gauge. This feature should be carefully noted. Moreover, when in working condition, the reduction of pressure in the glass which arises when E is opened causes the water in pipe H to rise above its normal level. This objectionable feature should also be noted.

Referring to Figure 5 only

Sometimes there is a bend, L, in the steam pipe I leading from cock A to cock B. This has occasionally escaped observation when new boilers have been fitted on board ship. In most cases this bend arises from the pipe being led in an abnormal direction to escape other pipes, beams or fittings near the smoke-box. With such a bend the condensed steam collects in the pipe and falls to the bottom of the bend and in time it completely fills the pipe from J to K. The steam from K down to the level of the water in the glass is thereby trapped and, as condensation proceeds, leads to a reduction of pressure in the pipe below that of the boiler and an equivalent rise of the water in the bend and also in the gauge glass. When the vessel is quiescent the water in the gauge glass increases in height until cock E is opened or until the pressure in the boiler is so much in excess of that in the lower part of pipe I as to cause the water in the bend to be blown into the gauge glass. In either case instantaneous change of water level in the glass ensues.

In the ordinary course of working, the phenomenon described above is more or less modified by the presence of air in the upper part of the gauge and by the rise and fall of the water in the boiler and gauge glass arising from the rolling or pitching motions of the vessel.

Fig. 6.



Other Special Points to be Noted

When cocks A and C are omitted, as in Figure 2, this is owing to the bore of the stand pipe being sufficiently large to enable it to be regarded as part of the boiler. Such pipes require, however, to be examined and cleared at intervals by passing a rod through the holes provided for the purpose at P.P. and Q.Q.

Cocks at A and C are not necessary for the testing of gauges arranged as shown in Figures 4 and 5. Candidates, however, should be fully aware of the impossibility of testing the reliability of the indications of water-gauges arranged as in Figure 3 when the cocks A and C are absent, and of the effect which the choking of cock A or C, or pipe H or I, has on the indications of the test cocks T.T.T. when attached to column Y.

Many ships afloat are fitted with water-gauges as shown in Figures 3 and 4, and it is therefore specially important that engineer candidates should thoroughly understand their construction, the principle on which they act, and the steps which must be taken to keep them in an efficient condition.

When fitting a gauge glass into its place, it is specially important that it should not be placed so high as to prevent a clearing rod being inserted at G, Figures 1, 2, 3, 4 and 5. This defect, especially if it occurs in a water-gauge attached to a boiler subject to priming permits a rapid accumulation of scum around the top of the glass and results in the choking of the orifice leading from cock B to the gauge glass in each of the figures.

When a gauge glass is too short, or is placed either too high or too low in the fittings, it is also liable to become choked by the packing material being forced over its ends by the glands whilst being screwed up.

The use of unsuitable or insecure internal pipes in connection either with the ordinary glass gauge cocks of the description shown in Figure 1, or with test cocks which are jointed to the boiler itself, should also be carefully guarded against.

Boiler casualties have resulted from the cocks B and D having the parts wrongly placed as shown in Figure 6, Plate 2. In one case of that kind, which forms the subject of Report No. 208 under the Boiler Explosions Acts, the engineer in testing the water-gauge omitted to see that the passages in the cocks B and D were clear *when the handles were in their proper working position.* This defect could easily have been discovered if proper attention had been paid to the condition of the cocks. A defect of this nature may be due to faulty construction originally, or to the handle of the cock having been overstrained, and the neck twisted. Whether the passages in the plugs are fair and clear can, however, be verified in a few minutes. As an illustration, the water cock D, Figure 6, Plate 2, can be verified by blowing through E with B shut and then moving the handle of D to one side until it is just closed, and then to the other side until it is again just closed; the proper working position of the handle is about equally distant from each of the above positions. The other cocks can be verified in the same manner.

Another serious casualty occurred through the handle of the cock A, Figure 3, having been twisted from its original position relatively to the orifice of the cock, resulting in the cock being shut when apparently open.

When a water-gauge, that is clear in all its parts, has been thoroughly blown through, the water in the glass rises above the level at which it formerly stood immediately the drain cock E is closed, but if left undisturbed for a time it

gradually falls to its former position. The amount of rise which occurs on these occasions depends chiefly on the temperature of the contents of the boiler and on the length of the pipes by which column Y is connected top and bottom to the boiler, but in cases where the gauge is of the description illustrated in Figures 3, 4 and 5, it amounts in high pressure boilers to about 4 inches, while the time occupied by the water in returning to its former level ranges from 30 to 40 minutes. The cause of this rise is twofold, namely, (*a*) the displacement of the comparatively cold water in the pipe H by hotter and proportionately lighter water from the boiler and (*b*) a slight condensation of the steam and a corresponding fractional reduction of pressure in pipe I. The cause of the gradual subsidence of the water in the glass to its former level is also of a dual character, namely, (*a*) the cooling of the water in pipe H, and (*b*) the diminution in the condensation of steam in pipe I owing to the collection therein of air released from the steam condensed.

These results will, however, be somewhat modified if the water in the boiler is of higher density than in pipe H, and this will nearly always be the case owing to the condensation of the steam in the glass and upper fittings of the water-gauge, causing the water in the lower part to be fresher than that in the boiler.

Candidates should understand the necessity for periodically blowing through the water-gauge on each boiler (no matter what the form may be) in a systematic and thorough manner, and in cases where a boiler is fitted with two water-gauges, of keeping both in constant use; finally, they should realise the necessity for keeping the water-gauges well-lighted, clean, and in all respects efficient.

APPENDIX H

Department of Trade

Mercantile Marine Offices

		Telephone
Aberdeen*	41½ Union Street Aberdeen AB1 2BN	0224–26272
Avonmouth	Post Office Buildings Avonmouth Road Bristol BS11 9EX	02752–2931
Belfast*	Custom House Belfast BT1 3LT	0232–34466
Cardiff*	3 Bute Place Cardiff CF1 6ND	0222–29556
Clydeports (Glasgow)*	200 Broomielaw Glasgow C2	041–221 4873
Dover	157 Snargate Street Dover CT17 9BZ	0304–201029
Falmouth	Imperial Buildings Bar Road Falmouth	Falmouth 312761/2
Grimsby	Murray Street Grimsby	0472–2862
Hull*	Posterngate Hull HU1 2LW	0482–36811
Ipswich	38 Museum Street Ipswich Suffolk	0473–213963
Leith*	1 John's Place Leith, Edinburgh 6	031–554 5488
Liverpool*	Graeme House Derby Square Liverpool L2 7SH	051–227 1131

Appendix H

		Telephone
London*	Dock Street London E1 8LJ	01–480 6501
Manchester	Maritime House Manchester Docks Salford M5 2XN	061–872 0726
Middlesbrough	Custom House North Street Middlesbrough TS2 1JU	0642–43052
Milford Haven	Jubilee Buildings Milford Haven	Milford Haven 3188
Plymouth	c/o Customs and Excise Custom House Parade, Plymouth	0752 62091
Southampton*	Canute Road Southampton SO9 3ST	0703–22369
Swansea	Pier Street Swansea SA1 1SP	0792–54792
Tilbury	Tilbury House Calcutta Road Tilbury	0375 82–3342/3 4462/3
Tyne and Wear Ports (*South Shields*)	25/26 Market Place *South Shields*	08943 63937/8

Note: In other ports Mercantile Marine Office duties are carried out by the local office of HM Customs and Excise.

* Examination centres are located at these ports.

APPENDIX I

Approved centres conducting four-day fire-fighting courses

Edinburgh	MacDonald Road Fire Station Edinburgh 7
Hull	North Hull Fire Station Clough Road Hull
Liverpool	Banks Road Fire Station Garston Liverpool
Plymouth	Fire Brigade Divisional Headquarters Greenbank Plymouth
Southampton	School of Navigation Warsash Southampton

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Subject and Number of Paragraph or Letter of Appendix

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Ⅵ－2. 英国ポリテクニクの船舶機関士養成教育訓練

教科策定（ガイドシラバス）

Department of Education and Science
Elizabeth House 39 York Road London SE1
Telegrams Aridge London Telex 23171
Telephone 01-928 9222 ext 3296

To Local Education Authorities
and certain major Establishments
of Further Education

Your reference

Our reference
FECL 11/70
Date
30 April 1970

Dear Sir

ENGINEER CADET TRAINING SCHEME OF THE MERCHANT NAVY TRAINING BOARD

1. The Merchant Navy Training Board has drawn up a new scheme for the education and training of Marine Engineers to replace the existing Alternative Entry Scheme and to be known as the Engineer Cadet Training Scheme of the Merchant Navy Training Board.

2. Under the new scheme, the present G courses, ONC in engineering courses and courses leading to Part A of the Board of Trade Second Class Engineers Certificate of Competency will be discontinued and replaced by courses leading to the City and Guilds of London Institute Marine Engineering Technicians and Advanced Technicians Certificates. Provision is also included in the new scheme for courses for the OND in Engineering with a marine bias to continue to be offered for suitably qualified cadets. The new arrangements will apply to cadets entering the scheme in September 1970; those already on courses under the Alternative Entry Scheme will complete them in accordance with existing arrangements.

3. The industry's needs under the Alternative Entry Scheme have been adequately met for a number of years by the provision available in a very limited number of colleges, and there are no indications that the needs to be met via the new education and training scheme call for an increase in this number. Recruitment to the scheme will, as with its predecessor, be the responsibility of the shipping company by whom the cadet is employed, and cadets will be allotted to colleges under already established arrangements which have regard to the availability of places throughout the country. The responsibility for deciding whether cadets should enter the OND course (subject to the conditions prescribed in Rules 126) or the CGLI Technicians' course will rest with College Principals, who will no doubt collaborate closely with the training officer of the shipping company concerned.

PATTERN OF EDUCATION AND TRAINING UNDER THE NEW SCHEME

4. The Cadet Training Scheme comprises 3 stages:

PHASE I: Two years at a technical college, each year consisting of at least 38 weeks' tuition during which cadets will study for the OND in Engineering or the new CGLI Marine Engineering Technicians' Course (No 457). During the course, instruction in workshop practice will be given for a minimum of 6 hours each week and for a period of 6 weeks full-time in the college vacation between the first and the second years.

PHASE II: One year of shipboard service including leave as a cadet engineer (in place of one and a half years' sea service under the old Alternative Entry Scheme): of this period at least nine months must be service at sea under Articles and during this peri the cadet must cover the training activities set out in the record book obtainable fro the Merchant Navy Training Board.

PHASE III: One year of combined education and practical training during which OND cadets will study for supplementary subjects of the OND in Engineering course and other cadets will study for the CGLI Marine Engineering Advanced Technicians' Certificate. The training element in this Phase, which will normally take place in a college of further education but may, in some cases, be done in industry, has been reduced from 1200 to 600 hours.

THE COURSES

5. For those colleges currently operating the Alternative Entry Scheme appendices are attached to this letter. Appendix I describes the variations in the OND in Engineering course arrangements as they apply to cadets in the Engineer Cadet Training Scheme, and the recommended course structure. Guide syllabuses are also attached. Colleges should consult Rules 126 (July 1967), as amended by the recent supplement issued under cover of FEC\ 8/70, for details of the conditions and arrangements for the award of ONDs.

6. The CGLI Marine Engineering Technicians' and Advanced Technicians' courses are described in detail in Appendix II. A copy of the CGLI Regulations for the new courses will be sent to the colleges currently operating the Alternative Entry Scheme as soon as possible. Further copies may be obtained from the Institute.

EXEMPTIONS

7. Exemptions from the Board of Trade Engineers Certificates of Competency will be granted to cadets who successfully complete the scheme by qualifying as follows:-

OND IN ENGINEERING AND SUPPLEMENTARY SUBJECTS

Cadets who are awarded the OND in Engineering having passed in mathematics, applied mechanics, applied heat, electrical principles A and engineering drawing and design at the end of Phase I, and who pass the supplementary subjects mechanical technology, marine power plant technology, naval architecture and marine electrotechnology at the end of Phase III, will, provided that they have satisfactorily completed their Phase II sea service, qualify for full exemption from Part A and Part B Section 1 of the Board's examinations for second and first class Certificates of Competency.

CGLI MARINE ENGINEERING TECHNICIANS' CERTIFICATE AND ADVANCED TECHNICIANS' CERTIFICATE

Cadets who are awarded the technicians' certificate and the advanced certificate having passed applied mechanics, electro-technology, naval architecture and marine heat engines will qualify for full exemption from Part A and Part B Section 1 of the Board's examinations for second class Certificate of Competency, provided that they have satisfactorily completed their Phase II sea service.

8. Further details regarding the exemptions which may be granted by the Board of Trade to cadets who do not meet the full requirements set out in paragraph 7 above, and the courses which they should follow to secure maximum exemptions, will be notified to colleges as soon as possible.

APPROVAL OF OND SCHEMES

9. OND courses under the new scheme must be approved by the Joint Committee for ONCs and ONDs in Engineering and the Department in the usual way, and colleges should submit fresh applications on Form 95 FE in accordance with Rules 126. It would be appreciated if details of the CGLI technician courses were also sent to the Department for information, on Forms 95FE in triplicate.

10. Further copies of this letter, the appendices and the guide syllabuses may be obtained on application to FE B (Schemes), Department of Education and Science, Elizabeth House, 39 York Road, London SE1 (telephone No 01-928 9222 extension 3296).

Yours faithfully

H JORDAN

SYLLABUS RECOMMENDED FOR USE IN THE ORDINARY NATIONAL DIPLOMA COURSE IN ENGINEERING WHEN USED IN THE ENGINEER CADET TRAINING SCHEME OF THE MERCHANT NAVY TRAINING BOARD

NOTE

Reference should be made to Rules 126 (June 1967) and in particular to paragraph 4 of FECL 15/67 dated 6 July 1967 and the relevant parts of the appendix and Notes issued with this letter.

For ease of identification, these new syllabuses are to be referred to as Guide Syllabuses (Marine) and quoted as G(M) in col 3 paragraph 11 of Form 95FE (Note should be taken of the fact that no changes are proposed in the syllabus of Mathematics 01 and 02 and Physics 01 and 02. The Guide Syllabus issued with the rules in 1967, copies of which are attached for ease of reference, should be used).

PHASE I

MATHEMATICS 01 and 02

NOTES

Throughout the course emphasis should be placed on the teaching of fundamental mathematical ideas. Although a degree of confidence and competence in handling and interpreting a variety of mathematical situations will be developed, skill in manipulation for its own sake and the solution of artificially contrived examples to test this skill are considered inappropriate.

It is intended that course examinations should reflect this view, and that those should be devised to test the understanding of the mathematics rather than the use of particular tricks of formulae. Feats of memory, as such, need not be encouraged, and it is suggested that a full list of formulae, relationships etc be available for examination purposes. Such a list could include trigonometric relationships, standard integrals, series, and also notes on any 'trick' required to which, in practice, the student would have access in 'real life'.

Examination of the practical parts of the course (eg desk machine work) may present some difficulties in terms of availability of sufficient machines. If it is thought desirable that this practical element be assessed, it is suggested that this may be achieved in one or more of the following ways:-

i. by a separate practical paper designed so that a 'shift system' of examination is possible; eg by setting a large number of equivalent questions from which any batch of students are required to do 2 or 3;

ii. by maintenance and sample external assessment of practical notebooks;

iii. by theoretical questions in the normal written paper designed to test grasp of the principles of computation eg by 'programming' a given algorithm for machine computation.

The objective of section a. is to instruct the student in economic and accurate computation. After a brief revision of the use of logarithms, instruction should be concentrated on the routine calculations for the slide rule and on the correct use of desk machines for the fundamental arithmetic processes. Attention should be given to correct register setting, use of complements and partial complements and to economic layout and performance of calculations; some elementary flow programming of given algorithms may be appropriate. When familiarity with the machine has been attained, recourse should be made to it wherever appropriate. Sections marked * present obvious opportunities for further practice. The numberical methods suggested merely give a lead for discussion of flow-programming simple algorithms and need only to be stated.

In section d. the content enclosed in brackets should be used as a vehicle for the illustration of integration as summation, and it is anticipated that different colleges may wish to select different parts of this section for this purpose. Students need not necessarily be required to have studied every topic mentioned.

Development of the theory of section e, particularly probability and the idealised-distributions, should be preceded or accompanied by suitable experimental illustration. Most of the theoretical concepts can be demonstrated quickly and effectively by means of simple apparatus and it should be unnecessary to develop the mathematical theory with too much rigour at this stage. The essential feel and understanding of the inferential nature and power of statistical methods can thus be obtained by students with quite limited mathematical ability.

a. Computation

The layout of numerical calculations, significant figures, errors and accuracy, checking. Brief revision of logarithms as an aid in computation, and the use of slide rule and desk calculating machines. Use of simple approximate and interative methods (eg for square roots, reciprocals etc).

b. Algebra

Change of base of logarithms; Napierian logarithms; solution of equations such as $a^x = c$,

Graphical solution of equations, including transcentals; location of roots. Solution of three simultaneous linear equations by successive elimination* (with current sum checks).

Fitting equations to experimental data; linear form and those reducible to linear form; use of log-linear and log-log paper.

nP sum to infinity; elementary discussion of convergence.

The $\binom{n}{r}$ notation; (mention of permutations and combinations). Use of the Binomial expansion for any real index. Use in approximation of the series for the exponential, logarithmic, sine and cosine functions. (These series to be given in any examination.)

c. Geometry and Trigonometry

Radian measure. Trigonometric ratios of angles of any magnitude; periodicity and graphs of the circular functions.

Addition, product, and double-angle formulae. Notation of inverse circular functions; principal values.

Superposition of sine waves. Reduction of $a\cos\theta + b\sin\theta$ to the form $R\cos(\theta \pm c)$ etc.

Rectangular and polar co-ordinate systems; algebraic equation of a straight line. Simple curve sketching, characteristics of plane curves, eg symmetry, behaviour as x, y become large.

d. Calculus

Idea of limiting values; functionality; differentiation of algebraic, circular, exponential and logarithmic functions, of products, quotients, functions of a function, and simple implicit functions. Gradients; rates of change, maxima and minima. Idea of partial differentiation (1st order only).

2nd and higher order ordinary differentiation.

Integration as a summation and as the reverse of differentiation. Easy integration of standard forms by substitution, and by parts. Numerical integration*. (Illustrations from determination of areas volumes of revolution, mean and rms values, centroids and centres of gravity. Second moments of area of regular plane figures; parallel and perpendicular axes theorems; moment of inertia of a circular cylinder about its axis).

Formation of simple differential equations; solution by direct integration; boundary conditions.

e. *Statistics and Probability

Necessity for and limitations in collection of data; approximations and accuracy. Tabulation, graphical representation of data. Frequency tables. Types of average and measures of dispersion.

Elementary ideas of probability. Use of probability distributions as models. Binomial, normal and Poisson distributions. Sampling; standard error of the mean.

(Standard list of formulae to be issued for examination use).

GUIDE SYLLABUS (Marine)

PHASE I

ELECTRICAL ENGINEERING SCIENCE 01

It is not intended that all the subject matter should necessarily be covered by lectures, but that, where appropriate, students may acquire their knowledge of basic principles by means of suitably designed laboratory work.

THE ELECTRIC CIRCUIT

Kirchhoff's Laws and their application to the solution of resistive network problems not involving more than two simultaneous equations.

1 FROMAGNETISM

Magnetic fields, units and laws. Ferromagnetic properties of materials. Magnetisation curves and permeability. Use of B/H curves in calculations for series magnetic circuits ignoring leakage and fringing. Field due to a current in a straight conductor. Emf produced by induction. Force on a current carrying conductor in a magnetic field and force between parallel conductors. Torque on a rectangular coil in a uniform magnetic field. Mutual and self-inductance. Unit of inductance.

ELECTRIC FIELDS

Electric charge and Coulomb's Law. Force on a charge in a field, flux density, permittivity. Capacitance. Capacitors in series and in parallel.

ALTERNATING QUANTITIES

Definitions of cycle, period, frequency, peak and instantaneous values. RMS and average values of sine-wave, full- and half-wave rectified sine waves. The consideration of resistance, inductance and capacitance separately in ac single phase circuits with phasor diagrams for voltage and current Reactance.

ELECTRONICS

Outline qualitative treatment of conduction in conductors, semi-conductors and insulators. P- and N-type materials. The junction diode and simple applications. Zener action.

Thermionic emission. The vacum diode.

Rectification. Principles of operation and characteristics of common types of rectifier. Single-phase half-wave, full-wave and bridge connections. Waveforms and smoothing.

Simple treatment of the principles of operation of the cathode ray tube. Use of the cathode ray oscilloscope for the display of current and voltage waveforms.

ELECTRICAL MEASUREMENTS

Essential features of an indicating instrument, including deflecting, controlling and damping torques. The moving coil instrument including rectifier and thermocouple variants. The moving iron instrument. Use of these instruments and extension of range.

Resistance measurement by ammeter-voltmeter method (including correction for instrument loading), substitution, Wheatstone bridge, ohm-meter and insulation testers.

The simple d c potentiometer and its application to the measurement of voltage, current and resistance.

GUIDE SYLLABUS (Marine)

PHASE I

MECHANICAL ENGINEERING SCIENCE 01

MECHANICS

The principles of static equilibrium for co-planar forces, composition and resolution of forces, graphical determination of forces in simple framed structures.

Moments and couples, determination of centroids and centres of gravity for simple regular shapes.

Friction between dry surfaces, application to inclined planes, angle of repose.

The laws and efficiencies of simple machines.

Further work on simple elasticity, Young's modulus.

Introduction to the load-extension diagrams to fracture, and to yield and ultimate stress. The concept of factor safety.

Measurement of pressure by means of manometers and simple pressure gauges, calibration of gauges and sources of error. Work done by variable pressure, indicator diagrams.

The kinematics of uniformly accelerated linear motion, space velocity and acceleration - time graphs.

Relative velocity images and vector diagrams for unconnected bodies and for simple mechanisms. Centripetal acceleration.

Newton's laws of motion and their application to uniformly accelerated linear and uniform angular motion, the concepts of momentum and inertia

Impact of jets on fixed vanes. Centrifugal forces and their applicatio to simple co-planar balancing.

APPLIED HEAT

Basic Concepts

Temperature and measurement, the application of, and source of error in various types of thermometers, including thermocouples and radiation pyrometers. Qualitative treatment of heat transfer by conduction, convection and radiation: simple quantitative treatment of conduction

and radiation including conduction through a plane composite wall. Energy and principle of conservation of energy. Concept of a system; specification of its boundary. Work and heat; definition for thermodynamic purposes. Units. Properties of and state of a system. Specific properties.

First Law

First law of thermodynamics. Energy of a system as a property; $Q - W = \Delta E$. Terms involved in ΔE; internal energy, kinetic energy and potential energy. Definition of enthalpy. Choice of datum.

Non-flow Processes

Application of the first law to non-flow processes; constant volume, constant pressure, and adiabatic processes.

Steady flow

Application of the first law to steady flow processes. Continuity equation and "Steady flow energy equation". Application to simple plant, eg boiler, compressor, turbine, nozzle, throttle.

GUIDE SYLLABUS (Marine)

PHASE I

WORKSHOP PROCESSES, MATERIALS AND COMMUNICATIONS 01

The syllabus is designed to encourage the study of a limited range of production or working processes in such a way as to link them with the drawing and diagramming which are the language of manufacture. Instruction in processes should summarise the main principles involved and give selected practical examples to illustrate them rather than to describe a wide range of skills and techniques. Instruction should take into account throughout that factors such as time, cost and safety are implicit in all production operations. The purpose of the drawing section is not to develop draughtsmanship skills but to show how engineering drawing is employed in a system of communication to transmit exact instructions for work to be done, including a realisation of the importance of manufacturing costs. Much of the factual material of processes might be given in pre-produced note form with many of the diagrams forming part of the communications practice.

Introduction

Revision through practical examples of basic concepts in engineering drawing such as layout, spacing, relationship of views, pictorial representation, and dimensions.

Where several teachers are involved in the presentation of this syllabus it is considered essential that close harmony of working be achieved so that the two parts can be properly integrated.

Processes	Communications
1. Geometric basis of machining processes. Solid objects as a combination of plane surfaces, circles and cylinders related to machine movements. Alternative ways of producing elements of form by setting and manipulation of the lathe, shaping machine, milling machine, and drill. Typical components and machine settings.	Drawing of components to be produced by machining methods. Relating the article to the method and practicalities of production.
2. Introduction to relationship between performance and geometry in the basic metal-cutting wedge. Examples of the wedge in tools for the above machines. Choice of simple tools and cutters for typical machinery operations.	Drawing and diagrammatic representation of cutting tools and cutters. Use of standard nomenclature. Indication of tool angles and sizes. Typical tool-holding and locating devices.

3. Introduction to the control of size on machine tools eg precise movement of slides and tools. Measurement of work-pieces by micrometer, vernier, and comparator methods. Accuracy of determination. Sources of error due to forces acting, heat and lack of support. Use of simple plug and gap gauges.	Use of dimensions to BS308 and tolerances to indicate manufacturing requirements. Application of BS1916C (Primary Selection of Fits), BS surface finish numerals and machining symbol. Other instructions such as reference points or planes and conventional representations. Avoidance of redundant dimensions.
4. Marking out and production of profiles and hole centres to assist machining.	Use of points, lines, circles, and the geometry of combination and intersection to produce profiles and layouts. Simple cases of dimensioning.
5. Examples of the combination of hand and machine cutting methods in typical components. Limitations of hand processes and tools. Operation sequences to describe machining and assembly. Examples of choice of materials in relation to machining and performance. Basic composition, properties, uses and machining characteristics of plain carbon steel, cast iron, plain brass, bronze, and gun-metal.	Drawing of typical assemblies with mechanical and electrical application. Use of parts lists and cross-referencing. Drawing of details for and from assemblies. Simple examples of the accumulation of tolerances. Use of standard drawingsheets.
6. An outline of the principles of sandcasting using wooden patterns and pattern plates with simple cores.	Drawings of simple castings having regard to the method of casting and to dimensioning for casting and for machining.
7. Choice and use of joining processes for typical applications in sheet and plate up to ¼ inch thick including soldering, brazing, fusion welding and rivetting.	Exercises in the development of simple bent, folded and built-up shapes in sheet and plate. Use and indication of joints. Symbols for the indication of simple welds.
8. Properties of the more common types of pipe; methods of bending and joining for the transmission of water, gas, and oil under pressure.	Diagrams and drawings to describe simple pipework circuits and connections.
Outline of properties and use of the more common conducting and insulating materials used in electrical and electronic equipment. Typical wires and cables and their uses. Wiring systems (Electrical and electronic). Simple standard	The use of diagrams, charts and standard symbolic notations to describe wiring requirements, circuits and systems of distribution. General layout of typical circuits. Drawings and constructional details of electrical assemblies such as

connections, joints and terminations. Cable forms. Non-insulated connectors, eg bus-bars, switches and isolators. Fixing and handling in relation to voltage and current rating. Introduction to the basic functions and requirements of a marine electrical installation. The need for Regulations (IEE, BoT and Classification Societies). The importance of protection against excess current, shock, fire and explosion risks, corrosion, mechanical damage, moisture. Basic ideas on protection against excess currents.

switchboards and panels. Drawings and constructional details of equipment packs and small motive units (eg navigational lights, fans and heaters). Indication of component requirements, fixing details and methods.

PHASE I

PHYSICS 01 and 02

The syllabus is intended to provide a sound foundation in those branches of physics likely to be of use to the engineer. An attempt has been made to provide a course which is a coherent whole extending over two years. The syllabus is, in general, outline only and details have been purposely omitted to give individual lecturers some scope for originality within the suggested framework. Amplification should be in breadth rather than depth remembering that, where appropriate, emphasis should always be given to engineering applications. Some of the traditional mathematical approach could be eliminated without, it is hoped, loss of understanding eg in the section on optics the student should appreciate how the principles of optics are applied in the field of engineering measurement. Thus, it is not intended that ALL formulae should be rigidly derived but it is essential that where this is not done the physical basis of the problem should be carefully explained, the problem formulated, the method of attack indicated, and then the result quoted (or very quickly derived) and its physical significance carefully explained. Nevertheless the need still remains for adequate practice with numerical examples in certain parts of the syllabus to emphasise principles and give students familiarity with the magnitudes of the quantities with which they are dealing. Although "units and dimensions" is not a topic specifically mentioned in the syllabus, this could be discussed profitably at some convenient point, indicating the relationship between the various systems of units in common use, the advantages and disadvantages of each system and giving examples to show the numerical values of the same physical quantity in different units.

The time for individual practical work is short and hence it is extremely important that lectures be illustrated by carefully designed demonstrations, animated models, etc. Visual aids in the shape of slides, film strips and full length films should be used whenever possible. Some class practical work should be included in which the lecturer acts as supervisor only during the actual experiment but subsequently initiates a discussion on the merits of the observations, limits of accuracy, errors involved and how they could be minimised, etc. THE POSSIBILITY OF INCLUDING PROJECTS, PARTICULARLY IN THE FIELD OF MEASUREMENTS IN THE PRACTICAL WORK SHOULD BE EXPLORED - more benefit is derived from a few well-chosen experiments than from many of a routine nature in which the result is already known to the student to a much greater accuracy than he can ever hope to achieve.

PHASE I

PHYSICS 01

HEAT

Revision of gas laws and their combination. Gas thermometer.
Absolute temperature scales. The International Temperature Scale.
Thermocouple, optical pyrometer, resistance thermometer with industrial application. Use of recorders.
Continuous flow calorimetry. Fuel calorimetry.
Change of state.
Conduction (good conductors).
Revision of mechanical equivalent of heat and its determination.
Saturated and unsaturated vapours. Dalton's law of partial pressures.

GEOMETRICAL OPTICS

Optical reflection and refraction and their engineering applications, including:-
Reflection at plane surfaces. Optical lever and applications.
Rotation of mirror.
Reflection at spherical surfaces. Formation of images by spherical mirrors (graphical only).
Refractive index of solids and liquids.
Refraction through prisms. Deviation. Dispersion.
Formation of images by single thin lenses, convex and concave (graphical only).
Chromatic aberration. Achromatic combinations (qualitative only).

SOUND

Simple harmonic motion.
Wave motion - transverse and longitudinal.
Pitch, loudness and quality. Velocity of sound.
Reflection and refraction of sound - application to echo-sounding and crack detection. Beats.
Progressive and stationary waves.
Vibrations of beams and plates.

SOUND

Simple treatment of force vibrations and resonance.
Intensity and loudness of sound. The decibel and phon.
Simple acoustics of buildings - reverberation.
Principles of methods of recording and reproducing sound.

PHASE I

PHYSICS 02

GENERAL PHYSICS AND HEAT

Elementary treatment of kinetic theory of gases - idea of mean free path.

Simple vacuum apparatus; the rotary pump, the diffusion pump and the McLeod gauge.

Hygrometry; industrial hygrometers.

Adiabatic and isothermal changes. Use of $pv = k$ (no proof).

Conduction (good and bad conductors). Commercial heat-insulating materials.

Radiation. Full radiators. Stefan's law.

Qualitative account of energy distribution in the spectrum of a full radiator.

Elements of quantum theory (qualitative only) leading to $E = 6$

OPTICS

The Electromagnetic spectrum. Production of visible spectrum.

Simple emission and absorption spectra.

Colour, additive and subtractive. Filters.

Principles of photography. The camera and photographic plate.

Use of filters in photography. Exposure, developing and fixing.

Optical interference. Division of wave front - Young's slits. Division of amplitude - Newton's rings.

Qualitative account of the diffraction grating and its use in the control of machine tools.

Qualitative account of polarisation of light. Uses of polarised light in stress analysis, etc.

ATOMIC PHYSICS

Simple atomic structure. The electron, proton and neutron.

The Periodic table and valency. Isotopes.

Process of ionisation; + and - ions. Ionisation current. Excitation and ionisation by collision.

Discharge through air at low pressures. Cathode rays.

Release of electrons by heat, light, particle bombardment and the action of electric fields.

Deflection of an electron beam in electric and magnetic fields. Cathode ray tube; electrostatic and magnetic focussing (qualitative).

NUCLEAR PHYSICS

Radioactivity. Half-life. Qualitative description of α, β and γ radiation.

Detection and counting of ionising particles; cloud chamber, counter and photographic plate.

Shielding and radiological safety precautions.

Applications of radio-isotopes.

Note on Examinations

Topics in the 01 year under Heat, Geometric Optics and Sound will be included in the Final assessed examinations at theend of the 02 year.

GUIDE SYLLABUS (Marine)

APPLIED MECHANICS 02

The subject matter should be developed in a logical manner so as to emphasize the general application of basic principles. 'Training' in the solution of standard problems should be avoided and in contrast every effort should be made to develop the students' analytical technique in the application of basic principles to a wide variety of engineering problems.

Equilibrium

Analytical and graphical conditions - application to more difficult problems than previously met.

Application to framed structures.

Application to fluids at rest - total thrust, centre of pressure.

Bending Moment and Shearing Force

Consideration of concepts.

Application to simply supported beams and cantilevers subjected to concentrated and uniformly distributed loads.

Deformation of Materials

Direct and shear stress and strain - revision with more difficult examples than previously met.

Stresses in compound bars, thin cylinders, rotating hoops. Stresses due to temperature change.

Principles and significance of tensile compression, torsion hardness and impact tests of materials.

Theory of bending - proof of relationship $\frac{\sigma}{y} = \frac{M}{I} = \frac{E}{R}$ and applications.

Theory of torsion - proof of relationship $\frac{\tau}{r} = \frac{T}{J} = \frac{G\theta}{L}$ and applications.

Equations of motion

Revision of previous work and extended to the consideration of the relationships between space, velocity, acceleration and time when acceleration varies.

Laws of Motion

Revision with more difficult examples - d'Alembertis principle.

Momentum, energy and work - impact.

Motion under forces varying with time, distance and velocity.

Angular Motion

Torque and acceleration, moment of inertia, moment of momentum, kinetic energy of a rotating body.

Work and energy in angular motion.

Centre of percussion.

Fluids in Motion

Bernoulli's equation. Flow through orifices, pipes and venturis.

Impact of jets on moving plates and vanes.

Simple Vibration

Basic principles and the analyses of given systems.

Circular Motion

Centripetal acceleration - centripetal and centrifugal force.

Naval Architecture

Weight, buoyancy and displacement. Simpsons first rule, application to areas, volumes, first and second moment of areas, TPC. Effect on draught of density, centre of flotation, buoyancy, centre of buoyancy, reserve buoyancy, centre of gravity, Displacement curve, deadweight, deadweight scale.

GUIDE SYLLABUS (Marine)

PHASE I

APPLIED HEAT 02

Gas Laws

Simple qualitative treatment of the kinetic theory of gases; concept of a perfect gas, leading to an explanation of Boyles Law, and Charles Law, and Daltons Law of partial pressures. Characteristic gas equation; gas constant and units, universal gas constant; specific heats; relationship between specific heats and gas constant. Mixtures of gases; proportions by mass and volume. Conversion from mass to volumetric analysis, and vice versa.

Reversibility

Reversibility and irreversibility. Concept and characteristics of a reversible process. Specification of a process path. Significance of area under the path on a pressure-volume diagram.

Perfect gases

Evaluation of specific heats and gas constant for a mixture of perfect gases. Behaviour of real gases compared with the perfect gas.

Other simple substances

Properties of real fluids where more than one phase occurs. General phase diagrams. Wet, dry saturated and superheated states. Tabular and graphical representation of properties.

Displacement work

Evaluation of displacement work for certain simple equilibrium processes (for any fluid), viz: constant volume, constant pressure and polytropic. Special cases of the isothermal and the reversible adiabatic processes for a perfect gas.

Property diagrams

Representation of the state of a system and of the above simple equilibrium processes on property diagrams in terms of the properties pressure, specific volume, temperature, internal energy, enthalpy and combinations of such processes to form simple ideal cycles (both for a perfect gas and for other fluids).

Heat Engine

Definition of a heat engine. Efficiency. Reversed heat engine. Carnot principle. Impossibility of 100% efficiency. Statement (but not derivation) of maximum efficiency of a heat engine where heat transfer occurs at two temperatures only, in terms of an absolute scale of temperature.

Chemistry of fuels

Minimum air requirements for combustion of solid, liquid and gaseous fuels. Calorific value and its experimental determination. Determination of the proportions by mass and volume of products of combustion and their conversion. Effects of excess and inadequate air supply.

GUIDE SYLLABUS (Marine)

PHASE I

ENGINEERING DRAWING AND DESIGN 02

Instruction should proceed through a planned sequence of practice and familiarisation to the use of drawing and analysis to describe a complete design. The student should be encouraged to incorporate commercially available standard parts, and to make liberal use of commercial literature in the selection of these parts. He should be constantly reminded that a successful design has to be manufactured and assembled, and to this end as many as possible for the final projects should be constructed. In some cases mock-ups in plaster, plasticine, wood, cardboard or polystyrene may be more useful.

It is for the college to arrange the topics or drawing and design to be meaningful within the field of marine engineering in which the student is serving or for which he is being prepared, and to encourage him to observe and to draw upon his works experience wherever possible.

A considerable amount of the background reading and the preliminary work for the project and the other exercises should be done by the student in his private study.

Geometry

Application of geometrical principles to practical problems such as:-

a. three dimensional structural frameworks, tunnels and pipes, bus-bar systems, and the inclination of strata;

b. interpenetration of plane, cylindrical, conical and spherical surfaces, including transition pieces;

c. construction of envelopes, outlines and forms of practical consequence as in the movement of typical mechanisms, or the use of templates and projection masters.

Machine Drawing

Revision of the basic principles of orthographic projection using shapes of increasing visualisation difficulty. Drawing and sketching of orthographic views from given isometric views and isometric views from given orthographic views. Auxiliary views.

Sectioning. Conventions for sectioning. Sectioning of single components, including removed, revolved and stepped-plane sections. Sectioning of simple given assemblies.

Assemblies. Drawing of assemblies from given details.

Detailing. Detailing from given assemblies, without tolerancing.

Drawings containing tolerances. Acceptable values, based on function only. Introduction to the application of very simple geometrical and positional tolerances. Detailing from given assemblies with tolerancing.

Drawing examples requiring the use of typical drawing office standard parts lists, commercial standards parts and components such as bearings and fastenings, liquid and gas seals, and other bought-out items. Extraction of information from catalogues and specifications.

Familiarisation with common engineering components and assemblies (including electrical equipment) through stripping down, measurement and observation, leading to drawing and sketching exercises.

Materials: Applications of materials in common use with reference to their effective mechanical and other properties. Influence of properties, forms of supply, availability and cost on their suitability for the various components and assemblies used in the drawing exercises done throughout the course.

Design

Basic Considerations in Design

Illustration of the application of the basic ergonomic principles in the design of simple equipment, instruments and controls.

Factors influencing design. The need to consider function, selection and availability of materials, methods of forming and joining the materials and surface finishing processes. Aesthetic considerations; proportion, form, texture, colour. User, sales, and service factors in designs, particularly in consumer goods.

Analysis and construction of specifications. Feasibility studies on simple design problems based on given specifications.

Introduction to Engineering Design

Practical analysis and design of simple single components.

Simple designs framed around a principal manufacturing process, eg casting, fabrication, machining, sheet forming, plastic moulding. Problems of emergency repairs, recognition of causes of failure. Exercises in re-design for fewer parts, greater ease of manufacture, improved operation cost reduction and change of material or technique.

Critical appraisal of existing designs. Introduction to elementary value analysis.

An elementary introduction to the idea of force flow through an assembly and its consequence in engineering design.

GUIDE SYLLABUS (Marine)

PHASE I

ELECTRICAL ENGINEERING 'A' 02

It is not intended that all the subject matter should necessarily be covered by lectures, but that, when appropriate, students may acquire their knowledge of basic principles by means of suitably designed laboratory work.

ELECTRONICS

(It is essential that this section is dealt with early in the session so that it can back up the Instrumentation syllabus and the practical work on electronics included in Workshop Practice).

Basic concept of the amplification of small signals by electronic and other means.

Construction and operation of the transistor and the vacuum triode. Introduction to their characteristics. Precautions with transistors. Setting biases and quiescent conditions. Graphical treatment by means of load-line for transistor (common-mitter configuration) and resistance-loaded triode (common-cathode connection). Introduction to the parrameters and the concept of an equivalent circuit. The transistor as a switch.

SINGLE-PHASE A C THEORY

Series a c circuits with phasor diagrams. Phase angle, impedence, triangle, power, kVA and kVAr, resonance. Simple parallel circuits: admittance triangle, resonance. Power factor improvement.

POLYPHASE A C THEORY

Three-phase supplies: reasons for adoption. Simple three-phase alternator. Star and delta connection of three-phase circuits. Voltage, current and power relationships in balanced systems only.

FURTHER ELECTROMAGNETISM AND ELECTROSTATICS

Energy stored in an inductor and in a magnetic field. The B/H loop. Energy losses in iron due to cyclic magnetisation. Simple descriptive treatment of voltage and current changes in inductance - resistance series circuits: time constant.

Energy stored in a capacitor and in an electric field. Simple descriptive treatment of voltage and current changes in capacitance - resistance series circuits: time constant.

TRANSFORMERS AND MACHINES

Transformers: brief details of construction; principles of operation under no-load conditions, the e m f equation. Load conditions ignoring leakage reactance and winding resistance, simple phasor diagrams.

The production of an induced e m f and torque in a coil rotating in a two-pole magnetic field, leading to a simple unified treatment of the principles of electrical machines. The general factors affecting e m f torque and speed of the coil. Energy balance in electro-dynamic systems.

Classification of windings as concentrated, phase and commutator. The more common types of machine defined by the combination of windings employed and the nature of their supply. Production of a rotating magnetic field by three-phase currents. Speed and torque relationship of the three-phase induction motor and d c motors derived from GENERAL CONSIDERATION.

Construction and connections of d c generators and motors. Commutation and poles. Generator: e m f equation, self-excitation, characteristics. Motor: torque production, e m f characteristics, starting, speed control.

Measurements

Principle and use of the air-core dynamometer wattmeter. Extension of range of instruments by the use of instrument transformers. The universal test meter.

GUIDE SYLLABUS (Marine)

PHASE I

WORKSHOP TECHNOLOGY 02

Instruction in this subject should be so organised as to convey important basic principles rather than to describe common practice at length.

Information should, as far as possible, be conveyed through experiment, demonstration, project work and other forms of practical activity rather than extensive note-taking. Students should be expected to amplify and extend summarised information by personal reference to technical and trade literature and other suitable directed reading.

Safety and safe practices should form an integral part of all instruction especially that relating to machinery in motion and to electrical supplies.

It is expected that equal amounts of time will be allocated to each main section of the syllabus.

Engineering Materials

A summarised account of the relationships between basic composition, physical properties, and typical engineering uses of the following metals:-

Plain carbon steels;

Plain brass, bronze, and gun-metal;

Low alloy Ni and Ni Cr structural steels;

Basic Al base alloys;

Common bearing metals;

Common Zn base and Al base die-casting alloys;

High duty, malleable, and SG cast irons;

An outline and comparison of the properties and applications of the more common high speed steels and sintered carbides for cutting tools.

A brief outline of the more common thermo-setting and thermo-plastic plastics of importance in engineering, including p v c and nylon. Importance of catalytic resins adhesives and in fabrications, such as glass-fibre construction.

Heat Treatment

Basic principles and terminology of heat-treatment explained by reference to the heat treatment of plain carbon steel.

An outline of the effects on properties and response to heat-treatment of Ni, Cr, Mo and Mn in steel, including temper-brittleness.

An elementary account of solution and precipitation treatment of AL alloys.

A review and comparison of methods of local hardening by case-carburising and local heating.

Basic Forming Processes

The main process outline and equipment involved in the following processes:-

The sand-casting process and its extension by the use of pattern plates;

Pressure die-casting;

Injection and transfer moulding of plastics;

Hot and cold forging;

Rolling and extrusion;

Introduction to the principles of blanking, punching and bending with simple press tools.

Metal Forming by Cutting

An elementary treatment and analysis (related to previous work in O1) of the relations between tool geometry, cutting forces, power consumption, and tool life. Identification of essential tool angles in single point tools, drills, and milling cutters.

Explanation of the essential forming/generating function of metal cutting machine tools and derivation of accuracy from machine geometry.

Simple analysis of the geometry and range of functions of the centre-lathe, drilling machine, milling machine, and cylindrical grinder. Sources of error and normal expectation of accuracy.

Line diagram explanation of basic transmission systems for the above machines.

Methods of holding typical workpieces.

An outline of typical machining methods, including simple vee threads. Elementary process planning; consideration of production times, floor to floor times, and cost of production in relation to machining methods.

Dimensional Control

Principles of interchangeability. Basic principles of the British Standard system (BS 1916) of limits and fits for plain work. Examples of gauging by, fixed size, adjustable, and indicating gauges.

Principle of comparative measurement; operating basic principles of typical mechanical comparators and their uses; calculation of magnification and accuracy of determination. Simple consideration of the cost of increasing accuracy.

BS requirements for workshop standards of length, flatness, straightness and squareness.

Use of the dial indicator for setting and testing purposes.

The use of the optical projector for control of form and size; advantages and limitations. Preparation and use of typical master forms.

Welding

Plate cutting and welding. Oxy-acetylene, arc welding, resistance welding, submerged arc and inert gas welding. Details of butt and lap joints. Advantages and disadvantages of welding compared with riveting. Common faults. Methods of testing welds.

Welding sequences, prefabrication. Lloyd's requirements in respect of butt and fillet welds, scalloping.

GUIDE SYLLABUS (Marine)

PHASE I

INSTRUMENTATION 02

This subject is intended to be essentially an introduction to Control Engineering (Phase III), and in order to familiarise students with the instrumentation equipment and the application of measurement techniques, stress should be laid on demonstration and experimental work.

Pressure Measuring Instruments (used also to measure Flow and Liquid Level)

Operation of diaphragms, capsules and bellows for pressure measurement.

Use of draught gauges, inclined manometers, and U tube manometers.

Operation of Bourdon tubes: C type, spiral and helical.

Demonstration of pressure switches.

Introduce air supply for transmission. Use of filter/regulator.

Demonstrate pneumatic pressure transmitter and receiver pressure gauge.

Air purge and bubbler systems; use with liquid cargo tanks.

Range suppression on pressure head meters; corrections and calculations.

Use of seal and condensate chambers.

Differential pressure instruments. Use of manometers with orifice plate and venturi to measure flow. Application of Bernoulli's theorem to working flow formula.

Use of position balance and force balance instruments. Pneumatic and electrical flow transmitters and receivers. Linear and square root charts. (Emphasise principles used later for control, eg flapper/nozzle in pneumatic transmitters.)

Use of pressure switches with alarm contacts and electrical transmission for annunciator lights and warning systems. Use of strain gauges with bridge circuits. Scanning of several measurements and switches with multiplexing of signals for remote reading.

Additional Flow and Liquid Level Instruments

Positive displacement and turbine meters; variable area meters. Pulse transmission. Displacement gauges; float switches, external float cage instruments. Electrical probes for liquid level measurement.

Temperature Measuring Instruments

Bi-metallic thermometers; application of thermostats.

Filled systems, capillary tubes, pneumatic and electrical transmitters.

Resistance thermometers, thermocouples and compensating cables. Use of multi-point potentiometric indicators and recorders.

GUIDE SYLLABUS (Marine)

PHASE III

MARINE POWER PLANT TECHNOLOGY

MARINE BOILERS

Fire tube boilers. Water tube boilers for medium and high steam temperatures.

Construction and materials including refractories.

Gas, air, water and steam flow circuits in typical boilers. Tube sizes.

Boiler mountings and internal gear. Safety valves; principles of operation.

Water level control.

Superheaters; types and control.

COMBUSTION

Furnaces, registers.

Burners; pressure jet, steam assisted, rotary cup.

Oil fuel burning systems and safety devices.

Air supply, air/fuel ratio, air heaters and economisers.

STEAM TURBINES

General design and construction.

Blades and blade fixings.

Glands, gland sealing and aspiration.

Bearings, thrust blocks and couplings.

Lubrication and control system; self-closing emergency valves, governors, over-speed trips.

Reduction gear.

CONDENSERS AND FEED SYSTEM

Condensers, design and construction. Ship's side and emergency valves.

Closed feed system; extraction pumps, air ejectors, de-aerators, regenerative heating, system modules. Control of system when manoeuvring.

Feed pumps.

EVAPORATORS

Process of distillation

Principles of construction; single and two-stage submerged coil, flash evaporators, mountings, protection devices.

Output; conditions for stable operation.

DIESEL ENGINES

Two-stroke and four-stroke engines; general design and construction of major types.

Injection systems: injectors and pumps.

Combustion.

Scavenge and supercharge systems.

Timing. Interpretation of indicator diagrams.

Pistons and liners.

Cooling system; piston cooling.

Lubricating system.

Fuel system for high viscosity fuels; centrifuging, heating and viscosity control, viscosity curves.

Governors.

Crankcase safety devices.

Air starting and reverse systems.

Utilisation of exhaust gas.

Gearing and drives.

Auxiliary plant modules.

AUXILIARY MACHINERY

Bilge and ballast systems.

Oil fuel filling and transfer systems; centrifuges and filters.

Oily water separators; Oil in Navigable Waters Act.

Pumps and pumping principles, displacement and centrifugal pumps.

Fire pumps.

Power-operated water-tight doors.

Mechanical aspects of turbo and diesel generators and alternators.

Refrigeration and air-conditioning; cargo and domestic plant.

PROPULSION SHAFTING

Shaft construction and arrangements; thrust blocks, stern tubes, shaft bearings, locking and trailing methods.

STEERING GEAR

Types of steering gear and power unit.
Methods of connection to rudder.
Telemotor system.
Safety devices.

GAS TURBINES

Turbo superchargers.
Free piston/gas turbine.
Auxiliary open cycle gas turbine.

GUIDE SYLLABUS (Marine)

PHASE III

Mechanical Technology

APPLIED MECHANICS

Kinematics

Revision and extension of previous work on velocity in mechanisms. Rapson's slide. Calculation of piston displacement, velocity and acceleration for the reciprocating engine mechanism. Use of displacement-time and derived curves for design of cams.

Friction

Revision and extension of previous work on friction. Application to design and analysis of screw thread, thrust bearing, plate and cone clutches.

Dynamics

Application of previous work to the equilibrium of governors, central and spring loading, sleeve friction. Centrifugal pumps. Use of principles of relative velocity and of fluid flow over moving vanes to determine work, power and blade efficiency.

Stress analysis

Stress in oblique planes induced by a. single direct stress, b. two direct stresses at right angles, c. complementary shear stresses.

Theory of Bending

Revision of earlier work and extension to relations between loading, shear force, bending moment, slope, deflection. Calculation of deflection in cantilevers and simply supported beams by Macaulay's method. Combined bending and direct stress, eccentric loading of short columns. Struts, derivation of Euler formula, development of Rankine formula.

Theory of Torsion

Further work on torsion in solid and hollow shafts; close coiled helical springs.

Strain Energy

Calculation of strain energy in tension and in torsional shear. Impact loading of tie rods and springs.

Steam Power Cycles

Carnot and Rankine cycles; p-v and T-S diagrams.

Determination of power output, cycle efficiency, work ratio and steam consumption.

Rankine efficiency; effect of boiler pressure, superheat, reheat and regenerative feed heating.

Thermal efficiency.

Energy balance.

Application of Dalton's law of partial pressures to air/steam mixtures.

Steam Turbines

Basic cycle and modifications; impulse and reaction types, pressure and velocity compounding.

Determination of steam conditions at each stage.

Nozzles; calculation of velocity of flow, effect of friction.

Use of velocity diagrams to evaluate blade angles.

Shaft power and axial thrust, effect of friction, diagram or blade efficiency.

Refrigeration and Heat Pumps

Reversed Carnot cycle.

Vapour compression cycle; representation on property of state diagram, relation of pressure, volume, temperature and enthalpy. Coefficient of performance.

Vibrations

Natural frequency of springs and shafts. Examples of resonance including whirling.

APPLIED HEAT

Revision

Energy equation.

Reversibility.

Definition of a heat engine.

Carnot principle.

Entropy

Concept of entropy (explained using Carnot cycle)

Property diagrams incorporating the property entropy; representation of simple equilibrium processes in terms of the parameters of state, including that of reversible adiabatic as isentropic.

Ideal Cycles

Constant volume, constant pressure and dual combustion cycles; representation on property of state diagrams; relation of pressures, volumes and temperatures; air standard efficiency in terms of temperature for the constant volume cycle.

Air Compressors

Isothermal and isentropic compression and efficiency.

Calculation of work done in an ideal single cylinder air compressor.

Volumetric efficiency; effect of clearance.

Diagrammatic treatment of multi-stage compression and intercoolers.

Internal Combustion Engines

Actual cycles; determination of indicated and brake power, mechanical efficiency, thermal efficiency, gross and specific fuel consumption.

Energy balance.

Gas Turbines

Open and closed cycles.

Basic cycle; calculation of work and power.

GUIDE SYLLABUS (Marine)

PHASE III

Naval Architecture

Outline of design requirements for ships.

Basic ship types – restricted to general cargo ships, bulk carriers and oil tankers – typical deadweight, dimensions.
Structural sections of basic ship types showing system of framing.

Construction of all parts of steel ships for welded and combined welded/riveted ships.

Storage and ventilation. Ventilation of holds and oil fuel tanks. Bilge and ballast arrangements. Levelling arrangements for damaged side compartments. Dry docking. Docking stability. Inspection of hull, pipe fittings and connections. The preservation in good condition of the ship's structure, in particular the bilges, bunkers, watertight doors and tanks under boilers and watertight doors. Cathodic protection.

Simpson's rules.

Further work on – areas, volumes, 1st and 2nd moments, displacement, bouyancy, TPC, coefficients of form, wetted surface area. Centres of gravity including the effect of suspended weights.

Stability. Stability at small angle of heel, metacentre and metacentric height. Proof that $BM = \frac{I}{\nabla}$. Effect of free surface on stability. The inclining experiment.

Stability. The inclining experiment.

Statical. Outline of method used to derive cross curves. Stability information supplied to ships. Load line requirements.

Trim

Changed in end draughts due to adding, removing or moving weights of small and large magnitude. MCT 1cm Changed in mean draught due to bilging a midship compartment. Change in draughts due to bilging an end compartment (calculations restricted to box barge forms).

Resistance

Components of resistance. Dimensional analysis and the application to ship's resistance. Calculation of frictional resistance. Froude's Law of comparison. Estimation of residual resistance. Total resistance, roughness allowances and effective power. Admiralty coefficient, fuel coefficient and fuel consumption.

Propellers

Definition of propeller terms. Calculation of slip, wake and thrust. Relation between thrust. Presentation of propeller data. The causes, effects and avoidance of propeller cavitation. Care and maintenance of fixed and variable pitch propellers. Bow thrusters.

Powering

Thrust deduction. Hull efficiency. QPC. Relation between powers. Trial trips and interpretation of results.

Strength and vibration

Buoyancy, weight, load, shearing force and bending moment curves. Stress data supplied to ships. Use of stress indicators. Causes, reduction and prevention of vibration. Calculations using approximate formulae.

Gross and net tonnage, alternative tonnage. Load line regulations, conditions of assignment, markings.

GUIDE SYLLABUS (Marine)

PHASE III

Marine Electrotechnology

GENERATION

D C Generators: Control and operating techniques.

Comparison of characteristics with particular reference to suitability for marine applications.

Parallel operation, load sharing, equaliser connections.

Regulations with particular reference to instrumentation.

A C Generators: Brief comparison of salient, non-salient and brushless alternators with particular reference to applications.

Waveform improvement, winding factors.

Simple phasor diagrams, load characteristics, voltage regulation and the effects of armature reaction at various load power factors.

Estimation of synchronous impedence. Short circuit conditions.

Parallel operation; load sharing, synchronising techniques (manual and automatic), lamps dark and bright methods, phase rotation tests and the synchroscope.

AUTOMATIC VOLTAGE REGULATORS

Requirements: regulations stating permitted voltage limits - refer to response.

Basic design: detector, corrector and stabilising elements.

Types: outline of suitable types with detailed consideration of say two eg carbon pile, electronic, magnetic amplifier.

MOTORS

D C MOTORS

Comparison of characteristics with particular reference to suitability for marine applications, Speed torque control systems.

A C MOTORS

Induction motors; revision of basic theory and characteristics. Phasor diagrams. Losses. Types eg singlephase, cage, wound rotor.

Synchronous motors; basic principles including characteristics.

Reference should be made to other types of a c motor, eg a c commutator machines, linear motors.

STARTING AND CONTROL EQUIPMENT

Connection diagrams for d c starters and controllers, direct on line, star/delta, auto-transformer and wound rotor a c starters. Both single and polyphase starters should be outlined. Pole changing.

Note: particular reference to suitability for specific duties should be made throughout this section of the syllabus.

DISTRIBUTION SYSTEMS

Permitted systems (I E E & Lloyd's Regulations); factors affecting choice of system.

Emergency supplies; reference to self contained and integral a c and d c systems.

Protection; preferential tripping, switches, isolators, contactors, circuit and earth leakage breakers, fuses, current and power relays. Short circuit protection. Isolators with particular reference to earthing of high voltage equipments/systems for safety.

TRANSFORMERS

Further work on the construction of single and polyphase units. Connection diagrams.

On load phasor diagrams. Regulation. Short circuit conditions. The auto-transformer: general considerations of advantages/ disadvantages for marine applications eg in motor starters and instrumentation. Parallel operation of single and three phase units. Simple treatment of phase displacement. Instrument transformers: applications. Burden, class, terminal markings.

STEERING GEAR SYSTEMS

General requirements of the electrical plant.

Types; electro-hydraulic, Ward-Leonard and follow up syatems.

Alarm circuits.

BATTERIES

Application of primary and secondary cells for shipboard use. Comparison of types. Battery charging arrangements. Safety. Maintenance.

ELECTRICAL PROPULSION SYSTEMS

General requirements of the electrical system. Suitability of electrical systems for certain classes of ship. Outline of constant current and constant voltage d c and of polyphase a c systems.

Earthing, voltage distribution diagrams.

LIGHTING SYSTEMS AND ILLUMINATION

BOT requirements for illumination. Measurement of level of illumination. Types of lamps and applications, advantages and disadvantages.

Fluorescent lamp circuits.

CIRCUIT THEORY

Further development of general circuit theory; Bridge circuits eg gas detectors, strain gauges, temperature gauges.

RECTIFIERS AND INVERTERS

Basic types and applications for power supplies.

Three phase units. Controlled rectification.

Basic principles of motor speed control using solid state controls eg thyristors.

GUIDE SYLLABUS (Marine)

PHASE III

CONTROL ENGINEERING

Note

It is assumed that practical knowledge of measuring systems and transmission lags has been obtained during Phase I Instrumentation. These techniques will now be extended to control and regulate the variables that have been measured.

The subject matter should be covered by means of lectures for the theoretical work followed by application in laboratory work. In the practical work, characteristics of the demonstration plant should be described and auto/manual change-over demonstrated. Student experiments should include the use of various control mode settings to provide and correct hunting and offset, noting changes in controller output signal value and control valve action. The use of hydraulic stepping actuators, limit switches and remote valve position indicators should be demonstrated and inter-connections between control loops may be included in cascade control experiments.

The fundamental principles of marine instrumentation and control systems are contained in a *Recommended Code of Procedure* published by the British Ship Research Association and it is anticipated that many of the illustrated figures could be used as visual aids to lectures.

Control Valves and Regulators

Use should be made of manufacturers' descriptive literature and pre-prints that can assist in the study of control valves and regulators.

Description of the basic elements and construction of a control valve, including packing and lubricators.

Types of valve trim; plugs, single and double seat control valves. Direct andreverse action. Use of air fin bonnets and multiport valves. Butterfly valves.

Actuators; pneumatic operated diaphragms, power operated positioners, hydraulic and electric motors.

Feedback for valve position indication. Use of limit switches. Pilot valves, self operating regulators, pressure balance valves. Fail safe position of control valve on air failure etc.

Automatic Control

An outline of basic control theory is required and the application of settings and adjustments on demonstration plant is vital for the student to appreciate the use of automatic control systems.

The basic control loop; open and closed loop systems using graphical symbols and block diagrams.

Simple feed back techniques; sources and types of lags.

On/off and step control, Proportional, integral and derivative action.

Principles of pneumatic and electrical controllers with associated transmission equipment.

Examples of single, two and three element feedwater controls; steam pressure and temperature controls, fuel/air ratio control, cascade control, viscosity control of fuel oil.

General Items

Measurement of salinity, pH, CO_2 O_2 and viscosity.

Tachometers, torsionmeters, power meters.

Sequential starting of burners, turbines and pumping equipment; trip systems and relays.

Smoke and fire detectors with alarms; flame failure monitors.

Scavenge fire detectors. Oil mist detectors.

Bridge control systems, telegraph recorders.

Use of mimic diagrams with alarm annunciators.

Monitoring and scanning systems, use in data logging.

Use of integrators and digital voltmeters for readout.

Notes on safety and testing; maintenance and repair recommendations.

GUIDE SYLLABUS (Marine)

PHASE III

Applied Electronics

Careful coordination between this syllabus and the other electrical syllabuses at Phases I, II and III level is essential.

REVISION

Basic electronic valves and semi-conductors; comparison in tabular form of characteristics and applications.

Component identification relative to BSI symbols used in practical diagrams and circuits.

AMPLIFIERS

i. Voltage amplifiers

ii. Power amplifiers

Dc and ac units should be outlined. Function. Noise filtering.

Frequency range, drift, cathode and emitter coupled amplifiers, interstage coupling. Thyristor amplifiers.

INVERTERS AND RECTIFIERS

Practical applications for electronic equipment eg instrument rectifiers, detectors, modulators.

OSCILLATORS

Simple oscillator circuits eg blocking, feedback, relaxation.

Applications; phase shifting (Wien bridge), controlled frequency.

STATIC SWITCHING

Amplications; eg alarm annunciator equipments.

Testing methods, familiarisation with components.

MATERIALS AND COMPONENTS

Preparation of electronic circuits involving the use of screened cables, plug and socket connections, multicore cables, integrated circuits.

General maintenance techniques. Multiplexing (scanning circuits), Duty ratings, reliability, mean time between failures.

GUIDE SYLLABUS (Marine)

PHASE III

MARINE ENGINEERING PRACTICE AND TECHNIQUE

MARINE BOILERS (MAIN AND AUXILIARY)

Scotch boilers; internal and external examination procedures, tube removal and tube expansion, caulking, riveting, welding.

Water tube boilers; internal and external examination procedure, tube removal and replacement, construction of plastic refractory combustion cone, maintenance of furnace lining.

Boiler cleaning, preservation and water treatment, boiler water testing.

Pressure tests.

Safety valves; operation and setting.

Flash-up, steaming and shutting down procedures; precautions, emergency drills.

Instrumentation; interpretation of data.

Feed regulation, correct use of water gauge.

Soot blowers. Blow down cocks.

Burner maintenance.

STEAM TURBINES (MAIN AND AUXILIARY)

Procedure for opening for examination; measurement of turbine clearances and rotor concentricity, identification of corrosion and erosion, adjustment of rotor position.

Warming through, manoeuvring and shutting down.

Lubrication system; causes of oil contamination, tests for water and salinity.

CONDENSERS

Cleaning, examination and treatment.

Tube removal and replacement.

Steam-side and water-side pressure tests.

DIESEL ENGINES (MAIN AND AUXILIARY)

Measurement of crankshaft deflection; recording and interpretation of results.

Dismantling and assembly of injection gear, heads, valves, pistons, liners.

Injector and fuel pump testing.

Examination and measurement of liner.

Starting, running and stopping routines.

Timing diagrams.

Power, out-of-phase and light spring diagrams.

Measurement of power.

Protection devices.

Lubricating oils and fuel; sampling and testing.

SHAFTING AND PROPULSION

Shaft alignment techniques; taut wire, gap and sag, optical line, water trough.

Parallel shafts.

Inspection of main thrust block.

Fitting and removal of propellers

STEERING GEAR

Electro-hydraulic system; charging, creep test, change-over procedure.

Routine servicing of Hele Shaw pump.

GENERAL

Installation of auxiliary machinery: mountings, alignment, connections, controls.

Care and maintenance of water-tight doors, hatches and valves.

Use and management of compressed air systems.

Lifting appliances, wire ropes, cable and rigging; examination and usage.

Safe handling of fuel and inflammable stores.

Precautions against fire or explosions due to oil or gas, flash point.

Fire detection.

Action and maintenance of fire-fighting equipment including extinguishers and breathing apparatus.

APPENDIX I

ORDINARY NATIONAL DIPLOMA IN ENGINEERING COURSE

1. The syllabuses used in existing Alternative Entry OND schemes differ in some cases from those used in the normal OND courses in Engineering. The study of applied mechanics and applied heat, for example, is taken far beyond that outlined in the Joint Committee guide syllabuses in order to satisfy the requirements of exemption from the Board of Trade first and second class certificates of competency examinations in these subjects. It is considered, however, that some of these more advanced topics are better understood if they are introduced at a later stage in the development of the student.

The reduction in the workshop training time requirement in Phase III from 1200 to 100 hours under the new arrangements now allows this to be done. In the new scheme about 700 hours are available for the study of supplementary OND subjects and associated topics and the advanced parts of applied mechanics and applied heat have been transferred to Phase III under the supplementary subject title "mechanical technology". Additional subjects of instrumentation, control engineering, legislation and supervisory studies, and applied electronics have been introduced, and the opportunity has been taken to remedy a weakness in existing courses by introducing marine engineering practice in each year of the course. It is hoped that engineering cadets, on completing the course, will have more understanding of their work afloat than they have had hitherto.

2. The major change in the course structure thus appears in Phase III. There are now 5 assessed subjects. The 3 subjects of the old scheme remain, viz marine power plant technology (naval architecture) and marine electro-technology, but with some modification to the guide syllabuses. The two additional assessed subjects are mechanical technology (applied mechanics and applied heat) and control engineering. The 3 subjects applied electronics, legislation and supervisory studies, and marine engineering practice and techniques are compulsory but will not be assessed. The recommended course structure is given below and guide syllabuses (marine) are attached.

3. Although the revised course is now more in line with the normal OND in Engineering, there are still important variations and these are reflected in the guide syllabuses (marine). For example, applied mechanics has been enlarged to include some study of naval architecture, and there are changes in the order in which heat topics should be studied as compared with the guide syllabuses previously in use. In these syllabuses the O.1 mechanical engineering science subject was drafted to meet the needs of a wide variety of students, some of whomwould not continue with the study of heat beyond the O.1 stage, whereas in the new Engineer Cadet Training Scheme, applied heat is compulsory for everyone and the revised syllabuses are considered more suitable. A further change is that some additions have been made to the workshop processes and communications syllabus.

In order to enable students both to achieve the important basic aim of the drawing section, as outlined in the introductory note to the Joint Committee's syllabus, and to ensure that they attain a reasonable standard in formal draughtsmanship as required by the MNTB, the hours recommended for the subject have been made rather generous. It is hoped that it will be possible to introduce such work as "drawing of assemblies from given details" in the first year, rather than leaving it entirely to the second year.

4. There are no guide syllabuses for Phase 1 chemistry, general studies or marine engineering practice. Colleges should submit their own syllabuses in these subjects but for marine engineering practice the Joint Committee consider that the syllabus of the CGLI Marine Engineers Technicians' course is quite acceptable for OND purposes. Similarly, in the Phase III course, the CGLI syllabus in legislation and supervisory studies of the Advanced Technicians' course may be used.

5. Although power plant technology is an assessed subject in the Phase III course, time has been allowed for the closely associated study of marine engineering practice and techniques. This will not be assessed but a syllabus has been prepared which colleges may use as a guide in drafting a programme of work to implant a sound knowledge of engine room practice and procedures.

6. The subjects for study proposed by the MNTB in each year of the course are shown below. The Board of Trade has considered the overall time spent on the various subjects in relation to the exemption value of the Diploma and supplementary subjects for their first and second class Part A and Part B subjects, and accepts the structure recommended. The time suggested for each subject is also acceptable to the Joint Committee.

7. Colleges should submit their schemes on the lines of the recommended course structure below, and may vary the hours per subject to suit their own timetabling arrangements. There should, however, be no major departure from the subject breakdown recommended. The ratio of lecture/laboratory/tutorial work must be maintained in any variation proposed.

8. It should be noted that the conditions for the award of the OND in Engineering have been changed. The Diploma is now awarded for a pass in mathematics and any 4 assessed subjects. Students passing in 4 subjects only may qualify for reforment in one subject.

RECOMMENDED COURSE STRUCTURE

PHASE 1

Number of weeks per session - 38

FIRST YEAR		HOURS
SUBJECT		
Mathematics	(half tutorial)	133
Mechanical engineering science	(½ laboratory ½ tutorial)	152
Electrical engineering science	(½ laboratory ½ tutorial)	133
Workshop Processes, materials, communications		152
Physics	(½ laboratory)	76
Chemistry	(½ laboratory)	87
Marine engineering practice		95

SUBJECT		HOURS
General studies		95
Workshop practice		228
SECOND YEAR		
x Mathematics	(⅓ tutorial)	114
x Applied mechanics	(⅓ laboratory ⅓ tutorial)	114
x Applied heat	(⅓ laboratory ⅓ tutorial)	114
x Engineering drawing and design		95
x Electrical engineering "A"	(⅓ laboratory ⅓ tutorial)	133
x Workshop technology	(⅓ laboratory)	95
x Physics	(⅓ laboratory)	95
Marine engineering practice		57
General studies		95
Instrumentation		95
Workshop practice		228

x = assessed subjects

PHASE III

SUBJECT	HOURS
x Marine power plant technology	88
x Mechanical technology	88
x Naval architecture	88
x Marine electrotechnology	88
x Control engineering	88
Applied electronics	66
Legislation/supervisory studies	110
Marine engineering practice and techniques	55
Workshop training	600

x = assessed subjects

Supplementary certificates will be awarded for the assessed subjects passed.

NOTE

The structure of the college Phase III course has been based on a 38 week college session of which 16 weeks are spent on training; ie an educational course of 22 weeks at 30½ hours per week, and training for 16 weeks at 38 hours per week.

Colleges will no doubt arrange the pattern of training to suit the availability of staff and workshop facilities. They are reminded, however, of the normal maximum weekly load of 30 hours (Joint Committee paper NC 13/69). Although the sessional breakdown quoted above results in 30½ per week, it is nevertheless acceptable.

When the practical training is undertaken in industry it is left to the Board of Trade, together with the employer concerned, to determine the length of the training period in order to ensure that the candidate will serve only the minimum sea service required to make him eligible for the Board's Certificate of Competency.

APPENDIX 2

CITY AND GUILDS MARINE ENGINEERING TECHNICIANS' CERTIFICATE AND ADVANCED TECHNICIANS' CERTIFICATE COURSES

1. The Technicians' certificate course is to be completed in Phase I of the Engineer Cadet Training Scheme of the Merchant Navy Training Board and the Advanced Certificate course in Phase III. These replace the G/ONC and the Board of Trade Second Class Part A courses. For colleges currently offering these latter courses the CGLI regulations applying to the new Technicians' courses are attached. Para 2.1 of the regulations stipulates that the Certificate course requires 1800 hours of study and the Advanced Certificate course 700 hours. In Phase I of the Engineering Cadet Training Scheme at least 6 hours are to be spent on workshop practice in each week of the Certificate course, In Phase III 600 hours are to be spent on training.

2. When drawing up the scheme for the Certificate and Advanced Certificate courses the CGLI advisory committee had in mind that success in the courses could merit some exemption from the Board of Trade Second Class Certificate of Competency examinations. Accordingly, a pattern similar to that for the OND course has been followed; the study of mathematics and engineering drawing is completed in Phase I and engineering sciences continued in Phase III although under seperate subject headings.

3. It is envisaged that the overall time for the Certificate course in Phase I should be divided as follows:-

SUBJECT	HOURS
Mathematics	240
Marine engineering drawing, processes, materials	360
Engineering sciences	660
Marine engineering practice	240
General studies	100
Other requirements as determined by college	100
TOTAL	1800

If 6 hours per week are devoted to workshop practice, the above breakdown will mean a weekly programme of work of approximately 30 hours throughout 2 sessions of 38 weeks each.

4. The syllabuses of the Advanced Technicians' Course in Phase III are based on the following:-

SUBJECT	HOURS
Applied mechanics	100
Naval architecture	100

Electro technology	100
Marine heat engines	100
Control systems, instrumentation and power plant	200
Legislation and supervisory studies	100
	700

The hours quoted in both cases represent time recommended for lectures, laboratory and tutorial work.

5. In most colleges the pattern of education and training in Phase III will be the same for all engineering cadets. Applying the suggested 22 weeks education and 16 weeks training, referred to in Paragraph 8 of Appendix 1, to the CGLI course, the following structure results:

SUBJECT	HOURS
Applied mechanics	99
Naval architecture	99
Electrotechnology	99
Marine heat engines	99
Control systems, instrumentation and power plant	198
Legislation and supervisory studies	99

This will entail a weekly load of 31½ hours for 22 weeks and 38 hours/week for the 16 weeks training period. Colleges will no doubt arrange the pattern or work to suit staff and workshop availability, but the above illustrates one one way of operating the course

6. Paragraph 4.3 of the CGLI regulations states that students who have been referred in either mathematics or engineering drawing processes and materials, may be admitted to the Advanced Certificate course. These students may re-sit the examination within 4 years of the initial failure but it would be to their obvious advantage if the examination is passed before their Phase III training is completed. It is left to the college Principal to advise students as to the best action to take but it may be necessary for colleges to provide additional tutorial work on the subject or subjects concerned in the training period.

Ⅵ－3. ウンクオマールポリテクニクにおけるマリン・コースの教科策定（ガイドシラバス）

MARINE ENGINEERING COURSE
Updated as at 12th August, 1976.

First Year

Subject		No. Of hours per week
5.101 Bahasa Malaysia	Non-Technical subjects.	1 + 0
5.102 English		4 + 0
3.101 Mathematics		4 + 0
3.103 Engineering Drawing		0 + 3
3.104 Engineering Science		1 + 2
3.106 Workshop Technology		2 + 6
3.107 Heat & Fluid Technology		2 + 2
3.113 Marine Engineering Practice		2 + 0
3.114 Naval Architecture		2 + 0
4.181 Electrical Technology		2 + 2
Total (Technical Subjects)		15 + 15

Second Year

Subject	No. of hours per week
3.203 *Mechanics of Machines*	1 + 1
3.204 Strength of Materials	1 + 1
(3.226) (3.205) Internal Combustion Eng.	1 + 2
(3.226) (3.205) Steam Engineering	1 + 2
(3.226) (3.205) Auxiliary Engineering	1 + 2
3.206 Marine Workshop Technology	1 + 3
3.211 Control Systems Technology	2 + 2
3.227 Naval Architecture	3 + 0
4.281 Electrical Technology	2 + 2
Total (Technical Subjects)	14 + 15

POLITEKNIK UNGKU OMAR

MARINE ENGINEER COURSE

1.1. MATHEMATICS

1. Revision of algebraic formula solution, logs, use of tables. Extension of logs to negative and fractional exponents including Napierian logarithms. Use of the slide rule, desk calculating machines, multiplication, Division, Powers, roots, Trigonometric functions.

2. Workshop applications of averages, ratios, percentage proportions. Graphical solutions of equations and interpretation (Linear). Determination of laws from data; linear form and those reducible to linear form: use of log-linear equations by successive elimination (with current sum checks), GP sum to infinity; elementary discussion of convergence. The $\binom{n}{r}$ notation; (mention of permutation and combinations). Use of Binomical expansion for any real index. Use in approximation of the series for the exponential, logarithmic, sine and cosine functions. Workshop applications. Speeds and feeding in turning and drilling. Workshop applications. Speeds and feeds in milling, Revision.

3. Geometry of the circle, radian measure. Basic Trigonometry. Workshop applications. Simple layout. Sine bar and reference rollers.

4. Tapers, angle measurement, thread measurement. Trigonometric ratios of angles of any magnitude; periodicity and graphs of the circular functions. Addition, product, and double-angle formulae. Notation of inverse circular functions; principal values. Superposition of sine waves. Reduction of $A \cos\theta + B \sin\theta$ to the form $R \cos(\theta - C)$ etc. Pythagarous theorem and trigonometrical identities. Sine and cosine rules with workshop applications. Double angle formulae workshop application to large bores. Rectangular and polar co-ordinate systems, algebraic equation of a straight line. Simple curve sketching, characteristics of plane curves, e.g. symmetry, behaviour as X, Y become large. Idea of limiting values; functionality; differentiation of algebraic, circular, exponential and logarithmic functions, of product, quotients, functions of a function, and simple implicit functions. Gradients; rates of change, maxima and minima. Idea of partial diferentiation. (1st order only) 2nd and higher order ordinary differentiation.

5. Areas, volumes, weights, common planes and solids. Centres of area, centres of gravity, Pappus Theorem. Second moment of area.

6. Arithmetical progression and geometrical progression. Workshop application to spindle speeds. Approximation of gear ratios, continued fractions. Gear ratios applied to thread cutting, indexing, spiral milling.

7. Binomial theorem and approximation of small errors. Limits with application to graphs. Derivatives, rates of change, slope. Derivatives of formula from tables.

8. Differential calculas (continued) Maxima and minima - industrial applications. Mid-ordinate rule for finding irregular areas. Theorem of Guldinus (Pappus). Integration as a sumation and as the reverse of differentiation. Easy integration of standard forms by substitution and by parts. Integration - integral curves, graphical integration. Definite integration between limits. Integration of trigonometrical functions (Tan θ, Cos θ, Sine θ). Applications of integration, areas, mean values. Volumes of revolution by integration. Centroids, centre of mass. Moment of Inertia of a circular cylinder about its axis. Simple harmonic motion. Formation of simple differential equations; solution by direct integration; boundary conditions.

Engineering Statistics

9. Handling of data - approximation and accuracy graphs, frequency distributions, histograms. Probability - Simple; addition and multiplication laws. Repeated sampling - Binomial distribution. Poisson's approximation to Binomial distribution, normal distribution. Measures of average and dispersion interpretation.

10. Arithmetic mean and standard deviation, Elementary ideas of probability - Normal distribution - probabilities from normal curve. Normal distribution - approximation to Binomial.

11. Introduction to quality control charts. Control charts for ranges examples. Control charts for *means* - *use of* $= a_n w$ Quality control charts for fraction defective.

12. Introduction to sampling - characteristic curves. Single, double, and sequential sampling schemes. Introduction to significance test. Students 't' test - use, confidence limits. Students 't' test - examples, interpretation. Variance ratio test - confidence limit for X^2 test - introduction, use, examples X^2 test - examples and interpretation.

12. ENGINEERING DRAWING

1. Introduction to the importance of Engineering Drawing, Use of drawing instruments. Introduction to the use of standard lines. Introduction to Drawing Office standards including S.I.N, I.S.O. and B.S. 308.

2. Drawing of title blocks. Printing and dimensioning. Plain and diagonal scales reading to 1/100th, 1/64th, 1/32nd and 1/16th inches.

3. Construction of triangles, quadrilaterals and polygons. Construction of tangents and arcs. Drawing of gaskets and machines components involving arcs and tangency. Introduction to simple orthographic projection and sketching.

4. Orthographic projections of lines and plane figures. Sketching of machine parts. Areas of plane figures. Sketching of workshop tools. Orthographic projections of solids in first angle.

5. Ration of area of plane figures. Orthographic projection of machine part. Drawing Office Practice. Detailing pivot block. More difficult problems on areas of plane figures. Orthographic projection of machine parts. Drawing Office Practice. Detailing angle bracket.

6. Construction of conic section - Ellipse and Parabola. Introduction to thrid angle orthographic projections.

7. Construction of cycloids, epi-cycloids and hypo-cycloids. Construction of hyperbola and involute. Orthographic projections and solids in third angle projection. Construction of locus of mechanisms. Construction of bolts and nuts. Simple assembly of swivel bracket and bearing mounting.

8. Sectioning. Sections of solids. Principles of sectioning. Hidden detail. Sketching of simple machine tools and components. Introduction to Isometric drawing of solids. Drawing Office Practice. Bearing and Bearing housing. Use of datum surfaces for dimensioning.

9. Sketching. Introduction to oblique drawing. Further assembly drawing with sectional views. Sketching. First auxiliary views of solid. True shapes of sections. Sketching. Second auxiliary views of solids. Drawing Office Practice. Detail and assembly of Stuffing Box.

10. Intersection of solids. Cylinder and cylinder, cylinder and cones. Exercise on machine drawing. Further intersection of solids, sphere and cones forge rod and castings. Further exercise on machine drawing.

11. Introduction to development. Pattern of right and oblique cylinders and cones. Further work on development including triangulation method. More exercises on development.

12. Gears - nomenclature of gears. Types of gears. Machine drawing exercise. Construction of spur gears. General revision.

13. DESIGN

Basic consideration in design, basic ergonomic principles in the design of simple equipment, instrumentation and controls.

Factors influencing design, selection and availability of materials, method of forming and joining the materials and surface finishing processes.
General aesthetic consideration, proportion, form, texture, colour.
Necessary consideration in consumer good.
Analysis, studies of specifications including the feasibility study.
Introduction to engineering design. Practical analysis and design of simple simple components.
Simple designing processes, e.g. casting, fabrication, machining, sheet forming, plastic moulding.
Problems of emergency repairs, recognition of cause of failure. Exercises in re-design for fewer parts, improved operation cost reduction and change of material or technique.
Critical appraisal of existing designs. Introduction to elementary value analysis.
An elementary introduction to the idea of force flow through an assembly and its consequence in engineering design.

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POLITEKNIK UNIKO OMAR

MARINE ENGINEERING COURSE

13. ENGINEERING SCIENCE

1. Engineering units, symbols, unit ratio for converting units, I.S.O. matters, elements, compound, alloys, mixtures. Composition of air, oxidation, corrosion and combustion.

2. Heat, temperature scales, temperature measurement, kinds of thermometers and recorders. Gas laws and their combination. Continuous flow calorimetry. Fuel calorimetry. Change of state, Specific heat, sensible heat. Saturated and unsaturated vapours. Mechanical equivalent of heat. Dalton's law of partial pressures. Elementary treatment of kinetic theory of gases, idea of mean free path. Simple vacuum apparatus, e.g. the rotary pump, the diffusion pump and its load gauge. Explanation of hygrometry, industrial hygrometer. Adiabatic and isothermal changes. Use of $PV^n = K$. Conduction and conductors. Commercial heat-insulating materials. Radiation and radiators. Stefan's law. Qualitative account of energy distribution in the spectrum of a full radiator. Element of quantum theory. Heat transfer by conduction, convection and radiation.

3. Optical refraction and reflection and their engineering applications e.g., reflection at plane and spherical surfaces, optical lever and applications, relation of mirror, formation of images by spherical mirrors. Refractive index of solids and liquids. Refraction through prisms. Deviation, dispersion. Formation of images by single convex and concave lenses. Chromatic aberration. Achromatic combinations. The electro magnetic spectrum. Production of visible spectrum. Simple emission and absorption spectra. Colour, additive and subtractive. Filters. Principles of photography. The camera and photographic plate. Filters for photography. Exposure, developing and fixing. Optical interference. Division of wave front, Young's slits. Division of amplitude - Newton's rings. Qualitative account of the diffraction grating and its use in the control of machine tools. Qualitative account of polarisation of light. Uses of polarised light in stress analysis, etc.

4. Sound - simple harmonic motion, transverse and longitudinal motion. Pitch, loudness and quality. Velocity of sound. Reflection and refraction of sound, application to echo-sounding and crack detection. Beats. Progressive and stationary waves. Vibration of beams and plates. Simple treatment of force vibration and resonance. Intensity and loudness of sound. The decibel and phon. Simple acoustics of buildings, reverberation. Principles of methods of recording and reproducing sound.

5. Polygon of forces, vectors and scalars, parallelogram of forces. Graphic solutions to equilibrium problems. Moments, couples and torques. Workshop applications.

6. Simple reactions. Simple framework, Bode diagram.

7. Direct stresses and strains. Hooke's law, yield point. Introduction to shear stresses.

8. Shear force diagrams - distributed and concentrated loads. Bending moment. Diagrams - distributed and concentrated loads.

9. Centroids of areas. Regular shapes. Moments of volume, centre of gravity.

10. Friction - Friction between dry surfaces. Theory and applications in brakes, belts, pulleys, shafts, inclined planes.

11. Machines - velocity ratio, mechanical advantage efficiency. applications - gear trains, jack screws, pulleys, wheel, etc. Linear velocity and acceleration, velocity time graphs. Angular velocity and acceleration equations of motion.

12. Work, power, energy, Kinetic energy and potential energy. Circular motion, centrifugal inertia, forces. Centripetal force, applications, Vibration, simple harmonic motion. Momentum, impact. Motion under forces varying with time, distance and velocity, Torque and acceleration, moment of inertia, moment of momentum, kinetic energy of a rotating body, Work and energy in angular motion. Center of percussion.

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POLYTECHNIC HIGHER COURSE

MARINE ENGINEERING COURSE

14. WORKSHOP TECHNOLOGY

Welding

1. Oxy-acetylene gas welding. Chemistry of reaction and heat output. Construction details of cylinder, torches and regulators. Various types of flames available. Oxy-gas cutting, modification on torch and chemistry of cutting.

2. Metallic Arc Welding. Metallic arc welding continued. Principles of striking and maintaining an arc. Power supplies. D.C. welding generator. A.C. welding transformer. Other welding processes. Electric resistance welding process.

3. CO_2 gas arc welding method and welding machines. Argon gas arc welding method and welding machines continued. Characteristics of the arc. Testing of welds. Macro-etching. Slow bend test.

Workshop Practice

4. Safety in workshops. Introduction to the control of size on machine tools, e.g. precise movement of slide and tools. Measuring equipment - rulers, dividers. Micrometer, Vernier caliper etc. Sources of error due to forces acting, heat and lack of support. Use of simple plug and ring gauges. Marking out and production of profiles and hole centres to assist machining. General explanation of the combination of hand and machine work in typical components.

5. Explanation of geometric basis of machining processes. Solid objects as a combination of plane surfaces, circles and cylinders related to machine movement. Introduction to relationship between performance and geometry in the basic metal-cutting tools. Explanation how to use the drawing to make machine parts and assembly.

6. Fitting - Marking out, sawing, filing, clamping and drilling. Use of jigsaws and other modern equipment. Explanation of simple tools and cutter for typical machinery operation.

Drilling machine - drills, types and main parts. Laying out, setting up, care of drills, grinding, Grinding theory, abrasives, grinding wheels. Off hand grinders, uses and operation, mounting wheels.

7. Lathe - main types, main parts and functions. Operations - between centres, face plates, chucks. Cutting tools, angles, shapes, materials. Other operations - threads, boring, drilling, knurling. Cutting speeds and feeds and cutting external threads.

8. Shaping machine - main features and driving mechanism. How to use, clapper box and tools, machining inclined surfaces.

9. Milling machine - type, functions of main parts. Various milling operations, gang milling, facing, profiling, indexing - milling cutters. Various adjustments, how to step and slot, feeds and cutting speeds.

10. Properties of materials e.g. plain carbon steel, cast iron, plain brass, bronze and gun metal, etc.

11. Principles of sandcasting, using wooden patterns and pattern plates with simple cores.

12. Soldering, brazing, fusion welding, riveting of the plates and bending and joining of water, gas and oil pipes.

13. Explanation of properties and use of insulating and conducting materials in electrical and electronic equipment. Explanation with wires and cables and wiring systems. Electrical connection diagrams, connections, joint and terminations. Insulation and safety precaution for marine electrical equipment such as excess current, shock, fire and explosion, corrosion and mechanical damages.

14. Tolerance & Limits - Flat surfaces, measurement. Dial indicators, slip gauges, reference blocks.

15. Limits - introduction to limits and interchangeability. Tolerances, clearances, interference. Plug, ring, slip gauges, British standards. I.S.O. standards. Cutting tools - forces on tool, chips, coolants. Heat produced, clearances, high speed steel. Tools.

16. Batch production. Use of the Capstan lathe. Tooling and setting.

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POLITEKNIK UNGKU OMAR
MARINE ENGINEERING COURSE

15. HEAT AND FLUID TECHNOLOGY

1. Work, Energy, Power. Forms of Energy - Units, Mechanical and Electrical energy. ~~Change~~ Conversion of Energy, relationship between units -simple calculations. Revision of conduction, convection and radiation. Properties of and state of a system. Specific properties. First Law of thermodynamics. Energy of a system as a property; $Q - W = \triangle E$. Terms involved in $\triangle E$: internal energy, Kinetic energy and potential energy. Definition of enthalpy. Choice of datum. Heat transfer through walls. Concept of a system, specification of its boundary.

Properties of steam

2. Formation of Steam - relationship between pressure and temperature of formation, saturated steam, dryness fraction of wet steam, superheated steam, Calorimetry.

Sensible heat, latent heat, superheat, Total heat (Enthalpy). Use of steam tables. Calculations relating to the total heat and specific volume.

Problems involving enthalpy - constant enthalpy processes, mixing of steam at different states.

Steam Boilers

3. Problems on boilers producing saturated and super-heated steam, boiler efficiency. Heat balance, Second Law of Thermodynamics.

Steam Engines

4. Reciprocating steam engines - steam turbines. P.V. Diagrams, Work done. M.E.P. Compounding, Power. Introduction to use of Entropy charts.

Calculations on the heat content and thermal efficiency of steam used for process work and space heating.

Combustion

5. Chemistry of combustion. Analysis by weight and volume, Calorific values. Methods of determining calorific values.

I.C. Engines

6. Cycles of operation for two stroke and four stroke engines based on compression ignition, spark ignition and hot bulb ignition.

Calculation of power output and mechanical and thermal efficiencies of internal combustion engines.

Gases

7. Properties of air in relation to its compression, expansion, density, humidity and temperature.

Boyle's Law, Charles Law, Universal Gas Laws. Calculations of volume, pressures, temperature during compression, expansion.

Application of the first law to non-flow processes; constant volume, constant pressure, and adiabatic processes. Application of the first law to steady flow processes. Continuity equation and "Steady flow energy equation". Application to simple plant, eg. boiler, compressor, turbine, nozzle, throttle.

Specific heats at constant pressure and constant volume and their relationship. Expansion and compression of air. Adiabatic and isothermal process. Air standard cycles. Internal energy and external work. Efficiencies of cycle Entropy and entropy charts. Partial pressures. Daltons law.

Kinetic theory of gases, concept of perfect gas, gas constant and units, universal gas constant, relationship between specific heats and gas constant. Mixtures of gases, proportions by mass and volume. Conversion from mass to volumetric analysis and vice versa.

Explanation of reversibility and irreversibility. Significance of area under the path on a pressure-volume diagram. Evaluation of specific heat and gas constant for a mixture of perfect gases. Behaviour of real gases compared with the perfect gas.

Properties of real fluids and general phase diagrams. Wet, dry saturated and superheated states. Representation of properties by tabulars and graphs.

Representation of the state of a system by property diagrams, pressure, specific volume, temperature, internal energy, enthalpy and simple ideal cycles.

Heat engine

8. Definition of a heat engine. Efficiency. Reversed heat engine. Carnot principle. Impossibility of 100 % of efficiency. Analysis of maximum efficiency of heat engine.

Air Compressure

9. Expansion and compression. Work done. Multi-stage Compression. Efficiency.

Fluids

10. Fluid-properties, density, specific weight, specific volume. Pressure-depth relationship, Pressure distribution of fluid at rest. Center of pressure. Condition for equilibrium of a floating body, metacentric height.

11. Flow measurement - orifice plate, venturimeter, Kinematics - streamlined flow. Continuity equation. Bernoulli equations, Floating energy grade lines.

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POLYTECHNIK UNGKU OMAR

MARINE ENGINEERING COURSE

16. MARINE ENGINEERING PRACTICE

1. General introduction of Merchant ships - Functions performed by merchant ship, Development of waterborn crafts, Kinds of ship, Organization of personnel of an ordinary merchant ship, Duty work and private life in merchant ships, Adaptation to able-seaman.

2. Guidance to merchant marine - Principal particulars of merchant marine, General terms found or used inside merchant ships.

3. Summary of engine department - Works in engine department, Propulsion system, General arrangement in an engine room and their names, Summary use of engines placed in a merchant ship, Tank arrangement and uses of tanks, Summary of pumping system (piping diagram) - Kinds and uses of pumps, Symbols on piping diagram, General piping arrangement on each fluids.

4. Summary of Navigation department - Works in navigation department, Nautical instruments and equipments - compass, Log, Sounding machines, other instruments - Summary of Nautical technic - Rudder operation, Circulation ability, Staying, Bearing, Stations, Cargo handling, Cooperation works, Symbols on nautical chart.

5. Summary of wireless department - Works in wireless department, Radio equipments and their resumptions, Symbols on weather chart.

6. Equipments and stations concerned to casualty and safety-keeping on a merchant ship - Equipments and tools in an emergency use, Necessary and important works in casualties, Prevention stations against casualties.

7. General notice and important mission in engine department - General attentions on embarkation, Matters to be reported to the chief engineer, Summary of navigation and staying watches, Log book writing, Warming up and cooking down engines, Necessary works on and against stormy sea, Necessary works on and against frozen sea.

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POLITEKNIK UNGKU OMAR

MARINE ENGINEERING COURSE

17. SHIP CONSTRUCTION AND NAVAL ARCHITECTURE

1. General description of ship types. Names of parts of ship. Principal structural members and their attachments. Construction of all parts of ships. Welding and rivetting. Common terms used in ship buildings and Naval Architecture.

Dead weight, deadweight scale. Simpson Rules, Areas and Volumes. First and Second Moments. Displacement, Wetted Surface, Block, mid-ship section, Prismatic and Water plane area Coefficients. Tonnes per cm. immersion. Centre of gravity and centre of buoyancy. Displacement curve.

Transverse Stability

2. Metacentre and Metacentric height. Stability at small angles of heel. $VM = \frac{I}{V}$. Inclining experiment. Moment of Statical stability, GZ curves, Cross Curves of Stability. Hydrostatic curves. Free surface and sub-division of tanks. Suspended weights, fuel and water and effect of filling and emptying tanks.

Longitudinal Stability

3. Longitudinal G.M. and B.M. centre of flotation, moment of change trim by one cm.

Draught trim and Heel

4. Addition and removing of ballast, fuel and cargo. Changes due to density. Effect of bilging. Heel when turning. Forces on rudder.

Tonnage

5. Measurement of tonnage, Gross and Nett and General terms used in tonnage measurements.

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POLYTECHNIK UNION OMAN
MARINE ENGINEER COURSE

18. ELECTRICAL TECHNOLOGY

1. Electric Circuits and Ohm's Law - Atoms and molecules; Electric current; the Ampere and the coulom; A water analogy; Potential difference (voltage); voltmeter and ammeter connections; Ohm's Law; series circuits, parallel circuits; series-parallel circuits; Kirchoff's Laws and their applications to the solution of resistive network problems.

2. Electrical Energy, Work and Power - Heat energy and electrical energy; electrical power; Mechanical power; M.K.S. units of electrical energy; efficiency of electric motors.

3. The Chemical and Heating Effects of an Electric Current - Chemical effect of a current; Electrochemical equivalent and Faraday's Laws of electrolysis; Measurement of heat-specific heat; Heating effect of a current; Joule's equivalent of heat; Efficiency of energy conversion.

4. Resistivity of Materials - Resistivity; conductors and insulators; materials used for insulation; voltage drop in cables; power loss in cables.

5. Change of Resistance with Temperature - Resistance variation of filament lamps; Temperature coefficient of resistance; the unit of temperature coefficient of resistance; calculation of change or resistance with temperature; Appendix on insulating materials.

6. Cells and Batteries - Electromotive for primary cells; secondary cells (accumulators, or storage batteries); Battery circuits - internal resistance; voltage drop due to internal resistance; cells in series; cells in parallel.

7. Cells and Batteries (cont'd) - Battery-charging circuits; constant voltage charging; constant-current charging; Efficiencies of batteries; Emergency lighting systems.

8. Magnetic Materials and Electromagnetism - Magnetic fields; unit and laws. Types of permanent magnet and their applications; Magnetic domanins; Magnetic fluex and magnetic flux density; Magnetic effect of and electric current; Right-hand rules; Magnetization of iron.

9. Magnetic Materials and Electromagnetism (cont'd) - Magnetic curves of materials; Force on a conductor carrying currents in a magnetic field; Force between parallel current-carrying conductors; Electromagnetic definition of the ampere.

10. Induced Electromotive Force - Magnitude of the e.m.f. induced by flux cutting; The unit of magnetic flux, the weber; Direction of the induced e.m.f.; Flux linkage and mutually-induced e.m.f., Magnitude of an e.m.f. induced by change of flux linkage; Self-inductance of any circuits Direction of self and mutally-induced e.m.f.s. - electrical "inertia"; Effects of inductance in electric circuits and equipment.

11. Electrostatics, and capacitance in a D.C. Circuit - Charge on the plates of a capacitor; Coulomb's law, outline qualitative treatment of conduction in conductors, semi-conductors and insulators, capacitance; The electric field of a parallel-plate; plate system; Permittivity of dielectric material, and its effect upon capacitance; working voltages of capacitor; capacitors in parallel; Capacitors in series.

12. Sinusoidal Quantities – Graphical investigation of an alternating e.m.f. Sinusoidal variation of e.m.f.; Periodic time, and frequency; Definitions; Measuring the effect of an alternating current.

13. Phase difference and Vector Representation – Voltage and current relationships; Display of a.c. wave-forms; Definition of cycle, period, frequency; peak and instantaneous values. R.M.S. and average values of sine-wave, full and half-wave rectified sine-wave. Lagging and leading quantities; Purely resistive circuit; Purely inductive circuit; Purely capacitive circuit; Vector representation; voltage and current vectors for various circuits.

14. A.C. Circuits: Power and Power factor – Resistance and reactance; Potential differences in a series a.c. circuit; Impedance; Impedance triangle; voltage and current vectors for a practical inductor; calculation of reactance and impedance.

15. A.C. Circuits: Power and power factor (cont'd) – A.C. power and power factor; graphical exercises; calculation of the power in any a.c. circuits; Active, reactive and apparent power.

16. Polyphase systems – Interconnection of phases, Symmetrical systems. Balanced systems; Two-phase, three-wire system, Power in balanced two-phase system – Three phase system. Star connection. Three-phase, four-wire system. Mesh connection. Power in balanced three phase system. Measurement of power in three-phase systems. The two-wattmeter method. Power factor from two wattmeter readings.

17. Electrical Measurements – Deflection methods; Instruments for use with d.c. and a.c. circuits; control and damping in instruments.

18. Electrical Measurements (cont'd) – Ammeters and shunts; Voltmeters and series multipliers; Sensitivity of voltmeters; Meter errors and corrections. D.C. potentiometer and its application to the measurement of voltage, current and resistance.

19. Simple Electronics; including Rectification – The vacuum diode; Electron flow in a vacuum diode; Thermonic emission; Photo-emission. A simple model to represent electron flow; Operation of vacuum diode; The diode as a rectifier, Metal rectifiers and junction rectifiers. Power action, cathod ray tube.

20. Graphs of Electrical and Magnetic Quantities – Notes on graph plotting.

21. D.C. Generators – Generation of e.m.f. (Fleming's rule); Types of generators – series, shunt, compound, Applications.

D.C. Motors – Motor action (Fleming's rule); Generated counter e.m.f. Types of motors – series, shunt, compound, Armature reaction and shifting of brushes; Armature losses; Motor starters, speed control, Applications.

22. Alternators – Construction; Production of rotating field; Types of alternators – stationary-field, revolving-armature and stationary armature revolving fields; Synchronous speed and slip; Generator paralleling and parallel operation.

23. Single Phase Motors – Construction, characteristics and applications of split-phase motors; capacitor motor, repulsion motors, universal motors

24. Three-phase Motors – Construction, methods of starting and applications of squirrel-cage induction motors, wound rotor induction motor, double squirrel cage motors; I.E.E. regulations regarding rotating machine

25. The transformer – Physical construction; Transformer efficiency – open circuit test, short circuit test, cooling of transformers.

12. Sinusoidal Quantities – Graphical investigation of an alternating e.m.f. Sinusoidal variation of e.m.f.; Periodic time, and frequency; Definitions; Measuring the effect of an alternating current.

13. Phase difference and Vector Representation – Voltage and current relationships; Display of a.c. wave-forms; Definition of cycle, period, frequency; peak and instantaneous values. R.M.S. and average values of sine-wave, full and half-wave rectified sine-wave. Lagging and leading quantities; Purely resistive circuit; Purely inductive circuit; Purely capacitive circuit; Vector representation; voltage and current vectors for various circuits.

14. A.C. Circuits: Power and Power factor – Resistance and reactance; Potential differences in a series a.c. circuit; Impedance; Impedance triangle; voltage and current vectors for a practical inductor; calculation of reactance and impedance.

15. A.C. Circuits: Power and power factor (cont'd) – A.C. power and power factor; graphical exercises; calculation of the power in any a.c. circuits; Active, reactive and apparent power.

16. Polyphase systems – Interconnection of phases, Symmetrical systems. Balanced system; Two-phase, three-wire system, Power in balanced two-phase system – Three phase system. Star connection. Three-phase, four-wire system. Mesh connection. Power in balanced three phase system. Measurement of power in three-phase systems. The two-wattmeter method. Power factor from two wattmeter readings.

17. Electrical Measurements – Deflection methods; Instruments for use with d.c. and a.c. circuits; control and damping in instruments.

18. Electrical Measurements (cont'd) – Ammeters and shunts; Voltmeters and series multipliers; Sensitivity of voltmeters; Meter errors and corrections. D.C. potentiometer and its application to the measurement of voltage, current and resistance.

19. Simple Electronics; Insulating; Rectification – The vacuum diode; Electron flow in a vacuum diode; Thermonic emission; Photo-emission. A simple model to represent electron flow; Operation of vacuum diode; The diode as a rectifier, Metal rectifiers and junction rectifiers. Cover action, cathod ray tube.

20. Graphs of Electrical and Magnetic Quantities – Notes on graph plotting.

21. D.C. Generators – Generation of e.m.f. (Fleming's rule); Types of generators – series, shunt, compound, Applications.

D.C. Motors – Motor action (Fleming's rule); Generated counter e.m.f. Types of motors – series, shunt, compound, Armature reaction and shifting of brushes; Armature losses; Motor starters, speed control, Applications.

22. Alternators – Construction; Production of rotating field; Types of alternators – stationary-field, revolving-armature and stationary armature revolving fields; Synchronous speed and slip; Generator paralleling and parallel operation.

23. Single Phase Motors – Construction, characteristics and applications of split-phase motors; capacitor motor, repulsion motors, universal motors

24. Three-phase Motors – Construction, methods of starting and applications of squirrel-cage induction motors, wound rotor induction motor, double squirrel cage motors; I.E.E. regulations regarding rotating machine

25. The transformer – Physical construction; Transformer efficiency – open circuit test, short circuit test, cooling of transformers.

POLITEKNIK UKAY UMAR

MARINE ENGINEERING COURSE

21. MECHANICS OF MACHINES

1. The principle of static equilibrium for co-planar forces, composition and resolution of forces, graphical determination of forces in simple framed structures. analytical and graphical conditions of application problems of equilibrium. Application to frame structures. Application to fluid at rest, total thrust, center of pressure.

2. Newton's laws of motion and their application to uniformly accelerated linear and uniform angular motion.

3. Friction - revision. Friction in screws - vee threads. Brief description of theory of lubrication. Friction in clutches and pivots. Belt and rope drives. Vee belt and rope drives.

4. Theory of bending - proof of relationship $\frac{m}{y} = \frac{M}{I} = \frac{E}{R}$ and applications.

5. Theory of torsion - proof of relationship $\frac{\gamma}{s} = \frac{T}{J} = \frac{C\theta}{L}$ and applications.

6. Gear trains - simple. Gear trains - compound. Epicyclic gears. Torque and power in gears.

7. Vibrations, simple harmonic motion. Vibrations in compound springs - effect of spring weight. Traverse vibration - torsional vibrations. Compound pendulums. Introduction to damped and forced vibrations. Introduction to cams - uses. Drawing and Construction - cam design.

8. Balancing of rotating masses - one plane. Balancing of rotating masses - two or more planes. General dynamics; the concepts of energy, momentum and inertia, etc.

9. Vehicle dynamics. Flywheels - fluctuation of speed and energy. Problems on flywheels. Velocity diagrams - velocity vector method. Velocity diagrams. Instantaneous centre method. acceleration diagrams. Vector method. Continuation of acceleration diagrams. Forces in link mechanism - velocity of rubbing.

10. Impact of jets on fixed vanes. Centrifugal forces and their application to simple co-planar balancing.

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POLITEKNIK UNIKU OMAR

MARINE ENGINEERING COURSE

22. STRENGTH OF MATERIALS

1. Simple atomic structure. The electron, proton and neutron. The Periodic table and valency. Isotopes. Process of ionisation, plus and minus ions. Ionisation current. Excitation and ionisation by collision. Discharge through air at low pressures. Cathode rays. Release of electrons by heat, light, particle bombardment and the action of electric fields. Deflection of an electron beam in electric and magnetic fields. Cathode ray tube, electrostatic and magnetic focussing. Radioactivity. Half-life. Qualitative description of α, β and γ radiation. Detection and counting of ionising particles, cloud chamber, counter and photographic plate. Shielding and radiological safety precautions. Applications of radio-isotopes.

2. Revision of mechanical properties: terms used. Hooke's law. Stress-strain. Familiarisation with British and metric units. Non-destructive testing. Magnetic flaw detection. Stress strain diagrams. Introduction to the load-extension diagrams to fracture, and to yield and ultimate stress. The concept of factor safety. Proof stress, Poisson's ratio, etc. Introduction to electrical resistance strain gauges. Compound bars and temperature stress. Measurement of principal stresses, use in manometers and simple pressure gauges, calibration of gauges and sources of error. Uses in electrical resistance strain gauges, work done by variable pressure, indicator diagrams.

3. Bending Moment and Shear force diagrams. Hardness testing. Vickers, Brinell, Rockwell. Continuation with Bending moment and shear force diagrams. Bending stresses in beams. Evaluation of Second Moment of Area. Shore hardness testing. Strain energy in bending. Use of Shore scleroscope for hardness testing of different materials.

4. Deflection of beams. Analytical. Macaulay's method. Estimating Young's modulus by bending. Deflection continued. Mohr's diagram. Strain energy.

5. Torsion of shafts. Strain energy in torsion. Estimating Modulus of rigidity for different materials. Impact loads. Axi-symmetrical systems.

6. Thin cylinders, thick cylinders. X-ray techniques. Struts and columns. Struts and columns continued. Springs close coiled helical springs.

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POLITEKNIK UNGKU OMAR
MARINE ENGINEERING COURSE

23. INTERNAL COMBUSTION ENGINEERING

1. Stroke cycle of operation in diesel engine – Four-stroke cycles, Two-stroke cycles, Timing.

2. Thermodynamics of Internal Combustion Engine – Basic terms in I.C.E., Laws concerning perfect gases. Fundamental laws of thermodynamics, Specific heat of gases, Change of state of gases, actual change of the gases in cylinder, Carnot Principle, Theoritical cycle of I.C.E. – Otto cycle. Diesel cycle. Sabathe cycle, Comparison of thermal efficiency of three kinds of "standard cycle", Fuel-air cycle, actual conditions in cylinders, Kinds and definition of respective thermal efficiency, Kinds and definition of mean pressure, Fuel consumption, Heat ballance.

3. Theory of Combustion – Combustion, Air required for combustion, Limit of combustion, Ability to be ignited of gasoline – Gasoline knock, Octane number, Ability to be ignited of diesel oil – Ignition lag, diesel knock, Cetane number – Combustion process in gasoline engine, combustion process in diesel engine.

4. Cylinder pressure indicators and indicator diagrams – Utilition of pressure indicator, Kinds of pressure indicator, Driving gear for operating drum of pressure indicator, Cautions when taking indicator diagrams, Method to obtain indicated horse power, Method to obtain mean indicated pressure, Diagrams for other specified purposes.

5. Main Constructional parts of Diesel Engine – Cylinders, Framing, Bed plates and engine beds, Main bearings, Piston-trunk type piston, cross head type piston, Piston ring, Piston rod, Crosshead guid shoes and guide plate, Connecting rods, Crank shafts – Kinds of crank shafts and their construction, Arrangement of cranks and Firing order of cylinders, Twisting system, Tortional vibration, Additional stresses, Repeating twisting stress, Wear down of bearing, crank arm deflection, Method to measure crank web deflection, Balancing weight, Fly wheel, Lubricating system, Cooling system, Air starting and reverse systems, Crank case safety devices, Gearing and drives governers, auxiliary plant modules.

6. Recharging process inside cylinder – Recharging process inside cylinders in 4-Cycle Diesel engine, Air-intake devices of 4-cycle diesel engine, Exhaust devices, Utilization of waste heat.pipe. valve. silencer, Volumetric efficiency and charging efficiency in 4-cycle diesel engine, Scavenging process in 2-cycle diesel engine, Scavenging process in symmetrical scavenging, Types of scavenging in 2-cycle diesel engine, Scavenging air supply devices in 2-cycle diesel engine, Scavenging efficiency and trapping efficiency in 2-cycle diesel engine.

7. Supercharging diesel engine – Supercharging, Method of supercharging, Exhaust turbo supercharger – construction, Surging zone, Utilization of exhaust gases.

8. Fuel injection system – Airless injection fuel pump, the bosh fuel pump, Burmeister and Wain Fuel-injection system, The common rail fuel-injection system, Fuel-pump driving cams, Airless injection fuel valves, High viscosity fuels.

9. Materials of construction and corrosion – Carbon, Silicon, Manganese, Phosphorus, Sulphur, Tensile strength, Hardness, Cast iron bedplate which have composition and mechanical property, column which have composition and mechanical property, cylinder beams which have composition and mechanical property, Crosshead guide bars which have composition and mechanical property, cylinder liners, Pistons, Piston rings, Exhaust valves, Crankshafts, connecting-rods, Piston rods, Crossheads, Bearing bolts, Through tie-bolts, camshafts, Cross-head guide shoes, H.P. fuel pump, Fuel valves, Compressed-air valves and seats.

POLITEKNIK UNGKU OMAR

MARINE ENGINEERING COURSE

24. STEAM ENGINEERING

I. Boiler

1. Introduction, Classification of boilers - cylindrical boiler, water tube boiler and special boiler.

2. Capacity and efficiency of boilers - Equivalent evaperation, boiler horse power, boiler rating, rate of heat generation, rate of vaperization and boiler efficiency.

3. Steam, fuel and Combustion - review with steam properties, classification of fuels, liquid fuels, heavy fuel oils and fuel oil additives, calorific value, combustion theory, theoretical combustion air required, excess air, combustion gas volume, troubles by the combustion product, low temperature corrosion, high temperature corrosion.

4. Heat transfer - Kinds of heat transfer, conductivity, convection, radiation, heat transmission, overall coefficient of heat transmission, heat transfer to a boiling liquid.

5. Construction of boiler - Boiler shell, end plate, furnace, combustion chamber, smoke tube, stay, water tube, superheater, de-superheater, man hole and mud hole, steam drum, water drum, header, combustion chamber wall, membrane wall (water wall, boiler casing, boiler bed, boiler water circulation pump and forced circulation boiler, forced through flow boiler, special boiler.

6. Boiler fittings and mountings - Kinds of fittings and mountings, detail of: superheater, de-superheater, reheater, economizer, air preheater, safety valve, water level gauge, steam stop valve, feed water check and stop valve, soot pan, soot and blow down valve, salinometer valve, pressure gauge, soot blower, steam pipe.

7. Combustion devices - Fuel supply system, classification of burners, automatic combustion control system.

8. Draft - Classification of draft, draft force by chimney, draft resistance and draft force, draft fan.

9. Boiler water treatment - Indication of impurities in the water, unit, Hardness of water, Alkalinity, pH, Kinds of impurities, gases in the water, kinds of corrosion, dissolved salt compound, alkali corrosion and sodium embrittlement, boiler scales, carry over, primary boiler water treatment, use of distilled water, ion exchange resin, use of deserater, secondary boiler water treatment, boiler compounds, Standard of boiler water.

10. Running and maintenance of boilers - Preparation for rising steam, wet fire, general precaution during rising steam, inspection of boiler.

II. Steam Turbine

1. Introduction, Fundamental of steam turbine - History of marine steam turbine, advantages and disadvantages of steam turbine, conception of steam turbine, classification of steam turbine, Impulse turbine; single stage impulse turbine, pressure compound impulse turbine, Velocity compound

impulse turbine, Pressure velocity compound steam turbine, Reaction turbine; axial flow reaction turbine, radial flow reaction turbine, Combined turbine, specialties of marine turbine, Review of simple thermodynamics, proportion of steam, pressure drop and heat drop, steam table and steam chart.

2. Details of structure - Structure of rotors and materials, Balancing of rotor; statical balancing and dynamical balancing, nozzles; steam flow in the nozzle, shape of nozzle, kinds of nozzle, kinds of turbine blades, materials, blading, shroud ring, velocity diagram of steam, Pitch of blading and blade tip clearance, turbine casing, sentinel valve, diaphram, labyrinth packing, carbon packing, packing steam system, journal bearing, thrust bearing, astern turbine; necessity of astern turbine, arrangement of astern turbine, structure of astern turbine, reduction gear, factors required as good reduction gear, tooth form, arrangement, materials and structure of reduction gear.

3. Speed control system and emergency devices - throttle governing, nozzle control governing, emergency governors.

4. Losses and efficiencies - Internal losses and external losses, stage diagram efficiency, stage internal efficiency, mechanical efficiency, effective efficiency, thermal efficiency, total thermal efficiency of propulsion engine plant.

5. Auxiliries - Condenser, condensate pump, air ejector, gland condenser, drainecooler.

6. Shaft line and stern tube - shaft line, intermediate shaft, propeller shaft, cooling system of shaft line.

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POLITEKNIK UNGKU OMAR

MARINE ENGINEERING COURSE

25. AUXILIARY ENGINEERING

1) Pumps

1. Review of Hydraulics concerned – mean velocity of flow, equation of continuity of flow, stored energy of fluid, Bernoulli's theorem.

2. Theory of pump – principles, heads of pump, powers, efficiencies.

3. Reciprocating, Rotary, Centrifugal and Variable discharge pumps – structures, characteristic curves, flow rate adjustment, operations, maintenances.

4. Routine servicing – Weir's pump, Worthington pump, Hele Shaw pump, William Janney pump. Fire pumps.

2) Steering gears

1. Types of steering gear – Prime-mover, controlling gear, rudder gear, hunting gear.

2. Safety devices and emergency gears.

3. Electro-hydraulic and electric steering gears – structures, operations, maintenances, Charging, testing and change over procedures for electro-hydraulic system.

4. Automatic steering gears.

3) Refrigeration and air-conditioning

1. Review of thermodynamics concerned – transmission of heat, 1st and 2nd law of thermodynamics, internal energy, enthalpy, entropy, reversible change of state of gas, Reversed Carnot cycle.

2. Theory of refrigeration – Vapour compression cycles, refrigerating effect, ton of refrigeration, coefficient of performance, efficiencies, P-i and T-S diagrams, Calculation of cycles with diagrams.

3. Refrigerants – Kinds and properties of refrigerant and brine, leak detect.

4. Cargo and domestic refrigerating plants – structures of reciprocating and rotary compressors, condensers, evaporators and oil separators. Safety devices.

5. Operations and maintenances – Testing, charging and pumping down, defrosting, automatic operations, refrigerating chambers, cargo carrying temperatures, cargo acceptance and stowing, refrigerating containers, routine servicing and mal-functions of vapour compression refrigerator.

6. Air-conditioning plants (cargo and domestic).

4) Air compressors

1. Theory of compressor – isothermal and isentropic compression and efficiencies, effect of clearance, Calculation of work done, multi-stage compression and intercoolers.

2. Reciprocating and rotary type compressors, coolers and air reservoirs. Structures, operations, maintenances.

5) Purifiers

Purifying principle, types of purifier, structures, operations, maintenances, self-cleaning purifiers.

6) Oily water separators

Principle, structures, operations, maintenances. "Oil in Navigable waters Acts".

7) Deck machineries

Cargo handling gears, cargo winches, cargo cranes, windlasses, mooring winches, capstans.

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POLYTEKNIK UNGKU OMAR

MARINE ENGINEERING COURSE

26. MARINE WORKSHOP TECHNOLOGY

1. Materials – Basic composition, physical properties and typical engineering uses of the following materials:- Plain carbon steels, Plain brass, bronze and gun-metal, Ni-steel, Ni-Cr-steel, Basic Al base alloys, Common bearing metals, common Zn base and Al base die-casting alloys, High duty, malleable, and SG cast irons, common high speed steels, sintered carbides for cutting tools, common thermo-setting and thermo-plastic plastics, P V C, nylon and glass-fibre.

2. Heat treatment – meaning terminology, and uses. Heat-treatment on steels, referring to the Fe-C system. Heat-treatment on steels continued. Annealing, Normalising, Spheroidising, T.T.T. curves and harden ability, hardening and tempering. Harden ability and quench cracking. Purpose of working processes, effects of cold working, hot working and annealing. Mechanism of deformation, role of crystal boundaries, deformation of poly-crystals.
An outline of the effects on properties and response to heat-treatment of Ni, Cr, Mo and Mn in steel, including temper-brittleness. Al alloy treatment. Local hardening by case-carbonizing and local heating.

3. Basic forming Processes – gravity and pressure methods of die casting. Die cast products – their machining. Investment moulding. Introduction to press tool work. The sand-casting process and its extension by the use of pattern plates, Injection and transfer moulding of plastics, Hot and cold forging, Rolling and extrusion, Introduction to the principles of blanking, punching and bending with simple press tools.

4. Metal Forming by cutting – an elementary treatment and analysis of the relations between tool geometry, cutting forces, power consumption, and tool life. Identification of essential tool angles in single point tools, drills and milling cutters.
Explanation of the essential, generating function of metal cutting machine tools and derivation of accuracy from machine geometry.
Simple analysis of the geometry and range of functions of the centre-lathe, drilling machine, milling machine and cylindrical grinder.
Sources of error and normal expectation of accuracy.
Line diagram explanation of basic transmission systems for the above machines.
Method of holding typical work pieces.
An outline of typical machining methods, including simple vee threads. Elementary process planning, consideration of production times, floor to floor times, and cost of production in relation to machining methods.

5. Dimensional control – Principles of interchangeability. Basic principles of the British Standard system: gauging by, fixed size, adjustable and indicating gauges.
Principle of comparative measurement, typical mechanical comparators and their uses, calculation and accuracy. Simple consideration of the cost of increasing accuracy. Application of B.S. system in measurement. Use of dial indicator, optical projector and preparation and use of typical master forms.

6. Division of gas welding and cutting, AC and DC welding; resistance welding and submerged arc and inert gas welding. Types and classification of electrodes. T.I.G. and M.I.G. welding.

Details of butt and lap joints. Comparison between welding and riveting. Common faults. Methods of testing welds. Ship's classification society requirements with welding sequence and prefabrication. Scalloping. Slip gauges and comparators. Cutting tool forces and surface finish. Sintered carbide tools. Hydraulic profiling on lathe. Grinding machines. The abrasive wheel. The auto collimator and angle dekker.

7. Screw thread measurement. Milling - slotting. Cutters and dividing head and construction. Methods of indexing - direct, simple angular. Differential indexing - spiral. Milling. Drilling machines; horizontal boring machine.

8. Capstan turret lathe. Standard tools. Planing and setting. Capstan lathe; tool layouts. Programmed machining. Advanced operations on lathe. Turning of large work; setting and operation times.

9. Surface finish - comparison. Lapping, honing and super finishing - their characteristics. Co-ordinate machine, principle of jig boring, Numerical controlled machine tools. Work lay and sequence of control. Heat treatment and salt bath furnaces.

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POLITEKNIK UNGKU OMAR

MARINE ENGINEERING COURSE

27. CONTROL SYSTEMS TECHNOLOGY

1. Introduction to different types of automatic control, controller units and correcting units, open loop and close loop with application to temperature, pressure, and level control. Time element - first order and time lags. The time constant. Pressure load, system response of step, ramp, sinusoidal input to single capacity system. Control units represented by block diagrams, positive or negative feedback, series and parallel arrangement, Gain factor.

Pressure Measurement

2. Manometers, simple U-tube, industrial U-tube, differential, inclined tube, two liquid U-tube. Ring balance manometer. Operation of diaphragms, capsules and bellows for pressure measurement. Industrial applications. Operation of bourdon tubes, C-types spiral and helical. Application of pressure switches. Pressure alarm and electrical transmission for annunciator light and warning systems. Static head correction. High vacuum measurement, McCloud Gauge, Pirani Gauge, Cathode Ionization Gauge, Magnetron Gauge. Types of pressure recorders and their functions and arrangement. Control circuit of pressure measuring devices. Introduce air supply for transmission. Use of filter, regulator. Demonstrate pneumatic pressure transmitter and receiver pressure gauge. Air purge and bubbler systems. Range suppression on pressure head meters, correction and calculations. Use of seal and condensate chambers. Differential pressure instruments.

Flow Measurement

3. Application of Bernoulli's theorem, differential pressure flowmeter, orifice pattern, use of manometers with orifice plate and venturi to measure flow, venturi and nozzle pattern, pitot tube pattern, dall tube pattern, variable area flowmeters, displacement and inferential flowmeter. Electromagnetic flowmeter, ultrasonic flowmeter, anemometer, integrators, recorders. Installation of measuring instruments, square law effect and methods of correction.

Level Measurement Instruments

4. Use of pressure measuring instruments for liquid level measurement. Displacement gauges, float switches, external float gauge instrument, electrical probe for liquid level measurement. Use of pressure switches with alarm contacts and electrical transmission for annunciator lights and warning systems. Use of strain gauges with bridge circuits. Scanning of several measurements and switches with multiplex of signal for remote reading.

Liquid and solid level measurement, sight glass, Enstron gauge, float gauge, liquid manometer instrument. Diaphragm. Diaphragm stack or bellows, instruments, fluid purging system, buoyancy or torque tube. Capacitor type, Nucleonic type, weighting type. Pulse transmission. Control circuit for level measurement.

Temperature Measurement

5. Non-electrical thermometer, liquid expansion type, gas expansion type, vapour expansion type, Bi-metallic type. Electrical thermometer, thermocouples, law of intermediate temperatures, metals, hot and cold junctions, positive and negative wires. Resistance thermometer.

Semi-conductor thermometer, null-balance instrument, radiation pattern thermometer, or Pyrometers - photo cell and optical pyrometers, measuring circuit, control of temperature, detecting devices, multi-point installations.

Moisture and PH Measurement

6. Wet and dry bulb, sling hygrometer, mercury-in-steel hygrometer, hair hygrometer, Gregory hygrometer. Dewcel hygrometer, Cassella Alnor Hygrometer, Electrolytic hygrometer. Ionic dissociation, PH scale, British Standard, PH scale and definition, hydrogen, glass, calomel, electrodes.

Introduction to pneumatic control

7. Use of position balance and force balance pneumatic and pneumatic electrical controllers. Flapper-nozzle type or "stack-type" pneumatic controllers with proportional plus integral and proportional plus integral plus derivative control, linear and square root charts. Proportional action, proportional band, off-set. Proportional plus integral control, integral action time. Use of motor point potential metric indicators and recorders. Use of various types of electrical transducers for inductive, capacitive, resistive strain gauges and others, signal conversion. Introduction to power hydraulic circuits: symbols and components, simple circuit design. Pneumatic relays, bleed type, non-bleed type.

Pneumatic Circuits using automatic control

8. Industrial applications, units and symbols, design of simple pneumatic circuits. (Hydro-pneumatic system and devices). Introduction to set theory and Boolean algebra. Subset, equality of sets, universal set, empty set, Venn diagram. Application to switch circuits (and pneumatic system).

Logic Theory: AND, OR, NOT, NAND circuits, combinational logic and sequential logic.

Flow Measurement in Open Channels

9. Rectangular type weir, V-notch or Thomson Weirs, Trapezoidal or Cippletti weir, Suppressed weirs, installation of weirs, Venturi flumes, measuring instruments.

Applications

10. Use of strain gauges with bridge circuits. Scanning of several measurements and switches with multiplexing of signals for remote reading. Use of communicating cables. Use of multi-point potentiometric indicators and recorders.

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POLITEKNIK UNGKU OMAR

MARINE ENGINEERING COURSE

20. SHIP CONSTRUCTION AND NAVAL ARCHITECTURE

Resistance and Propulsion

1. Frictional and residual resistance. Speed and fuel consumption. Admiralty and fuel coefficients. Laws of corresponding speeds and laws of comparison. Prediction of resistance from model experiments. EHP, DHP and QPC. Propellers. Pitch ratio, Wakefactor, Slip thrust Power and cavitation.

Ship Construction

2. Strength of ships. Bending moments and shear forces. Construction of all parts of a steel ship. Fire detection and extinction. Ventilation of tanks and holds.

Storage of Coal and oil fuel.

Preservation in good condition of all parts of a ship.

Load Line

3. Assignment of load lines, load line marks. Reserve buoyancy Conditions of assignment. Sub-division of cargo and passenger ships-general principles. Modern shipyard Practice of Construction of ships. Materials used in ship building. Launching of ships and launching calculations.

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POLITEKNIK UNGKU OMAR

MARINE ENGINEERING COURSE

29. ELECTRICAL TECHNOLOGY

1. D.C. and A.C. generators: Construction, windings phase and commutator, armature reaction, commutation, interpoles. e.m.f. equation of Generator, self-excitation, etc.

D.C. and A.C. motors: starting torque and acceleration, torque/speed and torque/current characteristics, construction of motors, shunt, series and compound motors, starts, speed control and applications, losses and efficiency, tests of D.C. and A.C. machines as used in ships. Production of a rotating magnetic field by three-phase current. Speed and torque relationship of the three phase induction motor and D.C. motors derived from General Consideration.

2. Electrical power distribution: D.C. and A.C. distribution, polyphase circuits analysis, star/delta connections, power 2 wattmeter method. Typical marine power distribution system.

3. Transformers: construction and operation, magnetising and load currents, equivalent circuits, open and short circuit tests, losses and efficiency. Load conditions, ignoring leakage reactance and winding resistance, simple phase or diagrams.

4. Synchronous machine: construction and operations, effect of change of load and excitation, power factor correction, starting and synchronisation.

5. Induction motor: construction and operation, vector diagram - equivalent circuit, torque-slip characteristics, starting methods and starter types.

6. Magnetic control: - control of A.C. machines, magnetic control of motors, automatic controls as in marine practice, ship propulsion and electric steering.

7. Measurements: Principle and use of the air-core dynamometer. Extension of range of instrument by the use of instrument transformers. The universal test meter.

8. Electronics: - Basic concept of the amplification of small signals by electronic and other means. Vacuum tubes; emission construction, characteristics Triodes; voltage amplifier, equivalent circuit, pentodes, photo tubes. Semi-conductors; materials, PN junction, diodes and rectification, Transistors; PNP and NPN, basic operation, characteristics, amplifier. Other semi-conductors; the unijunction, silicon controlled rectifier, field effect transistor, tunnel and Zener diodes. Bias stabilisation temperature effect. Graphical treatment by means of load line for transistor and resistance-loaded triode. Introduction to the parameters and the concept of an equivalent circuit. The transistor as a switch. Amplifiers: operation and simple calculations. Multi-stage - power and feedback amplifiers, Electronic test equipment and navigation.

9. Electrical and Electronic equipment maintenance and testing. Preventive maintenance, training experience and planning. Testing and trouble shooting of electrical and electronic equipment in ships installations. Maintenance and repair of electrical and electronic equipment and protective devices in ship installations. Use and interpretation of operation manuals.

Note: Where possible reference should be made to marine practice and requirements.

MARINE ENGINEERING TECHNICIAN COURSE (PHASE 4)

NO.	SUBJECT			NO. OF HOURS PER WEEK
1.	Applied Mathematics			1
2.	Metallurgy & Material Science			1
3.	Engineering Drawing & Design			2
4.	Marine Workshop Technology			1 + 1
5.	Marine Engineering Practice and Technique			1 + 1
6.	Naval Architecture			2
7.	Marine Electrical Technology			1 + 1
8.	Applied Electronics			2
9.	Mechanical Technology			2
10.	Marine power plant Technology	9-1	Internal Combustion Engines	~~2+2~~ 2
		9-2	Steam Engineering	2+2
		9-3	Auxiliary Engineering	~~2+2~~ 2
11.	Control Engineering			2
TOTAL (TECHNICAL SUBJECT)				21 + 9

GUIDE SYLLABUS (MARINE)
PHASE IV

APPLIED MATHEMATICS

Torsion.

Fundamental torsion equation. Relationships between torque, stress and power. Coupling bolt. Further work on torsion in solid and hollow shaft. Coiled helical spring.

Applied Mathematics for Marine Engineering.

Dynamics for piston-crank mechanism. Calculation of piston displacement, velocity and acceleration for the reciprocating engine mechanism. Use of displacement time and derived curves for design of cams.
Application to design and analysis of screw thread, thrust bearing, plate and cone clutches. Use of principles of relative velocity and fluid flow over moving vanes to determine work, power and blade efficiency. Rapson's slide.

Vibrations.

Natural frequency of springs and shafts. Examples of resonance including whirling. Torsional vibration of shafting. Critical vibration of engines. Vibration on steam turbine.

GUIDE SYLLABUS (MARINE)
PHASE IV

METALLURGY AND MATERIAL SCIENCE

Nonferrous Metal

Copper alloy, Brass, Bronze, White metal. Kolmet. Trimetal bearing. Aluminium alloy. Magnesium alloy. Nickel, Cobalt alloy. Titanium and Zirconium alloy. Zinc, lead, tin and those alloy.

Sintered Metal

Manufacturing system of sintered metal. Property of sintered metal.

Plastic

Thermosetting plastic. Heat hardenability plastic. Strengthening plastic.

Protection of corrosion.

STRENGTH OF MATERIALS

Properties of metals and testing techniques.

Tensile stress, compressive stress, shearing stress, hardness, toughness, brittleness, wear, fatigue.

Defects of steel block.

Blow holes, Segregation, Ghost line.

Surface hardening.

Flame hardening, high frequency hardening, short peening, carbonizing, nitriding, cynide process, chrome plating (polous chrome plating).

GUIDE SYLLABUS (MARINE)
PHASE IV

ENGINEERING DRAWING AND DESIGN

Drawing examples requiring the use of typical drawing office standard parts lists, commercial standards parts and components such as bearings and fastenings, liquid and gas seals, and other bought-out items.

Extraction of information from catalogues and specifications.

Familiarisation with common engineering components, Safety valves of boiler and assemblies through stripping down, measurement and observations, leading to drawing and sketching exercises.

Practical analysis and design of simple single components.

Simple designs framed around a principal manufacturing process, e.g., casting, fabrication, machining, sheet forming, plastic moulding, problems of emergency repairs, recognition of causes of failure. Exercises in re-design for fewer parts, greater ease of manufacture, improved operation cost reduction and change of material or technique.

GUIDE SYLLABUS (MARINE)
PHASE IV

MARINE WORKSHOP TECHNOLOGY

Efficiency measurements and their actual methods on Marine main engines. Operation technics their cautions in check points on marine engines. Standard maintenance period and check methods of running condition on marine engine. Overhaul and maintenance technics - removing and refitting. Trial technics and check point after maintenance works. Trouble shooting on marine engine and electric machine.

Practice.

Manoeuvering drills and running condition check on marine engines. Efficiency measurement and fuel consumption measurement on marine main engine. Overhaul and maintenance drills on marine engines. Trial and check drills on marine engines. Trouble shooting an electric machines.

Basic operation principles of steam turbine and feed water system. Basic operation of 4 cycle and 2 cycle diesel engines, compression ignition and spark ignition engines. Direct drive diesel engines. Marine instruments.

GUIDE SYLLABUS (MARINE)
PHASE IV

MARINE ENGINEERING PRACTICE AND TECHNIQUE

General - Installation of auxiliary machinery; mounting, alignments, connections, controls, Care and maintenance of water-tight doors, hatches valves, etc. Use and management of compressed air system, lifting appliances, wire ropes, cables and cordage; examination, usage and maintenance, Safety handling of fuel and inflammable stores, Fire detection, Action and maintenance of fire-fighting equipment, extinguishers and breathing apparatus.

Shafting and propulsion - Shaft alignment techniques; taut wire, gap and sag, optical line, water trough, Parallel shafts, Inspection of main thrust block, Fitting and removal of propellers, Lubrication of propeller shaft, Cooling of shafting.

Development of supervisory skills. Shipboard relations, leadership and teamwork.

Marine insurance, Safety and accident prevention. Education, training and welfare of seafarers.

GUIDE SYLLABUS (MARINE)
PHASE IV

NAVAL ARCHITECTURE

Ships construction. Review and application.

Forces acting on ships resulting in hogging, sagging, rocking, pinting and pounding. Arrangements of anchors and cables. Ventilation and heating. Insulation of refrigerated ships. The survey of ships, general requirements and procedures.

Trim, Statical stability and stability curve.

Trim and change of trim due to adding. Removing or moving weights of small and large magnitude. Change in moandraft due to bilging amidship compartment. Change in drafts due to bilging and end compartment. (Calculations restricted to box barge forms).
Statical stability at large angles of heel. Cross curve of stability. Construction of stability curve from cross curves. Important features of stability curve. Stability information supplied to ships. Stabilisers treatment of types and effect.

Fire and life saving equipment.

Fires and fire control systems. General fire fighting rules. Dangers of explosion of gas given off by coal and oil. Portable fire extinguisher. Automatic fire alarm system. Inert gas system. Pumping, flooding and draining, fresh water and sea water services. Regulations in respect of life saving appliances, boat and davits, crew spaces, water tight divisions. Construction and handling of life boat and life luft.
Tanker construction and equipment on prevention of pollution of the sea by oil. I.M.C.O.

Applied resistance and powering of ship.

Components of resistance, calculation of frictional resistance (Rf), wave making resistance (Rw), eddy making resistance (Re). Total resistance. Estimate of residual resistance. Froude's law of comparison. Speed and power. Estimation of effective horse power. Admiralty coefficient. Fuel coefficient and fuel consumption.

Propeller and Propulsion.

Definition of propeller terms. Construction and material of screw propeller. Controllable pitch propeller. Theory of screw propeller, thrust of propeller, relation between thrust, torque and efficiency. Presentation of propeller data. Cavitation, speed trial. Singing. Maintenance of propeller. Damage and method of repair of propeller. Stern bearing and stern tube. Calculation of slip.

Strength and vibration.

Shearing force and bending moment curves. Use of stress indicators. Causes, reduction and prevention of vibration. Calculations using approximate formulae.

GUIDE SYLLABUS (MARINE)
PHASE IV

MARINE ELECTRO TECHNOLOGY

Generation.

D.C. generators - Control and operating techniques. Comparison of characteristics with particular. Parallel operation, load sharing, equaliser connection. Regulation with particular reference to instrumentation.

A.C. generators - Brief comparison of salient, non-salient and brushless alternators with particular reference to applications. Simple phase phasor diagrams, load characteristic, voltage regulation. Waveform improvement. Estimation of synchronous impedance. Short circuit condition. Parallel operation of A.C. generators; Load sharing, synchronising techniques (manual and automatic), lamps dark and methods, phase rotation tests and the synchroscope.

Automatic voltage regulations - Requirements; Regulations statin permitted voltage limits-refer to response. Basic-design; Detector, corrector and stabilising elements. Outline of suitable types with detailed consideration of say two e.g., carbon pile, electronic, magnetic amplifier.

Motors.

A.C. motors - Commutator machines, linear motors. Starting and control equipment for A.C. motor; Pole changing.

Distribution system - Permitted system (I.E.E and LOYD'S regulation); Factors affecting choice of system. Emergency supplied; Reference to self contained and integral A.C. and D.C. systems. Protection; Preferential tripping, switches, insulators, contactors, current and power relays. Short circuit protection. Insulators with particular reference to earthing of high voltage equipment/system for safety.

Transformers - The auto-transformer; General considerations of advantages/disadvantages for marine application e.g., in motor starter and instrumentation. Instrument transformers; applications. Burden, class, terminal markings.

Steering gear system - General requirement of the electrical plant. Types; Electro-hydraulic, Ward-Leonard and follow up systems. Alarm circuits.

Batteries - Application of primary and secondary cells for shipboard use. Battery charging arrangement. Comparison of type. Safety. Maintenance.

Electrical propulsion systems - General requirement of the electrical system. Suitability of electrical system for classes of ship. Outline of constant current and constant voltage D.C. and of polyphase A.C. systems. Earthing, voltage distribution diagrams.

Lighting systems and illumination - B.O.T requirements for illumination. Measurement of level of illumination. Types of lamps and applications, advantages and disadvantages. Flourescent lamp circuits.

Circuit theory - Further development of general circuit theory; Bridge circuits e.g., gas detectors, strain gauge, temperature gauge.

Rectifiers and inverters - Basic type and applications for power supplies. Three phase units. Controlled rectifications. Basic principles of motor speed control using solid state controls e.g., thyristors.

GUIDE SYLLABUS (MARINE)
PHASE IV

APPLIED ELECTRONICS

Revision - Basic electronic valves and semi-conductors; Comparison in tabular form of characteristics and application. Component identification relative to B.S.I. symbols used in practical diagrams and circuits.

Amplifiers - D.C. and A.C. units should be outline. Function. Noise filtering. Frequency range, drift, cathode and emitter coupled amplifiers, interstage coupling. Thyristor amplifiers.

Inverter and rectifiers - Practical applications for electronic equipment e.g., instrument rectifiers, detectors, modulators.

Oscillators - Simple oscillator circuits e.g., blocking, feedback, relaxation. Applications; Phase shifting (Wien bridge) controlled frequency.

Static switching - Amplifications; e.g., Alarm annunciator equipment. Testing methods, familiarisation with components.

Materials and components - Preparation of electronic circuits involving the use of screened cables, plug and socket connections, multicore cables, integrated circuits. General maintenance techniques, Multiplexing (scanning circuits). Duty rating, reliability, mean time between failures.

MECHANICAL TECHNOLOGY

APPLIED TECHNOLOGY

Stress and Strain.

Stress in oblique planes induced by (a) Single direct stress, (b) two direct stresses at right angles, (c) complementary shear stresses. Calculation of strain energy in tension and in torsional shear. Impact loading of tie rods and springs.

Mechanics of Machine.

Equilibrium of governors, central and spring loading, sleeve friction, Centrifugal pumps.

Bending.

Relations between loading, shear force, bending moment, slope, deflection. Calculation of deflection in cantilevers and simply supported beams by Macaulay's method. Combined bending and direct stress, eccentric loading of short columns. Struts, derivation of Euler formula, development of Rankine formula.

Prevention of vibration on marine engine.

GUIDE SYLLABUS (MARINE)
PHASE IV

MARINE POWER PLANT TECHNOLOGY

(1) INTERNAL COMBUSTION ENGINEERING

Revisional applied heat - Important definitions of thermo dynamical terms and their units, Energy equation, Definition of a heat engine, Carnot principles, Comparison of Otto, Sabathe and Diesel cycles.

Entropy - Property diagrams incorporating the property entropy, comparison of diagrams (P-v, T-S, i-s), Equilibrium process in terms of the parameters of state.

Ideal cycles - Characteristic of dual combustion cycle and ideal simple processes, How to use state diagrams, Properties of isothermal, isovolumetric, isobaric and isoentropic changes, air standard efficiency.

Internal Combustion Engines:-

General design and construction of major types; Sulzer, B & W, M A N, G V, U E C etc. Fuel system for high viscosity fuels; Cautions how to use them with their properties, viscosity curves. Actual cycles; Revision of indicated and brake power, Revisions of efficiencies, Gross and specific fuel consumption. Energy balance.

Actual technique; measurement of crankshaft deflection and adjustment of crankshaft alignment, Procedures of dismantling and assembly of vital parts, Injection and fuel pump testing, Examination and Timing diagrams, Power, Out-of-phase and light spring diagrams, measurement of power, Sampling and testing of lubricating oil and fuel, Special technique of maintenance and repair works, Emergency operation technique.

Gas turbines. - Revision of turbo supercharger; Types of supercharging, Increment of power, surging, gas turbine cycles. Free piston turbine, Ideal cycle, Efficiency, Constructional view, Provisions and problems. Auxiliary open cycle gas turbine; Ideal cycle, Efficiency, Constructional view. Open and closed cycles; Ideal cycle, Efficiency, Provisions and problems. Basic cycle; calculation of work and power.

(2) STEAM ENGINEERING

STEAM POWER CYCLES

Carnot and Ranking cycles; P-V and T-S diagrams. Determination of power output, cycle efficiency. Work ratio and steam consumption. Total efficiency of steam ship.

MARINE BOILERS

Effect of boiler pressure, super heat, reheat and regenerative feed heating. Scotch boilers; internal and external examination procedures, tube removal and tube expansion, caulking, rivetting, welding.
Water tube boilers; internal and external examination procedure, tube removal and replacement, construction of plastic refractry combustion cone, maintenance of furnace lining. Repairing technic for emergency. Boiler cleaning, preservation and water treatment, boiler water testing. Pressure tests, accumulating tests.

Flash-up, steering and shutting down procedures. Precautions, emergency drills. Instrumentation, interpretation of data. Feed regulation, correct use of water gauge. Burner maintenance. Oil fuel burning systems. Gas, air, water and steam flow circuits in typical boilers. Tube sizes.

STEAM TURBINES

Lubrication and control system, self-closing emergency valves, governors. Over-speed trips.
Procedure for opening for examination; measurement of turbine clearances and rotor concentricity, identification of corrosion and erosion, adjustment of rotor position.
Warming through, manoeuvring and shutting down.
Lubrication system; causes of oil contamination, tests for water and salinity, Clarification of lubricating oil.

CONDENSERS

Application of Dalton's Law of partial pressures to air/steam mixtures. Cleaning, examination and treatment. Steam side and water side pressure tests.

FEED SYSTEM

Closed feed system; extraction pumps, de-aerators, regenerative heating, system modules. Control of system.

EVAPORATORS

Process of distillation. Principles of construction; single and two-stage submerged coil, flash evaporators, mounting. Protection devices. Conditions for stable evaporation.

CONDENSATE WATER SYSTEM

Condensate water pump; Balancing pipe, Return pipe, U tube for drain line.

(3) AUXILIARY MACHINERY

Ship general - Bilge and ballast system. Fuel oil filling and transfer system. Fire pump and emergency use. Power-operated water-tight doors. Mechanical aspects of turbo and diesel generators and alternators.

Steering gear - Methods of connection to rudder. Telemotors system. Routine servicing of Hele Shaw pump.

10. CONTROL ENGINEERING

ACTUATORS

Description of the basic elements and construction of a control valve, including packing and lubrications.

Types of valve trim, plugs, single and double seat control valve. Direct and reverse action. Use of air fin bonnets and multi port valves. Butterfly valves. Diaphram valve. Piston valve.

CONTROLLER (REGULATOR)

Procedure and adjustment of pneumatic controllers, electrical controllers, pneumatic electrical controllers, valve positioners, pilot valves, self operating controllers, pressure balance valves.

ACTUAL AUTOMATIC CONTROL

Examples of single. Two and three element feed water controls, steam pressure and temperature controls, fuel/air ratio control, cascade control, viscosity control of fuel oil.
Measurement of CO_2, O_2 and viscosity.
Example of exhaust range pressure control, gland steam pressure control, soot blower control, condenser circulating water temperature control, steam temperature control, automatic combustion control.

Warming and finish engine sequential control, auto spining system.

Jacket and piston cooling water temperature control.
Smoke and fire detections, flame failure monitors. Scavenging fire detectors. Oil mist detectors. Bridge control system. Telegraph recorders. Monitoring and scanning systems. Data logger. Use of mimic diagrams with alarm annunciators. Use of integrators and digital voltmeters for read out.

Maintenance and repair of control equipments. Testing of control equipments.

Ⅵ－4. ウンクオマールポリテクニクマリン・コース

5年生の試験問題例

POLITEKNIK UNGKU OMAR, Ipoh.

Terminal test: No. 1.
Date: 25th August, 1977.
Time: 2 Hours.

5th Year Certificate
Course in Mechanical
Engineering (Marine)

MARINE WORKSHOP PRACTICE.

Questions and Answers.

I. Pumps

Q1. How much is the mouth-ring clearance on a single-stage volute pump in general?

(A) 20/100 ～ 30/100 m/m.

Q2. How much is the limit of backlash for removing gears or adjusting center lines of gears on a gear pump?

(A) Module × 10/100 m.m.

Q3. Fill "Open" or "Close" in the following empty spaces.

(A)

Operational Stations	Before Start		Before Stop	
	Suction valve	Delivery valve	Suction valve	Delivery valve
Reciprocating pump	(Open)	Open	Open	Open
Gear pump	Open	(Open)	Open	Open
Volute pump	Open	Close	(Open)	Close

II. Boiler

Q1. How many turns does the boiler have on its path of exhaust gases?

(A) 2 turns (or 3 paths)

Q2. What is the advantage of a rotary burner?

(A) (1) Bigger turn-down ratio
(2) Easier maintenance.

Q3. Where is the location of air preheater (economizer) on this boiler?

(A) Inside top and rear wall above the combustion chamber.

Q4. How many safety valves does this boiler have?

(A) 1.

Q5. What is the lifting gear on a boiler?

(A) To open safety valve by handling this device in emergency cases.

Q6. Express the path of combustible air on this boiler from the air-intake port to the combustion chamber?

(A) Front top of the boiler – above combustion chamber – rear top wall – forced draft fan – beneath combustion chamber – burnercorn.

Q7. What is the caustic embrittlement on a boiler?

(A) When alkaline density in boiler water is concentrated, a phenomenon just like an acid corrosion is occurred on jointing parts, for instance, between the steam drum and water tubes or between the steam drum and end plates.

This is called caustic embrittlement.

III. Generator

Q1. Why should we adjust frequency at first when we operate A.C. generators?

(A) $f = ns \times \frac{P}{2}$

$E = 4.44 f w k \Phi$

f : frequency (Hz)
P : number of pole
W : winding number of a coil
K : coefficient of a coil
ns : synchronous speed (RPM)

From the above formulae, the voltage of A.C. generator is affected by its frequency, we should therefore adjust frequency at first.

Φ : number of magnetic flux

Q2. Why should we adjust frequency and voltage after a while we started A.C. generator?

(A) Electric current is affected by temperature rise. By the operation of A.C. generator, some quantities of electric current are converted into heat energy owing to electric resistance in its circuits.

The heat energy forces wiring coils to extend more than their sectional areas of the wires to expand, and also forces to change electric characteristics of elements composed its electric circuits. On the other hand, the temperature rises of lubricating oil and cooling water cause to make its revolution increase. So that we should adjust them again.

Q3. How do you operate the main switch board when a synchroscope is defective?

(A) We can operate by watching synchronous lamps.

When the top lamp is turned off and both bottom lamps are lightening, this timing shows just to be synchronized both generators' phases. So that on this timing we should switch on A.C.B.

Q4. When do you use decompression handle on the prime mover of A.C. generator?

(A) When we turn the crank shaft in order to set the engine on its starting position, to measure crank arm deflection etc. or when we lubricate the engine in idle condition.

Q5. What is checked by air blow (air running) through indicator valves?

(A) (1) Leakage of fuel oil or cooling water

(2) Remained exhaust gases and dirt inside the cylinders.

Q6. Which thermal efficiency is bigger between 2- and 4-stroke diesel engines?

(A) 4-stroke diesel engine is bigger.

Q7. Express briefly the operational procedure from stop condition to setting condition of normal operation with no-load on this 4-stroke diesel engine.

(A) (1) To prime up lubricating oil with several turning and to stop on starting position and to cut off decompression, after checking amount of lubricating oil in crank case.

(2) To open both fuel stop valves on A.O. service tank and on engine side.

(3) To open inlet valve for cooling water.

(4) To open (or confirm the opening) indicator valves.

(5) To open stop valve on starting air reservoir.

(6) To blow out dirt inside cylinders and to check leakage something in them.

(7) To shut off indicator valves.

(8) To check or to adjust starting position of the engine again with operating decompression handle.

(9) To operate the engine by the starting lever.

(10) To shut starting air stop valve off on the starting air reservoir.

(11) To keep the revolution in vicinity around 600 R.P.M for a while and to check its operational condition (Tachometer, cooling water pressure gauge, lubricating oil pressure gauge, sound, feeling etc.)

(12) To increase revolution of the engine gradually near to red zone on tachometer.

(13) To make the revolution of the engine steady under the red zone.

(14) To make the engine pass through the red zone quickly.

(15) To increase the revolution of the engine gradually and to settle the R.P.M. of the engine on the point of 1,200 R.P.M.

(16) To disconnect the turning handle of the governor and to check working condition.

Q8. When do you cut off disconnection switch in an ordinary merchant ship?

(A) When we check the electric circuits and equipments on its switch board or on the generator.

Q9. Express by what you can find dead earth on electric circuit at main switch board.

(A) There are three earth lamps for respective lines so-called R-S- and T- phases.

If there is dead earth on R- phase line, the earth lamp for the phase is turned off.

Q10. Which part is the most dangerous in experimental load-electrodes' tank?

(A) Inside area surrounded by load-electrodes.

Q11. Why the load of the A.C. generators are variable when the electrolyte is raised its temperature by their loads?

(A) Because, by boiling the electrolyte, the surface areas of load-electrodes are changeable.

Q12. Why cooling water can pass through suction and delivery valves on reciprocating cooling water pump, after 4-stroke diesel engines are stopped their operations?

(A) Because there are affected by a suction head of water and a syphon effect.

Q13. Why are you required to operate 4-stroke engine with no load of electricity when you commence its normal operation or when you finish its load operation?

(A) (1) To warm the engine up gradually and to keep it in good lubrication avoiding from heat stress, melting bearings etc.

(2) To cool the engine down gradually avoiding from heat stress etc.

Q14. What R.P.M. is the critical revolution of operation on these 4-stroke diesel engines and what is that?

(A) (1) Vicinity of 800 R.P.M.

(2) That is the revolution to be in synchronous resonance owing to coinside natural tortional frequency of the engine with forced frequency of vibration by itself.

Q15. Under fresh water cooling system in an ordinary motor ship, what is close to the role of a cooling tower?

(A) Heat exchanger cooled by natural sea water.

Q16. Point out briefly the causes of black-out in an ordinary merchant ship?

(A)(1) Accidental touch down on the trip button.

(2) Over-load

(3) Mishandling of A.C.B. in switching on timing on newly operated generator panel.

(4) Out of order on the generator.

(5) Out of order on the prime mover of the generator.

IV. Oil

Q1. Why should we check flash point of an oil and what is the function of flash point of it?

(A)(1) Because we should store an oil under flash point avoiding from a fire accident.

(2) Flash point is related to safety keeping from a fire and is not concerned with combustion of the oil.

Q2. What means bigger viscosity index number of a lubricating oil?

(A) The bigger the viscosity index number, the less the variability of viscosity by temperature change of it.

V. Steering Gear

Q1. What advantage can be aided on this steering gear if there is a spare pump?

(A) When the electric pump is coming out of order, this steering gear may be manoeuvered by power operation as well as electric pump does.

Q2. Referring to the given hydraulic diagram, express normal power operation following the diagram.

(A)(1) Change-over valve is pushed inner.

(2) By hand pump, oil pressure forces manual-electric change over valve to change its position to electric operating state.

(3) By handling steering wheel, follow cylinder is deviated its position.

(4) Connecting lever (floating lever) between follow cylinder and hunting lever forces control lever of the electric pump to deviate its position under the condition to make the pivot a fulcrum connected the control lever with the hunting lever.

(5) Electric pump sends pressured oil to one cylinder to push the plunger to one side of ram.

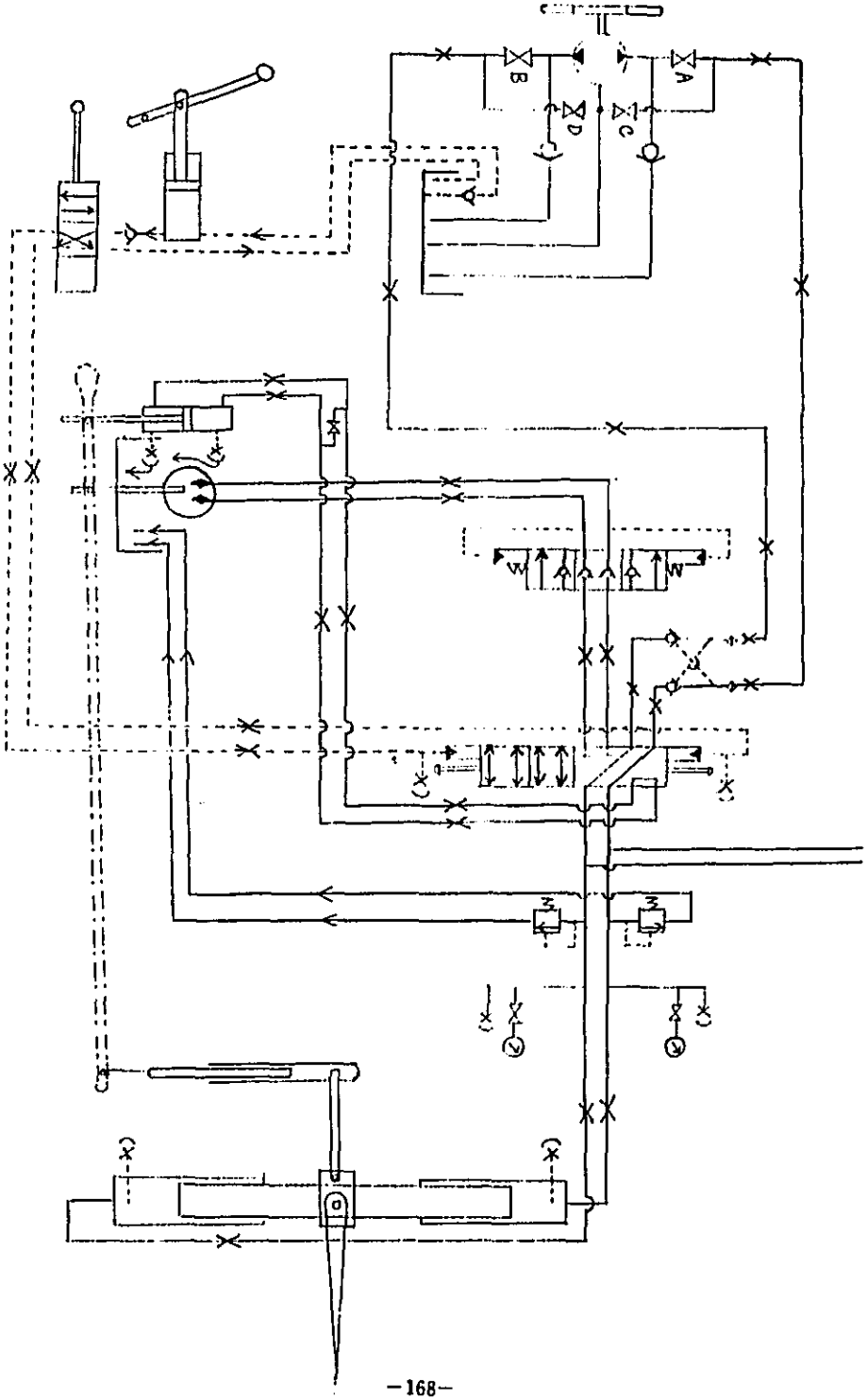
(6) Another side of the rams pushes oil back to the oil tank for electric pump.

(7) Rudder may be deviated to be in required angle.

(8) Hunting lever forces the connecting lever to deviate its position under the condition to make the pivot a fulcrum connected floating lever with the follow cylinder.

(9) Control lever of the electric pump is deviated its position in idle running condition.

(10) The rudder should be kept its position in required angle.


B
A
D
C

Ⅵ－5. 供与機材実習訓練方案書の一例

* 1. Start under No. 1; manual and No. 2; Stand-by.

(1) MFB on No. 1 starter should be turned on

→ W.L. (source lamp) lightens.
→ TL_1 may be excited (after an instituted time this A-contactor closes the circuit.

(2) MFB on No. 2 starter should be turned on

→ W.L. lightens
→ TL_2 may be excited.

(3) Push start button on No. 1 starter

→ RY_1 may be excited → AX_{12} may be excited →
→ AX_{11} may be excited → G.L. (running lamp) lightens

→ MC_1 may be excited → No. 1 motor drives
→ AX_{12} may hold by itself → AX_{13} may be excited →
→ AX_{24} may be excited →

→ TL_1 may be non-excited
→ AX_{24} may hold by itself
→ AX_{25} becomes Stand-by for exciting.

2. Stop under No. 1; manual and No. 2; Stand-by.

Push stop button on No. 1 starter

→ RYT_1 may be excited → AX_{12} may be non-excited →
→ GL turns off
→ AX_{24} may be non-excited → AX_{25} may be cancelled

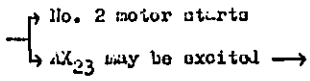
→ MC_1 may be non-excited → No. 1 motor stops
→ AX_{13} may be non-excited → TL_1 may be excited.

3. Over-load under No. 1; manual and No. 2; Stand-by

OC_1 changes the circuit from 39 to 40.

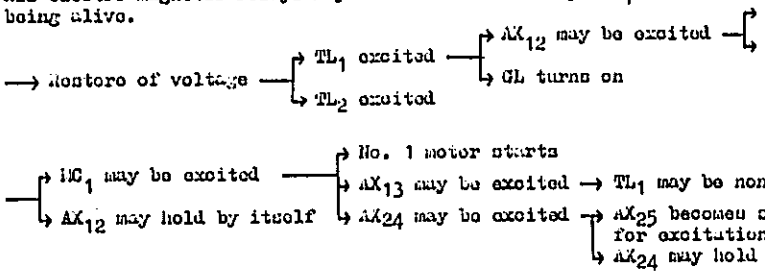
→ RYT_1 may be excited
→ AX_{12} may be non-excited → MC_1 may be non-excited → No. 1 motor stops
→ AX_{13} may be non-excited → AX_{25} may be excited
→ TL_1 may be non-excited
→ GL. turns off

→ RY_2 may be excited → AX_{22} may be excited → MC_2 may be excited →
→ AX_{21} may be excited → GL turns on → AX_{22} holds by itself



4. Low voltage under No. 1; manual and No. 2; stand-by.

All electro-magnetic relays may be non-excited except HY_1 contactor being alive.



AIR COMPRESSORS

Compressed air is used on board ship for starting diesel engines, in pneumatic control systems and for various pneumatic tools and cleaning equipment. By far the greatest use is for diesel engine starting using air pressures of 25 bar or more provided by reciprocating compressors.

This type of compressor will give a compression ratio of 7:1 in each stage depending on the size, cooling and speed of the machine.

Multi-stage units of various cylinder configurations and piston shapes have been used to produce the air pressures required. A selection of these are shown in Figure 4.1 but, because of its simplicity, accessibility and ease of maintenance, the two-stage two-cylinder, two-crank machine (type a) is now used almost invariably. Such machines are capable of compressing to 25 - 40 bar.

Cycle of operation

On the compression stroke the pressure rises to slightly above the discharge pressure. A spring-loaded non-return discharge valve opens and the compressed air passes through at approximately constant pressure. At the end of the stroke the differential pressure across the valve, aided by the valve spring, closes the discharge valve, trapping a small amount of high pressure air in the clearance space between the

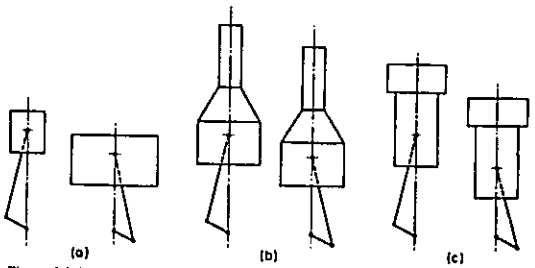


Figure 4.1 Compressor configuration

piston and the cylinder head. On the suction stroke the air in the clearance space expands, its pressure dropping until such time as a spring-loaded suction valve re-seats and another compression stroke begins (Figure 4.2).

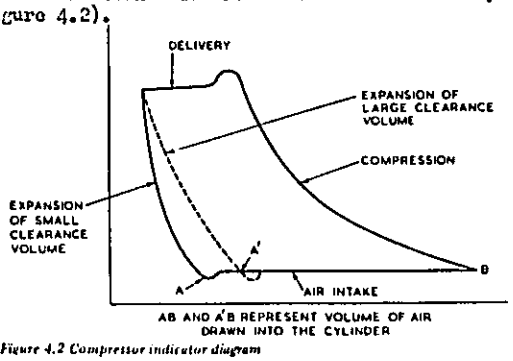


Figure 4.2 Compressor indicator diagram

Cooling

During compression much of the energy applied is converted into heat and any consequent rise in the air temperature will reduce the volumetric efficiency of the cycle. To minimise the temperature rise, heat must be removed. Although some can be removed through the cylinder walls, the relatively small surface area available severely limits the possible heat removal and as shown in Figure 4.3 it is preferable to compress in more than one stage and to cool the air between the stages.

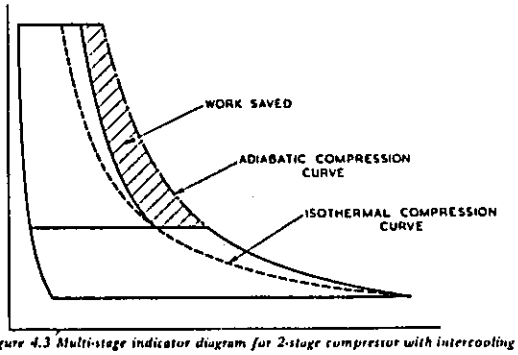


Figure 4.3 Multi-stage indicator diagram for 2-stage compressor with intercooling

Some small compressors use air to cool the cylinders and the intercoolers, the cylinder outer surfaces being extended by fins and the intercoolers usually being of the sectional finned-tube type over which a copious flow of air is blown by a fan mounted on the end of the crankshaft. In larger compressors used for main engine starting air it is more usual to use water-cooling for both cylinders and intercoolers.

Sea water is most commonly used for this purpose but fresh water ring mains serving compressors and other auxiliaries are not uncommon (see Chapter 1). In the former case the coolant can be circulated by a pump driven by the compressor or it can be supplied from a sea water ring main.

Operation and maintenance

Compressors must always be started in the unloaded condition since pressures otherwise build up rapidly producing very high starting torques (Figure 4.6). During running the accumulated moisture in the separators must be drained off regularly. This is extremely important, firstly because the condensate, if allowed to pass from the first compression stage to a subsequent stage, may give rise to lubrication problems and secondly the oily emulsion so formed, combined with dirt picked up from the atmosphere (where no suction filters are fitted) can, if conditions are right, result in an explosion in starting air lines or in the reservoir. Moisture lying in the starting air lines will give rise to corrosion and can cause water hammer. It is also good practice to check air reservoirs regularly for the presence of liquid by giving the reservoir drains a good blow occasionally. A compressor should never be stopped without first unloading it. This is done by opening the 1st and 2nd stage drains. Failure to do so could result in a severe explosion.

The maker's instructions on the lubrication of the machine must be closely followed. Poor lubrication, or the use of an incorrect oil, can cause severe wear and sticky valve operation.

By far the greatest item of maintenance concerns the valves. The seats of these may need refacing from time to time due to their constant pounding. Whenever this is done care must be taken to see that the valve lift is not altered since increased wear will then occur. Poor selection of lubricating oil, dirt, or overheating, will give rise to valve sticking or seat pitting.

Bad valve operation can be detected by observation of the interstage pressures and is usually accompanied by excessive discharge temperature although the latter will also be a symptom of poor cooling.

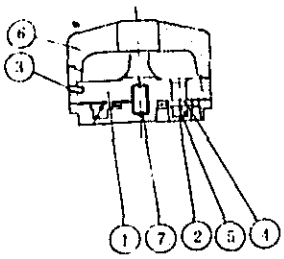
Adequate attention must be given to the water cooling system. Overcooling can cause condensation on the cylinder walls, adversely affecting lubrication, while poor cooling, due perhaps to scale formation (especially in a sea-water cooled machine) will result in a fall-off in volumetric efficiency and rapid valve deterioration. In extreme cases compressor explosions can occur. Lloyds require that the compressor should be so designed that the air discharge temperature to the reservoir should not substantially exceed 93°C. Comments on the maintenance of heat exchangers appear elsewhere.

Checking Item			Operating Time (hr.)					Remarks
Division	Checking Part	Nature of Work	Daily	200	400	1000	2000	
Rotary motion section	Main bearing	Checking of main bearing					O or biennially	
		Checking of main bearing setbolt					O or biennially	
	Crank-shaft	Checking of wear amount					O or biennially	
Cooling water system	Anti-corrosive zinc	Checking & replacing				O or biannually		
	Cooling water pump	Replacing of impeller				O or annually		Limited to JABSCO pump
		Checking & replacing of shaft seal					O or biennially	Replacing limited to JABSCO pump
		Checking of valve					O or biennially	Limited to reciprocating pump
	Water jacket part	Cleaning				O or annually		Sea-water
Air system	Valve	Blow-out checking & cleaning of valve				O or annually		
		Replacing of valve					O or biennially	
	Air passage part	Checking & cleaning				O or annually		
	Safety valve	Blow-out pressure confirmation & cleaning				O or annually		
	Check valve	Seal checking, replacing & cleaning					O or biennially	
Others	Various pipe lines	Leakage checking						
	External appearance	Checking for loose bolts and nuts & oil leakage						

8-6. Troubleshooting Procedure

Nature of Malfunction	1st Check	Result of 1st Check	2nd Check	Result of 2nd Check	Countermeasures
Abnormal heating of the clutch	Check to see if the clutch is in or out.	Under the condition of clutch in	Check for a play of the clutch handle	Play exists	
				No play	Adjust so as to achieve a play of the clutch handle.
			Check for the load condition of this compressor by means of the low-pressure step pressure gauge. (No pressure gauge is provided for Model SC5N, however.)	No abnormality	
				Abnormal condition exists.	Check high-pressure valves & valve packings. Check to see whether foreign matter is present inside the cylinder. Check for seizure of bearings.
			Check for soiling of clutch friction faces or quality change of clutch linings	No abnormality	
				Abnormal condition exists.	As for soiling, wipe off contamination with the use of thinner or gasoline. As for quality change of clutch linings, replace them with the new ones.
			Check for the length of clutch springs (in the case of Model SC5N/SC7N/SC10N/SC12.5N/SC15N/SC20N.)	Specified length	
				More than the specified length	Adjust so as to attain the specified length of clutch springs. (Refer to the Sub-section 8-3.)
		Under the condition of clutch out	Check for the clearance of clutch direct coupling	No clearance	First achieve the specified play of the clutch handle, and then enlarge the clutch stroke.
Early damage of driving rubbers	Check for precision of clutch direct coupling	Good precision			
		Poor precision			Redo centering of direct coupling.

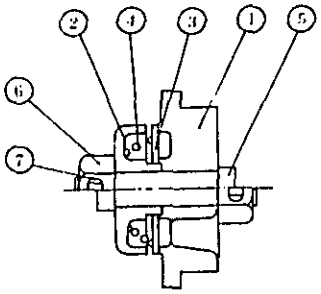
Model SC7N/SC10N/SC12.5N



No.	Part Name
1	Valve seat
2	Valve guard
3	Lock screw
4	Valve plate
5	Valve spring
6	Valve holder
7	Stud bolt

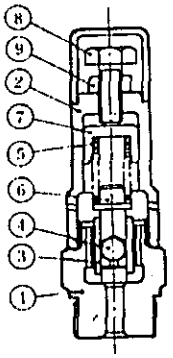
Fig 2 Low-pressure valve

Model SC7N/SC10N/SC12.5N



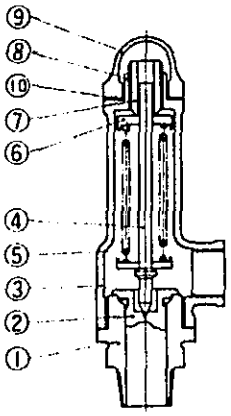
No.	Part Name
1	Valve seat
2	Valve holder
3	Valve plate
4	Valve spring
5	Valve setbolt
6	Valve setbolt lock nut
7	Split-tip taper pin

Fig 3. High pressure valve.



No.	Part Name
1	Body
2	Spring holder
3	Valve body
4	Steel ball
5	Valve spring
6	Lower spring holder
7	Upper spring holder
8	Spring adjusting screw
9	Lock nut

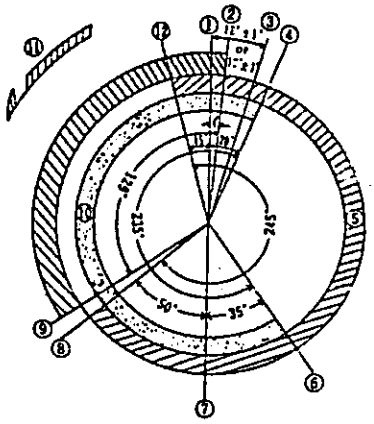
Fig 4 High-pressure safety valve



No.	Part Name
1	Valve seat
2	Valve body
3	Valve case
4	Valve keep rod
5	Valve spring
6	Spring holder
7	Spring adjusting screw
8	Lock nut
9	Cap
10	Gasket

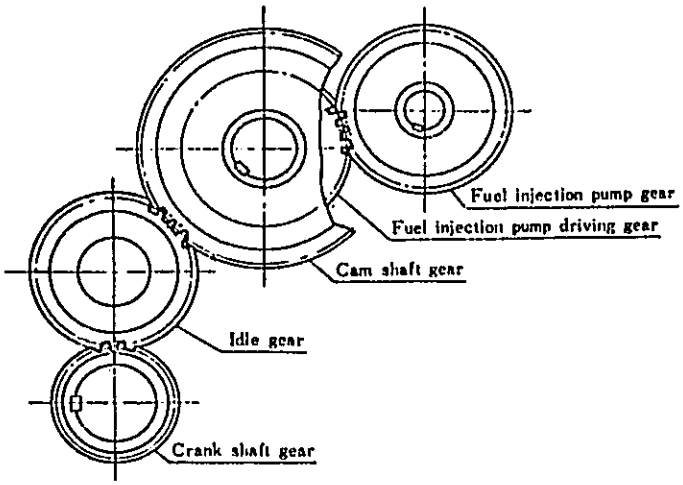
Fig 5. Low-pressure safety valve

VALVE TIMING DIAGRAM

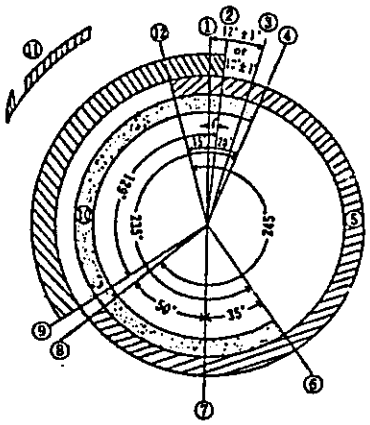


① Top Dead Center (TDC)
② Starting valve opens
③ Fuel injection begins
④ Intake valve opens
⑤ Exhaust stroke
⑥ Intake valve closes
⑦ Bottom Dead Center (BDC)
⑧ Exhaust valve opens
⑨ Starting valve closes
⑩ Suction Stroke
⑪ Rotational direction as viewed from flywheel side
⑫ Exhaust valve closes

TIMING GEARS INTERLOCKING DIAGRAM



VALVE TIMING DIAGRAM



① Top Dead Center (TDC)
② Starting valve opens
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⑤ Exhaust stroke
⑥ Intake valve closes
⑦ Bottom Dead Center (BDC)
⑧ Exhaust valve opens
⑨ Starting valve closes
⑩ Suction Stroke
⑪ Rotational direction as viewed from flywheel side
⑫ Exhaust valve closes

TIMING GEARS INTERLOCKING DIAGRAM

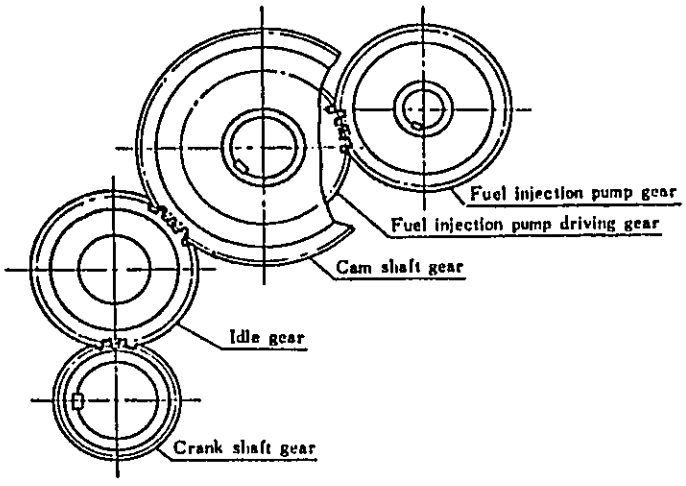
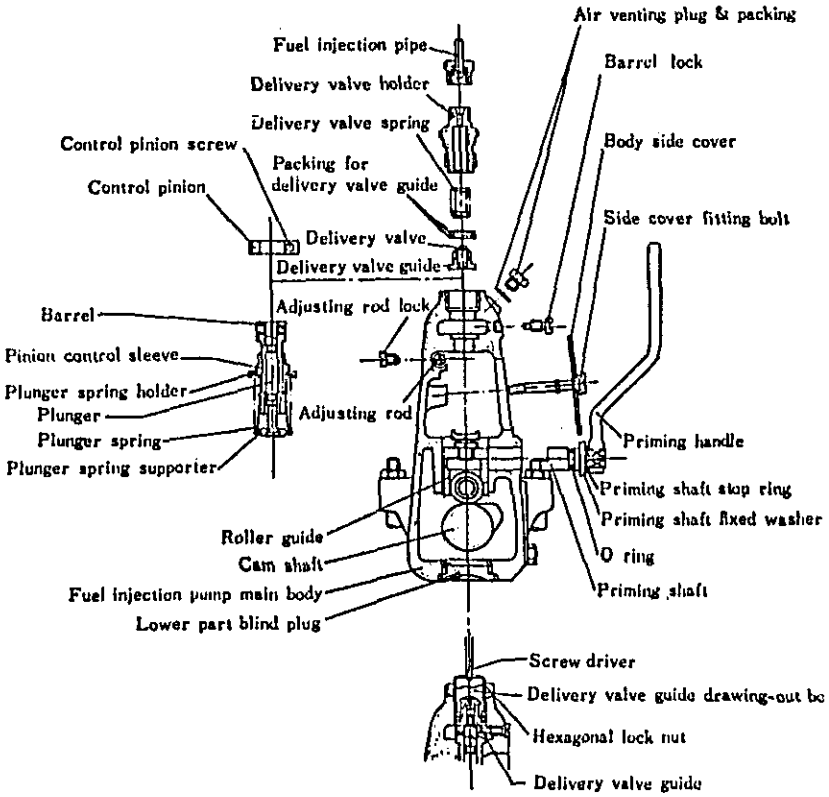


Fig. 5. FUEL INJECTION PUMP



Drawing-out of Delivery Valve Guide

MARINE WORKSHOP

Title: 2-Cycle Diesel Engine Pipe Line

Type _____

Builder _____

Rated Horsepower _____

It is absolutely necessary that Marine Engineer is completely familiar with the pipe lines on a ship. To accomplish this a detailed illustration of the following pipe lines as fitted with this 2-cycle diesel engine is required.

In performing this assignment you are to make your necessary observation yourself. You must take the initiative in doing this observation.

You will be required to answer questions based upon your observation. Your answer will be marked. The clarity, neatness, accuracy and completness of your answer will be required. Needless to say, your attitude with which you approach this workshop will be reflected in your grade.

Draw and label the following pipe lines

1) Lubrication system

   a) Main L.O.
   b) Piston cooling L.O.
   c) Turbo charger L.O.
   d) Exhaust valve and driving device L.O.
   e) Cylinder L.O.

(You have to investigate type of pump and filter, pipe diameter, valve, thermometer and pressure gauge).

2) Fuel system

   a) Transfer F.O.
   b) Injection F.O. (from F.O. service tank)

3) Cooling system

   a) Jacket cooling (include air cooler)
   b) F.O. valve cooling
   c) Cooling water (include water dynamometer water)

4) Scavenging air (Engine air intake system)

5) Starting air system.

MARINE WORKSHOP

Title : Boiler I

Type : _____

Steam Pressure and Temperature : _____

In performing this assignment you are required the necessary observation. You must take the initiative in doing this observation.

Investigate and describe (sketch) the followings:-

1) Feed water line
2) F.O. line
3) Draught system (air intake ⟶ exhaust)
4) Safety valve
5) Steam stop valve
6) Water gauge (glass gauge and detector for control)
7) Test cock
8) Pressure gauge
9) Soot Blower
10) Burners and Registor
11) Automatic combustion control system
12) General layout (Sectional elevation)
13) Inside the furnace (general impression, tube, refractory, quarls, air case, etc.).

INSTRUCTION FOR PRESSURE GAUGE

Recommendations Regarding the Installation and Use of Pressure Gauge.

Although pressure gauge can be expected to give a long period of reliable service if correctly selected, installed and used, careless installation may result in inaccurate readings and even early failure of the gauge.

Particular care is essential in selecting and installing a gauge which is to operate under adverse working conditions such as rapidly fluctuating pressure, vibration, excessive heat or cold, or with corrosive or explosive gases or liquids.

The maximum working pressure of the gauge, under steady pressure, should not exceed two-thirds of the maximum scale readings, if accurate the elastic-chamber is expected.

If the above recommendations are exceeded, the elastic-chamber may take a permanent set, thus causing error in the pressure indication.

In no case should the gauge even be exposed to a pressure beyond the maximum pressure provided on the scale.

When gauges are mounted on walls or panels they should be free from piping strains, and in the case of piping in liable to expansion and contraction with change of temperature, some means should be introduced to provide for flexibility in the piping.

When connecting gauges to the pressure connection they should be tightened by means of the flat provided.

Normally, gauge should be installed with the face of the dial in a vertical position.

To isolate the gauge or to permit it to be removed while the plant is under pressure a cock or valve should be fitted in the line to the gauge, preferably adjacent to the gauge, preferably adjacent to the gauge. Where the line is of considerable length it is desirable to have an additional cock or valve at the pressure tapping point.

Gauge cock or valve should be opened slowly, as it is most detrimental to the gauge for pressure to be suddenly applied or released.

Gauge for use with oxygen must be absolutely free of grease or oil.

On the dial rod letters USE NO OIL are plainly inscribed. For oxygen, gaskets and washers used in connections should be degreased annealed copper.

INSTRUCTION FOR DEAD-WEIGHT PRESSURE GAUGE TESTER TYPE P1

CONSTRUCTION

Dead-Weight Pressure Gauge Tester Type P1 is illustrated on the Figure.

The screwed pin which has an iron-rubber piston is operated with the handle (H). Pressure oil lead to the air through the valve (1), and to the measuring piston, the test gauge and the oil reservoir through the valve (2), the pressure tube and the valve (3).

PREPARATION BEFORE THE TESTING

a) Install the tester horizontally, if not so, produced pressure is not equal to pressure which correspond weights, in addition to the measuring piston will rub against the cylinder and wear away unevenly.

b) Fill up a mineral oil in the oil reservoir and avoid alien substance in it.

c) Reject the air in the pressure cylinder, turn the valve (1) clockwise and the valve (2), (3) counter-clockwise as far as it will go by a hand, turn the handle (H) 2 or 3 time the plunger screwed in and out as far as it will go by a hand.

d) When the described 'USE NO OIL' on the dial of the testing gauge, installed a 'SYPHON' between the valve (4) or (5) and the it.

USING

IN CASE OF USING THE WEIGHTS

a) The measuring cylinder is screwed to the union nut (4) and insert the measuring piston in it.

b) Testing pressure gauge is attached the most convenient situation to the union nut (5), using the suitable joint if necessary.

c) Suck the oil into the pressure cylinder that turn the valve (1) clockwise as far as it will go by a hand, the valve (2), (3) counterclockwise as far as it will go, the handle (H) clockwise as far as it will go, then turn the valve (3) clockwise as far as it will go.

d) Face the weights corresponding to the pressure to be tested (pressure valve is punched on the weight) on the carrier, the pressure by the carrier itself 0.5 Kg/cm must be added.

e) Turn the handle (H) clockwise slowly until weights floats by 10 15mm ('S' on the figure) rotate the weights gently to the right. In this case, the pressure produced by the weights is strictly measuring pressure. When the weights come down, turn the handle (H) again.

f) To reduce pressure, turn the handle (H) counterclockwise until the pressure becomes completely zero and open the valve (3) bit by bit. If open valve (3) suddenly, oil will gush out.

IN CASE OF USING THE STANDARD TEST GAUGE

Attach the standard test gauge in place of the measuring cylinder the most convenient situation to the union nut (4), using the suitable joint if necessary.

Suck the oil into the pressure cylinder same as above method, the handle (H) clockwise slowly until desirable pressure of the standard test gauge, and we can calibrated the gauge to be tested by refering to the error table of the standard test gauge.

PRESSURE PROOF TEST

To carry out the pressure proof test of the gauge, turn the valve (2) clockwise as far as it will go after the pressure is applied to the it by turning the handle (H) clockwise. If the pressure reduces, turn the valve (2) counterclockwise and apply the pressure by turning the handle (H) clockwise again. In this case, the standard test gauge cannot be use at the same time.

ATTENTION

a) A oil as the pressure medium does not use high viscosity or alien substance in it.

b) Horizontally put the weights on the carrier.

c) In case of the exchange the pressure gauge situation which screwed to the union nut (4) or (5), turn a little the union nut (4) or (5) counterclockwise.
Turn the pressure gauge the most convenient situation, the union nut (4) or (5) clockwise as far as they will go again fixing the socket of the gauge by a spanner.

MANAGEMENT AFTER THE TESTING

a) The measuring piston and cylinder are hardened, ground and lapped to the exactly definite area. They should always be oiled not to get rusty.

b) The weights do not get rusty too.
They are exactly machined to the stamped weight, therefore do not rub with a sand paper or a file.

c) To pressure the tester successfully long time, it is desirable to the valve (1) turning counterclockwise as far as it will go, and discharge the oil to a suitable pot from the oil drain. Take the measuring piston and cylinder or the standard test gauge off the union nut (4) or (5), and then put them into the box.

Cover the union nut (4), (5) in order to prevent them from dust.

VACUUM PRESSURE TEST

a) Screw a standard vacuum test gauge in place of the measuring cylinder the most convenient situation into the union nut (4), using the suitable joint if necessary.

b) Screw a vacuum gauge to be tested the most convenient situation into the union nut (5), using the suitable joint if necessary.

c) Reject the air in the pressure cylinder by means of the above mentioned, (an item PREPARATION BEFORE THE TESTING) and lastly turn the handle (H) clockwise as far as it will go.

d) Turn the valve (3) clockwise as far as it will go, the handle (H) counterclockwise slowly until desirable pressure of the standard vacuum test gauge, and we can calibrate the vacuum gauge to be tested by refering to the error table of the standard vacuum test gauge.

But high vacuum pressure can not be produced by this tester.

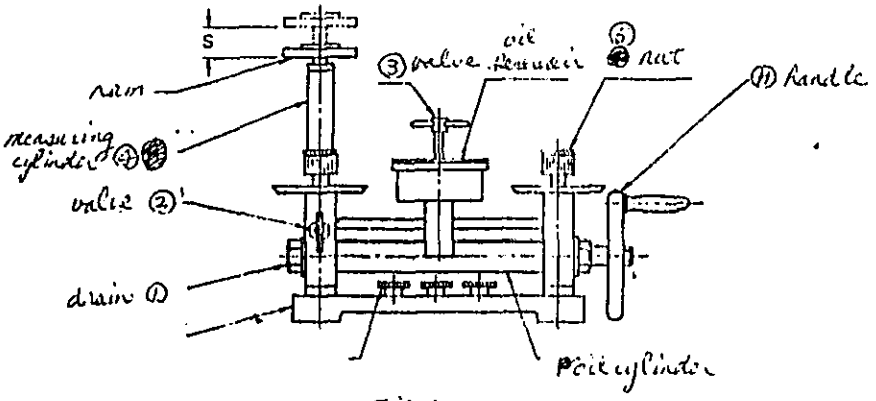


Fig 1.

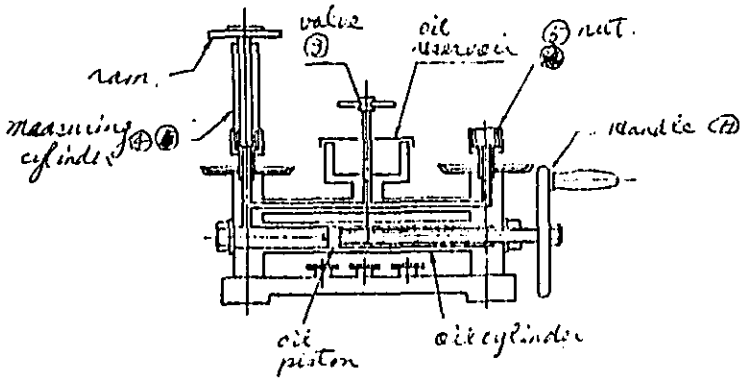


Fig 2.

Viscosity

Viscosity for commercial purposes is usually determined in Great Britain and Japan by the Redwood viscometer, in the U.S.A. by the Saybolt and in Europe by the Engler. All these are similar in principle, and differ only in the volume of oil held in the container, the size of the aperture and the volume of oil, the efflux of which is measured.

The Redwood viscometer (Fig. 1) consists of a cylindrical vessel silvered internally and provided with an agate jet of specific dimensions in the bottom, which is closed with a spherical plug attached to a wire.

Inside the oil cylinder and at a short distance from the top is screwed a small bracket terminating in a point which serves as a gauge of the height of the oil level.

A copper bath surrounds the oil cylinder and is furnished with a copper tube closed at the lower end, projecting at an angle of about 45° from the side of the bath near the bottom, which provides a means of heating the bath liquid; by use of a revolving agitator the heated liquid rising from the copper tube can be uniformly mixed throughout the bath. The agitator carries a thermometer to indicate the temperature of the bath. A short standard attached to the oil cylinder carries a clip to hold a thermometer in the oil. The instrument is supported on a tripod, and before using must be levelled by means of screws in the legs and a level provided for this purpose.

The sample of oil to be tested is placed in the oil cylinder up to the point of the gauge and the temperature adjusted to that required by regulating the temperature of the surrounding bath. The thermometer dipping into the oil cylinder is generally used as a stirrer. When the oil is at the required temperature the plug is lifted and simultaneously a stop watch started and the time in seconds noted for 50 c.c. to flow into a graduated receiving flask. To obtain accurate results in the Redwood viscometer the instrument must be level, the oil cylinder and orifice must be perfectly clean and the bulb of the oil cylinder thermometer must be sufficiently low in the cylinder to enable it to record the true temperature, but not so low as to impede the flow of oil through the aperture. It should also be noted that accurate results are only obtained for times of outflow ranging between 30 and 2000 sec., for efflux times exceeding 2000 sec. The No. 2 viscometer should be used, which gives readings convertible into No. 1 scale by multiplying by ten.

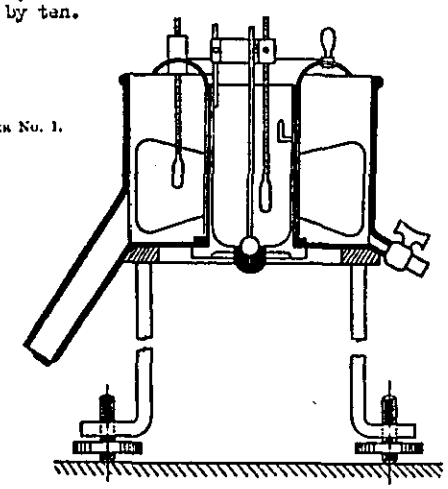


Fig. 1 —Redwood Viscometer No. 1.

Flash Point

The flash point is the lowest temperature of the fluid that allows inflammable vapors to be formed. It is found by heating the fuel or L.O. slowly and then sweeping a flame across the surface of the liquid. A distinct flash is obtained at flash point.

The flash point is important for safety purpose and serves as a measure of the fire hazard.

The Pensky-Martens and Abel-Pensky are generally used for making the test.

The Pensky-Martens apparatus (Fig. 2) consists of a brass cup fitting loosely in a cast-iron body, by which it is supported on the top rim but not touching on either the sides or bottom. The cup is closed at the top with a cover fitted with a perforated slide, and a spring lever is provided which, when turned, rotates the cover. The cover also carries a stirrer and a thermometer so fixed as not to foul the stirer. The oil to be tested is placed in the cup in such quantity as to just touch the prescribed mark on the inside of the cup. The cover is then fitted into position on the cup and heating of the apparatus by means of a suitable Bunsen burner commenced. During heating, the oil must be constantly stirred and the heating so adjusted as to give a temperature rise of the oil at the time of flashing of 5 - 6°C per minute. As the oil approaches the temperature of flashing, the injector burner is lighted and injected into the oil container at 12 sec., intervals (each 2°C arising) until a distinct flash is observed within the container.

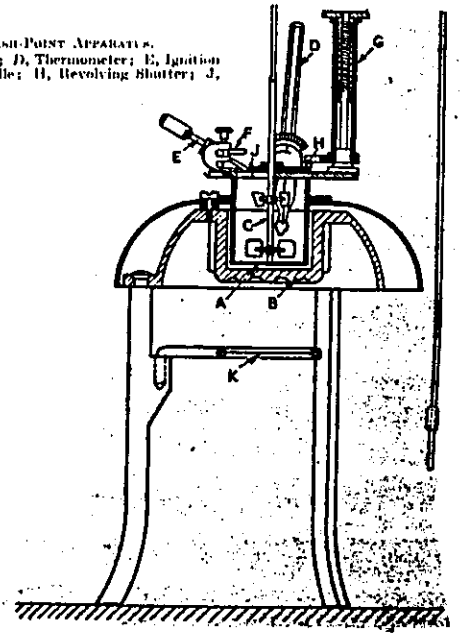


Fig. 2.—Pensky-Martens Flash-Point Apparatus.
A, Oil Cup; B, Heating Vessel; C, Stirrer; D, Thermometer; E, Ignition Burners; F, Pilot Burner; G, Spring Handle; H, Revolving Shutter; J, Orifice; K, Gauze Disc.

VISCOSITY CONVERSION TABLE

Redwood Sec.	Saybolt Universal Sec.	Engler Units.	Kinematic Viscosity in Centistokes.	Redwood Sec.	Saybolt Universal Sec.	Engler Units.	Kinematic Viscosity in Centistokes.
30	33·6	1·09	2·08	140	165·2	4·55	35·20
32	36·0	1·16	2·96	145	171·1	4·71	36·55
34	38·4	1·23	3·68	150	177·0	4·87	37·86
36	40·8	1·29	4·60	155	182·9	5·03	39·20
38	43·3	1·35	5·37	160	188·8	5·19	40·54
40	45·6	1·40	6·12	165	194·7	5·35	41·87
42	48·2	1·46	6·84	170	200·6	5·52	43·19
44	50·6	1·55	7·55	175	206·5	5·68	44·52
46	53·0	1·60	8·23	180	212·4	5·84	45·85
48	55·4	1·66	8·91	185	218·3	6·00	47·18
50	57·8	1·72	9·59	190	224·2	6·17	48·50
52	60·2	1·78	10·23	195	230·1	6·33	49·82
54	62·6	1·84	10·85	200	236·0	6·49	51·15
56	65·0	1·90	11·48	210	247·8	6·82	53·79
58	67·3	1·97	12·11	220	259·6	7·15	56·42
60	69·6	2·03	12·74	230	271·4	7·47	59·05
62	71·9	2·09	13·35	240	283·2	7·80	61·69
64	74·5	2·16	13·95	250	295·0	8·12	64·32
66	77·1	2·22	14·55	260	306·8	8·45	66·90
68	79·6	2·28	15·15	270	318·6	8·77	69·60
70	81·9	2·33	15·75	280	330·4	9·05	72·20
72	84·2	2·39	16·33	290	342·2	9·42	74·80
74	86·6	2·45	16·93	300	354·0	9·75	77·43
76	88·9	2·52	17·51	325	383·5	10·56	83·98
78	91·3	2·58	18·09	350	413·0	11·37	90·51
80	93·6	2·65	18·66	375	442·5	12·15	97·04
82	95·9	2·70	19·23	400	472·0	13·00	103·57
84	98·3	2·76	19·79	425	501·5	13·77	110·10
86	100·6	2·82	20·35	450	531·0	14·58	116·55
88	103·0	2·88	20·92	475	560·5	15·39	123·50
90	105·3	2·93	21·49	500	590·0	16·20	129·66
92	107·6	3·00	22·06	525	619·5	17·01	136·22
94	110·0	3·06	22·62	550	649·0	17·82	143·00
96	112·3	3·12	23·18	575	678·5	18·63	149·50
98	114·7	3·19	23·74	600	708·0	19·44	156·00
100	117·0	3·27	24·30	625	737·5	20·25	162·20
105	123·4	3·41	25·67	650	767·0	21·06	168·70
110	129·8	3·55	27·06	675	796·5	21·87	175·50
115	135·7	3·73	28·42	700	826·0	22·68	181·80
120	141·6	3·90	29·78	725	855·5	23·49	188·50
125	147·5	4·06	31·13	750	885·0	24·30	195·00
130	153·4	4·22	32·48	775	914·5	25·11	201·30
135	159·3	4·38	33·84	800	944·0	25·92	207·80

APPENDIX I—*continued*

Redwood Sec.	Saybolt Universal Sec.	Engler Units.	Kinematic Viscosity in Centistokes.	Redwood Sec.	Saybolt Universal Sec.	Engler Units.	Kinematic Viscosity in Centistokes.
825	973·5	26·73	214·0	1375	1622·5	44·55	357·3
850	1003·0	27·54	221·0	1400	1652·0	45·36	364·0
875	1032·5	28·35	228·0	1425	1681·5	46·17	370·5
900	1062·0	29·16	234·0	1450	1711·0	46·98	377·0
925	1091·5	39·97	240·5	1475	1740·5	47·79	383·5
950	1121·0	30·78	247·9	1500	1770·0	48·60	390·0
975	1150·5	31·59	253·3	1550	1829·0	50·22	403·0
1000	1180·0	34·50	259·8	1600	1888·0	51·84	416·0
1025	1209·5	33·21	266·1	1650	1947·0	53·66	429·0
1050	1239·0	34·02	273·0	1700	2006·0	55·08	442·0
1075	1268·5	34·83	279·3	1750	2065·0	56·70	455·0
1100	1298·0	35·64	285·7	1800	2124·0	58·32	468·0
1125	1327·5	36·45	292·3	1850	2183·0	59·94	481·0
1150	1357·0	37·26	299·0	1900	2242·0	61·56	494·0
1175	1386·5	38·07	305·3	1950	2301·0	63·18	507·0
1200	1416·0	38·88	311·9	2000	2360·0	64·80	520·0
1225	1445·5	39·69	318·3	2050	2419·0	66·42	533·0
1250	1475·0	40·50	324·9	2100	2478·0	68·04	546·0
1275	1504·5	41·31	331·3	2200	2596·0	71·28	572·0
1300	1534·0	42·12	337·9	2300	2714·0	74·52	598·0
1325	1563·5	42·93	344·3	2400	2832·0	77·76	624·0
1350	1593·0	43·74	350·8	2500	2950·0	81·00	650·0

The grade designations of the products described on this Data Sheet were changed on July 1, 1976, to conform to the viscosity classification system adopted by the International Standards Organization (ISO). The former designations are shown in the table of typical inspections.

EXXON

DG-2C

Supersedes issue of 9-14-73

Teresso/

TERESSTIC (Please note that in USA this brand is calle Teresstic but in Malaysia it is called Teresso

Premium R & O Lubricating Oils

TERESSTIC is the brand name for a line of long-service-life lubricating oils that have ranked for over four decades as among the finest products of their kind. Subject to continual improvement over the years, TERESSTIC oils are formulated with carefully selected base stocks that offer the characteristics necessary for dependable service. TERESSTIC is fortified with special additives selected for maximum compatibility and effectiveness. The proper combination of oxidation and rust inhibitors and anti-foam agents promotes its natural high-quality features and imparts other characteristics of major importance

Grades

The TERESSTIC line of premium circulating oils consists of six viscosity grades. Five of these grades conform to the International Standards Organization (ISO) viscosity classification system. TERESSTIC 77 is an intermediate grade between ISO viscosity grades 68 and 100 with an approximate viscosity of 77 centistokes at 40°C.

Typical Inspections

The values shown here are representative of current production. Some are controlled by manufacturing specifications, while others are not. All of them may vary within modest ranges.

TERESSTIC Grade	32	40	68	77	100	150
ISO viscosity grade	32	40	68	—	100	150
ASTM viscosity grade	100	215	315	—	—	—
AGMA number	—	1	2	—	—	—
Gravity, °API	33.2	30.7	30.4	30.0	29.4	28.5
specific	0.859	0.872	0.874	0.876	0.879	0.884
Viscosity, cSt at 40°C	30.1	42.9	63.7	77.0	105.0	157.5
cSt at 100°C	5.4	6.6	8.7	9.9	12.1	15.7
SSU at 100°F	154.5	222	329	398	546	815
SSU at 210°F	44.3	48.3	65.5	59.8	68.1	82.6
Viscosity index	112	105	108	109	106	102
Pour point, °C	−9	−9	−6	−6	−6	−6
°F	15	15	20	20	20	20
Flash point, °C	210	224	235	252	266	271
°F	410	435	455	485	510	520
Neutralization No.	0.05	0.00	0.08	0.08	0.08	0.08
Former TERESSTIC Grade	43	47	52	56	65	65

Printed in USA 7-1-76

EBARA GEAR PUMP

TYPE — 25 GPFM
PRES — 6 kg/cm^2
Q'TY — 54 L/min.
SP'D — 1450 r.p.m.

* Operation and Maintenance

The EBARA Model GP Gear Pump is horizontal shaft, circumscribed type and involute gear type. Pump gear, provided with ample strength, is of precision machining. Suction performance and volume efficiency are much advanced. Casing is vertically split and the clearance between the casing inside and the pump gear outside is furnished with a high quality side plate of abrasion proof which is interchangeable.

For bearings, needle bearings are applied to facilitate maintenance. In the gland section, mechanical seal is adopted. A safety valve is furnished to protect the casing. This direct-acting safety valve efficiently discharges all the discharge quantity of the pump for excess of the regulated pressure by spring operation. But this is not a cotrolling valve. Therefore, if it is usually operated, valve and spring may be damaged and vibration and noise may be caused. Usual operation requires another valve in the pipe.

a) Precautions before Start

1) Understand the pump construction well and inspect alignment of shaft coupling and pipe conditions. Also confirm that there is no irregularity in any respect. If the gear surface of the pump gear is dry, the pump may not be able to pump up at first. If the pump has not been used for a long period, pour a small quantity of turbine oil into the gear pump to moisten the gear surface.

2) If the pump does not move well, it is because the pump rusts, the gland packing too tightly fastened, or forrign substances are inserted between tooth forms. Inspect irregularity and repair it. There may be some non-smoothness just after a mechanical seal is provided. But there is no unevenness.

3) Move the shaft alone and fasten shaft coupling bolts after confirming its rotating direction. Since the coupling bolts are not applied for small power pumps, confirm the rotating direction by operating the pump with the motor directly coupled for a short time.

4) Keep the sluice valve (stop valve) fully open without fail if it is provided on the suction side.

b) Precautions at Starting time

1) Switch on the motor with the discharge valve fully open as a rule.

2) At first be sure that there is no irregularity, switching once or twice. And then continuous operation shall be started.

3) For using the pump in suction condition, the pump sucks up the air in the pipe at first and it will take a little time to suck the oil. If the pump shall not pump the oil in one minute despite the regulated revolutions (a discharge pressure gauge does not show pressure rise), switch off and inspect the pump.

4) Since the bearing is self-lubricated, dry running shall be avoided by all means.

5) When starting the pump after a short period of shut-down, switch on the motor for pump operation. But after a long period of shut-down, in cold winter or if oil is solid at the bearing part, suggestions required for trial running shall be observed.

c) Precautions during Operation

1) Bearing temperature will rise up naturally for continuous operation. If you can touch it with hand, it will be all right. If bearing temperature rises up higher than 30°C over oil temperature, or max. temperature exceeds 90°C, stop the pump.

2) The cocks of the pressure gauge and vacuum gauge shall be closed usually and shall be opened only when it is necessary for inspection to confirm normal operation of the pump.

3) If the strainer or the sluice valve is clogged with solids, the indicator of the pressure gauge is shaken hard, discharge quantity decreases suddenly or abnormal noise is developed.
Take a good care to avoid clogging.

4) For the gland packing, check if the shaft seal is not heated owing to over-fastening or partial fastening of the packing. It will be safe up to 60°C. It will be proper that oil leaks a little from the shaft seal constantly.

5) When the pump discharge valve is shut off, the safety valve is fully opened and oil will return to the pump suction side. But a long period's operation of the safety valve will cause liquid temperature rise and steam generation, thus heating of the inside.
The operation of the safety valve attached to the pump over 10 minutes shall be avoided as much as possible. If necessary by any means, oil shall be returned through a pipe. (Over 5 kg/cm^2 of discharge pressure, avoid over 5 minutes' operation.)

6) Time of safety valve operation, i.e. opening or closing the discharge valve shall be minimized. Also avoid, as much as possible, half-opening of the discharge valve under the condition of more than the regulated pressure. The safety valve may develop abnormal noise. This will cause not only a damage of the valve but give a bad effect to the pump itself.

7) Always be careful of the discharge pressure gauge and be sure that the pump operate within the regulated pressure. Avoid blind operation as much as possible.

d) Precautions at pump Stopping time

1) For stopping the operation, as a rule, stop the motor after opening the discharge valve totally. If it is absolutely necessary to stop the motor after shut-off of the discharge valve, finish it within 5 minuts.
When stopping and starting the pump are frequently repeated, another pipe shall be installed from discharge pipe to suction reservoir.

2) For a long period's shut-down, overhaul and lubricate the bearing and the pump gear with grease to prevent them from rusting. Also prevent the machine-finished surface of the shaft coupling from rusting.

3) When stopping the pump in cold season, take care not to solidify the oil in the suction pipe. If the oil is solidified, the pump may not pump up at further operations.

* Disassembly and Assembly

(I) Disassembly

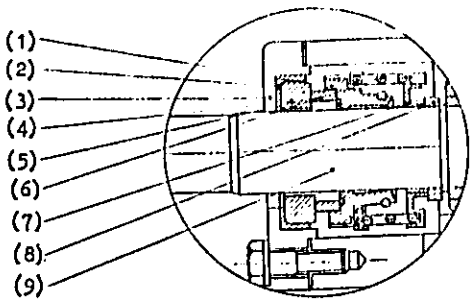
1) Close Suction and Discharge stop valves, and drain in the pump casing.
2) Take Coupling guard out.
3) Remove motor after disconnect supply main and remove electric wires.
4) Remove pump Coupling and take Coupling Key out.
5) Take off Mechanical seal cover and take Mechanical seal out.
6) Remove bolts for side cover and take off the side cover.
(They can be taken out with the outside ring of the needle bearing.
So take care so that the inside surface of the ring will not be attached by dust.)
7) Take off the side plate.
8) Take out Driving shaft and Idling shaft carefully never to damage the casing inside.
9) The inside ring of needle bearing is fastened with snap ring after insertion. When exchanging the bearing, unfasten the snap ring and take it out carefully not to damage the shaft.
10) The outside of needle bearing is remained in the side cover. If it is necessary to remove it, a special tool should be used.
11) Unscrew the cap for safety valve and take Safety valve out with spring.

(II) Assembly

1) Assembly can be done in the reverse manners to the Disassembly.
2) Use a wooden hammer to insert the outside and inside rings of needle bearing.
3) When insert the Mechanical seal, it should be cleaned carefully and an oil should be applied on the surfaces of floating seat and seal ring.
Never scratch on the surfaces of floating seat, seal ring and lip of rubber ring.
4) Check the shaft center by applying a scale on the four points of the outside surface of the coupling, after completely remove the paint on the outside surface. Next, measure the dimensions of the four clearances between the shaft couplings by thickness gauge.
Correct different levels and clearances by inserting or taking out a liner.
Different levels shall be within 3/100 mm and error of clearances within 5/100 mm.

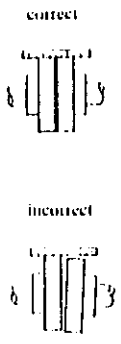
*** Caution:

1) Before disassemble pump, never fail to put join-mark on the necessary parts.
2) Care should be taken to protect every part from scratches and damages in the event disassembly, assembly and adjustment are carried out.



(1) - packing ring
(2) - buffer ring
(3) - cover
(4) - floating seat
(5) - seal ring
(6) - spring
(7) - spring retainer
(8) - adjusting ring
(9) - driving shaft

Detail of Mechanical Seal



Shaft center alignment

Disassembly and Assembly

(I) Disassembly

1) Close Suction and Discharge stop valves, and drain in the pump casing.
2) Disconnect Suction piping or remove Suction side distance piece.
3) Remove fastening bolts for casing and suction cover.
4) Remove suction cover.
5) Release stopper for impeller nut and screw off impeller nut.
6) Remove impeller.

** If a perfect disassembly is desired,

7) Take coupling guard out and remove Coupling bolts.
8) Remove motor after disconnect supply main and remove electric wires.
9) Remove Pump Coupling.
10) Remove Flinger, Gland and take Gland Packing out by using such as scriber.
11) Remove fastening bolts for bearing cover and remove the bearing cover.
12) Remove shaft together with bearings.
13) Release stopper for bearing nut and screw bearing nut off.
14) Remove ball bearings from shaft.

(II) Assembly

1) Assembly can be done in the reverse manners to the Disassembly.
2) Impeller nut should be fastened firmly.
3) After casing and impeller are assembled, all bolts should be fastened properly and firmly.
4) When Gland packings are replaced,
   i) insert packing straight and put cross-section of packing in a line alternatively by 180°.
   ii) tighten packing uniformlyand don't tighten packing too much.
5) Before connect pump coupling and motor coupling, the horizontal level should be confirmed.
   i) In order to investigate level difference of shaft center, painting on the coupling surface should be removed completely.
   ii) Put ruler on four positions of coupling face and investigate dissonance of the face.
   iii) Measure dimensions of coupling space at four positions by thickness gauge.
   iv) If the level is not correct, adjust the said level difference and space by liner.
   v) The level difference should be less than 3/100 mm and the error of the space should be less than 10/100 mm.

*** Caution:

1) Before disassemble pump, never fail to put join-mark on the necessary parts.
2) Care should be taken to protect every part from scratches in the event disassembly, assembly and adjustment are carried out.

Shaft center alignment

EBARA CENTRIFUGAL VOLUTE PUMP

TYPE —— 65 SGM
HEAD —— 17.5 M.
Q'TY —— 0.37 m^3/min.
SP'D —— 1450 r.p.m.

* Machine Operation and Maintenance

a) Precautions before Start

1) Confirm gland packings about their correct arrangement.

2) Turn the pump manually and if the pump did not turn smoothly, it is anticipated that there are such disorders as inner rust and too much tightening of gland. Find discrepancies at once.

3) Operate the motor only and confirm its rotating direction. Then tighten coupling bolts.

4) If sluice valve is provided on the suction side, this valve should be kept fully open.

5) If sluice valve is provided on the discharge side, this valve should be fully closed

b) Precautions at the time of start

1) Ample priming should be carried out.

Open the air cock provided on the upper part of casing.
Supply water into casing from priming funnel.
If water supplied becomes full, turn the shaft many times to drain air in the impeller completely.

2) Then, start and rotate the pump for a moment (several seconds), and stop the same.
Open air drain cock to remove further air. This process shall be done in order to ascertain no existence of air.

3) If an idle operation of the pump is conducted without priming of water, seizure at pump inner part will happen resulting in the fatal damage of the pump. Therefore, the idle running should be prohibited.

c) Start of Operation

1) After water is primed, pump shall be started by keepong sluice valve closed on the discharge side.

2) Prior to enter into a continuous operation, switch on or off once or twice to ascertain that there is no any disorder.

3) Operate the pump until it reaches the specified speed and confirm values shown by gauge, ammeter etc. And stop the pump to give cautions to noise, vibration and heat excess of every part and to ascertain amount of liquid leakage at gland packing.

4) Pump shall be entered into normal operation and if the pump reaches the specified r.p.m., discharge valve shall be opened gradually.

5) After pump is started, decrease or increase of pressure, noise and vibration may occur if air pocket or solid matter is in suction pipe.
Pressure gauge, ammeter, bearing temperature rise etc. shall, therefore, be ascertain by gradual opening of the discharge valve.
Pump is allowed to run continuously unless disorders are found.

d) Precautions during Operation

1) Conduct careful inspection of bearing.

2) Give caution to the temperature rise.
Bearing temperature is safe if it is less than room temperature + 40°C.

3) Inspection of gland

Check excess heat caused by excessive tightening of packing or gland.
Give constant care to the leakage. It is recommended that a small amount of leakage water is allowable.

4) Cautions to the indications by gauges.

I. Give cautions to gauges at suctionand discharge sides and ammeter.

II. Give special attention to the condition of suction side.
If strainer is provided on the suction side, pressure gauges shall be installed on the front and rear parts of the strainer.
Pay attention to the indications by needles of pressure gauges.

III. Open gauge cock for seeing indication only, and it must be closed exoluding the above case. Otherwise, service life of gauges shall be shortened.

5) Cautions to noise and vibration

Cavitation, noise and vibration occur if suction strainer is clogged or suction valve is closed.
Do not close suction valve during operation.

e) Precautions at the time of stopping the pump

Close discharge valve prior to stop the prime-mover.

f) Precautions after Operation

1) Care must be taken so that the finished surface of shaft, coupling etc. shall not rust.

2) If the pump is not operated for a long time or there is an afraid about freezing in winter, drain cock, air cock etc. shall be opened up to drain water remained in the inner part of the pump.
This is indispensable for preventing freezing.

3) Close the discharge valve of the pump in the event of suspension of power failure. It is necessary to avoid a sudden start of the pump when power is resumed. It is danger to switch on without seeing pump condition.
It is,therefore, recommended that the switch is installed in the vicinity of the pump.

5) If the suspension of pump operation is extended over a long period, gland part may rust, so the packing should be taken out and be replaced with new one in addition to the supply of grease.

* Technical Explanation on Machine Operation:

1) If the valve at discharge side is opened too much during pump operation, flow volume which is higher than the value designed may be given resulting in the over-load of the electric motor. Consequently, precaution is required for reading of ammeter.

2) To operate the pump at the condition which is, far from the point designed is not economical. Further, this operation for a long time is not good in view of maintenance and service life.
If pump valve is closed for a long time and the pump is operated under the said condition, water temperature will go up and steam may be created.
This will be the cause for galling. Care should, therefore, be taken.

EBARA 3-STAGE VOLUTE PUMP

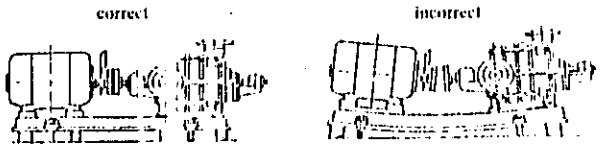
TYPE — 50MS3M
HEAD — 28 M
Q'TY — 0.225 m^3/min.
SP'D — 1450 r.p.m.

* Technical Explanation on Machine Operation:

a) Shaft is equipped with impellers of identical dimensions at every stage and one piece of balance disc. Thrust produced by impeller shall be hydraulically and perfectly balanced by balance disc. No thrust bearing is provided for rotating elements. During pump is in operation, the balance disc rotates with clearance of 3/100 to 7/100 mm between the disc and sheet.
However, when the pump is started or stopped, metals shall contact mutually and their sliding surface is getting to wear, thus rotating elements tend to move toward the side of coupling.
The needle of indicator is attached at the bearing provided on opposite side from motor to be able to see with eyes amount of shaft moved. If the said amount of shaft moved becomes 1.5 mm, balance disc and sheet should be replaced. Liner ring, intermediate bush, balance bush shall also be replaced if they wear as much as 0.5 mm in semi-diameter at the time of regular inspection.

b) 'O' ring packing shall be used at joint part of intermediate casing to prevent leakage. Fastening bolts for casing should be tightened manually and symmetrically when the pump is disassembled or assembled. If this fastening is not properly made, rotating elements shall not be manually turned smoothly and leakage at joint part shall occur.

c) In case of normal temperature, Valquar No. 134 shall be used as gland packing.



* Machine Operation and Maintenance:

a) Precautions before Start

1) Supply oil to bearing for the amount which reaches supplying inlet of oil cup.

2) Turn the pump manually to confirm a smooth turning.

3) In case the sluice valve is on the suction side, this valve should be opened fully. This is very important. If the pump is operated with suction side closed, cavitation occurs and pump shall be damaged greatly by this phenomenon. Special caution is therefore, required.

4) Sluice valve on the discharge side shall maintain its full close.

b) Precautions at the time of Start

1) Sufficient priming should conducted.
Open suction valve and drain air from cock at upper part of casing.
Supply water into casing. If water supplied becomes full, turn the shaft with hands many times to completely drain air remained in the impeller. Then, start and rotate the pump for a moment (several seconds) and stop the same. Open air drain cock to remove further air. This process shall be done several times in order to ascertain no existence air.

2) Starting.
After air is drained completely, the pump shall be operated with sluice valve closed on the discharge side and the operation shall be continued until the pump reaches at the specific speed. Confirm indications of suction and discharge gauges and the value indicated by ammeter and stop the pump to give cautions to noise vibration and heat excess of every part.

Ascertain amount of liquid leakage at gland packing. Pump shall then be entered into normal operation and if the pump reaches at the specified speed, discharge valve shall be opened gradually. After pump is started, decrease or increase of pressure, noise and vibration may occur if air pocket or solid matter is in the suction pipe.
Pressure gauge, ammeter, bearing temperature rise etc. shall, therefore, be ascertained by gradual opening of the discharge valve. Pump is allowed to run continuously unless disorders are found. If an idle operation of the pump is conducted without water priming, seizure at pump inner part will happen resulting in fatal damage of the pump.
In order to confirm rotating direction of the motor, coupling bolts should be removed to permit turning of motor only.

c) Precautions during Operation

1) Bearing inspection.
Confirm whether or not oil ring turns smoothly and rakes oil. Pay attention to the bearing temperature. It is safe that the bearing temperature is less than 60 °C.

2) Inspection for gland.
Check excess heat caused by excessive tightening of packing or gland.
Give a constant care to the leakage. It is recommended to assure adequate tightening that a small amount of leaked water is allowable.

3) Cautions to the indications by gauges.
Give cautions to gauges at suction and discharge sides and ammeter.
Special attention should be paid to the condition of suction side. If strainer is provided on the suction side, pressure gauge shall be installed on the front and rear parts of the strainer. Pay attention to the indications by needles of pressure gauges.
Open gauge cock for seeing indication only, and it must be closed excluding the above case. Otherwise, service life of gauges shall be shortened.

4) Cautions to noise and vibration.
Cavitation, noise and vibration occurs when suction strainer is clogged or suction valve is closed. Do not close suction valve during operation.

d) Precautions at the time of Stopping the Pump

Close discharge valve prior to stopping of the prime-mover.

e) Precautions after Operation

1) Care must be taken so that the finished surface of shft, coupling etc. shall not rust.

2) If the pump is remained in no operation for a long time or there is an afraid about freezing in winter or cold zone, drain cock, air cock etc. shall be opened up to drain water remained in the inner part of the pump. This is indispensable for preventing freezing.

3) Close the discharge valve of the pump in the event of suspension of power failure. It is necessary to avoid a sudden start of the pump when power is resumed. It is danger to switch on without seeing pump condition. It is, therefore, recommended that the switch is installed in the vicinity of the pump.

* Disassembly and Assembly

I) Disassembly

(1) Close Suction and Discharge stop valve, and drain in the pump casing.

(2) Take Coupling guard out and remove Coupling bolts.

(3) Remove Sealing water pipe.

(4) Remove Bolts for dicharge side Bearing cover.

(5) Release Stopper for Dis' side bearing nut and take Bearing Nut out.

(6) Remove Bolts for discharge side bearing case and remove Bearing by turning it to the left and right directions.

(7) Remove Flinger and Gland and take Gland Packing out by using such as marking-off pin.

(8) Remove Sleeve Nut, O ring and Shaft Sleeve.

(9) Disconnect Discharge pipings from the pump.

(10) Put a Wooden piece between lower part of intermediate casing and Common base to prevent dropping of the intermediate casing.

(11) Remove Fastening Bolts for casing.

(12) Remove Bolts which fix Discharge Cover on the common base.

(13) Remove Discharge Cover.
(In this case, removal shall be done with care so that its weight will not give any influence to the shaft.)

(14) Remove Impeller.
(If it is hard to remove impeller, use a wooden hammer.)

(15) Remove Intermediate Casing in the same manners as the Discharge casing.

(16) Remove Impeller and Intermediate Casing of the next stages by turns in the same manners as the above cases.

** After that, every part can be inspected. If a perfect disassebly is desired,

(17) Remove Motor. (Disconnect from supply main and remove electric wires.)

(18) Take Pump Coupling out.

(19) Remove Bolts for Suction side bearing cover.

(20) Remove Suc' side Bearing Nut. (Bearing Adaptor)

(21) Remove Bolts for Suction side bearing case and remove Bearing in the same manners as the Discharge side.

(22) Remove Flinger, Gland and Gland Packing in the same manners as the Dis' side.

(23) Remove Shaft.

(24) Remove Suction Casing from Common base, after disconnect Suction pipings, if necessary.

II) Assembly

(1) Assembly can be done in the reverse manners to the disassembly.
However, O ring, if it is used for a long time, should be replaced.

(2) It is needless to say that in both cases of disassembly and assembly, the shaft should be perfectly protected from the influence of casing weight or from other's contacting to the shaft.

(3) After casing and impeller are assembled, bolts shall be tightened properly.

(4) When gland packings are replaced,

i) insert packing straight and put cross-section of packing in a line alternatively by 180°.

ii) tighten packing uniformly and don't tighten packing too much.

*** Caution:

Before disassemble Pump, never fail to put join-mark on the necessary parts.

Item	Subject	Details and Remarks
II-1-1	Single stage volute pump (B-2-2-1)	1) To make planning and practical methods to overhaul, to check, to measure and to remount a single stage volute pump. 2) Free-hand drawing for the purpose to order spare parts. (Study and practice).
II-1-2	Gear pump (B-2-2-2)	1) To make planning and practice methods to overhaul, to check, to measure and to remount a gear pump. 2) Free-hand drawing for the purpose to order spare parts. (Study and practice).
II-1-3	Worthington pump (1) (A-4-1-1)	1) Observation of constructional design for making plans to overhaul, to remount and to operate a worthington pump. 2) Overhauling the pump. (Study and practice).
II-1-4	Worthington pump (2) (A-4-1-2)	1) Recording the result of measurement of working parts. 2) Free-hand drawing for the purpose to order spare parts. 3) Remounting and adjusting practices. 4) Operation and confirmation of good working conditions. (Practice).
II-1-5	Viscosity (B-2-1-1)	1) Recognization of the device. 2) To make a plan to take measures of viscosity. 3) Safety keeping preparation. 4) Measurement of viscosities of both fuel and lubricating oils. 5) Analysis of the above result for an actual purifier. (Study and Practice).
II-1-6	Igniting point (B-2-1-2)	1) Recognization of the device. 2) To make a plan to take measures of igniting point. 3) Safety keeping preparation. 4) Measurement of igniting points of both fuel and lubricating oils. 5) Analysis of the above result for an appliance. (Study and practice).

II-1-7	Purifier (B-1-4-1)	1) Observation for constructional design and piping arrangement. 2) Comparison of the system with that in an actual merchant ship. 3) Proper methods of both operation and maintenance works. 4) To make a plan to overhaul and to remount the device. (Study).
II-1-8	Purifier (B-1-4-2)	1) Operation and maintenance works. 2) Dismantling and cleaning works. 3) Changing method of discharge screw. 4) Remounting work. 5) Proper trial technique. (Practice).
II-1-9	Steering gear (B-1-3-1)	1) Inspection for constructional design. 2) Comparison of the system with that of the other types in actual ships. 3) Planning both trial and maintenance manual. 4) Operation and maintenance works. 5) Warning and alarming system in an actual ship. (Study and Practice).
II-1-10	General work (A-all, B-all)	1) Leakage test on piping lines. 2) Lubrication for idle engines. 3) Cleaning-up works. 4) Checking works of spare parts and tools. 5) Miscellaneous works (touching-up paints, small repair work). (Practice).
II-2-1	Pressure Gauge (B-2-1-3)	1) Adjusting technique of pressure gauge. 2) Investigation of constructional kinds of pressure gauges. 3) Relation between location of pressure gauge and indication of it. 4) Investigation of pressure convertor. 5) Investigation of pressure-control system. (Study and Practice),
II-2-2	Servomechanism (B-2-1-4)	1) Investigations of effects on individual elements of servomechanism. 2) Inspection of constructional mechanism. 3) Checking method of each device. 4) Investigation of many kinds on servo-mechanism. (Study and Practice).

II-2-3	Refrigerator (B-1-5-1)	1) Observation of constructional design and piping arrangement. 2) Planning the proper procedures for for actual operation and for maintenance work. 3) Programming the method to get necessary data for measurement of thermal efficiency and capacity. (Study).
II-2-4	Refrigerator (B-1-5-2)	1) Operation and maintenance practice on the refrigerating system. 2) Practical work for charging refrigerant. 3) Practical work for rebottling refrigerant. 4) Practical work for purging air. 5) Practical work for supplying of lubricating oil. 6) Technical check of gas-leakage. (Practice).
II-2-5	Refrigerator (B-1-5-3)	1) Operation for efficiency and capacity examination. 2) Practical work on defroster. 3) Analysis of the above-mentioned result to make performance diagram and heat balance diagram. (Practice and Study).
II-2-6	Boiler (A-4-1)	1) Observation of constructional design and piping arrangement. 2) Proper procedures of extracting boiler water, of testing it, of supplying boiler compounds and of blowing of boiler water. 3) Actual calculation method to keep boiler water in good density of elemental matters. (Study and Practice).
II-2-7	Diesel generator -4 stroke cycle engine (A-2-1-1)	1) Observation of constructional design and piping arrangement. 2) Inspection for operating device of water rheostat. 3) Investigation of the rules about marine dynamo-engine. (Study).
II-2-8	Diesel generator - main switch board & A.C. generator (A-2-2-1)	1) Observation and investigation of constructional design. 2) Investigation of types of them in actual merchant ships. 3) Investigation of automatic operation devices. (Study).

II-2-9	Fresh water generator (A-2-3-1)	1) Observation and investigation of constructional design. 2) Investigation of types of them in actual merchant ships. 3) To make plans to operate the system, to maintain it and overhaul it. (Study).
II-2-10	General work (A-all, B-all)	1) Leakage test on piping lines. 2) Lubrication for idle engines. 3) Cleaning-up works. 4) Checking works of spare parts and tools. 5) Miscellaneous works (touching-up paints, small repair work). (Practice).
II-3-1	Diesel generator - 4 stroke cycle engine, main switch borad & fresh water generator. (A-2-1,2,3-2)	1) To make plans of operation and maintenance for dynamo engine and fresh water generator. 2) To make actual technical manual for operation of main switch board - parallel running technic. 3) To make measurement method for performance test. (Study).
II-3-2	Diesel generator - 4 stroke cycle engine, main switch board & fresh water generator. (A-2-1,2,3-3)	1) Starting and stopping technique of 4 stroke cycle engine. 2) Practice to take indicator diagram. 3) Practice to operate main switch board for parallel running with handling water rheostat. 4) Measuring data necessary for performance test. 5) To make heat-balance diagram and to obtain thermal efficiency. (Practice and study).
II-3-3	Diesel generator - 4 stroke cycle engine (A-2-1-4)	1) General checking method. 2) Practice how to examine fuel-injection pump and valve. 3) Practical measuring method of crank-arm deflection. 4) Practical measuring method of oil clearances on crank and journal bearings. 5) Analysis of data measured. (Practice and study).

II-3-4	Diesel generator - 4 stroke cycle engine (A-2-1-5)	1) Practical check of respective valve-timings. 2) Adjusting method for tappet clearance (valve lever clearance). 3) Practical measurement of O-injection point. 4) Inspection work on gear case and governor. (Practice).
II-3-5	Diesel generator - 4 stroke cycle engine (A-2-1-6)	1) To make a plan of proper order for voerhaul and remounting. 2) To make recording paper for measurement of working part. 3) Preparation work to provide tools and special gauge. 4) Study for getting accurate data on measuring working part. (Study and practice).
II-3-6 II-3-7	Diesel generator - 4 stroke cycle engine (A-2-1-7) (A-2-1-8)	1) Practice to pull piston out with checking work. 2) Cleaning technique drill for vital working parts. 3) Measuring and checking practice on vital necessary working part. 4) Remounting work in proper good order. 5) Checking method before trial after overhauling. 6) Trail practice. 7) Analysis of result of measured data. (Practice).
II-3-8-1	Diesel generator - main switch board. (A-2-2-4)	1) Checking work for maintenance. 2) Safety keeping preparation. (Practice).
II-3-8-2	Boiler (A-4-2-1)	1) Observation of constructional design and equipments fitted on the surface directly. 2) Entering combustion chamber for observation. 3) Operation drill of the simulator panel. (Practice and study).
II-3-9	Air compressor (A-1-1)	1) Observation of constructional design. 2) To make a plan to operate and to maintain it. 3) Checking method for maintenance. 4) Operation drill for charging air. 5) Overhauling and sketching suction and delivery valve. (Practice and study).

II-3-10	General work (A-all, B-all)	1) Leakage test on piping lines. 2) Lubrication for idle engines. 3) Cleaning-up work. 4) Checking works of spare parts and tools. 5) Miscellaneous works (touching-up paint, small repair work). (Practice).

MARINE WORKSHOP PRACTICE (MM-III)

Item	Subject	Details & Remarks
III-1-1 (III-1-2)	Boiler (A-4-1-1)	1) Observation of constructional design and pipe arrangement. 2) Investigation of control circuits and their devices. 3) Inspection of safety keeping devices and their working points. 4) Observation of locations for measuring points. (Study).
III-1-2 (III-1-1)	Steam turbine (A-3-1-1)	1) Observation of constructional design and pipe arrangement. 2) Investigation of manoeuvering devices and interlocking safety system and their working points. 3) Observation of location for measuring point. (Study).
III-1-3 (III-1-4)	Boiler (A-4-1-2)	1) Observation of working circuit and construction of similator. 2) Operation drill of simulator. 3) To make a plan of proper operation and inspection manuals. (Practice and Study).
III-1-4 (III-1-3)	Steam turbine (A-3-1-2)	1) Observation of constructional design and working mechanism of steam ejector and hydro-dynamometer. 2) To make a plan of proper operation and overhauling manuals. - warming up, trial, operation cooling down, injection etc. (Study).
III-1-5 (III-1-6)	Boiler (A-4-1-3)	1) Operation practice of boiler and Worthington pump. 2) Calculation of boiler efficiency. 3) Drill of blowing boiler water off. 4) Drill of obtaining sample of boiler water for density examination. 5) Drill of supplying boiler compound. (Practice and Study).

III-1-6 (III-1-5)	Steam turbine (A-3-1-3)	1) Warming-up engine practice with making expansion diagram. 2) Handling and checking drill on the trail process. 3) Operation and maintenance with measuring necessary data for obtaining mechanical efficiency and heat balance diagram. 4) Cooling-down practice. (Practice and Study).
III-1-7 (III-1-8)	Boiler (A-4-1-4)	1) Inspection practice of both water and fire sides. 2) Cleaning and repair drills of both water and fire sides. 3) Overhauling, checking and remounting practice on worthington pump. (Practice).
III-1-8 (III-1-7)	Steam turbine (A-3-1-4)	1) Overhauling and inspecting practice. 2) Practice for wear-down and thrust-pad clearance measurement. 3) Remounting practice. (Practice).
III-1-9	A.C. motor cargo winch & Electro hydraulic cargo winch (B-1-2-1,2)	1) Observation of constructional designs and mechanisms. 2) Investigation of speed control circuit and system. 3) Operation practice. 4) Trouble shooting. (Study and Practice).
III-1-10	General work (A-all, B-all)	1) Leakage test on piping lines. 2) Lubrication for idle engines. 3) Cleaning-up work. 4) Checking work of spare parts and tools. 5) Insulation test of main circuit and control circuit. 6) Miscellaneous works (touching-up paint, small repair work). (Practice)
III-2-1	Diesel generator & Fresh water generator (A-2-1,2)	1) Observation of constructional designs and mechanisms. 2) Operation and maintenance practices - start and stop, parallel running, alternator changing technique, combustion checking technique, efficient operation of fresh water generator etc. (Study and Practice).

III-2-2	2-stroke cycle diesel engine – engine and piping (A-1-1)	1) Observation of constructional designs and mechanisms. 2) Observation and designing piping arrangement comparing with actual merchant ship. (Practice and Study).
III-2-3	2-stroke cycle diesel engine – engine and circuit. (A-1-2)	1) Investigation of control circuit. 2) Observation of location of measuring point, enterlocking safety devices and their normal working condition. 3) To make a plan to operate engine in proper order – warming-up, trial, operation (maintenance) and cooling-down) (Study).
III-2-4	2-stroke cycle diesel engine – engine and hydraulic dynamometer. (A-1-3)	1) Observation of constructional design and mechanism of hydraulic dynamometer. 2) To make a plan to obtain mechanical efficiency and heat balance diagram. 3) To make a plan of general checking points followed operation. 4) Preparation work for actual operation. (Study and Practice).
III-2-5	2-stroke cycle diesel engine – whole system (A-1-4)	1) Warming-up practice. 2) Drill of trial technique. 3) Start-and-stop exercise. 4) Operation and maintenance practices. 5) Taking practice of indicator diagram. 6) Measurement to obtain necessary data for mechanical efficiency and heat balance diagram. 7) Cooling-down practice. 8) General checking practice. (Practice).
III-2-6	2-stroke cycle diesel engine – engine. (A-1-5)	1) Practice of measuring technique of crank-arm deflection. 2) Practice of measuring technique of oil-clearance on both crank-pin and journal bearings. 3) Analysis of the result obtained by the above practice. (Practice and Study).

III-2-7	2-stroke cycle diesel engine - engine (A-1-6)	1) Inspection and examination of both fuel injection pump and valve. 2) Maintenance practice of both fuel injection pump and valve. 3) Practice how to obtain 0-injection point. 4) Measurement valve-timings and drawing their diagrams. (Practice and Study).
III-2-8	2-stroke cycle diesel engine - control circuit (A-1-7)	1) Practice to check control circuit. 2) Study one sample of actual remote control circuit. (Practice and Study).
III-2-9	2-stroke cycle diesel engine - supercharger (A-1-8)	1) Observation of constructional design and mechanism. 2) Opening, cleaning, checking and remounting practice. (Study and practice).
III-2-10	General work (A-all, B-all)	1) Leakage test on piping lines. 2) Lubrication for idle engines. 3) Cleaning-up work. 4) Checking work of spare parts and tools. 5) Insulation test of main circuit and control circuit. 6) Miscellaneous works (touching-up paint, small repair work). (Practice).
III-3-1	2-stroke cycle diesel engine - engine (A-1-9)	1) To make a plan to overhaul and to remount engine in good proper order. 2) To make recording paper to measure data necessary and proper measuring method - piston top clearance, piston ring, piston ring groove, wear-down of piston crown, piston diameter, cylinder bore, gudgeon pin (hardness, diameter, oil clearance), crank pin (diameter, oil clearance), journal (wear down, oil clearance), checking gears. (Study).
III-3-2 III-3-3 III-3-4	2-stroke cycle diesel engine - engine (A-1-10, 11, 12)	1) Overhauling practice. 2) Measuring practice. 3) Checking practice. 4) Adjusting and fitting practice. 5) Remounting practice.

		6) Final adjusting and checking practice. 7) Lubrication and water-running practice. 8) Later adjustment practice. 9) Trial practice after overhaul. 10) Analysis of the result recorded by measurement. (Practice and Study).
III-3-5	Multiple-staged valute pump (B-2-2-1)	1) To make planning and practical methods to overhaul, to check, to measure and to remount a multiple-staged valute pump. 2) Free-hand drawing for the purpose to order spare parts. (Study and Practice).
III-3-6	Electric motor starter (B-1-1-1)	1) To make actual drawing of electric motor starters. 2) Trouble shooting of the starters. 3) Practice to repair elements for the starters. (Study and Practice).
III-3-7	Refrigerator (B-5-1)	1) Practice to operate refrigerator. 2) Adjusting practice of manual expansion valve. 3) Practice how to supply lubricating oil and refrigerant. 4) Practice how to recharge refrigerant to gas-cylinder. 5) Practice how to maintain automatic expansion valve. 6) Practice how to separate and purge air from refrigerant. 7) Practice how to check gas-leakage. 8) Practice how to defrost in evaporator. 9) Practice how to check proper quantity of refrigerant. 10) Practice how to check efficient working condition. (Practice).
III-3-8	2-stroke cycle diesel engine (A-1-13) (A-2-3)	Case study for emergency. 1) Countermeasure to black out. 2) Countermeasure to sudden stop. 3) Countermeasure to double astern.

		4) Countermeasure to breakdown of supercharger. 5) Countermeasure to breakdown of cylinder cover. 6) Countermeasure to breakdown of piston. 7) Countermeasure to use diesel engine for air compressor. 8) Countermeasure to operation in stormy sea. 9) Countermeasure to flood. 10) Countermeasure to fire. (Practice and Study).
III-3-9	Steam turbine (A-3-1-5) (A-4-1-5)	Case study for emergency. 1) Countermeasure to leakage of water tube. 2) Countermeasure to out of order on one of the boilers. 3) Countermeasure to out of order on low pressure cylinder of steam turbine. 4) Countermeasure to out of order on high pressure cylinder of steam turbine. 5) Countermeasure to stormy sea. 6) Countermeasure to shortage of fuel oil. 7) Countermeasure to flood. 8) Countermeasure to fire. 9) Countermeasure to steam leakage. 10) Countermeasure to black-out. 11) Countermeasure to sudden stop order. 12) Countermeasure to double astern.
III-3-10	General work (A-all, B-all)	1) Leakage test on piping lines. 2) Lubrication for idle engines. 3) Cleaning-up work. 4) Checking work of spare parts and tools. 5) Insulation test of main circuit and control circuit. 6) Miscellaneous works (touching-up paint, small repair work). (Practice).

ELECTRIC & ELECTRONIC PRACTICE

Item	Subject	Details & Remarks
II-1	Multiple tester (B-2-2)	1) To recognize constructional design and mechanism. 2) Practice how to measure resistant valve. 3) Practice how to check capasitor. 4) Practice how to measure voltage on both A.C and D.C and the reason why the A.C range is employed individually from D.C range. 5) Practice how to measure small D.C current. 6) Practice to shoot melted fuse out. 7) Practice to check actual circuit on starters of electric motor. 8) Practice how to check commutator.
II-2	Resistance tester (B-2-2)	1) To recognize constructional design and mechanism. 2) Main points to handle the resistance tester. 3) Practice how to measure the value of insulation. 4) Practice how to shoot earthing point. 5) To understand different recording methods by 500 V meg-ormer and by 1000V meg-ormer. 6) Matters to be checked under the law. 7) Method to increase insulated resistance of electric generator and motor.
II-3	Starter of electric motor (B-1-1)	1) Study how to read down electric circuit. 2) Comparison of circuit elements with actual starters. 3) To recognize the constructional design and mechanism of essencial elements. 4) To make actual electric circuit diagram comparing with skeleton diagrams. 5) Trouble shooting.
II-4	Ward Leonard system (B-1-1)	1) Investigation how to control speed of A.C and D.C electric motors. 2) Observation of electric circuit of Ward Leonard system. 3) To make actual electric circuit-diagram comparing with skeleton diagram. 4) Practice to get performance test record

III-1	TRS pulse circuits experimental equipment (B-2-2)	1) To recognize the constructional design and mechanism of oscilloscope. 2) Experiments. i) Rectifier and filter circuit. ii) D.C voltage regulator circuit. iii) Waveform conversion circuit. iv) The astable multi-vibrator. v) The monostable multi-vibrator. vi) The bistable multi-vibrator. vii) Counter circuit. viii) Schmidt trigger circuit. ix) Clamp circuit. x) Logic circuit. 3) Schematic diagrams. i) Power supply circuit. ii) Waveform conversion circuit. iii) Multi-vibrator circuit (astable and bistable). iv) Multi-vibrator circuit (monostable) v) Schmidt and clamp circuit. vi) Logic circuit.

HYDRODYNAMICS EXPERIMENTAL EQUIPMENT

I-1	Hydraulic experimental equipment (B-1-5)	Experiment. 1) To make load-quantity diagram of cavitation pump and 3-stage turbine pump.

Structure of Cutter (Refer Fig. 1, 2, 3, 4).

1. Keel
3. Stem
4. Stem Plate
6. Stern Post
7. Transer
9. Frame
11. Bottom Board
12. Plank
15. Gunwale
17. Rubbing Strake
18. Bilge Strake
21. Thwart
22. Thwart Stachion
23. Sailing Thwart
24. Mast Clamp
25. Mast Trank or Tabernacle
26. Mast Step
27. Hand Step
28. Stern Seat
29. Stern Bench
30. Dicky
31. Stretcher
32. Stretcher Check
33. Rowlock
34. Poppet
35. Pintle
36. Gudgeon
37. Rudder
40. Rudder Lanyard
41. Tiller
42. Plug
44. Fender

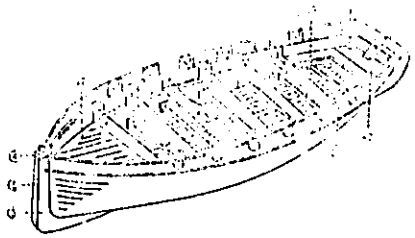


Fig 1
structure of cutter

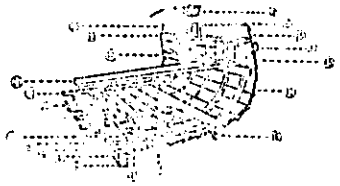


Fig 2
structure of cutter

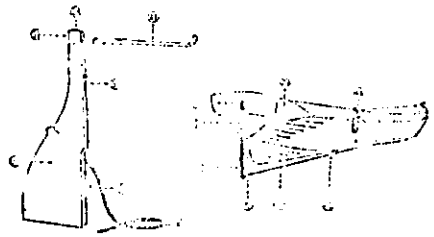


Fig 3.
Structure of cutter

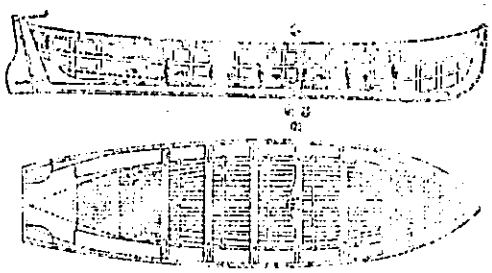


Fig 4
structure of cutter

Arrangement of Boat crew

- Boat charge
- Cockswain or Coxn
- ① … ⑬ Oarsmen
- Sparemen or Spare

} Boat crew

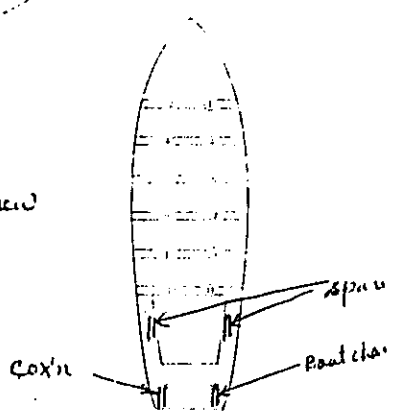


Fig 5. arrangement of boat.

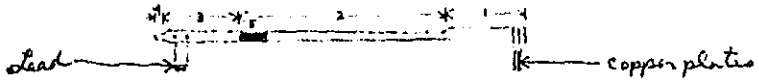


Fig 6. Oar.

① Blade ② Shaft ③ Loom ④ Grip.
⑤ Leather.

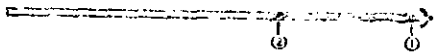


Fig 7 Boat hook

① Hook ② Boat hook lanyard.

Fig 8. Arrangement Oar, Boat hook.

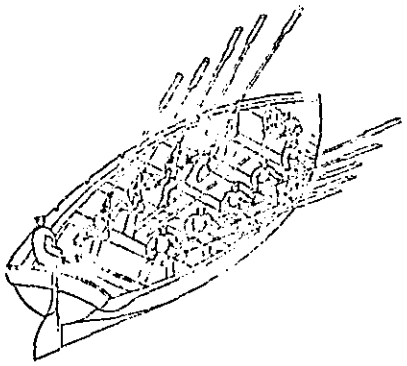


Fig 9.
Stand by Oars!
Out Oars!

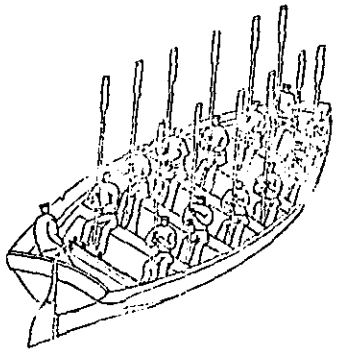


Fig 10
Up Oars!

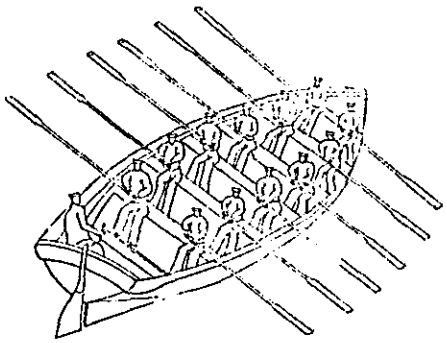


Fig 11.
Let Fall!

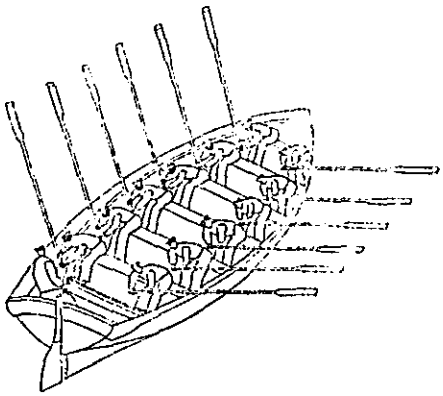


Fig 12.
Ready!

Fig 13. Grip

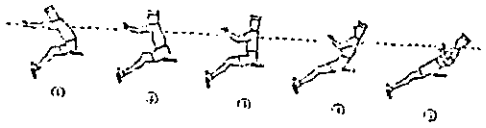


Fig 14 (A).
Give Way!

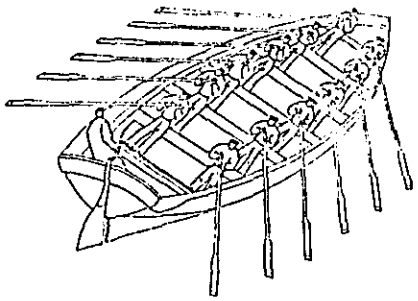


Fig 14 (B).
Give Way!
(Stroke pitch)

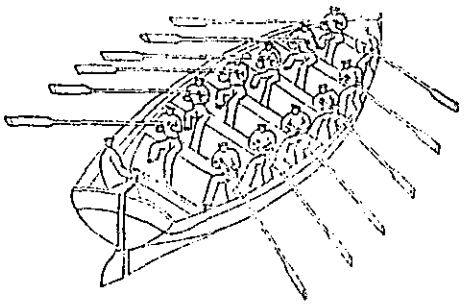


Fig 15.
Lay Oars!
Hold water!
Astern all!

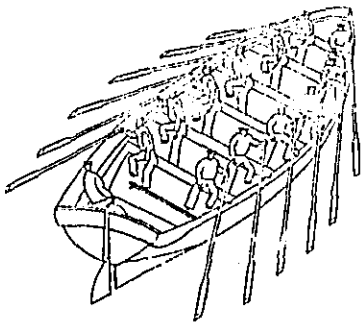


Fig 16
Trail!

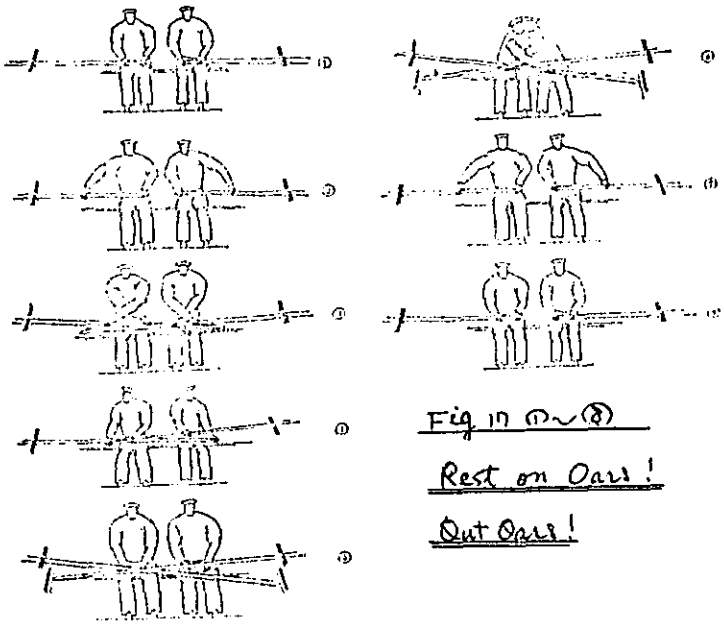


Fig 17 ①~⑧
Rest on Oars!
Out Oars!

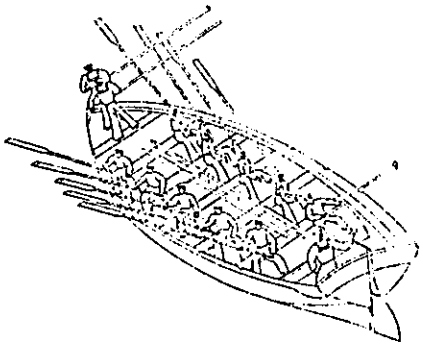


Fig. 18.
Boat in Oars!

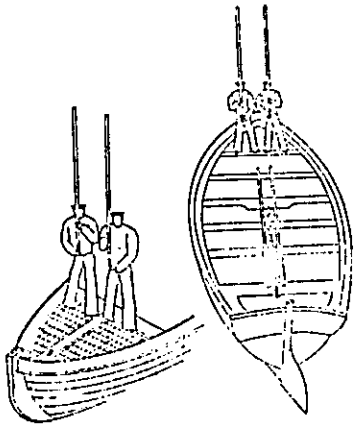
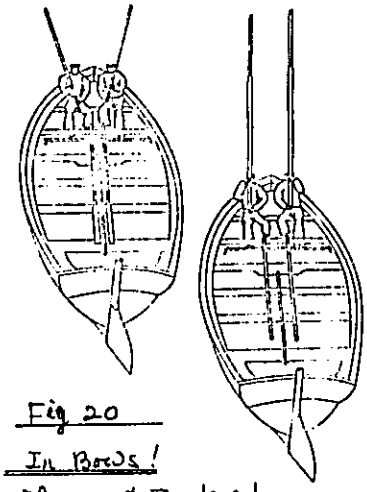
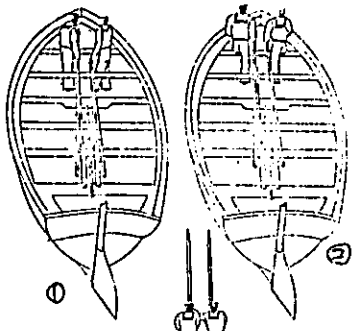


Fig 19
Shove off!
Take in Fenders!





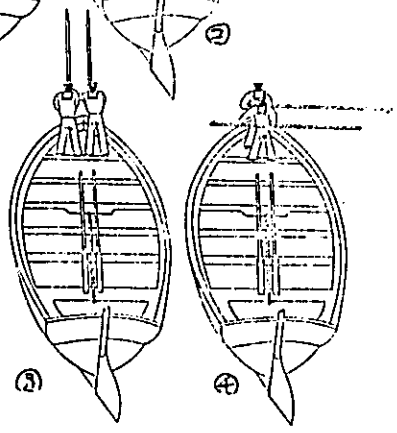


Fig 20
In Bows!
Throw out Fenders!
weight Enough!

Fig 21 ①~④
In Bows!
Throw out Fenders!
weight Enough!