GUIDELINES FOR APPROVING MARINE ENGINEERING COURSES

INTRODUCTION

The following material has been provided for the purpose of establishing the minimum subject material for marine engineering courses to be submitted to the US Coast Guard for approval.

Five major subject areas have been designated. The major subject areas have been further divided into selected base topics. Each base topic has been provided with a set of recommended course outlines as a point of reference. The minimum lecture and/or laboratory times and the prescribed topics may be varied to some extent by the school seeking approval. Therefore, it must be realized that all course submissions will not be in 100% agreement. Through comparison, however, a better determination of the presented subject material by the schools can be gauged.

Courses identified as "basic" are intended to provide introductory material as base operation and function of equipment for the individuals seeking certain unlicensed ratings and license courses. For the unlicensed ratings of Oiler and Fireman/Watertender, the basic courses have been reviewed specifically for appropriate subject matter. Only those subject and topic areas provided with an asterisk (*) in the indicated course outlines are considered necessary for the training of these specific ratings.

It has been taken into consideration that a **Training Record Book** is not required by STCW for the training of unlicensed ratings. However, these individuals may apply for a license at some time in the future, and, therefore, requirements for engineering licenses are to be considered when designing a related course for approval. Therefore, the training organization has the responsibility to produce assessment criteria and supplemental check-off sheets or logs. This criteria is to support a standard of performance and the consistent assessment of each student completing the program of instruction and is to be submitted as part of the course approval package.

The intent of the "advanced" courses, while covering the basic subject material as refresher information, must provide additional maintenance and trouble shooting subject material. Both the basic and advanced courses must be performance-based and incorporate hands-on practice to be considered effective.

As training is a dynamic process, periodic updates will be incorporated into the guidelines based upon comments from the maritime industry. Comments may be submitted to the Director, National Maritime Center, Marine Personnel Division (NMC-4B), Suite 510, 4200 Wilson Boulevard, Arlington, VA 22203-1804; or by fax (703) 235-1062; or by e-mail at Eteam@ballston.uscg.mil.

SUBJECTS FOR APPROVED MARINE ENGINEERING COURSES

BASE SUBJECTS	1	2	3	4	5	6	7	8	9	10
Electrical Subjects										
1.Basic Electricity		●				●			●	
2.Advanced Electricity				●					●	
3.Basic Electronics		●							●	
4. Applied Electronics				●					●	
General Subjects										
1. Safety & Fire fighting	●	●	●	●	●	●			●	
2. First Aid	●	●	●	●	●	●			●	
3. Ship Construction						●			●	
Industrial Arts Subjects										
1. Machine Shop			●						●	
2. Welding			●						●	
3. Sketching & Blueprint Reading						●			●	
Marine Engineering Subjects										
1. Basic Auxiliary Machinery	●			●	●	●			●	
2. Advanced Auxiliary Machinery		●	●						●	
3. Basic Main Propulsion-Steam	●							●	●	
4. Basic Main Propulsion-Diesels	●				●	●	●		●	
5. Advanced Propulsion - Diesels		●					●		●	
6. Marine Control Systems									●	
7. Marine Hydraulics		●				●			●	
8. Adv Propulsion Systems-Steam		●						●	●	
9. Refrigeration & Air Condition		●		●		●			●	
Mathematics & Science Subjects										
1. Mathematics				●		●			●	
2. Physics									●	
3. Marine Chemistry									●	
4. Thermodynamics									●	

LICENSE/RATING CODES

1 - QMED (Fireman/Watertender, Oiler Steam/Motor) * indicates required topics for training
2 - Junior Engineer
3 - Pumpman
4 - Electrician
5 - Engineman Utility (Motor vessels of less than 1600 GT)
6 - Designated Duty Engineers (horse power level must be considered)
7 - Motor Endorsement - Existing Steam license
8 - Steam Endorsement - Existing Motor license

9 - Cross over to Third Assistant Engineer's License from any license

CURRICULUM BY SUBJECTS

ELECTRICAL SUBJECTS	MINIMUM HOURS LECTURE/LAB
1. Basic Electricity Pt 1	40/0
2. Basic Electricity Pt 2	40/0
3. Basic Electricity Pt 3	30/0
1. Advanced Electricity - Maintenance and Troubleshooting, Part 1	40/24
2. Advanced Electricity - Maintenance and Troubleshooting, Part 2	40/16
3. Advanced Electricity - Maintenance and Troubleshooting, Part 3	40/16
1. Basic Electronics - Pt 1	40/16
2. Basic Electronics - Pt 2	40/16
3. Basic Electronics - Pt 3	40/16
4. Basic Electronics - Pt 4	40/24
5. Basic Electronics - Pt 5	40/24
1. Applied Electronics - Pt 1	32/32
2. Applied Electronics - Pt 2	32/32
GENERAL SUBJECTS	
1. Safety & Fire fighting	32/0
2. First Aid	48/0
3. Ship Construction & Stability	64/0
INDUSTRIAL ARTS	0/224
1. Machine Shop	
2. Welding	
3. Sketching & Blueprint Reading	

MARINE ENGINEERING	MINIMUM HOURS LECTURE/LAB
1. Basic Auxiliary Machinery Pt 1*	20/0*
2. Basic Auxiliary Machinery Pt 2*	20/0*
3. Basic Auxiliary Machinery Pt 3*	20/0*
1. Basic Main Propulsion - Steam Pt 1*	40/0*
2. Basic Main Propulsion - Steam Pt 2*	32/0*
3. Basic Main Propulsion - Steam Pt 3*	40/0*
4. Basic Main Propulsion - Motor	40/0*
5. Advanced Propulsion Systems - Steam	32/0
1. Advanced Auxiliary Machinery	40/0
2. Advanced Auxiliary Machinery	40/0
1. Advanced Main Propulsion - Diesels	32/16
2. Advanced Main Propulsion - Diesels	32/16
3. Advanced Main Propulsion - Diesels	32/16
4. Advanced Main Propulsion - Diesels	32/0
1. Marine Control Systems Pt 1	32/16
2. Marine Control Systems Pt 2	32/16
3. Marine Control Systems Pt 3	32/16
4. Marine Control Systems Pt 4	32/16
1. Basic Hydraulics	24/16
2. Marine Hydraulics - Systems	24/0
1. Refrigeration & Air Conditioning	40/16
2. Refrigeration & Air Conditioning	40/16
MATHEMATICS & SCIENCE	
1. Mathematics	96/0
2. Physics	72/0
3. Marine Chemistry	64/0
4. Thermodynamics	96/0

*NOTE: * indicates topics that must be covered for unlicensed rating training. Other topics in recommended outlines may be covered as considered necessary and practical by the training organization.*

BASIC ELECTRICITY
PART I
(40 HOURS LECTURE)

1. Structure of Matter/Atomic Theory
2. Electrical Charges/Electron Theory
3. How to Produce Electricity
4. Electric Current
5. Effects of Electricity
6. Magnetism
7. Electromagnetism
8. Electricity & Magnetism at Work
9. The Electric Circuit
10. Resistance
11. Resistors/Color Coding
12. Wire Measurements/AWG
13. Analyzing Resistance Values with Variations in Temperature/
14. Ohm's Law
15. Power
16. Series Circuits
17. Parallel Circuits
18. Parallel Circuit Analysis
19. Series Parallel Circuits
20. Series Parallel Circuit Analysis
21. Series Parallel Circuit Problems
22. Kirchoff's Law - Voltage
23. Kirchoff's Law - Current
24. Kirchoff's Law - Problems
25. Voltage Dividers
26. Review of Magnetism/Hysteresis
27. Rowland's Law/Flux Density
28. Hysteresis Loop
29. Circuit Protective & Control Devices

BASIC ELECTRICITY
PART II
(40 HOURS LECTURE)

1. Effects of Electromagnetism
2. Inductance
3. Inductive D.C. Circuits
4. Inductive A.C. Circuits
5. Mutual Inductance/Transformers
6. Capacitance and the Capacitor
7. Capacitive A.C. Circuits
8. Capacitor Types
9. R-L Circuits
10. Parallel R-L Circuits
11. R-C Circuits
12. Parallel R-C Circuits
13. R-C Time Constants
14. L-C-R Circuits
15. Series L-C-R Circuits
16. Parallel L-C-R Circuits
17. D.C. Generator
18. The Field Winding
19. The Armature Winding
20. D.C. Generator Construction
21. D.C. Generator Regulation
22. D.C. Motor
23. Practical D.C. Motors
24. D.C. Motor Construction
25. Motors vs. Generators
26. CEMF
27. D.C. Motor Classification
28. Direction of Rotation
29. Compound Motors
30. LVR, LVP
31. Starters
32. Controllers

BASIC ELECTRICITY
PART III
(30 HOURS LECTURE)

1. The A.C. Generator
2. Generation of an A.C. Voltage
3. Three Phase Generator
4. Voltage & Speed Regulation
5. Watts, VARS, KVA, & Power Factor
6. A.C. Generator Operation
7. Alternators in Parallel Operation
8. Delta and Wye Connections
9. Transformers
10. Transformer Connections
11. Auto Transformer
12. Single Phase Distribution Systems
13. Three Phase Distribution Systems
14. Electrical Test Equipment
15. Measuring Current
16. Measuring Voltage
17. Three Phase Motor
18. Wound Rotor Induction Motor
19. Split Phase Induction Motor
20. Synchronous Motors
21. Turbo-Electric Propulsion
22. Reading & Interpreting Control Diagrams
23. A.C. Motor Control
24. Electrical Safety at Sea

ADVANCED ELECTRICITY MAINTENANCE AND TROUBLESHOOTING
PART I
(40 HOURS LECTURE/ 24 HOURS LAB)

1. The megger

2. Electro-dynamometer
   a. watt meter
   b. watt-hour meter

3. Moving iron vane;
   a. inclined coil iron vane
   b. thermocouple type meters

4. A.C. instruments;
   a. rectifier type a.c. meters
   b. instrument transformers
   c. hook-on type a.c./d.c. ammeters
   d. a.c. bridges; capacitance, inductance, impedance,
   e. vibrating reed frequency meter and moving disc frequency meter,
   f. crossed-coil power factor meter and moving iron-vane power factor meter
   g. synchroscope and synchronizing lamps,
   h. switches and relays, reverse current relays and reverse power relays

5. Operation and maintenance of fluorescent and incandescent lamps

6. Classification of insulation;
   a. permissible temperature rise
   b. insulation resistance
   c. temperature correction

7. Insulation resistance meters
   a. 60 second insulation test
   b. voltmeter method
   c. dielectric absorption test, polarization index;
   d. insulation resistance standards
   e. nondestructive high potential testing
   f. a.c. high potential testing
   g. d.c. high potential testing
   h. insulating liquids testing; sampling and filtering
   i. insulating liquids,
   j. cleaning of electrical insulation;
      1. submerged or flooded equipment
      2. drying electrical insulation
      3. care of electrical apparatus during periods of inactivity;
      4. revarnishing of electrical insulation

8. Batteries
    a. primary cells
        1. zinc
        2. carbon dry cells
        3. combining cells
    b. secondary cells
        1. lead - acid,
        2. wet cells
            a. specific gravity
            b. hydrometer readings, rating and charging

9. Alkaline batteries
    a. nickel - cadmium
    b. nickel - iron

10. Fuses
    a. current limiting fuses
    b. fuse testing

11. Molded case circuit breakers
    a. ratings
    b. interrupting capacity
    c. tripping curves
    d. adjustable air type
    e. oil-circuit breakers
    f. over current protection
    g. protection of motors
    h. coordination of over current protective devices
    i. short circuit current
    j. monitor and testing

12. Transformers
    a. principle of operation
    b. load
    c. autotransformer
    d. terminal markings and connections

ADVANCED ELECTRICITY MAINTENANCE AND TROUBLESHOOTING
PART II
(40 HOURS LECTURE/ 16 HOURS LAB)

1. D.C. generators
   a. construction
   b. generated voltage and commutating poles
   c. self and separately excited voltage generation
   d. compound generators
   e. armature reaction
   f. three wire generators
   g. single generator operation
   h. parallel operation
   i. instrumentation
   j. load sharing
   k. reversed polarity and voltage failure

2. D.C. motors

   a. principle of motor action
   b. reversing a d.c. motor
   c. generator action in a d.c. motor
   d. starting
   e. speed adjustment
   f. shunt motors
   g. compound and series motors
   h. motor connections,
   i. determining motor performance

3. Commutator surface film
   a. brush sparking
   b. cleaning commutators
   c. commutator resurfacing
   d. mica undercutting
   e. brush adjustment
      1. Clearance
      2. Staggering
      3. brush angle
      4. Spacing
      5. Pigtails
      6. Seating pressure
      7. brush neutral
   f. physical inspection test
      1. inductive kick test
      2. commutating pole testing
      3. reverse-rotation test

4. Troubleshooting d.c. motors
    a. shorted field
    b. open field
    c. grounded field coils
    d. testing for a reversed shunt or commutating coil
    e. locating open armature coils and emergency repair
    f. locating shorted armature coils and emergency repair
    g. locating grounded armature coils and emergency repair
    h. disassembly of machines
    i. re-assembly of machines
    j. bearing sleeve and ball
    k. vibration
    l. rebanding
    m. shaft currents

5. Ungrounded distribution system
    a. troubleshooting ungrounded distribution systems
    b. troubleshooting grounded distribution systems
    c. system grounding

6. Power factor improvement of a distribution system
    a. maintenance of power capacitors
    b. lightning protection

7. Maintenance
    a. high voltage insulators
    b. cable
    c. switch gear

8. A.C. generators
    a. generation of an alternating voltage
    b. three phase generator construction and theory
    c. voltage and speed regulation
    d. watts; vars; kva and power factor;
    e. procedure for single A.C. generator operation
    f. procedure for parallel operation
    e. removing an alternator from the bus
    g. motorization
    h. synchronizing a.c. generators
        1. Instrumentation
        2. load sharing
        3. power factor problems in alternators in parallel
        4. phase sequence
        5. voltage failure
        6. operating at nameplate rating

9. A.C. motors

a. three phase squirrel cage induction motor
b. reversing three phase induction motors
c. speed adjustment
d. performance data
e. wound rotor induction motor
f. effects of off-standard operation
g. single phase operation of three phase motor
h. split phase induction motors
i. capacitor motors
j. shaded pole motors
k. repulsion start motors
l. a.c. series motor
m. synchronous motors

10. Troubleshooting an a.c. motor
a. locating shorted and grounded stator coils and emergency repair
b. locating open stator coils and emergency repair,
c. squirrel cage rotor troubles
    1. wound rotor troubles
    2. single phase induction motor troubles
d. locating shorted, open, and grounded field coils
e. testing for a reversed field coil

11. Magnetic amplifiers
a. characteristics - review of magnetism
b. reactors
    1. core material
    2. transformer principles magnetic amplifiers
    3. basic magnetic amplifiers
    4. improved magnetic amplifier
c. three legged core magnetic amplifiers
    1. half wave rectifier function of rectifiers - effect of hysteresis on operation
    2. full wave rectifier
    3. cross over windings
    4. principles of feedback circuits

ADVANCED ELECTRICITY MAINTENANCE AND TROUBLESHOOTING
PART III
(40 HOURS LECTURE/ 16 HOURS LAB)

1. Cathodic Hull Protection - purpose

    a. Capac
    b. Theory of Corrosion,
    c. Glossary of Terms
    d. Service and Maintenance
    e. Galvanic Series
    f. Optimum Reference Potentials
    g. Automatic Controller
    h. Power Supply
    i. Propeller Shaft Grounding

2. Synchro Rotor and Stator Construction
    a. Transmitters and Receivers
    b. Synchro Rotor and Stator Currents
    c. Differential Synchros Additive and Subtractive Receivers
    d. Troubleshooting Synchros
        1. Control Transformers
        2. Motor Controller Troubles
        3. Procedure for Troubleshooting a Magnetic Controller
        4. Maintenance of Magnetic and Electronic Controllers
        5. Reading Control Diagrams
        6. Auto-transformer Starting

3. Ship board winches
    a. A.C. Hoist Control
    b. D.C. Reversing Controller
    c. Arrangement of gears
    d. Motors Required;
    e. Safety Considerations
    f. Economic Factors
    g. Speed-Load Characteristics
    h. Brake
4. Constant Voltage D.C. Winch;
    a. Components
    b. Arrangement
    c. Operation
5. Mag-Amp Controlled Winch;
    a. Components and Operation
    b. Maintenance and Troubleshooting
6. SCR Controlled Winch
    a. Components
    b. Operation
    c. Maintenance and Troubleshooting

BASIC ELECTRONICS
PART I
(40 HOURS LECTURE/ 16 HOURS LAB)

1. Introduction to Electronics
2. Atomic Structure
3. Electrical Charge (Displacement & Flow)
4. Resistance & Conductance
5. Components of an Electric Circuit
6. Sources of Voltage
7. Ohm's Law
8. Power and Work
9. Series Circuits
10. Parallel Circuits
11. Series-Parallel Circuits
12. Resistors
13. Power Rating of Resistors
14. Voltage & Current Division
15. Voltmeters
16. Ohmmeters
17. Meter Applications
18. Kirchoff's Laws
19. Node Voltage & Mesh Currents
20. Conductors & Insulators
21. Wire Resistance
22. Batteries
23. Voltage & Current Sources
24. Magnetism
25. Types of Magnets
26. Magnetic Units
27. Magnetic Circuits
28. Electromagnetic Induction
29. Lenz' Law
30. AC Voltage & Current
31. The Sine Wave
32. Frequency
33. Non-Sinusoidal Waveforms & Measurement

BASIC ELECTRONICS
PART II
(40 HOURS LECTURE/ 16 HOURS LAB) αβπ

1. Inductance, Self Induced Voltage, Transformers, Inductive Reactance, $X_L = 2\pi FL$
2. Inductive Circuits; X_L and R in Series, Impedance
3. Inductive Circuits; X_L and R in Parallel, E_L, L/R t.c., inductive circuit problem review
4. Capacitance
    a. Charge Capacitance
    b. Series-Parallel
    c. Troubles
5. Capacitance Reactance, Xc = $1/2\pi FC$, Series and Parallel Reactance
   Phase Relations in Capacitive Circuits
6. Capacitive Reactance, Problem Review
7. Capacitive Circuits; X_C and R in Series,
8. Capacitive Circuits; X_C & R in Parallel
9. Capacitive Voltage Dividers - Capacitive Circuits, Problem Review,
10. L/R Time Constants, R-C Time Constants, Long and Short Time Constants, Universal Time Constant Graph, L/R and R-C Time Constant Problems
11. A.C. Circuits with Resistance or Reactance Alone
    a. Opposite Reactances Cancel
    b. Series Resistance and Reactance
    c. Parallel Resistance and Reactance
    d. Series - Parallel Resistance and Reactances Apparent, True & Reactive Power
12. A.C. Meters; Summary of A.C. Circuits
13. The Resonant Effect
    a. Series Resonance
    b. Parallel Resonance
    c. Resonant Frequency
    d. "Q" Factor of a Resonant Circuit
    e. Band width of a Resonant Circuit
    f. Tuning - incorrect tuning of a Resonant Circuit,
    g. Analysis of Parallel Resonant Circuit

BASIC ELECTRONICS
PART III
(40 HOURS LECTURE/ 16 HOURS LAB)

1. Introduction to Electronics
2. Semiconductor Fundamentals
3. N-type and P-type Crystals
4. PNP and NPN Junction
5. Diode Characteristics
6. Special Purpose Diodes
7. Typical Diode Applications
8. Power Supply Fundamentals
9. Half-Wave Rectification
10. Full-Wave Rectification
11. Voltage Conversions
12. $\pm$ Power Supplies
13. Power Supply Filtering
14. Voltage Multipliers
15. Ripple and Regulation
16. Zener Regulator
17. Power Supply Troubleshooting
18. Bipolar Transistor (BPT)
19. Transistor Action
20. Current Ratios and Parameters
21. The "T" Equivalent
22. Transistor Characteristics
23. Testing The BJT
24. Other Transistor Types
25. The Ideal Amplifier
26. Transistor Amplifier Configurations
27. Common Emitter Amplifier (CE)
28. Q-Point, Biasing, and Load Lines
29. Biasing Methods
30. AC Equivalent Circuits
31. The Emitter Resistor
32. CE Amplifier Design
33. Common Collector Amplifier
34. Interstage Coupling
35. Voltage vs. power Amplification
36. Multistage Amplifier Design

BASIC ELECTRONICS
PART IV
(40 HOURS LECTURE/ 24 HOURS LAB)

1. Amplifier Classification
2. Class A Amplifiers

3. Class B Amplifiers

4. Class AB Amplifiers

5. Class C Amplifiers

6. The Differential Amplifier

7. Radio Theory
   a. Modulation
   b. Detection

8. The Superheterodyne

9. Oscillator Circuits
   a. Hartley
   b. Colpitts
   c. Armstrong
   d. Crystal
   e. Phase Shift

10. Electronic Control Devices

11. The SCR

12. Full Wave Devices

13. Introduction to Integrated Circuits

14. Fabrication

15. IC Applications

16. Troubleshooting ICs

BASIC ELECTRONICS
PART V
(40 HOURS LECTURE/ 24 HOURS LAB)

1. Jacquard, Babbage, and Boole Computers
    a. Two State Operation
    b. Saturated And Non Saturated Logic
    c. Bipolar IC's

2. TTL Circuits
    a. MOS IC's
    b. VMOS Binary Numbers
    c. Binary Addition
    d. Binary To Decimal Conversion
    e. Decimal To Binary Conversion
    f. Binary Subtraction
        1. Complement 2's
        2. Complement Octal Number
        3. Octal-Binary
        4. Conversion Hexadecimal Numbers
        5. Binary Codes

3. Parity
    a. Alphanumeric Displays
    b. Decimal Decoders
    c. Seven Segment
    d. Decoders
    e. Dot-Matrix Decoding
    f. LEDs and Liquid Crystals

4. Logic
    a. The "or" Gate
    b. The "and" Gate
    c. Positive and Negative Logic
    d. The "Not" Gate
    e. "Or" Addition And Multiplication
    f. The "Not" Operation

5. De Morgan's Theorems

6. The Universal Building Block, Laws and Theorems of Boolean Algebra,

7. TTL NAND Gates
    a. Open Collector TTL
    b. Wire-Or
    c. Three-State Gates
    d. X Or And X Nor Gates
    e. Half Adder
    f. The Full Adder
    g. A Parallel Binary Adder,

8. Simplifying Logic Circuits
    a. Fundamental Products
    b. Sum Of Products And Or Networks
    c. Algebraic Simplification,

9. Multivibrators
    a. The RS Flip-Flop
    b. The D FLip-Flop
    c. Edge- triggered D Flip-Flops
    d. JK Flip-Flops
    e. JK Master Slave Flip-Flops
    f. The Schmitt Trigger
    g. The Astable Multivibrator
    h. The Monostable Multivibrator

10. Counter Technique
    a. 4-Bit Binary Counter
    b. Binary Ripple
    c. Counters Asynchronous
    d. Counters Using Feedback
    e. Parallel Counter
    f. Combination Counters
    g. Binary Decade Counter With Decoding Gates
    h. MSI Decade Counter
    i. Higher Modulus Counters
    j. A-BCD Counter
    k. Special Counters and Registers
    l. Serial Shift Register
    m. A Ring Counter
    n. Up/Down Counter
    o. Shift-Register Operations

12. Digital Clocks
    a. Basic Clocks
    b. Clock Systems
    c. TTL Clock
    d. Microprocessor Clocks
    e. Multi-Phase Clock Generator

APPLIED ELECTRONICS
PART I
(32 HOURS LECTURE/ 32 HOURS LAB)

1. Introduction to the Applied Electronics Course
2. General Electric COS General Description
3. Engine Room Console Physical Layout
4. Surface and Coordinate Location Numbers
5. Elementary Diagram Practices
6. Power Distribution, AC and DC
7. Print Reading Examples and Symbols
8. TANO Print Reading
9. Operational Amplifier
10. Operational Amplifier
11. Diode Clamping
12. Summing Amplifiers
13. Function Generators
14. Square Root Function Generator
15. Cubic Function Generator
16. G.E. Function Generators
21. G.E. Throttle Control General Description
22. Throttle Control One-Line Diagram
23. Crackpoint Operation
24. Crackpoint + Reference Operation
25. Crackpoint + Reference + Speed Error Operation
26. Low Steam Pressure Override
27. Hi-Water Level Override
28. Auto Rotation
29. Bursting
30. Throttle Control Elementary Diagrams
31. Throttle Control Elementary Diagrams
32. Throttle Control Elementary Diagrams
33. SCR Package
34. Throttle Test Procedure
35. General Troubleshooting Procedure
36. Westinghouse Throttle Control
37. Explanation of the Data Scanner
38. Programming Concepts
39. Clock Circuits
40. Address Relays
41. Introduction to Analog Sensors RTD Characteristics
42. Temperature Measurement Circuit
43. RTD Bridge Card
44. RTD Calibration
45. Force Balance Pressure Transducer
46. GE/MAC Pressure Transducer
47. GE/MAC Pressure Transducer
48. GE/MAC Calibration
49. The A/D Converter
50. A/D Comparisons & Conversions
51. Limit Checking

BASIC AUXILIARY MACHINERY
PART I
(40 HOURS LECTURE)

I. <u>Shipboard Organization</u>

- A. Engine Subjects Billets and duties*
- B. Deck Subjects Billets and duties*
- C. Steward Subjects Billets and duties*
- D. Interrelationship of Subjects*

II. <u>Hull Construction</u>

- A. Parts of the Hull*
- B. Ship's Plans and Prints
  1. Views of a ship
  2. Lines
- C. General Arrangements*
  1. Break Bulk*
  2. Container*
  3. Tanker*

III. <u>Vessel Propulsion Types</u>*

- A. Steam Turbine*
  1. Geared*
  2. Electric*
- B. Diesel*
  1. Geared*
  2. Direct*
  3. Electric*
- C. Gas Turbine*
- D. Nuclear

IV. <u>Propellers, Stern Tubes, Bearing and Shafting</u>

- A. Propellers
  1. Types
  2. Theory of Operation
- B. Tailshafts and Stern Tubes
  1. Water lubricated types
  2. Oil lubricated types
- C. Line Shaft Bearings

V. Basic Plant Cycles*

A. Steam Turbine Plant Cycle*
   1. Basic components and flow patterns *
   2. Component functions and interactions*
B. Diesel Plant Cycle*
   1. Basic components and flow patterns*
   2. Component functions and interactions*

VI. Pressure Measuring Devices*

A. Gage vs. Absolute Pressure*
B. Bourdon Tube Devices*
C. Manometers*
D. Various Pressure Scale Conversions*
E. Draft Gages*

VII. Introduction to Basic Thermodynamics

A. Terminology
B. Temperature Scale Conversions

VIII. Valves*

A. Basic Functions*
B. Types: Globe, Gate, Ball, Check, Plug, Butterfly*
C. Pressure Reducing Valve*

IX. Heat Exchangers*

A. Theory of Operation*
   1. Methods of heat transfer*
   2. Factors affecting heat transfer*
B. Types*
   1. Constructional Variations*
   2. Methods of allowance for expansion*
C. Steam Traps*
   1. Mechanical*
   2. Thermostatic*
   3. Thermodynamic*
D. Temperature Control Valves*
E. Operational Troubleshooting and Maintenance

BASIC AUXILIARY MACHINERY
PART II
(40 HOURS LECTURE)

I. **Pumps***

A. Concept of Head*
B. Reciprocating Pumps*
   1. Principle of operation*
   2. Classification*
   3. Steam end construction*
   4. Valve gear*
   5. Water end construction*
   6. Start-up and shutdown procedures*
   7. Maintenance*

C. Rotary Pumps*
   1. Types and shipboard uses*
      a. gear*
      b. screw*
      c. lobe*
   2. Operation*
D. Centrifugal Pumps*
   1. Theory of operation and characteristic curves *
   2. Types - functions*
   3. Construction and component fundamentals*
      a. casing*
      b. impeller*
      c. volute*
      d. diffusion ring*
      e. wearing rings*
      f. lantern rings*
   4. Operation - start-up and shutdown*
   5. Maintenance

II. **Compressed Air Systems ***

A. Ship's Service System Arrangement*
B. Control Air System Arrangement*
   1. Pressure control
   2. Air filter and dehydration equipment
C. Compressors*
   1. Construction*
   2. Operation*
   3. Troubleshooting
D. Cross Connections*

III. Pneumatic Control Devices*

A. Diaphragm and Piston Driven Valves*
1. Upward and downward seating*
2. Direct and indirect actuators*

B. Pneumatic Controllers*
1. Principle of operation*
2. Direct and indirect controllers*

C. Applications*
1. Pressure control*
2. Level control*
3. Temperature control*

IV. Lubricating Oil Systems*

A. Service Systems Functions*
1. Arrangements and component fundamentals*
   a. gravity feed*
   b. pressure feed*
   c. combination*
2. Operation*
   a. start-up*
   b. shutdown*
   c. emergency procedures*

B. Storage, Transfer, and Purification Systems *
1. Arrangement and component functions*
2. Principles of purification*
3. Tubular type purifiers*
   a. construction*
   b. operation*
   c. maintenance*
4. Disc type purifiers*
   a. construction*
   b. operation*
   c. maintenance*

BASIC AUXILIARY MACHINERY
PART II
(40 HOURS LECTURE)

I. <u>Refrigeration Systems</u>*

A. Principles of Refrigeration*
   1. Commonly Used Refrigerants
   2. Basic vapor compression cycle

B. Typical Ship's Service System*
   1. Arrangement and component functions*
   2. Operations
      a. pumping down
      b. removal of refrigerant
      c. testing for leaks
      d. charging system
      e. purging air from system

C. Indirect Systems*

II. <u>Distilling Plants</u>*

A. Process of Distillation*

B. High Pressure Types*
   1. Operation
   2. Maintenance

C. Low Pressure Types*
   1. Submerged tube type*
      a. operation*
      b. maintenance*
   2. Flash type*
      a. operation*
      b. maintenance*

III. <u>Steering Gear Systems</u>*

A. Basic Hydraulic Principles*

B. Hydraulic Telemotor System*
   1. Arrangement and component function*
   2. Operation*
   3. Maintenance*

C. Electro-Hydraulic System*
   1. Arrangement and component function*
   2. Operation*
   3. Maintenance*

D. Regulations

IV. Potable Water Systems *

A. Arrangement and Component Functions *
   1. Heaters and temperature control*
   2. Hydro-pneumatic tanks*
   3. Pressure control*

B. Operation*

V. Sanitary Systems and Sewage Treatment*

A. Arrangement and Component Functions *
   1. Hydro-pneumatic tank*
   2. Pressure control*

B. Disposal of effluent - Basic arrangements and component functions*

C. Regulations

VI. Bilge and Ballast Systems*

A. Arrangements and Component Functions*

B. Operation*

C. Regulations*

D. Priming Systems*
   1. Vacuum pumps*
   2. Alternate use of vacuum pump for compressed air*

ADVANCED AUXILIARY MACHINERY
PART I
(40 LECTURE HOURS)

I. Heat Exchangers

A. Forms of Heat Transfer
   1. Radiation
   2. Conduction
   3. Convection

B. Common Factors Affecting Heat Transfer

C. Classification of Heat Exchanger with Regard to:
   1. Number of passes
   2. Direct or indirect contact
   3. Relative direction of flow
      a. parallel
      b. counter
      c. cross
   4. Construction
      a. types of heat exchangers
         (1) shell and tube
         (2) grid or plate
         (3) multi-coil
         (4) others
      b. tube surfaces
         (1) smooth
         (2) extended
      c. installation of tubes/allowance for expansion
         (1) bowed tubes
         (2) ferrule packing
         (3) shell expansion joint
         (4) floating heads

II. Fluid Control Devices

A. Steam Traps
   1. Mechanical
      a. ball float
      b. upright bucket
      c. inverted bucket
   2. Thermostatic
      a. bimetallic
      b. bellows
   3. Dynamic
      a. impulse
      b. disc
   4. Fixed orifice

B. Pressure Control Devices
   1. Simple air pressure reducer
   2. Steam/air internal pilot spring loaded reducer
   3. Air pilot controls and pneumatic valves

C. Level Control Devices
    1. Float type drain controls
    2. Floatless drain controls
D. Temperature Regulators
    1. Straight thermostatic
    2. Thermostatic - steam pressure reducer
E. Electromechanical Valve Actuators
F. Steam/Air Whistles

III. <u>Main Condenser</u>

A. Functions
B. Types
    1. Top entry
    2. Side entry
C. Construction
    1. Water side: Main circulation and injection systems
        a. high and low sea suctions
        b. emergency bilge injection
        c. cross - over connection
        d. check valves
    2. Steam side components
        a. steam lane
        b. dead air space
        c. air cooler section
        d. main tube banks and construction materials
        e. tube support sheets
D. Operation Monitors
    1. Terminal difference
    2. Temperature rise
    3. Condensate depression
E. Maintenance
    1. Zincs and Capac
    2. Cleaning tubes and division plate
    3. Testing for leaks

IV. <u>Condensate System Components</u>

A. Air Removal Equipment
    1. Air ejectors and related condensers
        a. theory of jet pump operation
        b. steam and condensate flow paths
        c. operating practices
            (1) loop seal
            (2) after condenser drain
            (3) recirculating line
    2. Vacuum pump

B. Gland Seal System
   1. Gland exhaust condenser
   2. Inputs and outputs
C. Extraction Steam Systems
D. First Stage Heater and Drain Cooler
E. Improved Efficiency with L.P. Combine Feed heater

V. <u>Deaerating Feed Heaters - Jet Spray</u>

A. Process of Deaeration
B. Steam/Water Flow Paths
C. Inputs
   1. Auxiliary exhaust (back pressure) systems
   2. Steam makeup and dump systems
   3. H.P. drains
D. Operational Practices
E. Steam Dump Systems

VI. Saltwater Distillation

A. Saltwater and distilled water parameters
B. H.P. Evaporators -
   1. Makeup
   2. Saltwater
   3. Contaminated steam generators
      a. functions
      b. fittings
      c. inputs and outputs
      d. general operation
C. Low pressure evaporators
   1. Submerged tube - solo shell
      a. water/steam/vapor paths
      b. operation and maintenance
   2. Flash type
      a. water/steam/vapor paths
      b. operation and maintenance
      c. troubleshooting
   3. Other types

ADVANCED AUXILIARY MACHINERY

PART II

(40 LECTURE HOURS)

I. Lubrication

A. Test and characteristics of petroleum based oils
   1. Viscosity
   2. Viscosity Index
   3. Cloud, floc, and pour point
   4. Flash, fire, and auto ignition point
   5. Neutralization number
   6. Precipitation number
   7. Carbon residue number
   8. Demulsibility

B. Lubricating oil systems
   1. Functions of lube oil
   2. Theory of lubrication
      a. friction
      b. boundary lubrication
      c. hydrodynamic lubrication
      d. mixed film condition
   3. Main lube oil systems
      a. gravity feed system
      b. pressure feed system
      c. pressure-gravity system
   4. Main engine governor system
   5. Turbo-generator set
      a. overspeed trip
      b. back pressure trip

C. Purification and cleaning of lubricating oils
   1. Occurrence of contaminants
      a. water
      b. sludge
      c. metals
   2. Methods of lube oil contamination removal
      a. filtering
      b. straining
      c. settling
      d. centrifuging
   3. Types of centrifuges and their basic components
      a. tubular Bowl
         (1) construction
         (2) operation
         (3) maintenance

      b. disc type

(1) construction
(2) operation
(3) maintenance

c. operational procedures common to both
(1) separator
(2) clarifier
(3) purifier
(4) rule of thumb operation
(5) troubleshooting

4. Alternative to centrifuging - Coalescing

II. <u>Pumps</u>

A. Concept of Head

B. Reciprocating Pumps
1. Classification
2. Liquid end operation
3. Steam end operation
a. lost motion
b. setting the steam valve gear
c. proper use of cushioning valves
d. variable capacity triplex reciprocating pump

C. Centrifugal Pumps
1. Theory of operation and characteristic curves
2. Classification
3. Construction and function of major components
4. Maintenance and trouble shooting
5. Coffin and similar feed pumps
a. general construction
b. governing mechanisms

D. Propeller (Axial Flow) Devices
1. Theory of operation
2. Application and propeller type devices
a. forced draft fans
b. main circulating pumps
3. Graphic comparison of axial and radial flow devices

E. Vacuum pumps
1. Theory of operation
2. Application
a. air ejector replacement
b. priming system pumps
c. air compressors

III. <u>Compressed Air Systems</u>

A. Air Systems
1. Control air system
2. Ship's service system

B. Low pressure reciprocating air compressors

1. Principle of operation
2. Use of intercoolers and after coolers
3. Unloaders
    a. function
    b. unloader control
    c. methods of unloading
    d. Ingersol-Rand unloading system

C. Additional equipment
1. Trip-L-Trap
2. Refrigifilter

D. Troubleshooting

IV. Domestic Water Systems and Pollution

A. Domestic water systems
1. Potable water systems
2. System components
3. Coast Guard regulations

B. Sanitary water systems
1. System components
2. Requirements
3. Flushometer and vacuum breakers

C. Marine sewage devices
1. Current requirements
2. Basic systems
    a. holding tanks
    b. biological systems
    c. mechanical-chemical
    d. incineration

D. Oil pollution
1. Coast Guard regulations
2. Methods of tank cleaning
    a. manual
    b. chemical
    c. water washing
    d. crude oil washing

V. Positive Inert Gas Systems

A. Coast Guard regulations
B. Practical reasons for installations - inert gas atmosphere
C. Basic system
    1. Sources of inert gas
    2. Scrubbers
    3. Fans
    4. Gas pressure regulation
    5. Deck water seals
    6. Pressure-vacuum protection
    7. Gas relief devices - Mast vent riser
D. Starting and stopping procedures
E. Troubleshooting

MARINE CONTROL SYSTEMS
PART I
(32 LECTURE HOURS/16 LAB HOURS)

I. Measurement Fundamentals

- A. Variables
- B. Engineering units
- C. Measurement terms and characteristics
  1. Signal terms - complete block diagram of a simple system
  2. Range related terms
     a. range
     b. span
     c. zero base
     d. span elevation
     e. span suppression
  3. Accuracy related terms
     a. calibrate
     b. error
     c. hysteretic error
     d. dead band
     e. hysteresis
     f. linearity

II. Pressure Sensing and Measuring

- A. Elasticity
  1. Characteristics
     a. deflection
     b. modulus of elasticity
     c. modulus of rigidity
     d. materials
  2. Springs
     a. tension
     b. compression
     c. variables in design
- B. Pressure gages
  1. Elastic elements
     a. diaphragm
        (1) Metallic
        (2) Nonmetallic
     b. bellows
     c. bourdon tube
        (1) C-type
        (2) Spiral
        (3) Helical
        (4) Principles of operation

2. Gage types
    a. simplex pressure
    b. duplex pressure
    c. simple vacuum
    d. compound pressure-vacuum
3. Calibration
    a. comparison method
    b. dead weight tester method

C. Pressure transmitters
1. Purpose
2. Applications
3. Configurations
    a. pneumatic motion detectors
        (1) flapper and nozzle
        (2) bleed type relays
        (3) non-bleed type relays
    b. electrical motion detectors
        (1) strain gages
        (2) rheostat
        (3) carbon pile
        (4) inductor
    c. feedback balancing
4. Calibration

III. <u>Differential Pressure and Flow Sensing and Measuring</u>

A. Purposes of differential pressure sensing
1. Head measuring
2. Flow measuring

B. Primary elements required for creation of head due to flow
1. Orifice plate
    a. concentric
    b. eccentric
    c. segmental
2. Flow nozzle
    a. application
    b. description
3. Venturi tube
    a. application
    b. description
4. Advantages and disadvantages of each type
5. Other primary elements

C. Devices which sense or measure differential pressure
    1. Liquid column element manometers
        a. u-tube
        b. well
        c. inclined tube
        d. ring balance
    2. Differential pressure cell
        a. principle of operation
        b. uses
        c. types
D. Differential pressure transmitters
    1. Uses
        a. head due to level
        b. head due to flow
    2. Examples
E. Flow transmitters using head variation
    1. Application
    2. Differential pressure-to-flow relation
    3. Square root extraction
F. Flow transmitters using area variation
    1. Rotameter
    2. Piston
    3. LeDoux bell
G. Positive displacement flow meters
    1. Nutating disc
    2. Oscillating piston
    3. Other types

IV. Level Sensing and Measuring

A. Classification
    1. Direct
    2. Inferential
B. Direct methods
    1. Gage glass
    2. Ball float
    3. Chain or tape float
    4. Displacer
C. Inferential methods
    1. Differential pressure cell
    2. Pneumercator
    3. Conductive
    4. Capacitive
D. Level transmitters
    1. Application
    2. Operation

V. Temperature Sensing and Measuring

A. Temperature scales and conversions
   1. Fahrenheit
   2. Rankine
   3. Celsius
   4. Kelvin

B. Liquid-in-glass thermometer
   1. Applications
   2. Limitations

C. Bimetallic thermometer
   1. Applications
   2. Operation

D. Filled thermal systems
   1. Classification
   2. Principles of operation
   3. Methods of ambient temperature compensation
      a. full
      b. case
   4. Applications
   5. Limitations

E. Thermocouples
   1. Principles of operation
      a. Thomson effect
      b. Peltier effect
      c. Seebeck effect
   2. Laws of thermoelectricity
      a. law of homogeneous circuits
      b. law of intermediate temperatures
      c. law of intermediate metals
   3. Applications
      a. boiler uptakes
      b. diesel engine exhaust
      c. thermopile
         (1) Description
         (2) Purpose

F. Thermoresistive devices
   1. Types
   2. Principle of operation

G. Temperature transmitters
   1. Applications
   2. Operating principles

VI. Miscellaneous Transmitters

A. Types
   1. Viscosity
   2. Specific gravity
   3. Speed
   4. Torque
   5. Conductivity
   6. Vibration

B. Operation of each type

MARINE CONTROL SYSTEMS
PART II
(32 LECTURE HOURS/16 LAB HOURS)

I. Pneumatic Computing Elements

A. Purposes
B. Force Balance and Torque Balance Principles
C. Types of Elements
    1. Summing and Differential
    2. Multiplying and Ratioing
    3. Inverting
    4. Averaging
    5. Selecting and Limiting
    6. Toggling
D. Typical Examples

II. Fundamentals of Automatic Process Control

A. Objectives of a Control System
    1. Regulator Operation
    2. Servo Operation
B. Block diagram analysis
C. Basic definitions
    1. Process
    2. Controlled variable
    3. Sensing Element
    4. Transducer
    5. Pneumatic sensor transmitter unit
    6. Set point
    7. Automatic controller
    8. Final control element
    9. Control agent
    10. Manipulated variable
    11. Disturbance
D. Basic schemes or methods of automatic control
    1. Open loop
    2. Environmental
    3. Feedback
    4. Feedforward
E. Analysis of Closed Loop Feedback Control
    1. Process
    2. Process time lags
        a. Capacity and resistance
        b. Dead time
    3. Disturbances

4. Process reaction curves
5. Effect of time lag on feedback control
6. Block diagram analysis of a typical control system
    a. Component gains
    b. Component time lags

III. <u>Types of control actions</u>

A. Two Position
    1. Single Point
    2. Differential Gap
    3. Adjustments
    4. Examples aboard ship
B. Proportional
    1. Time
    2. Position
    3. Proportional band adjustments
C. Floating Control Action
    1. Principle of Floating Control Action
    2. Types
        a. Single speed floating
        b. Multiple speed floating
        c. Proportional Speed floating (reset or integral)
    3. Proportional plus reset combination
        a. Proportional band adjustment
        b. Reset time adjustment
D. Rate Control Action (Derivative)
    1. Principle of rate action
    2. Functions
        a. Acceleration
        b. Anticipation
    3. Combination with proportional and reset actions
    4. Adjustments

MARINE CONTROL SYSTEMS
PART III
(32 LECTURE HOURS/16 LAB HOURS)

I. Control Stability

A. Frequency response analysis
B. Effects of control actions on stability
C. Effects of load changes
D. Component non-linearity problems
E. Stability changes with time
F. Noise

II. Automatic Controller Adjustments

A. Calibration
B. Tuning
C. Tuning methods
    1. Systematic trial
    2. Ultimate-sensitivity
    3. Considine reaction curve

III. Manual-Automatic Transfer Stations

A. Types of stations
    1. Simple transfer
    2. Biasing
    3. Set point generating
    4. External set point
    5. Cascade
B. Transfer procedures and precautions
    1. Self tracking stations
    2. Controller tracking of hand loading signal

IV. Final Control Elements

A. Valve positioners
    1. Typical shipboard devices
    2. Calibration procedures and precautions
B. Valve motion transmitters
    1. Typical shipboard devices
    2. Calibration procedures and precautions
C. Valve characteristics
    1. Types
    2. Applications
    3. Functions
D. Choosing the correct valve

V. Pressure Control Systems

A. Spring loaded reducing valve
B. Contaminated evaporator

C. Auxiliary exhaust
D. Pump discharge pressure
E. Boiler steam dump
F. LNG compressor suction pressure
G. Compressor surge

VI. <u>Temperature Control Systems</u>

A. Fuel oil heater
B. Water heater
C. Steam desuperheating

VII. <u>Level Control Systems</u>

A. Condenser hotwell
B. Atmospheric drain tank
C. Contaminated evaporator
D. Deaerating feed tank
E. Boiler feedwater regulator

MARINE CONTROL SYSTEMS
PART IV
(32 LECTURE HOURS/16 LAB HOURS)

I. Principles of Combustion Control

A. Fuel oil atomization
   1. Types
      a. straight mechanical
      b. return flow
      c. steam
   2. Comparisons
      a. characteristics
      b. turn-down ratios

B. System classifications
   1. Number of elements
      a. single
      b. two
   2. Physical layout
      a. parallel
      b. series
      c. series - parallel
   3. Administration of air
      a. per-burner
      b. per-burner combination
      c. per-boiler
   4. Administration of oil
      a. simple pressure tie-back
      b. characterized pressure tieback
      c. simulated flow tieback
      d. metered flow tieback

II. Combustion Control Systems

III. Flame Scanner Systems

IV. Burner Management Systems

V. Throttle Control Systems

MARINE HYDRAULICS
PART I
(24 LECTURE HOURS/16 LAB HOURS)

I. Introduction to hydraulics

A. Definition of hydraulics: hydrostatics vs. Hydrodynamics
B. Advantages of hydraulic systems over other power systems
C. Pressure closed systems vs. constant flow systems
D. Pascal's law and its application to hydraulics
E. Generation of pressure
F. Fluid flow
    1. Velocity vs. flow rate
    2. Laminar vs. turbulent flow
    3. Series vs. parallel flow

II. Hydraulic power transmission systems

A. Mechanical advantage
B. Work
C. Speed of actuation
D. Horsepower
E. Torque

III. Use of graphic symbology in schematics

IV. Hydraulic pumps and motors

A. Hydraulic pumps
    1. Pump configurations
        a. single unit
        b. two stage unit
        c. double pump unit
        d. combination unit
    2. Rotary
        a. spur gear
        b. generated rotor
        c. vane
        d. screw
    3. Reciprocating pumps
        a. radial piston
        b. axial piston
        c. bent axis
B. Hydraulic motors
    1. Theoretical difference between hydraulic pumps and hydraulic motors.
    2. Physical differences between hydraulic pumps and hydraulic motors.
    3. Torque, speed, power and displacement relationships.

V. Hydraulic linear actuators

A. Basic types of actuators
   1. Ram
   2. Differential piston
   3. Non-differential
   4. Telescoping

B. Accessories
   1. Rod wipers
   2. Cushioning
   3. Deceleration devices

C. Piston and rod seals

VI. Directional control valves

A. Spool valves vs. Rotary

B. Modes of control
   1. Manual
   2. Mechanical
   3. Cam
   4. Solenoid
   5. Hydraulic and pneumatic pilots

C. Positioning devices
   1. Spring centering
   2. Spring offset
   3. Detent

VII. Pressure control valves

A. Relief valves

B. Sequence valves

C. Counter balance or holding valves

D. Unloading valves

E. Pressure reducing valves

F. Pilot actuation

VIII. Flow control

A. Flow control devices

B. Flow control circuits
   1. Metered-in
   2. Metered-out
   3. Bleed-off

IX. Servo valves

A. Function

B. Basic types and applications

X. Hydraulic plumbing

A. Conduits
   1. Tubing
      a. preparation
      b. joint types
         (1) flanges
         (2) flare connections
         (3) compression fitting
   2. Hoses
      a. Installation - lay line
      b. Serial number
      c. high pressure versus low pressure construction

B. Manifolds

XI. Fluids, filters and seals

A. Functions of hydraulic oils
B. Properties and characteristics
   1. Viscosity
   2. Viscosity index
   3. Pour point
   4. Toxicity
   5. Flammability

C. Maintenance
   1. Strainers
   2. Filters

D. Seals
   1. Types
      a. "0" rings
      b. backing rings
      c. piston rings
      d. gaskets
      e. sealing tape
   2. Materials
      a. teflon
      b. neoprene
      c. buna-N
      d. nitrile

XII. Hydraulic reservoirs

A. Functions
B. Considerations for construction

XIII. Hydraulic accumulators

A. Types
B. Functions

MARINE HYDRAULICS
PART II
(24 LECTURE HOURS)

I. Typical Shipboard Circuits

A. Water tight shaft alley door
   1. Regulations
   2. Operation
      a. constant flow - reversible direction pumps
      b. counter balance valve
      c. pressure switch

B. Hydraulic crane
   1. Operation
      a. directional control valves
      b. bi-directional hydraulic circuit
   2. Safety devices
      a. fundamental hydraulic brake circuit
      b. counter balance valves

C. Hydraulic anchor windlass
   1. Operation
      a. variable delivery axial piston pump
      b. horsepower limiter and servo control
      c. bi-directional hydraulic motor
      d. replenishing pump - functions
   2. Safety devices
      a. fundamental hydraulic brake circuit
      b. neutral stroke interlock

D. Hydraulic constant tension mooring winch
   1. Operation
      a. hydronic pressure closed remote control
      b. variable delivery axial piston pump
      c. speed-tension servo control
      d. bi-directional axial piston variable displacement motor
      e. hydraulic motor pressure compensator
      f. multi-function replenishing pump
   2. Safety Devices
      a. normal brake release circuit
      b. emergency brake release
      c. neutral stroke interlock

E. Steering gears
   1. Steering gear rules and regulations
   2. Steering gear controls
      a. hydraulic telemotors
         (1) reciprocating ram type
         (2) axial piston-fixed displacement pump

b. electric synchronous transmission system
c. electronic whetstone bridge system

3. Electro-hydraulic steering gears
   a. ram type - unitized
      (1) variable delivery axial piston pump
      (2) multi-function replenishing pump
      (3) hydraulically piloted valves
         (a) unloading valve
         (b) distributor valve
      (4) servo pump
         (a) servo control
         (b) rotary actuator - rotary potentiometer
         (c) solenoid directional control valves
   b. vane motor type
      (1) variable delivery axial piston pump
      (2) multi-function replenishing pump
      (3) unit valve
      (4) servo control
         (a) linear actuator control system
         (b) linear potentiometer
         (c) servo control valve
4. Emergency operating procedures

F. Hydraulic hatch covers
1. Individual cell - torque motor type
   a. solenoid directional control valve
   b. electromechanical limit switches
   c. torque motor
   d. metered-out circuit
2. Full cargo hold - linear actuator type
   a. common power unit
   b. sequence valve
   c. truck and outrigger jacking circuits
   d. metered-in circuit
   e. metered-out circuit
   f. accumulator - pressure switch operation

II. <u>Troubleshooting Hydraulic Circuits</u>

A. Steps to diagnosing problems
1. Know the system
2. Operate the machine
3. Inspect the machine
4. List all possible causes
5. Reach a conclusion
6. Test the conclusion

B. Pump problems
    1. Cavitation
    2. Plugged suction strainer
    3. Fluid contamination
    4. Worn pump parts
C. Actuator problems
    1. Worn seals
    2. Worn motor parts
    3. Air in system
D. Faulty pressure controls
    1. Broken springs
    2. Worn valve components
    3. Dirt holding valve off seat
E. Charging and bleeding system of air
F. Cleaning system
G. Care of spare components
H. Storage of hydraulic fluid

REFRIGERATION AND AIR CONDITIONING
PART I
(40 HOURS LECTURE/ 16 HOURS LAB)

I. Introduction to Refrigeration

A. Need for food preservation, spoilage, bacterial action
B. Uses and applications
C. Brief history of refrigeration

II. Basic Theory of Refrigeration

A. Pressure
B. Temperature
C. Work
D. Energy
E. Power

III. Theory of Heat

A. Specific heat, sensible heat, latent heat
B. Condensation and evaporation
C. Superheat, total heat, Joule's constant
D. Modes of heat transfer

IV. Thermodynamic Processes

A. Physical properties and their relationships
    1. Density
    2. Volume
    3. Pressure
    4. Temperature
B. Effect of heat on the physical properties
C. Processes of interest for gases
    1. The general gas law
    2. Charles' law
    3. Boyles' law
D. Work, heat and energy equations
E. Adiabatic, isothermal and isobaric processes
F. Enthalpy and entropy
G. Steam and refrigerant tables

V. The Vapor Compression Refrigeration Cycle

A. Definitions
    1. Refrigerant or refrigerating agent
    2. Heat load
    3. Refrigeration
    4. Cycle

B. Discussion of the vapor compression cycle
    1. Four essential components
        a. compressor
        b. condenser
        c. flow control device
        d. evaporator
    2. High side - low side division of the system
    3. Cycle processes
        a. compression
        b. condensation
        c. expansion
        d. evaporation
C. System capacity
    1. Tons of refrigeration
    2. BTU and BTU/HR.
    3. Refrigerating effect
    4. Suction vapor volume
    5. Compressor capacity
D. Thermodynamic analysis
    1. Pressure-enthalpy diagram
    2. Plotting the simple saturated cycle on the P-H diagram
    3. Analysis of variables using the P-H diagram
        a. theoretical horsepower per ton
        b. variations in suction and condensing temperatures
        c. cycle efficiency
        d. heat removed
        e. work of the compressor
E. Actual vapor compression refrigeration cycles
    1. Subcooling
        a. effects
        b. methods
    2. Suction vapor superheat
        a. useful cooling
        b. non-useful cooling
    3. Pressure drops
        a. frictional
        b. difference in elevation

VI. <u>The direct compression refrigeration system</u>

A. Components
    1. Purposes
    2. Arrangement
B. General operation

C. Use of system in lab
    1. Identification of parts
    2. Start-up and secure procedures
    3. Pumpdown and charging procedures
    4. Purging and evacuating procedures
    5. Changing over compressors

VII. <u>Dehydration problems</u>

A. Basic temperature and humidity control
    1. Vapor pressure and dew point
    2. Use of back pressure regulators

VIII. <u>Refrigerants</u>

A. Properties
    1. Latent heat of vaporization
    2. Evaporating and condensing pressures
    3. Specific volume
    4. Critical pressure and temperature
    5. Freezing temperature
    6. Chemical stability
    7. Viscosity
    8. Miscibility
    9. Toxicity
    10. Flammability
    11. Availability and cost
    12. Refrigerant identification numbering system
B. Compatibility with oil and water
C. Leak detection
    1. Methods
    2. Detection equipment
D. Common refrigerants in particular
    1. R-11
    2. R-12
    3. R-22
    4. Azeotropes
    5. Non-halogenated hydrocarbons

IX. <u>System components</u>

A. Metering devices
    1. Manual expansion valves
    2. High and low side floats
    3. Automatic expansion valves
    4. Capillary tubes

5. Thermostatic expansion valves
    a. force analysis
    b. superheat adjustment
    c. effects of evaporator pressure
    d. MOP expansion valves
    e. bulb charges
    f. bulb location
    g. valve ratings and selection
6. Effect of evaporator pressure on motor load
7. Disassembly and testing of TXV in lab
8. Superheat setting and adjustment

B. Solenoid valves
1. Purpose
2. Types

C. Suction line controls
1. Back pressure regulators
2. Suction pressure regulators

D. Evaporators
1. Types
    a. flooded or dry expansion
    b. plate type, bare tube, finned tube
2. Sizing and materials
3. Defrost methods
    a. pre-defrost procedures
    b. hot water defrost
    c. hot gas defrost
    d. electric defrost

E. Compressors
1. Types
    a. reciprocating
    b. rotary
    c. centrifugal
2. Reciprocating compressor theory .
    a. the compression cycle and P-V diagrams
    b. compressor capacity
    c. volumetric efficiency
    d. effect of evaporating and condensing temperature
    e. horsepower determinations
    f. compression processes
    g. wet compression

3. Compressor-construction
    a. components and arrangement
    b. disassembly of compressors in lab for inspection
    c. operation of compressor in lab
    d. compressor lubrication
4. Compressor capacity control
    a. reasons for capacity control
    b. types of capacity control
    c. inspection of capacity control mechanisms in lab

F. Condensers
1. Air cooled
2. Water cooled
    a. capacity
    b. connections
    c. maintenance
    d. problems with air in system
3. Condenser water regulating valves
4. Cooling towers

G. Refrigeration piping
1. Piping design
    a. joint connections
    b. sizing
    c. materials
    d. layout particulars
2. Lab piping project
    a. discussion on copper tubing
    b. silver brazing instruction
    c. assembly of a small vapor compression system
    d. evacuating, charging, operating and testing of system

H. Refrigeration system accessories
1. Oil separators
2. Mufflers and vibrasorbers
3. Liquid - suction heat exchangers
4. Strainers and dryers
5. Accumulators and receivers
6. Sight glasses and moisture indicators
7. Solenoid valves
8. Evaporator and suction pressure regulators
9. Oil pressure failure switch
10. Relief valves and fusible plugs
11. Electrical pressure and thermostatic switches
12. Shut off valves

I. Variations of vapor compression systems
1. Multiple staging
    a. reasons for multiple staging
    b. intercooler applications

2. Cascade systems
3. Indirect systems
    a. secondary refrigerants
    b. eutectic conditions
    c. equipment layout
    d. brine testing

J. Refrigeration system electric control circuits
1. Schematic interpretation
    a. symbols
    b. wiring diagrams
    c. functional diagrams
2. Main power circuits
    a. starters
    b. methods of protection
3. Control circuits
    a. analysis
    b. troubleshooting

REFRIGERATION AND AIR CONDITIONING
PART II
(40 HOURS LECTURE/ 16 HOURS LAB)

I. Marine Container Refrigeration

A. Introduction to Container Refrigeration
   1. Units available by manufacturer
   2. General requirements of the units and principles of operation
      a. cooling
      b. heating
      c. defrost
      d. automatic operation

B. The Thermo-King Units
   1. Refrigeration circuit
      a. arrangement of three-way circuit
      b. arrangement of the various unit models
      c. component analysis
      d. modes of operation
         (1) cooling mode
         (2) heat mode
         (3) defrost mode
      e. analysis of refrigeration circuit in lab
   2. Electrical circuit
      a. functional and wiring diagrams
      b. main power and control circuit analysis
         (1) with electric motor operation
         (2) with engine operation
      c. modes of operation
         (1) cooling mode
         (2) heat mode
         (3) defrost mode
      d. electrical circuit analysis in lab
         (1) tracing and familiarization
         (2) troubleshooting
            (a) continuity checks
            (b) potential checks
            (c) operating with disabled components
            (d) locating faults
            (e) relay panels

C. Carrier Container Units
   1. Refrigeration circuit, mode 69NU137T-124
      a. arrangement
      b. components
      c. analysis of refrigeration unit

2. Electrical circuit, model 69NU137T-124
    a. wiring and functional diagrams
    b. main power and control circuit analysis
    c. analysis of electrical circuit in lab
3. Operation
    a. cooling mode
    b. heat mode
    c. defrost mode
    d. control system
4. Carrier
    a. refrigerant circuit arrangement
    b. electrical circuit
    c. control analysis
    d. troubleshooting techniques

D. York Container Units
1. Models
    a. CRU-6
    b. TNE-092-200
2. Refrigeration circuits
    a. arrangements
    b. components
3. Modes of operation
    a. cool
    b. heat
    c. defrost
4. Electrical circuit
    a. arrangement
    b. analysis
    c. troubleshooting

II. <u>Marine Air Conditioning</u>

A. Psychrometrics
1. Definitions and concepts
    a. air composition
    b. water vapor - air mixtures
    c. humidity
    d. wet bulb and dry bulb temperatures
    e. volume and density
    f. dew point
    g. saturation conditions
    h. enthalpy
2. Development of the Psychrometric Chart
    a. physical quantities shown on the chart
    b. locating the condition of the air

3. Psychrometric processes
    a. effect of changing variables
    b. Processes shown on the chart
        (1) sensible heating and cooling
        (2) humidifying and dehumidifying
        (3) air mixing
        (4) reheating
    c. analysis of processes

B. Marine Air Conditioning Systems
1. Central system
    a. temperature control
    b. humidity control
2. Individual reheat systems
    a. temperature control
    b. humidity control
3. Double duct systems
    a. temperature control
    b. humidity control
4. Heat load analysis
5. Air conditioning system controls
    a. Honeywell Pneumatic Control System
    b. Individual reheat systems

C. Cargo Hold Humidity Control Systems
1. Hold humidity problems
    a. spoilage
    b. rust
    c. wetness damage
2. CargoCaire Units
    a. system design arrangement
    b. components
    c. controls
    d. operation

D. Special Refrigeration Systems and Applications
1. R-11 centrifugal systems
    a. application
    b. components
    c. operating characteristics
2. Ice Machines
    a. principle of operation
    b. discussion of particular machines
        (1) Scotsman
        (2) Carrier
        (3) York
3. Absorption systems
    a. application

b. system operation
    (1) ammonia system
    (2) lithium bromide system
4. Window air conditioning units
    a. basic layout
    b. typical electrical circuitry
    c. troubleshooting and repair

MAIN PROPULSION
BASIC STEAM PLANTS
PART I
(40 HOURS LECTURE)

I. History and Development *

A. Early Boilers*
B. Fire Tube Boilers*
   1. Basic construction*
   2. Advantages and disadvantages*
C. Early Water Tube Boilers (Sectional Header) *
   1. Basic construction*
   2. Free natural circulation*
   3. Advantages and disadvantages*
   4. Small vs. large generating tubes *
D. Drum (Express) Type Water Tube Boilers*
   1. Types*
   2. Reasons for greater capacity*
      a. furnace size*
      b. accelerated natural circulation*
         (1) greater height differential*
         (2) vertical tubes*

II. Steam and Water Cycle *

A. Arrangement of Machinery in Cycle *
B. Basic Functions of Components*
   1. Boilers*
   2. H.P. and L.P. turbines*
   3. Main condenser/auxiliary condenser*
   4. Makeup feed/reserve feed tank*
   5. Main condensate pump*
   6. Air ejector condenser*
   7. Deaerating feed tank/D.C. heater*
   8. Main feed pump*
   9. Feed heaters

III. Thermodynamic Properties of Steam*

A. Definitions*
   1. Energy*
   2. Thermal energy*
   3. Kinetic energy*
   4. Heat*
   5. Temperature*
   6. BTU*
   7. Sensible heat*
   8. Latent heat*
      a. fusion*
      b. vaporization*
      c. condensation*

9. Specific heat*
10. Steam*
11. Saturated steam*
12. Quality*
13. Superheated steam*
14. Pressure*
15. Saturated temperature*
16. Saturated pressure*
    a. definition*
    b. gage and absolute*

B. Heat Transfer*
1. Methods*
2. Resistances*
3. Factors affecting the rates of heat transfer*

IV. <u>Boiler Classification</u>

A. High pressure*
B. Low pressure*
C. Tube configuration*
1. "M" type*
2. "D" type*
3. "A" type*

D. Drum type*
E. Header type*
F. Fire tube/water tube*
G. Top fired*
H. Tangential fired boilers*

V. <u>Boiler Components</u> *

A. Boiler Overview*
B. Steam Drum*
1. Location*
2. Purpose*
3. Construction and nomenclature*

C. Water Drum/Headers*
1. Locations*
2. Purpose*

D. Tubes*
1. Location*
2. Purpose*
    a. generating tubes*
        (1) advantages of small tubes*
        (2) methods of securing*
        (3) plugging and renewing*
        (4) staggered vs. in-line installation*
        (5) numbering sequence*
        (6) bent tubes - normal to drum*
        (7) tube expansion/welding*

b. rear wall/side wall tube*
c. downcomers*
d. floor tubes*
e. drum support tubes*

E. Boiler Internals*
1. Baffles, swash plates, separators*
2. Dry pipe*
3. Feed pipe (thermal sleeve) *
4. Surface blow pipe*
5. Chemical feed*
6. Desuperheater*
7. Safety valve nozzles*

F. Boiler Mountings*
1. Drum safety valves*
2. Superheater safety valve*
3. Surface blow valve*
4. Bottom blow valve*
5. Superheater circulating vent valve*
6. Superheater header drain valve*
7. Waterwall drain valves*
8. Superheater header vent valve*
9. Superheater pressure gage shut-off valve *
10. Thermal sleeve blowdown valve*
11. Chemical feed shut-off valve*
12. Drum pressure gage shut-off valve*
13. Gage glass shut-off valves*
14. Air vent cock*
15. Superheater outlet stop valves*
16. Auxiliary steam stop valve*
17. Auxiliary feedwater stop valve*
18. Main feedwater stop valve*
19. Soot blower stop valve*
20. Economizer vent valve*
21. Economizer drain valve*
22. Economizer sentinel valve*
23. Economizer valves*

G. Boiler Externals*
1. Inner casing*
2. Outer casing*
3. F.O. burners/air register assembly*
4. Steam smothering*
5. Soot blowers*
6. Smoke pipe/uptakes*
7. Smoke indicating system*
8. Saddles/supports*
9. Water level indicators*
a. direct*
b. remote*

10. Blowdown system(s) *
11. Superheater protection system*

H. Boiler Furnace - Basic Construction*
   1. Refractory*
      a. firebrick*
      b. insulating brick*
      c. insulating block*
      d. fireclay*
      e. plastic chrome ore*
      f. floor pebbles*
      g. high temperature castable*
      h. air setting mortar*
      i. construction (refractory) *
      j. repair*
         (1) vanadium deposits*
         (2) gas laning*
         (3) expansion joints*

I. Safety Valves (Components) *
   1. Nozzle reaction*
   2. Huddling chamber*
   3. Jet flow*
   4. Pilot actuator*
   5. Pilot actuated S/H valves*
   6. Operation/testing*
   7. Hand easing gear and escape piping (regulations)

J. Superheaters*
   1. Purpose*
   2. Classification*
   3. Construction*
   4. Desuperheater*
   5. Vents and drains*
   6. Temperature control*
      a. attemperator*
      b. control desuperheater*
   7. Vanadium deposits*
   8. Welding process*
   9. Operational factors affecting superheat outlet temperature*

K. Combustion Air System*
   1. Flow path*
   2. Components*
      a. prerotation vane damper*
      b. force draft blower*
      c. outlet dampers*
      d. air heaters*
   3. Uptakes - Economizer*
   4. Stack*
   5. Casings*
   6. Draft gages*

L. Fuel Oil Systems*
    1. Service*
        a. tanks*
        b. piping*
        c. pumps*
        d. strainers*
        e. heaters/heating coils*
        f. micrometer valves/F.O. control valves*
        g. F.O. coolers*
    2. Storage/transfer*
        a. tanks*
        b. piping*
        c. pumps*
        d. strainers*
        e. heaters, heating coils*
        f. micrometer valves/F.O. control valves (automatic) *
M. Fuel Oil Burners/Air Registers *
    1. Straight mechanical*
    2. Return flow*
    3. Steam atomization*

MAIN PROPULSION
BASIC STEAM PLANTS
PART II
(40 HOURS LECTURE)

I. Boiler Operation: Regulations

A. Lighting Off and Cutting in Boilers (Automatic Combustion Control) *
B. Fuel Oil System Casualties/Abnormal Operation *
   1. Water in fuel oil*
   2. Sediment in fuel oil*
   3. Air in system*
   4. High/low oil temperature*
   5. Low fuel pressure*
   6. Effects on plant operation/efficiency
C. Firing Abnormalities and Associated Problems*
   1. Flarebacks*
   2. Panting*
   3. Smoking*
   4. Casing air leaks*
   5. Insufficient/excess air*
   6. Flame impingement*
   7. Slag deposits and spalling*
   8. Loose or cracked refractory*
   9. Burner monitoring/management system malfunctions
D. Feedwater Abnormalities/Casualties *
   1. High/low feed temperature - abnormal flue gas temperature*
   2. High level*
   3. Low level*
      a. low steam pressure*
      b. annealing process*
   4. Feedwater contamination - prevention, control and the effects of operating with contaminated feedwater *
   5. Effects on total plant operation/efficiency*
   6. Ruptured tubes*
E. Boiler Capacity Limitations (End Points) *
   1. Combustion*
   2. Moisture carry-over*
   3. Water circulation*
F. Cause and Effect Relationships*
   1. High superheat outlet temperature*
   2. Low superheat outlet temperature*

II. Water Level Indicators*

A. Types*
   1. Local*
   2. Remote*

B. Automatic Feedwater Regulators*

1. Single element*
2. Thermo-hydraulic*
3. Thermo-pneumatic*
4. Shrink and swell*
5. Multi-element*

C. Automatic Combustion Control Theory*
   1. Purpose*
   2. Components*
      a. purpose*
      b. location*
   3. Basic operation*
      a. increase demand*
      b. decrease demand*
   4. Four basic pneumatic systems in the steam plant
      a. simple pressure tie back
      b. characterizing tie back
      c. simulated oil flow tie back
      d. metered flow tie back

III. <u>Combustion Indicators</u>*

A. Flame Colors*
B. Smoke*

IV. <u>Soot Blowers</u>*

A. Purpose*
B. Construction*
C. Operation*
D. Requirements

V. <u>Emergency Procedures (Regulations)</u> *

A. High Water*
B. Low Water*
C. Ruptured Tube*
D. Flareback*
E. Economizer/Air Heater Fire*
F. Loss of Vacuum*

MAIN PROPULSION
BASIC STEAM PLANTS
PART III
(40 HOURS LECTURE)

I. Introduction to Marine Turbines - Uses of Turbines*

A. Main unit*
B. Generators*
C. Auxiliaries*

II. Turbine Classification

A. Operating Principle*
   1. Impulse
   2. Reaction
   3. Combination - Impulse, Reaction
B. Method of Staging
   1. Simple impulse
   2. Velocity compounded
   3. Pressure compounded
   4. Pressure - velocity compounded
   5. Reaction
C. Direction of Flow
   1. Axial
   2. Radial
   3. Tangential
D. Division of Flow
   1. Single flow vs double
   2. Compound flow
      a. cross compound
      b. tandem flow
E. Repetition of Flow
F. Drive Connection*
   1. Direct*
   2. Geared*
   3. Turbo-electric*
G. Application*
   1. Condensing*
   2. Non-condensing*

III. Basic Turbine Construction

A. Foundations*
   1. Purpose
   2. Location
   3. Description
B. Casings*
   1. Purpose
   2. Location

C. Rotors*
   1. Purpose
   2. Location

D. Blades*
   1. Construction
   2. Fastenings
   3. Shrouding
   4. Blade sealing

E. Diaphragms*

F. Glands*
   1. carbon*
   2. labyrinth*
   3. combination*

G. Astern Turbines*
   1. Purpose*
   2. Location*
   3. Description*

IV. <u>Bearings</u>*

A. Radial*
   1. Purpose*
   2. Location*
   3. Description*
      a. anti-friction*
      b. sleeve*

B. Thrust*
   1. Purpose*
   2. Location*
   3. Description*

V. <u>Couplings</u>*

A. Purpose*

B. Location*

VI. <u>Measurements</u>

A. Axial

B. Radial

VII. <u>Turbine Accessories</u>

A. Reduction Gears*
   1. Purpose-location
   2. Classifications
      a. single reduction
      b. double reduction
      c. spur gears vs helical gears
   3. Arrangements*
      a. articulated*
      b. nested*
      c. locked-train*

4. Casing construction
    a. components
    b. oil-spray nozzles
    c. inspection plates
    d. sump-oil excluding pan
    e. vents

B. Jacking Gear*
    1. Purpose*
    2. Location*

C. Turbine Governors - Functions*
    1. Speed limiting
    2. Constant speed
    3. Overspeed
    4. Other protective and warning devices*

VIII. <u>Turbine Operation</u>*

A. Turbine Throttle Arrangement*
    1. Throttle valves*
    2. Nozzle control valves*
    3. Nozzle bypass valves*
    4. Steps in warming up*

B. Turbine Operation*
    1. Maneuvering*
    2. Sea speed*

C. Emergency Procedures*
    1. Turbine casualties*
    2. Emergency Steaming*

MAIN PROPULSION
BASIC DIESEL PLANTS
PART IV
(40 HOURS LECTURE)

I. Introduction to Diesel Engines*
- A. Definition of the Diesel Engine
- B. Usage and Advantages
- C. Major Manufacturers

II. Mechanical Engine Cycles*
- A. Four Stroke Cycles*
  1. Events*
  2. Timing Diagrams
- B. Two Stroke Cycles*
  1. Events*
  2. Timing diagrams

III. Basic Terms*
- A. Compression Ratio*
- B. Compression Temperature and Pressure*
- C. Clearance Volume*
- D. Expansion Ratio*
- E. Work*
  1. Indicated Horsepower*
  2. Brake Horsepower *
  3. Shaft Horsepower*
  4. Full Horsepower *

IV. Basic Construction of Diesel Engines*
- A. Bedplate and Frame*
- B. Cylinders and Heads*
- C. Pistons and Rings*
- D. Connecting Rods*
- E. Crankshafts*
- F. Valves and Valve Actuating Gears*

V. Basic Diesel Engine Systems*
- A. Fuel System*
- B. Lubrication System*
- C. Cooling Water System*
- D. Intake and Exhaust Systems*
  1. Supercharging*
  2. Turbocharging*
  3. Scavenging*
- E. Starting Systems*

VI. Plant Layout, Operation and Engine Maintenance*

ADVANCED MAIN PROPULSION
STEAM PLANTS
(32 HOURS)

I. Boiler Auxiliary Systems

A. General Boiler Layout
B. Typical Feedwater Systems
C. Typical Fuel Oil Service Systems
D. Typical Air Handling Set Up
E. Basic Principles of Combustion Control

II. Boiler Operations

A. Lighting Off and Cutting in Boilers
B. Fuel Oil System Casualties/Abnormal Operations
    1. Water in fuel oil
    2. Sediment in fuel oil
    3. Air in systems
    4. High oil temperature
    5. Low oil temperature
    6. Low fuel oil pressure
C. Firing Abnormalities and Associated Problems
    1. Flarebacks
    2. Panting
    3. Smoking
    4. Casing air leaks
    5. Insufficient air
    6. Too much excess air
    7. Slag deposits and spalling
    8. Loose or cracked refractory
    9. Flame impingement
D. Feedwater Abnormalities/Casualties
    1. High feedwater temperature/associated flue gas temperature
    2. Low feedwater temperature/associated flue gas temperature
    3. High water level
        a. carry-over
        b. priming
    4. Low water level
        a. low steam pressure
        b. annealing process
    5. Feedwater contamination
        a. prevention
        b. controlling
        c. effects of operating with contaminated feedwater
    6. Effects on total plant operations and efficiency
    7. Ruptured tubes

III. Boiler Cleaning

A. Fireside Cleaning
   1. Mechanical cleaning
   2. Hot water washing
      a. water lance method
      b. soot blower method
   3. Wet steam lancing
   4. Air lancing
   5. Fuel oil additives
   6. Fireside drying

B. Waterside Cleaning
   1. Mechanical
   2. Chemical

IV. Boiler Testing

A. Hydrostatic Testing
   1. Requirements
   2. Procedure
   3. Destructive versus non-destructive testing

B. Safety Valve Testing
   1. Requirements
   2. Accumulation test
   3. Popping pressure and blowdown test

V. Boiler Lay-Up

A. Dry Method
   1. Desiccant method
   2. Heated air method

B. Wet Method

VI. Turbine Construction

A. Impulse Turbines
   1. Staging
   2. Pressure compounding
   3. Velocity compounding
   4. Pressure-velocity compounding

B. Reaction Turbines

C. Path of Steam Flow

D. Bearings and Lubrication

VII. Turbine Operation Procedures

A. Warming Up
   1. Precautions
   2. Effects of improper warm-up

B. Standby

C. Bring Turbine Up To and Down from sea speed
D. Insuring High Vacuum
E. Securing Main Engine

VIII. <u>Turbine Casualties and Abnormalities</u>

A. Vibrations and Unusual Noises
B. Lubrication Failure
C. Locking Propeller Shaft
D. Overspeed
E. Emergency Use of High Pressure Turbine
F. Emergency Use of Low Pressure Turbine

IX. <u>Reduction Gears</u>

A. Gear Nomenclature
B. Tooth Contact, Wear and Failure
C. Alignment Check
D. Lubrication
E. Couplings
F. Bearings
G. Turning Gear

ADVANCED MAIN PROPULSION
DIESEL ENGINES
PART I
(32 HOURS LECTURE/ 16 HOURS LAB

I. Introduction to the Diesel Engine

A. Theoretical "Air Standard Cycles"
   1. Otto Cycle - Spark ignition
   2. Diesel Cycle - Compression Ignition
B. Applications of the Diesel engine
C. Load/Fuel Comparisons
   1. Spark Ignition
   2. Diesel
D. Mechanical Engine Cycles
   1. Four Stroke Cycle
      a. events
      b. timing Diagrams
   2. Two Stroke Cycle
      a. events
      b. timing Diagrams

II. Basic Engine Components

A. Bedplates, Block, Cylinder Head
   1. Location
   2. Function
   3. Types
B. Crankshaft, Connecting Rod, Piston, Rings
   1. Location
   2. Functions
C. Camshafts, Valves, Valve Gear
   1. Location
   2. Function
   3. Requirements
D. Fuel Injection Equipment
   1. Location
   2. Functions

III. Basic Terminology

A. Piston Displacement
B. Clearance Volume
C. Compression Ratio
   1. Minimum Requirements
   2. Effects of Changing Compression Ratio
D. Volumetric Efficiency
   1. Factors Affecting
   2. Methods of Improving

E. Scavenging
   1. Requirements
   2. Methods
   3. Crankcase Scavenging
   4. Scavenging Efficiency

IV. Engine Performance and Load Balance Indication

A. Exhaust Gas Pyrometers
   1. Location
   2. Interpretation
   3. Maintenance and Replacement
B. Maximum Pressure Indicators
   1. Usage
   2. Interpretation
C. Card Drawing Indicators
   1. Construction
   2. P-V Diagrams
      a. indicated mean effective pressure
      b. indicated horsepower calculations
   3. P-V Indicators
   4. Firing and Compression Diagrams
   5. Out-of-Phase and Hand Pulled diagrams
   6. Weak Spring diagrams
D. Dynamometers
   1. brake mean effective pressure
   2. brake horsepower
E. Mechanical Efficiency
   1. Calculation
   2. Losses Involved
F. Thermal Efficiency
   1. Indicated
   2. Brake
   3. Comparison between Spark Ignition and Diesel

V. Engine Speed Concepts and Classification

A. Piston Speed
   1. Calculation
   2. Acceleration
   3. Inertia
B. Crank Shaft Speed
C. Speed Factor
   1. Calculation
   2. Classification

VI. Engine Fuels

A. Methods of Production
B. Grade
C. Characteristics
D. Fuel Additives
E. Brake Specific Fuel Consumption
    1. Calculation
    2. Factors Affecting

VII. THEORY OF COMBUSTION

A. Phases of Combustion
B. Factors Affecting Combustion
    1. Ignition Quality
    2. Combustion Knock
    3. Detonation
    4. Pre-Ignition in spark ignition Engines
C. Interpretation of Hand Pulled Indicators
D. Combustion Chamber Design
    1. Open Combustion Chamber
        a. usage
        b. methods of creating turbulence
    2. Precombustion Chamber
    3. Turbulence Chamber
    4. Energy Cell
    5. Air Cell

ADVANCED MAIN PROPULSION
DIESEL ENGINES
PART II
(32 HOURS LECTURE/ 16 HOURS LAB

I. Fuel Injection Systems

A. Function and Requirements
B. Air Injection
    1. System Layout
    2. Disadvantages
C. Common Rail
    1. System Layout
    2. Disadvantages
D. Modified Common Rail
    1. System Layout
    2. High Pressure Pump and Metering Valve
    3. Injector
        a. operation
        b. metering
        c. unloading
E. Distributor
    1. System Layout
    2. Construction and Operation
F. Individual "Jerk Type" Pump Systems
    1. APE
    2. APF
        a. construction and metering
        b. delivery valves
        c. timing and maintenance
    3. Unit Injectors
        a. construction
        b. timing
    4. Sulzer Fuel Pump and Nozzles.
        a. construction and operation
        b. timing
    5. B and W Fuel Injection Nozzles
G. Injection Nozzles
    1. Types and Operation
    2. Cooling
    3. Testing and Maintenance
H. Operation with Heavy Fuel
I. Fuel Storage and Handling

II. Engine Governors

A. Governor Characteristics and Terms
B. Functions
C. Straight Mechanical Governor

D. Hydraulic Oil Relay Governors
    1. Woodward PG Governor
        a. usage
        b. construction and operation
        c. adjusting and trouble shooting
    2. Woodward UG 8 and UG 32
        a. construction
        b. operation
        c. controls
        d. applications
            (1) parallel operation with speed droop
            (2) isochronous operation
    3. Woodward PGA
        a. construction
        b. operation
        c. application

ADVANCED MAIN PROPULSION
DIESEL ENGINES
PART III
(32 HOURS LECTURE/ 16 HOURS LAB

I. Cylinders and Liners

A. Types
   1. Dry type
   2. Wet type
      a. integral
      b. integrally jacketed

B. Sealing of wet liners

C. Liner Wear
   1. Measurements
   2. Scuffing and Scoring
      a. causes
      b. Remedies

D. Maintenance of Liners
   1. Deglazing
   2. Honing
   3. Chrome Plating
   4. Running in new liners

E. Liner Cracks
   1. Detection
   2. Prevention

F. Cavitation pitting
   1. Causes
   2. Prevention

II. Pistons, Piston Pins and Crosshead Assemblies

A. Piston Types
   1. Trunk Type
      a. terminology
      b. materials
      c. design characteristics
      d. composite and built-up pistons
      e. rotating pistons
         (1) non-positive (GM)
         (2) positive (Sulzer)
   2. Crosshead pistons
      a. Characteristics
      b. Crosshead Guides
         (1) types
            (a) open
            (b) closed
         (2) lubrication of crosshead
      c. piston rods

d. piston rod glands
(1) sealing ring
(2) oil rings

B. Piston Cooling
1. Ribs
2. Conduction of heat via rings
3. Direct Methods
a. water Cooling
b. oil Cooling
(1) shaker
(2) circulation
(3) spray

C. Piston Pins
1. Types
a. floating
b. semi-floating
c. fixed
2. Bearings, Bushings and Locking Devices
a. materials
b. removal and replacement
3. Piston Pin Carriers

III. <u>Piston Rings</u>

A. Compression Rings
1. Functions
2. Locations
3. Design Characteristics
4. Face Coatings
5. Compression Ring Joints

B. Oil Control Rings
1. Functions
2. Location
3. Design Variations

IV. <u>Maintenance and Repair of Pistons and Rings</u>

A. General Procedure for Piston Removal

B. Piston Inspection and Repair
1. Carbon Removal
2. Piston Wear
a. causes
b. remedies
3. Cracks
a. crown
b. lands
4. Piston Seizure

5. Piston Pin and Bushing Wear
    a. indications
    b. causes

C. Piston Ring Troubles
1. Excessive wear
    a. indications
    b. causes
2. Sticking
3. Breakage
4. Micro seizure

V. Connecting Rods and Crankshafts

A. Types
1. Automotive
2. Marine
    a. advantages
    b. use of shims
    c. vee type connecting rods
        (1) side by side
        (2) fork and blade

B. Construction
1. Loading
2. Joint Configurations
3. Oil Passages
    a. rifle drilled
    b. offset
    c. cup

C. Crankshaft
1. Nomenclature
    a. main bearing journals
    b. webs
    c. crankpins
    d. fillets
2. Construction
    a. single piece forging
    b. semi-built up
    c. fully built up
3. Lubrication
4. Alignment and deflection readings
5. Balancing and Vibration
    a. crankshaft arrangements
    b. counter weights
    c. balance shafts
    d. torsional vibration dampers and Absorbers

D. Flywheels

VI. Cylinder heads and Valves

A. Head Construction and Materials
   1. Cast heads
   2. Forged Heads
B. Porting
C. Cooling
D. Head Gaskets
   1. Materials
   2. Proper installation procedures
E. Valves
   1. Nomenclature
   2. Valve Design Characteristics
      a. seat angle
      b. seat width
      c. interference angle
      d. carbon scrapers

   3. Materials
      a. general
      b. intake valves
      c. exhaust valves
      d. valve facing
      e. valve stem
      f. valve stem seals
      g. valve head and neck coatings
   4. Valve Cooling
      a. direct
      b. sodium filled
   5. Replaceable Parts
      a. valve seat inserts
      b. valve guides
      c. valve cages
F. Valve problems
G. Valve maintenance
H. Valve actuating gear
   1. Cam drives
   2. Cam shafts
   3. Cams
   4. Cam followers and tappets
   5. Valve actuation
      a. springs
      b. lash adjusters
         (1) mechanical
         (2) hydraulic
      c. hydraulic lifter
      d. valve rotator
      e. setting of springs

VII. Cooling Systems

A. Classification
   1. Open or raw
   2. Closed
B. Components and Controls
C. Cooling Water Treatment
D. Fresh Water Distillers
   1. Nyrex fresh water distillers
   2. Atlas fresh water distillers
   3. Operation

ADVANCED MAIN PROPULSION
DIESEL ENGINES
PART IV
(32 HOURS LECTURE

I. Bearings, Lube Oil and Lube Oil Systems

A. Bearing Types and Characteristics
   1. Conventional
   2. Precision
B. Bearing Adjustments and Measurement
   1. Installation
      a. crush
      b. shims
   2. Plastigage
   3. Ball and Anvil Outside Micrometer
C. Bearing Wear
   1. Causes
   2. Symptoms and Detection
D. Engine Lube Oils
   1. Characteristics
   2. Additives
E. Lube 0il Systems and Arrangements
   1. Bypass
   2. Full Flow
   3. Shunt
   4. Sump
F. Operation and Maintenance
G. Contamination and Dilution

II. Crankcase

A. Types
   1. Integral
   2. Dry
   3. External
B. Crankcase Explosions
   1. Cause
   2. Prevention
      a. mist detectors
      b. crankcase ventilation systems
      c. explosion relief doors

III. Air Intake Systems and Pressure Charging

A. Piping Arrangement
B. Charge Air Cooling
C. Air Silencers and Cleaners

D. Supercharging
    1. Theory
    2. Positive Displacement
    3. Turbo-Chargers
        a. impulse
        b. constant pressure
    4. Comparison and Performance
    5. Valve-Overlap

IV. Exhaust Systems

A. Piping Arrangement
B. Silencers and Spark Arrestors
C. Accessories and Waste Heat Recovery
D. Maintenance and Regulations

V. Starting Systems and Reversing

A. Cylinder Air Starting Systems
    1. Arrangements and Variations
        a. Sulzer
        b. B and W
        c. air start to turbo-charger
    2. Components
        a. distributors
        b. air start pilot valves
        c. air start check valves
    3. Starting Positions
    4. Air Start Capacities
    5. Operation and Maintenance
B. Gear and Clutch Starters
    1. Electric
    2. Hydraulic
    3. Air Motor
C. Aids for Low Temperature Starting
D. Emergency Generator Alarms and Shutdown Devices
E. Direct Reversing Engines
    1. Methods for Two-cycle
    2. Methods for Four-Cycle
F. Air-Flex Clutch

VI. Engine Operation

A. Starting
    1. Precautions and Procedures
    2. Interlocks
B. Securing

C. Watch Standing
    1. Routine Inspections
    2. operating Faults
        a. detection
        b. correction
    3. Routine Duties
D. Emergency Operation
    1. Shutdown Devices
    2. Overrides
    3. Runaways

SAFETY, FIRE FIGHTING, AND ENVIRONMENTAL PROTECTION
(32 Hours)

I. U.S. Coast Guard - Marine Inspection
- A. Routine Tests, Drills and Inspections
- B. Required Documents

II. Fire Theory and Chemistry

III. Practical Fire fighting
- A. Hand and Semi-Portable Fire Extinguishers
  1. Soda acid
  2. Foam
  3. CO2
  4. Dry chemical
- B. Fire Main Systems
- C. Steam Smothering Systems
- D. Fixed CO2 Extinguishing Systems
- E. Fixed Foam Extinguishing Systems

IV. Respiratory Protectors
- A. Self Contained bearing Apparatus (S.C.B.A.)
  1. High pressure cylinder type
  2. Self generating type
- B. Fresh Air Breathing Apparatus
- C. Canister Type Gas Masks
  1. General purpose
  2. Refrigeration

V. Flame Safety Lamps

VI. Fire Detecting Systems
- A. Automatic Sprinkler System
- B. Electric Fire Detecting System
- C. Pneumatic Fire Detecting System
- D. Smoke Detecting System

VII. Required Knowledge of Coast Guard Rules and Regulations

VIII. Actual Fire fighting

IX. Handling of Flammable and Combustible Liquids
- A. Classification by Grade of:
  1. Flammable
  2. Combustible Liquids
- B. Common Hazards in Handling and Storage

X. Anti-pollution Control
- A. Safe Bunkering Practices
- B. Pollution Control Laws and Their Practical Application

LIFEBOAT TRAINING

(32 Hours lecture - 24 Practical)

I. Lifeboats

A. Construction and Nomenclature
B. Marking and Numbering
C. Equipment
D. Sail and Rigging
E. Protective Cover
F. Davits
G. Launching
H. Recovery
I. Commands for Lowering Lifeboat with Mechanical Davits
J. Emergency Boats
K. Distress Signals
L. Man Overboard, Lifesaving Signals and Breeches Buoy Instructions

II. Life Rafts

A. General
B. Construction and Materials
C. Equipment
D. Launching
E. Manual Release
F. Automatic Release

III. Knots for Lifeboatman

IV. Commands for Boats Under Oars

V. Practical Lifeboat Training

A. The Operation of Davits, Boat Launching and Recovery
B. Rowing of Lifeboat
C. Operation of Diesel Engine
D. Sailing of Lifeboat Under Sails
E. Installing Protective Covering
F. Launching of Life Rafts

TANKERMAN - ENGINEER
Dangerous Liquids
(40 Hours Lecture)

I INTRODUCTION

A. The Oil Tanker
B. Terminology - oil and chemical tankships
C. Evolution of Tankers and Tanker Safety
   1 Oil tanker types
   2 Tanker terminology
   3 Safety through Technology

II PROPERTIES AND HAZARDS OF DANGEROUS LIQUIDS

A. Characteristics
   1. Petroleum
   2. Volatility
   3. Pour point, viscosity and temperature
   4. Classification of dangerous liquids
B. Hazards of petroleum cargoes
   1. Toxicity
   2. Pyrophoric combustion
   3. Flammability limits of ideal gases from crude oil

III. TANKER CONSTRUCTION

A. Principles of Environmental protection and Containment Systems
B. Evolution of tanker design
   1. Construction, materials, and tank coatings
   2. General arrangement of tanks
      a. crude oil
      b. product
      c. chemical

IV CARGO HANDLING SYSTEMS

A. Piping and valve arrangements
B. Pumps
   1. Types
   2. Characteristics
   3. Functions
C. Inert gas systems - general operational requirements
   1. Inerting of gas free tanks
   2. Ballasting and ballast passage
   3. Discharging ballast
   4. Loading of cargo
   5. Loaded passage
   6. Discharging cargo
   7. Purging prior to gas freeing
   8. Gas freeing and tank entry
   9. Re-inerting after tank entry
D. Crude oil washing - general operational requirements

V IDEALIZED INERT GAS SYSTEM

A. Available sources and acceptability
   1. Separately fired inert gas generators
   2. Main propulsion boiler uptakes
   3. Auxiliary boiler uptakes

B. Comparison of separately fired gas generator versus exhaust gas generators
   1. Composition of inert gas
   2. Long term operating costs
   3. Long term maintenance
   4. Affects of variable combustion load conditions
   5. Inert gas quality
   6. Solids present

C. Safety interlocks

D. Gas scrubbers
   1. General functions
   2. Designs for removing particulate matter
      a. bubble cap
      b. random packing
      c. impingement plates
   3. Methods of gas cooling
   4. Methods of rinsing and removal of corrosive fluids
   5. Corrosion
      a. predictable level of corrosion
      b. methods of corrosion prevention
   6. Demisters
   7. Alarms and set points
   8. Required shut downs

E. Blowers
   1. Functions
   2. Capacities

F. Pressure regulating and gas recirculation arrangements
   1. General functions
   2. Safety requirements
   3. Prevention of hydrocarbons returning to safe zone
   4. Automatic gas pressure regulation and recirculation
      a. Constant pressure - blower discharge pressure
      b. Constant pressure - gas main pressure

G. Deck water seal
   1. Functions
   2. Types

H. Deck isolation valve

I. Inert gas distribution piping
   1. Distribution branch lines
   2. Distribution of inert gases to cargo tanks
   3. Provisions for tank venting
   4. Pressure/vacuum protection
   5. Provisions for isolating tanks

J. Pressure - vacuum control
   1. Liquid filled

2. Mechanical

K. Tank purging arrangements
   1. Principle of gas infusion
   2. Dilution
   3. Displacement

L. Tank venting
   1. Through inert gas main
   2. Venting through mast vent riser
   3. High velocity vent for individual tanks
   4. Purging and gas freeing

M. Inspection and cleaning of an idle gas plant
   1. Scrubber
      c. checking for toxic gas accumulation
      d. condition of internal coatings
      e. condition of spray nozzles
      f. damage to scrubber elements
   2. Blowers
      a. deposition/corrosion of impellers
      b. free rotation of impeller
      c. vibration/imbalance
   3. Deck water seal
      a. adequate water flow
      b. operation of water-drain regulators
      c. maintaining adequate water level-daily

N. Typical inert gas plant operating problems
   1. Inability to provide quantity and sufficiently low oxygen content flue gas
      a. poor combustion control - low load conditions
      b. boiler output low (IG blowers pull air in through stack opening)
      c. oxygen content at plant start up
      d. High oxygen content due to excessive recirculation
      e. Difficulty in maintaining positive pressure in cargo tanks mechanical failure

VI <u>INSTRUMENTATION AND ALARMS</u>

A. Cargo level measurement
   1. Types of measurement
      a. innage
      b. ullage
   2. Gauging equipment - traditional methods and limitations of acceptability with IGS
      a. electric resistance devices
      b. electronic
      c. radar type
   3. Gauging
      a. closed gauging and final calculations
      b. required information for cargo calculation
      c. factors affecting cargo measurement
      d. alarms and controls
      e. vessel tables
      f. role of cargo supervisor
      g. precautions for manual gauging

B. Gas measurement and detection

1. Fixed position oxygen analyzer
2. Portable oxygen analyzer
3. Combustible gas analyzer
4. Hydrocarbon gas analyzer
5. Calibration of gas detectors

C. Temperature monitoring of cargo

D. Automatic shut down

VII CRUDE OIL WASHING - OVERVIEW

A. Crude oil washing in contrast to hot water washing (Butterworth System)
1. Crude oil as a solvent
2. Simplification of supply system components
3. Reduction in total man-hours
4. Regulatory input

B. Pollution prevention
1. No overboard discharge of oily water when butterworthing tanks
2. Elimination of necessity to decant slop tanks
3. Elimination of load on top process

C. Benefits of crude oil washing cargo tanks
1. Reduced manual cleaning of tanks
2. More effective cleaning of tank surfaces
3. Reduction in scale and sludge accumulation

D. Crude oil washing system
1. Types of washing machines
   a. deck mounted programmable units
   b. fixed power units
   c. portable power units
   d. submerged non-programmable units and shadow diagrams
2. Typical crude oil supply systems for washing machines
3. Tank stripping systems and requirements
4. Tank level measuring devices for closed loop operations

E. Generalized crude oil washing procedures
1. Review of qualifications of personnel eligible to carry out crude oil washing
2. Determination of tanks to be crude oil washed
   a. relevant trim and draft requirements
   b. tanks to be washed in discharge port
   c. washing schedule of remaining tanks
   d. crude oil washing of tanks at sea
3. Required use of the inert gas system while crude oil washing tanks
4. Programming of washing machines
   a. number of cycles per machine
   b. number of stages per cycle

F. Associated procedures
1. Check lists
   a. discharge port pre-arrival
   b. pre-commencement of crude oil washing
   c. operation during crude oil washing
   d. after completion of crude oil washing operation
2. Minimizing on board retention of residue

a. stripping of cargo tanks
b. draining and stripping of cargo lines
c. final discharge of cargo ashore
d. ballasting of crude oil washed tanks
e. measurement of oil on top of departure ballast

3. Required water rinsing the tanks
4. Filling and discharging of arrival ballast
5. Discharging of departure ballast
6. Accumulation and decanting of slop tank
7. Procedures to be followed to avoid hydrocarbon venting during loading and ballasting

G. Oil record book and record keeping
1. Tank soundings
2. Tanks washed
3. Ballasting and deballasting

H. Operations and equipment manual

VIII VAPOR CONTROL AND RECOVERY SYSTEMS

A. Purpose
B. Principles
1. Concepts
2. Vapor balancing

C. Components
D. Hazards
1. Improper connection
2. Over/under pressurization
3. Overflow
4. Sampling and gauging
5. Additional dangers
6. Condensation
7. Electrostatic charge

IX SAFETY CONSIDERATIONS

A. Definitions and hazards of confined spaces
B. Evaluation and assessment of risks and hazards
1. Respiratory hazards
2. Hydrocarbon vapor
3. Oxygen deficiency
4. Toxicity of gases

C. Precautions and testing of gas atmospheres
1. Hydrocarbons
2. Benzene
3. Hydrogen sulfide
4. Oxygen

D. Confined space/tank entry
1. Responsible officer
2. Entry procedures
3. Entry permit
4. Unsafe/suspicious atmosphere

E. Personal protective equipment (PPE)
1. Respiratory hazards

2. SCBA
3. Air line breathing apparatus
4. Cartridge/canister face masks
5. Fresh air breathing apparatus

F. Maintenance of PPE
1. Inspection, care and stowage
2. Training

G. Work in enclosed spaces
1. Procedures and precautions
2. Opening of equipment and fittings
3. Tools
4. Electric lights and equipment
5. Sludge/scale
6. Cold work
7. Hot work
8. Inflatable work boats
9. Outside contractors

H. Emergency procedures
1. Emergency team
2. Resuscitation

I. Regulations, standards and industry guidelines
1. Requirements at sea
2. Inspections by a marine chemist
3. Inspections by other competent and responsible persons

X VESSEL RESPONSE PLANS

A. Purpose, content and location of information

B. Procedures for notification and mitigation of spills
1. Geographic - specific appendices
2. Vessel - specific appendices

C. Emergencies - Action Checklist and procedures
1. Precautions to limit static electricity generation
2. Extinguishing pump room fires with IGS
3. Emergency shut down procedures
   a. operating procedures following the failure of the inert gas plant
   b. immediate actions to be taken
   c. resumption of cargo operations following inert gas plant failure
   d. precautions to be taken upon resumption of cargo tank discharging operations