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WORLD MARITIME UNIVERSITY
MALMO, SWEDEN

TRAINING OF THE FLEET OFFICERS OF
THE SHIPPING CORPORATION OF INDIA LTD.
IN
INDUSTRIAL HYDRAULICS

by

R. PRASAD.
INDIA

A paper submitted to the Faculty of the WORLD MARITIME UNIVERSITY in partial satisfaction of the requirements for the award of a MASTER OF SCIENCE DEGREE in

MARITIME EDUCATION AND TRAINING
(Marine Engineering)

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

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Abstract

TRAINING OF THE FLEET OFFICERS OF
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INDUSTRIAL HYDRAULICS

From my own service experience as well as through the discussions with some of the technical superintendents and senior fleet officers a deficiency is noticed in the knowledge and skill repertoire of fleet officers responsible for operations and maintenance of hydraulic machinery. Over the years, shipboard machinery has substantially increased in volume, diversity and complexity. Formal training in industrial hydraulics has been considered as a solution to improve the knowledge and skills of the fleet officers for better performance.

This paper develops a training scheme in industrial hydraulics as applicable to shipboard installations. Proposing the training at two levels through basic and advanced courses, the paper elaborates upon the syllabi of courses, methodology and requirements of logistics. It, neither includes specific details of instructions and exercises nor the supporting reading material for trainees. Procedures for selection and training of instructors, evaluation of training and frequency of courses have been suggested recommending an early implementation of the scheme at the newly established "S.C.I. Maritime Training Institute".

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- ii) Graph II... Fleet diversification shown in terms of number of general cargo ships, tankers and bulk carriers. page 10.
- iii) Graph III.. Increase in the number of officers and petty officers under the headings of navigating officers, engineer officers and petty officers. page 14.
- iv) Graph IV.. Growth in the extent of hydraulic machinery indicated in terms of the number of ships equipped with four main types of hydraulic power transmission machinerypage 20.

TRAINING OF THE FLEET OFFICERS
OF THE SHIPPING CORPORATION OF INDIA LTD.

IN
INDUSTRIAL HYDRAULICS

C H A P T E R - I

Introduction

The Shipping Corporation Of India Ltd.(S.C.I) is a Government of India enterprise. This shipping company, which was established on 2 October 1961, owns and operates a large and diversified fleet of ships on commercial basis. During the twenty five years of its existence the fleet of the company has gone through many phases of rapid expansion and continued modernisation. At present it has 129 ships comprising general cargo ships, container oriented general cargo (combi) ships, crude oil tankers, petroleum products tankers, oil-bulk-ore carriers, passenger ships, and specialised ships to serve the off-shore oil industry. In addition, the S.C.I. mans and manages scientific research vessels, light house tenders and passenger ships on behalf of the government. The ships of this fleet differ, not only on the basis of their commercial activities, but also on the types of machinery they are equipped with.

During this period, the other shipping comp-

anies in India also grew in their fleet size. The Indian shipbuilding industry being inadequate to meet the demand, the acquisition of ships was mainly from foreign shipyards. Consequently the ships inducted into the fleet were equipped with advanced systems and equipment.

The last few decades have seen an overall industrial growth in the world, which was coupled with technological developments for higher economy. This industrial growth had the effect of increasing global trade. As a consequence, during the sixties and the seventies, the world shipping fleet increased by 148% based on the number of ships and by 378% based on the dead weight tonnage (1). To cope with the increased demand of shipping, efficient and faster turnaround of ships was necessary. Marine machinery and equipment underwent a rapid technological development to achieve optimisation.

In the context of the Indian shipping scenario the expansion and modernisation of the fleet put heavy demands on the pre-sea training institutions. These institutions were required to produce more trained manpower quickly to meet the demand of an enlarging fleet. At the same time the fast technological developments in the shipboard machinery and commercial operations called for updating of the pre-sea training curricula. The pre-sea training institutes did respond to these demands to a certain extent which however, was not sufficient to meet the needs. This was due to three factors: (i) period that lapsed between the time the need arose and the time of implementation of changes in the syllabus, (ii) due to the time delay corresponding to the training period, and (iii) because there existed a large number of fleet offi-

cers serving on board ships who were trained under earlier curricula. These officers did not have any facilities available to them in India for updating their knowledge to meet the challenge of a commercially competitive and technologically dynamic environment.

During the last two decades, there has been a significant increase in the hydraulic equipment on board ships. On tankers hydraulic deck machinery has practically replaced the steam machinery completely. Because of its reliability and the safety associated with it, hydraulic equipment increased on deck as well as in the machinery spaces on all kinds of ships. Not only did the hydraulic equipment on board ships increase in its extent it also grew more sophisticated.

The ships' officers responsible for operation and maintenance of this equipment were required to cope with this change on their own. In the absence of formal training in the hydraulic systems and their applications, the learning process was through experience and mistakes. This process, apart from being unavoidably slow, many a times relies on a breakdown or an accident as a lesson in the learning process. The lack of adequate knowledge causes delays, damage to the equipment, inconvenience and anxiety to the responsible staff.

The S.C.I. has always realised the importance of updating the skills of its employees. Many in-house short training courses have been developed and are being regularly conducted. Training courses offered by various institutes in India and abroad are also utilised to train the personnel. In the field of industrial hydraulics, (which herein refers to oil hydraulics), short training

courses on specific equipment, that is, hydraulic cranes, have been arranged on three occasions through the crane manufacturers. Through these courses however:

- only a few officers could be trained,
- the scope of training was limited to the particular system and equipment only,
- in the absence of general and basic knowledge of industrial hydraulics, the full benefit of these training programmes could not be reaped by the trainees.

The analysis of the evaluation reports from the participants of these training programmes clearly indicated their emphasis on the need of formal training in other hydraulic systems and equipment as well. The S.C.I. follows a system of rotation for posting of its fleet officers on ships. An officer therefore, proceeding on leave from one type of ship normally gets posted on a different type of ship when he resumes duties. Training for one particular piece of equipment or system thus has very limited benefit.

In order to meet the increasing training needs the S.C.I. management in the year 1978, had taken a decision to establish a training institute. This institute is in the final stages of its completion and will be fully operational soon. The project report of this "S.C.I. Maritime Training Institute" identified training in hydraulics at two levels, amongst the courses to be developed and conducted.

Personal discussions were held with some of the technical superintendents of S.C.I., who are respon-

sible for the technical management of ships. They opined that the training of officers in this field is essential and will be very useful. Personal interviews with some of the senior engineer officers on board company's ships strongly indicated the need of training in this field.

Training for only those shipboard personnel who have the responsibility for operations, maintenance or monitoring the performance of hydraulic equipments is proposed here. It is envisaged that the required knowledge will percolate down from them to the personnel in the junior categories.

Company Profile

2.1. Background

The Shipping Corporation Of India Ltd. a public sector shipping company, is the largest shipping company in India. It came into being as a result of the post independence industrial policy of the government which assigned an expanding role to the public sector. Two of the important objectives of the public sector in India have been :

- development of infrastructure for economic development, and
- promotion of self reliance

Accordingly, two public sector shipping companies, namely The Eastern Shipping Corporation and The Western Shipping Corporation, were established in the year 1950 and 1956 respectively. In order to achieve co-ordination in its policy and greater economy and efficiency in the long run, the Government of India decided to amalgamate these two public sector shipping companies. The two corporations were merged to form The Shipping Corporation Of India Ltd. on 2 October 1961 with the following corporate objectives(2):

- to acquire, own and operate ships on a commer-

- cial basis so that the public sector has an increasing and predominant role within the national shipping industry,
- to promote and serve India's national foreign trade in general cargo and bulk commodities,
 - to contribute towards meeting the requirements of coastal shipping within the overall governmental policy for this sector,
 - to provide noncommercial shipping services at the direction of the Government of India or on behalf of the government in the larger national interest,
 - to assist the Government of India in formulating and implementing appropriate national shipping policies,
 - to serve and maintain India's position as one of the important maritime nations of the world.

Based on the micro-objectives of the company, flowing out of above corporate objectives, the strategic planning warranted regular, and in the initial stages, fast acquisition of ships.

Jayanti Shipping Company Ltd., a private enterprise whose management was taken over by the Government of India, became a subsidiary of the S.C.I. and was later merged with S.C.I. on 1 January 1973. A fleet of its 16 ships thus became part of the S.C.I.

On 30 June 1986, another shipping company, The Mogul Line Ltd., also a Government of India undertaking, was merged with the S.C.I., adding 12 ships to its fleet.

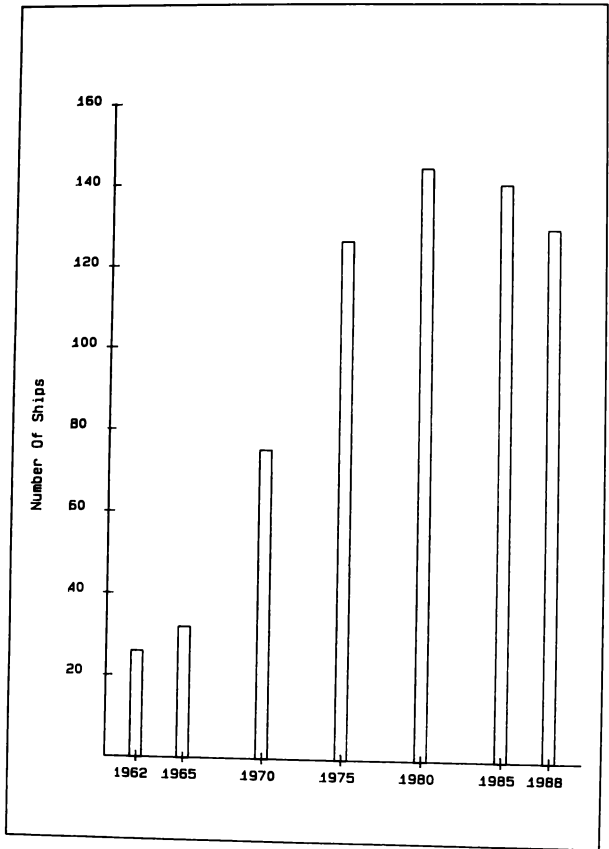
2.2. Fleet Structure

The S.C.I. commenced its operations in the year 1961 with a fleet aggregating a tonnage of 192,000 DWT, comprising 19 general cargo vessels, two passenger ships and two tankers.

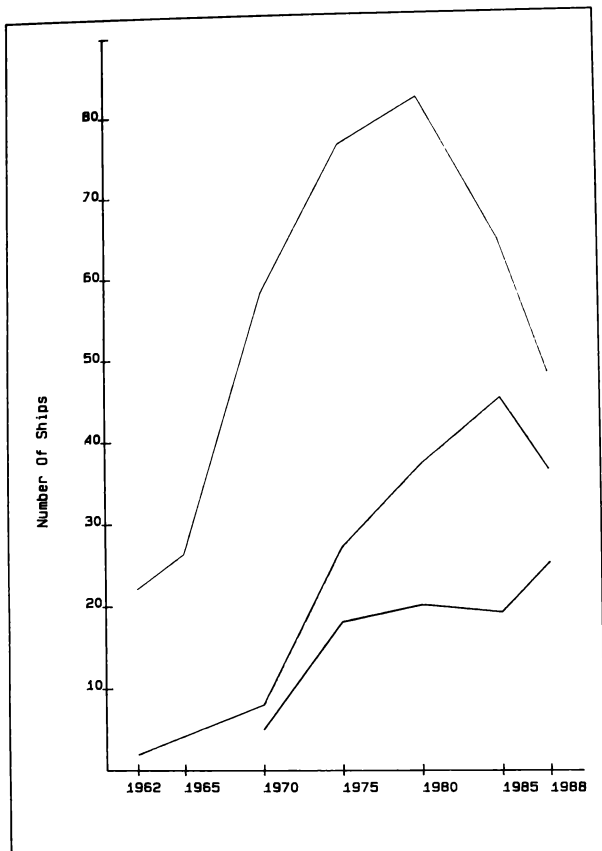
Because of its own expansion plans and the merger with two other shipping companies, the S.C.I. now has a diversified fleet of 129 vessels with an aggregate tonnage of 4,899,720 DWT (3). The fleet as of 1 Jan 1988 consists of:

Types of vessels	Nos.	DWT
General Dry Cargo Ships (30 container oriented, 17 break bulk & one timber)	48	730,097
Bulk Carriers	25	1,164,619
Combination Carriers (OBO)	4	474,978
Crude Oil Tankers (including two VLCC's)	23	2,142,731
Product Tankers	12	353,600
Passenger-cum-Cargo Ships	7	19,437
Off-Shore Supply Vessels	10	14,259

Graph I. shows the growth of the fleet in terms of number of ships owned from 1962 to 1988.



GRAPH I



GRAPH II

_____ General Cargo Ships
 _____ Tankers
 _____ Bulk Carriers

Graph II shows the magnitude of fleet diversification in terms of three types of ships; Dry General Cargo, Dry Bulk Cargo and Tankers.

In addition the S.C.I. mans and manages 23 vessels on behalf of the government. The break down of these vessels being(3):

Type of vessels	Nos.	DWT
Passenger-cum-Cargo Vessels	8	16,072
Off Shore Supply Vessels	7	11,459
Light House Tenders	2	1,782
Research Vessels	6	4,782

2.3. Fleet Personnel

The fleet personnel or the floating staff of S.C.I. fall under the following three categories :

Officers

Petty Officers

Crew

The officers and the petty officers are in permanent employment of the company. The crew is employed on rotational basis through the Seamen's Employment Directorate, Government of India. They serve on board on

a rotational basis. Each time they are employed for an artical period of nine to twelve months. After expiration of one artical period a crew member may get his next employment on a ship belonging to a different shipping company.

On 1 April 1988 the company had on its roster 2858 officers and 1297 petty officers (4).

The officers are further categorised as:

Deck Department:

Master (FG or HT)
Chief Officer - " -
Second Officer - " -
Third Officer - " -
Fourth Officer
Junior Officer(HT)
Cadet(Trainee)
Radio Officer
Trainee Radio Officer*
Medical Officer
Purser

Engine Department:

Chief Engineer Officer
Second Engineer Officer
Third Engineer Officer
Fourth Engineer Officer
Fifth Engineer Officer
Trainee Marine Engineer*
Electrical Officer

Note: F.G. ... Foreign Going Certificate
H.T. ... Home Trade Certificate
* Not a regular catagory

The petty officers are categorised as:

Deck Dept.

Engine Dept.

Catering Dept.

Skipper (FV)

Mechanician

Catering Off.

Deck Dept.	Engine Dept.	Catering Dept.
Skipper Mate (FV)	Fitter	Asst. Catering Off.
Immigration Off.	Asst. Fiter	
Nurse	Wireman	
Compounder	Pumpman	
Petty Off. Maint.	Asst. Pumpman	

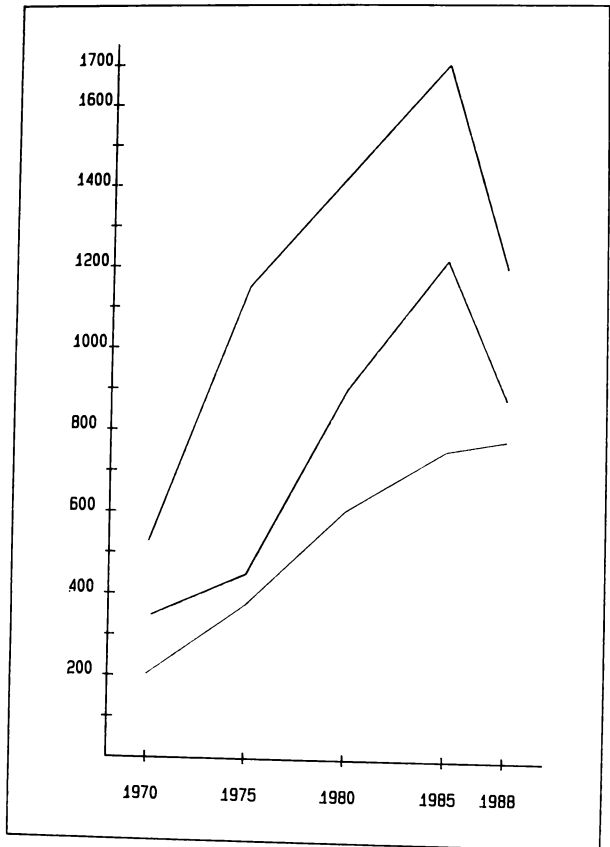
Graph III shows the growth of officers and petty officers from 1970 to 1988. These personnel are shown under the headings of navigating officers (masters to fourth officers), engineer officers (chief to fifth engineer officers) and petty officers (petty officer maintenance, fitters, assistant fitters, pumpmen, and assistant pumpmen)

2.4. Recruitment and progressive service:

Requirements for induction of fleet personnel into S.C.I. and their subsequent promotions to higher ranks has been described here. Categories as mentioned in paragraph 2.5. later are only considered.

Induction of officers and petty officers into the service of S.C.I. is normally at the lowest level of a particular category. In circumstances of acute shortage of personnel, however, induction has been at the higher levels also. All the new entrants have to meet the required medical standards. Under normal circumstances induction of officers and petty officers are as below.

2.4.1. Requirements for induction as officers :



GRAPH III

— Engineer Officers
— Navigating Officers
— Petty Officers

Deck Department :

Induction is as a cadet. The new entrant should have completed pre-sea training of two years duration on training ship " Rajendra " under the Ministry of Surface Transport.

Engine Department :

Induction is as a fifth engineer officer. The new entrant should have completed a pre-sea training course of four years at the Directorate of Marine Engineering Training (DMET), under the Ministry Of Surface Transport.

The above are the normal requirements and are presently being followed for recruitment of engineer officers. In the past, however, persons in the rank of fifth engineer officers have been recruited:

- (a) who completed a degree course of five years in either mechanical or electrical engineering from a recognised college and completed a one year course for marine orientation at DMET,
- (b) who completed four years apprenticeship in the marine workshops approved by the Ministry of Surface Transport and meeting the minimum educational and medical requirements,
- (c) graduate mechanical engineers from approved colleges who completed a six months apprenticeship in approved marine workshops followed by six months training at sea on board company's ships as Trainee Marine Engineers (TME),
- (d) graduate electrical engineers from approved colleges who completed a nine months apprenticeship in

approved marine workshop followed by six months training at sea as TME,

(e) graduate mechanical and electrical engineers directly recruited by the S.C.I. and trained under its supervision in approved marine workshops as well as in theoretical subjects for marine orientation in collaboration with the DMET.

The schemes (a) to (e) have been discontinued for the last four years due to surplus manpower.

2.4.2. Requirements for induction as petty officer:

Deck Department :

Initial employment is as a carpenter through seamen's employment office like a crew member. After a number of years of service with the company and based on their capability and good performance, they can be inducted as Petty Officers Maintenance on regular employment.

Engine Department :

Induction for all the categories as mentioned in para 2.5.2. is in the rank of assistant pumpman. The new incumbent should have completed a two years diploma course in mechanical engineering from a recognised institute or a two years national apprenticeship course in a marine workshop in the trade of engine fitters.

2.5. Categories proposed to be trained:

For the purpose of training in industrial hydraulics only those fleet personnel who are involved in the operation or maintenance of hydraulic equipment will

will be considered. They fall under the following categories only:

2.5.1. Officers:

Deck Department : Chief Officer (FG), Second Officer (FG) Third Officer (FG),Fourth Officer.

Engine Department : Chief Engineer Officer, Second Engineer Officer, Third Engineer Officer and Fourth Engineer Officer.

2.5.2. Petty Officers:

Deck Department : Petty Officer Maintenance.

Engine Department : Fitters, Asst.Fitters, Pumpman and Asst. Pumpman.

Hydraulic Machinery

3.1. Growth and Extent

At the time of inception of the company the only hydraulic equipment on board some of its ships was the electro-hydraulic steering gear, its power unit and or the transmission unit. Such ships accounted for only 50% of the fleet. All the ships which were further added to the fleet were equipped with hydraulic steering gears. Besides the steering gear, the other hydraulic system that steadily increased on dry cargo vessels was either one or a combination of opening, closing, jacking and cleating arrangements for cargo hatch covers. While till the year 1965 not a single ship in the fleet was equipped with such a system, by the year 1975 nearly 58 % of the dry cargo ships had some involvement of hydraulics in the hatch covers operations. By that time the company also had 27 oil tankers which had all the deck machinery operating on hydraulic power transmission.

More and more hydraulic systems, such as remotely operated tank valves, winches and winch brakes, cranes, power tools for engine maintenance etc. gradually made their place on ships. The increase of hydraulic equipment was on all kinds of ships. At present there are only 10 % of the ships in the fleet which do not have any other hydraulic equipment on board, besides the stee-

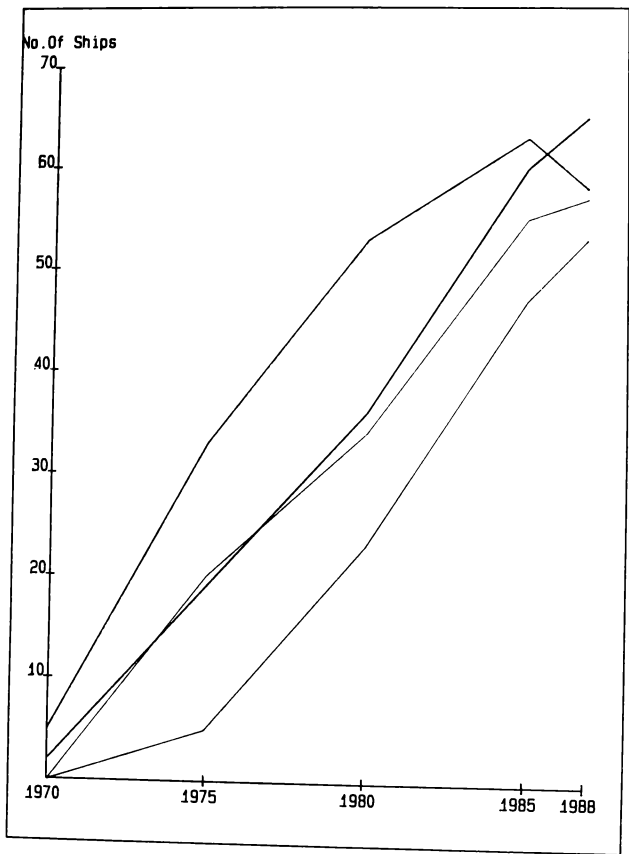
ring gear. As the ships belonging to this small percentage are very old, they are liable to be scrapped within a short time. A break down indicating the extent of different types of hydraulic machinery on board is given below. For the purpose of this comparison, steering gear and other equipment such as hydraulic power tools, shaft couplings, operating systems of skylights and shaft tunnel or keel duct doors etc., have not been considered.

Type of system	No. of ships fitted with	Percentage of fleet
ship handling machinery	67	51
cargo handling machinery	53	41
remotely operated valves	57	44
hatch covers operations	58	45

Growth in the extent of above mentioned hydraulic machinery and equipment, since 1970, in terms of the number of ships equipped with it, is shown in graph IV.

3.2. Types of hydraulic machinery on board:

The wide range of hydraulic machinery on board ships falls in the category of low and medium pressure power transmission systems, involving both, the hydrosta-



GRAPH IV

— Hatch Covers
 — Hyd. Valves

— Deck Machinery
 — Deck Cranes

tic as well as the hydrodynamic transmissions. The design and the construction of the system depends upon the particular application. The application on board ships ranges from high power transmission of main engines and deck machinery to low power transmission in servomechanisms and remote control systems. The hydraulic equipment on board ships exists in many locations because of its diverse applications. The equipment based on its applications has been listed below.

3.2.1 Deck Machinery

For ship handling

- windlass
- mooring winches
- capstan
- autotension winches
- fender davits
- tugger winch and towing pin arrangements

For cargo handling

- single and twin cranes
- winches for hose handling derricks
- cranes for stores and engine room services
- cargo winch drum brakes for jumbo and single derrick operations
- grab release operations

3.2.2. Main propulsion machinery

- servo-mechanism and controls on main engine
- hydraulic coupling for main engine

- hydraulic amplifiers for speed governors
- drive for cylinder lubricators
- exhaust gas by-pass flap control
- shaft brake clippers
- tools for propeller nut, shaft coupling and engine maintenance

3.2.3 Auxiliary engines

- hydraulic amplifier for engine governor
- servo-mechanism for turbo-alternator steam valve control
- tools for maintenance of aux. engines

3.2.4 Hatch covers

- ram operated multifold type (internal or external rams)
- pinion and rack actuated side rolling covers
- cover jacking arrangements
- chain pulled rolling covers
- cleating arrangements for covers

3.2.5 Remotely operated valves

- oil cargo tank valves
- ballast tank valves
- bilge line valves
- emergency fire pump suction valves
- quick closing valves for fuel oil and lub. oil deep tanks

3.2.6 Other equipment

- shaft tunnel watertight door operation
- duct keel water-tight door operation
- engine room skylights operation
- boiler combustion control actuators
- forced draught fans flap control
- starting arrangements for emergency generators
- steering gear units
- gyro and auto-pilot system
- cargo oil pump governor control
- stripper pump counter
- fire fighting system

3.3. Make Of Machinery:

The make of machinery on a particular ship or a particular series of ships depends upon the shipyard where the ship has been built. The ships of the present fleet of S.C.I. have been acquired from shipyards in G.D.R., India, Japan, Poland, Rumania, South Korea, Sweden, U.K., U.S.S.R., and Yugoslavia. A great diversity exists in the makes of equipments. There are more than twelve makes of hydraulic steering gears on board different ships of the company. However, while the hydraulic systems in the machinery spaces come from many manufacturers, the hydraulic machinery on deck is more standardised and comes from a very few manufacturers only. More than 65 % of the ships fitted with the hydraulic deck machinery for ship-handling are equipped with machinery manufactured by M/s. Norwinch of Norway or their licensees, the remaining being from M/s. I.H.I. Hydrowinch, Fukushima, Allweiler A.G. and Towimor.

The hydraulic cranes on most of the ships are from M/s. Hagglunds A.B., the others being from M/s.

Hydrolift and Norwinch.

The hydraulic system for operations of hatch covers on most of the ships is from M/s. Macgregor and on a very small number of ships from either M/s. Kayaba Navire or Bartran or Kvaerner or Hydraulic Brattvag.

The remotely operated valves come from M/s. I.H.I., Rotator, Nakikita Seisakusho, Superfos, SKF or Bartran.

Present Training System

4. Persons seeking employment on board Indian flag ships are required to undergo a marine orientation training irrespective of the category or department that they are desirous of joining. This training is available at the institutions run by the government or at those approved by it. The purpose of this training is to orient the trainees towards marine profession with particular emphasis on safety at sea. The curricula and duration of the training depends upon the department for which the persons are trained and whether they are trained as prospective officers or ratings. The existing training schemes of only those categories as mentioned in chapter II para 2.5 are considered here with the view to evaluate the training given in industrial hydraulics.

Maritime education and training in India conforms to the monovalent pattern of training. In order to develop the professional skills as navigating officers or as engineer officers the candidates are trained at separate institutes. They further receive on-job training on board ships through their work experience as well as go through specialised training courses at shore based institutions. The entire training that the officers go through is categorised under two headings.

4.1 Pre-sea training : prior to taking up sea career.

4.2. Post-sea training : in service training.

4.1.1. Pre-sea training for navigating officers:

The trainees are selected based on the competitive examinations on all India basis. The candidates are those, who have completed twelve years of schooling with English, mathematics, physics and chemistry among other subjects. This general education in the schools is by way of classroom lectures, home exercises, demonstrations and practicals in the science laboratories. In very few cases there is practical training for development of technical skills in the use of tools for machining, carpentry, masonry, plumbing etc.

The pre-sea training to the navigating officers is imparted on board a stationary training ship T.S. "Rajendra". This residential training of two years duration comprises theoretical as well as some practical training for the profession. The main topics of study in the academic and professional subjects are(5): Nautical mathematics, nautical physics, geography, social studies, navigation, electronics, general ship knowledge, seamanship, ship construction and stability, engineering knowledge, signalling and meteorology.

The practical training includes maintenance work about the ship's structure, boat handling, practical seamanship and safety drills.

In the subject of nautical physics following topics in hydrostatics and hydrodynamics are covered(6):

Hydrostatic pressure, Bourdon pressure gauge,

factors influencing hydrostatic pressure, Archimedes principle and principles of floatation, floatation in salt water and in fresh water, floating iceberg, marine hydrometer, Plimsoll mark, toy diver, submarines, bathyscaphe, surface tension and its role in water waves, stream line and turbulent flow, Bernoulli's equation and its application to sailing yacht and rotor ship, flow of viscous fluid through pipes and Stokes's law.

(The pre-sea training course for navigating officers is being modified. Its duration will be increased to three years and will be brought to a bachelor's degree level of a university.)

In the case of direct entry cadets, recruited in the event of shortages, the theoretical subjects taught are to nearly the same extent as done at T.S. Rajendra.

4.1.2. Pre-sea training for engineer officers :

The pre-sea training for engineer officers varies depending upon their academic and professional qualifications.

4.1.2.1 Training at the DMET:(Ref. chapter II para 2.4.1)

The DMET is a shore establishment conducting two types of courses, (i) four years regular course in marine engineering and (ii) one year orientation course for graduate engineers depending upon the need of personnel to cope with the shortages. Both the courses are residential. The entry behaviour and the process of selection for the four year regular course is same as

that for navigating officers as mentioned in 4.1.1. The training comprises class room lectures in fundamental engineering sciences, marine engineering subjects and social sciences. Nearly half of the time is devoted to practical training by way of workshop practice in the institute's own workshop as well as apprenticeship in approved marine workshops.

(a) The main subjects of study for the regular course are : mathematics, mechanics, thermodynamics, strength of materials, steam engineering, internal combustion engines, naval architecture, ship construction, marine propulsion plants, auxiliary machinery, electrical engineering, engineering drawing, refrigeration, fire prevention and fire fighting, marine control engineering and automation.

The subject of industrial hydraulics as such does not form part of the syllabus. Some of the basics applicable to this subject are covered in fluid mechanics. The contents of the subject pertaining to hydraulics and fluid mechanics are (7):

Introduction: Definition of fluid, different properties, i.e., capillarity, surface tension, viscosity etc.

Hydrostatics: Equilibrium of floating bodies, fluid pressure, measurement of pressure, total thrust due to liquid pressure on immersed plane surface, centre of pressure, total force and centre of pressure on immersed surfaces such as tanks, bulkheads, lock gates, manhole doors etc.

Fluid in motion: Energy of flowing fluid, pressure ener-

gy, potential energy, kinetic energy, total energy, Bernoulli's equation for steady motion, variation in pressure head along a pipe, measurement of pipe flow rate by venturimeter, discharge through a small orifice under a constant head, co-efficients of discharge for small orifice, experimental determination of orifice co-efficients, power of jet, force exerted by a jet normal to stationary or moving flat vane, jet inclined to a stationary or moving flat vane.

Flow through pipes: Losses of energy in pipe lines, loss due to sudden increase in pipe diameter, losses due to sudden contraction in diameter, friction losses, derivation of Darcy's and Chezy's formula, parallel flow through pipes, transmission of power by pipeline, condition for maximum power transmission, time required to empty reservoirs of various shapes, flow from one reservoir to other reservoir, inflow and outflow.

Fluid friction, viscous and laminar flow: Resistance co-efficient, variation of resistance co-efficient with Reynold's number, oiled bearings, viscous flow, flow between parallel planes, critical velocity, viscous flow in pipes, power required for viscous flow.

Vortex motion and radial flow: Real and ideal fluid flow steady and unsteady flow, two dimensional flow theory, forced vortex, free vortex, radial flow, free spiral vortex and compound vortex.

Reciprocating pumps: Various types, single and double acting, single and multi-cylinder, co-efficient of discharge, theoretical indicator diagram, effects of acceleration and friction, use of air vessels.

Centrifugal pumps: Calculations of various heads, losses and efficiency, work done per unit weight, dimensions of impellers, velocity diagram at inlet and exit, calculation of power input, torque on shafts, cavitation in centrifugal pumps.

Impulse and reaction turbines: Pelton wheel, inward flow reaction turbine, efficiency and vane angles, vane speed and head lost in runner, specific speed, applied problems.

Experiments in fluid mechanics: Determination of: meter constant of venturimeter, efficiency of Pelton wheel, co-efficient of velocity, coefficient of contraction, co-efficient of discharge of water through various orifices, friction co-efficient for flow of water through a pipe, co-efficient of discharge through various notches. Determination of metacentric height of a floating body.

(b) Ship's hydraulic steering gear and telemotor systems are taught under the subject of marine auxiliary machinery.

(c) The practical training is intended to develop the psychomotor skills of the trainees in the use of different hand tools and machines like lathe, drilling, milling, cutting, grinding, etc., so that they can perform the fitting and machining operations for maintenance purpose. During this training the trainees are rotated through different departments of a marine workshop and on board ships under repair to gain experience on overhauling and repair techniques.

4.1.2.2. Training at DMET (one year course):

(a) The entrants are graduates in mechanical and electrical engineering, selected on the basis of entrance examination. The theoretical part of the training is by way of lectures on the marine engineering subjects. These trainees already have higher level of knowledge in the engineering subjects. During studies at their respective colleges the subjects of fluid mechanics, hydraulics and hydraulic machinery are covered in great details. The contents of syllabus on the specific subject of hydraulics and hydraulic machinery generally covered are (B):

Basic principles of hydraulics: Properties of fluid-density, viscosity and bulk modulus of elasticity. Hydrostatic pressure at a point, Pascal's law, variation of pressure with height, Piezometer U tube manometer and pressure gauges.

One dimensional continuity and momentum equation: Bernoulli's equation, orifice nozzle and venturimeter, elements of flow through pipes, power transmission through pipes.

Hydraulic turbines: Force of a jet on flat and curved plates, velocity triangles, Pelton wheel - condition for maximum efficiency speed ratio, jet ratio, multijets. Reaction turbines, radial, mixed and axial flow, details like spiral casing, guide vanes, runner, draft tube, function of draft tube, cavitation, specific speed, unit quantities characteristics of turbines. Governing of turbines, study of governing system with compensating device, selection of turbines, water hammer and surge tanks.

Pumps: reciprocating-single acting, double acting, inertia load, indicator diagram, discharge-crank angle diagram, use of air vessel and the performance characteristics.

Centrifugal pumps: Working principle, head developed, method of recovering kinetic energy, manometric head characteristics and specific speed.

Other pumps: Elementary principle of gear pumps, vane pumps, radial and axial piston pumps.

Machines: Elementary principle of accumulators, intensifiers, hydraulic cranes, hydraulic press.

(b) Those of the mechanical engineers who take production engineering as their specialisation subject have following additional subject:

Oil hydraulic circuits: Introduction to hydraulic circuits, general classification of valves in circuit, meter in and meter out circuits.

Hydraulic pumps and motors: Variable capacity and fixed capacity type, gear, vane, piston, rotary abutment etc., ram units and rotary actuators. General theory of pumps, theory of pump and motor units, performance curves of variable speed drives. Combination of pumps and motor units.

Valves: Check valve, relief valve, speed control valve, pressure compensating valve, pressure compensated flow control valve, unloading valve, direction control valves, spool valve, sequence valve. General theory of orifi-

ces, application to control valves, simple servo systems using rams and valve units, compensation of valve reaction forces.

Accumulators: Flow graphs, size of gas filled and piston type accumulators, the economics of accumulators, thermodynamic consideration. The use of accumulator to absorb shocks, accumulator and intensifier circuits.

Circuits: Development of circuits with basic components for shapers, drilling machines, lathes and presses etc.

(b) In the study of marine subjects at DMET the ship's hydraulic steering and telemotor systems are taught.

(c) Practical training: The trainees are expected to have obtained basic knowledge and practical experience in the use of tools, machines etc. during their engineering studies. Under their pre-sea training, the theoretical classroom lectures and the practical training are arranged in sandwiched pattern. In this arrangement classroom lectures for three months are followed by practical training of three months alternately. Through their rotation in different departments of the workshop and ships under repairs the trainees get a general idea and experience in the techniques of maintenance and repairs.

4.1.2.3. Direct entry graduates:

Under this scheme the trainees get practical workshop training only. It is of six months duration for the mechanical and of nine months duration for the electrical engineers. There are no theoretical classes. After this workshop training the trainees sail for six

months on board ships as trainee marine engineers before getting confirmed as fifth engineer officers. The subjects of study are same as enumerated in 4.1.2.2.

4.1.3. Pre-sea training of petty officers:

The petty officers, prior to joining the services of the company normally go through a training of two years in technical institutes. This training is in the general fitters trade, not particularly oriented to the marine field. The trainees have lower academic qualification and during this training receive very basic and limited theoretical knowledge in engineering. The main emphasis is in the use of tools and machines for the purpose of overhauls and repairs. The other source is apprenticeship in fitters trade in a marine workshop. These trainees normally do not get any theoretical training. The objective being to develop their skills through practical training and experience. The persons serving as Petty Officers Maintenance, generally rising from the category of crew, do not get any technical training.

4.2. Post-sea or in service training:

This is the training received by the persons through their work experience, formal or informal instructions, training courses, seminars etc.

4.2.1. On job training:

During their duties on board ships the officers gain knowledge about the functioning, operations and

maintenance of equipment through observation and guidance from seniors. This informal type of training which constituted the main source of learning in the past is gradually diminishing. Technical circulars from the head office are available to enhance the self learning process.

4.2.2. Preparatory courses for the certificates of competency:

This training is by way of classroom lectures on professional subjects of navigation and engineering at the Lal Bahadur Shastri Nautical and Engineering College run by the government. The candidates are basically coached in the safety aspects associated with navigation, shiphandling and operation of machinery to ensure safety of men and ships at sea. The attendance at the college is optional.

(a) Navigating officers: Coaching is provided in all the professional subjects as mentioned in 4.1.1. at a level appropriate to the grade of certificate. Additional subject pertaining to the commercial and legal aspects of shipping, ship management and engineering knowledge are taught at the Master's certificate level.

(b) Engineer officers: Limited coaching is available only to the candidates preparing for the Second Class Engineer's Certificate of Competency. The subjects taught are mathematics, mechanics, thermodynamics, naval architecture, ship construction, general engineering knowledge and internal combustion engines. In the absence of proper coaching classes for engineer officers, they prepare for the examinations on their own based on

the questions normally asked.

4.2.3. Training for specialised operations:

These training courses for compliance with the recommendations of the S.T.C.W. and other related conventions of I.M.O. are mandatory in nature. Some of the courses applicable to the operations in the S.C.I. fleet and available in India are: Tanker Familiarisation Course, Specialised Tanker Safety and Crude Oil Washing Course, Carriage of Dangerous Goods Other Than in Bulk, Radar Observer's Course, Radar Simulator Course, Personal Survival Techniques, Basic and Advanced Fire Fighting courses.

4.2.4. Specialised training for developing and updating the professional skills:

The pre-sea and the post-sea training enumerated above are based on the statutory requirements. The S.C.I. organises and makes use of training programmes available at other institutes. Some of the courses regularly conducted or organised for the fleet officers as in-house training courses are:

Name of the course	Duration
Marine Control Engineering	3 weeks
Chief Officers' Orientation	2 weeks
Second Engineer Officers' Orientation	2 weeks
Cost Control in Shipping Management	2 weeks
Containerised Shipping Management	2 weeks
Welding Technology and Practice	6 weeks

Name of the course	Duration
Assistant Pumpmen's Course	2 weeks
Wireman's Course	2 weeks
Course on Main Engines	1 week
Hydraulic Deck Cranes	1 week
Carriage of Dangerous Goods	1 week

4.2.4.1. During the Marine Control Engineering courses, meant for senior engineers and electrical officers, two sessions of three hours each are devoted to the subject of hydraulics. Basic theory of oil hydraulics, types of pumps and motors, system components, their applications, simple hydraulic circuits are explained by an expert from M/s. Sperry Vickers, manufacturers of mobile hydraulic equipment.

4.2.4.2. In the Chief Officer's Orientation course, meant for newly promoted chief officers and prospective chief officers, two lectures of one hour each are devoted to this subject. Operations of the system, normal faults, procedures for operations and maintenance of hydraulically operated tank valves are discussed. The lectures are delivered by one of the marine superintendents.

4.2.4.3. In the Second Engineers Orientation Course, for newly promoted and prospective second engineer officers, two lectures of one hour duration each are delivered on hydraulic deck machinery and hatch covers by one of the engineer superintendents. These cover explanations of circuits, common faults and general precautions to be taken during operations and maintenance.

4.2.4.4. In the Assistant Pumpmen's course two lectures are arranged on hydraulically operated cargo tank valves and hydraulic deck machinery. These lectures cover the precautions and correct procedures to be followed for the operation, overhaul and routine maintenance of the systems.

4.2.4.5. Two courses on hydraulic deck cranes have been organised in the past. Both the courses were conducted by instructors from the manufacturers, M/s. Hagglund Hydraulic Cranes of Sweden. The courses covered constructional details, operations, common faults and trouble shooting procedures specific to these cranes.

4.3. Evaluation of the present training system indicates that in the field of industrial hydraulics:

- 1) The navigating officers get some exposure during the Chief Officer's Orientation course on cargo tank hydraulic valve systems.
- 2) Engineer officers from regular DMET training course get some theoretical knowledge in the fundamentals at the pre-sea stage in the study of the steering gears and telemotor systems.
- 3) Graduate engineers get theoretical knowledge of fundamentals in study of simple circuits and basic components.
- 4) Graduate engineers with production engineering as specialisation get adequate theoretical knowledge in the subject.

5) Engineer officers get some exposure on hydraulic systems through refresher courses.

6) Some engineer officers get training on Hagglund's hydraulic cranes.

7) Petty officers get some exposure during refresher courses.

Training Needs Identification

5.1. Training Needs:

In order to have a meaningful and economic training scheme, it is imperative that it is based on the specific needs of training. In an effective and systematic approach for identification of training needs, the performance deficiency should be the basis of such an evaluation. The performance deficiency may itself be attributed to two factors:

- a) the deficiency in knowledge
- b) the deficiency in execution.

The later factor can be the cause of performance deficiency even though the required knowledge is possessed by the performer. The characterisation of the performance deficiency is indeed most essential to recognise whether the solution lies in formal training or not. This involves a detailed diagnostic procedure comprising task analysis from the view point of:

- i) topic evaluation to identify the cognitive skills needed to perform the task,
- ii) job evaluation to identify the psychomotor skills needed for the task.

The performance deficiency will in fact flow out of the comparison of the skills identified by such task analysis and the skills possessed by the performer (9).

Approach based on the improvement of execution deficiency *inter alia*, involves "fitting the job to suit the performer". It is not only unrealistic in the context of existing situation, it is beyond the scope of this paper.

The task situation, i.e., the working environment on board ships are unique and complex compared to those in the shore based industry. While the systematic approach through task analysis can be followed word to word with ease in the shore industry, the same is not easily adoptable to the same perfection for shipboard situations. This is basically because of the dynamic nature of operations and great diversity in the equipment. The task situation for an individual working at sea changes every six to nine months. Consequently, training needs identification through detailed task analysis on individual units (ships) and an inventory of individual's skills repertoire is a very complex process.

The process of topic evaluation for task analysis relies on the minimum standards of cognitive skills and comparison of these standards with existing skills (of the prospective trainee) to find the skill gaps. When the task analysis is done by a person who himself has some background of the field of performance, it is only natural that the comparison tends to be based on his own standard of skills. This standard may not be adequate for such comparison especially if the person is

not a subject matter expert. At the same time due to the marked diversity in the equipment, the availability of subject matter expert itself, is questionable. It will hence be most prudent not to rely on the skills of one person only, but to involve others with knowledge and experience in the field.

Such an approach has been adopted for identification of training needs in the field of industrial hydraulics for the fleet officers of the company. Benefit of the expertise and experience of persons in this field has been the basis of this identification. The persons involved have been:

The technical superintendents from the operating divisions and the technical services divisions.

Senior engineer officers from ships.

Engineers from the manufacturers of the industrial hydraulics equipment.

Engineers from the workshop involved in the repairs of the hydraulic machinery.

The needs in the future will be different than those prevailing at present because of skill repertoire and the change in technology. It is advisable to follow similar approach for identification of training needs in the future as well.

5.2. Skill gaps:

The growth in the extent and diversification

of hydraulic machinery has been elaborated in Chapter III. The equipment has become more sophisticated and consequently more complicated. The skills needed to operate and maintain the equipment have increased at a regular pace. Training available at present and the extent of exposure that the fleet personnel are getting in this field are enumerated in chapter IV. The analysis of the two indicates a wide gap between the skills available and those needed for efficient operation of hydraulic machinery.

5.2.1. The operation and to a certain extent the maintenance of the hydraulic machinery for ship handling and cargo handling located on deck, is the responsibility of navigating officers. They however, do not get a formal systematic training in this area. The present training scheme has the following deficiencies:

- 1) There is no exposure to the fundamentals of hydraulics at the pre-sea stage.
- 2) There is no exposure at the preparatory courses for the certificate of competency examinations.
- 3) The exposure during the Chief Officer's Orientation course is limited to cargo tank valve systems only.
- 4) The lectures are delivered by one of the marine superintendents and are based on his own experience which may be ten to fifteen years old. He has not received any training in the field himself and the lectures are consequently limited to the sharing of experience.

- 5) The exposure at this stage is late in service.
- 6) Regularity is not assured as the superintendents, being from the operating divisions, are sometimes not available for lecture delivery.
- 7) There are no practical demonstrations of components or through models to facilitate understanding and physical recognition of components.

5.2.2. Responsibility for maintenance of most of the hydraulic machinery lies with the engineer officers. The skill gaps are much more wide due to lack of exposure at various stages. In case of engineer officers the deficiencies are:

- 1) There is very limited exposure to the fundamentals of oil hydraulics to regular DMET trainees. The only detailed study being on hydraulic steering gear and telemotor system.
- 2) The graduate engineers getting adequate theoretical knowledge in industrial hydraulics are very small in number. There is no exposure to marine machinery.
- 3) Due to lack of demonstrations or practical training there is no association of physical components with theoretical knowledge.
- 4) Exposure through refresher training is at a late stage. It lacks marine orientation.
- 5) Refresher training through Second Engineer Officer's Orientation course has similar deficiencies as in case of Chief Officer's Orientation Course.

6) Courses on cranes do not cover basics. They are not frequent, only two courses have been conducted in five years. Consequently, they are not available to all the senior engineer officers.

5.2.3. In case of petty officers there is no exposure before they attend the refresher course. These courses lack practical demonstrations.

Training Policy and Methodology

6.1. Training policy

Knowing the skill gaps and that the feasible solution is "fitting the performer to suit the job", two approaches are possible.

6.1.1. The existing skill gaps can be narrowed down by documented instructions for operations, job aids, instructions from the manufacturers etc. It is noticed that inspite of the availability of such documents there still exist a situation of performance deficiency. This system relies on the self learning process. The impediment to this process may be due to:

- a) Lack of importance attached to the systems especially if they do not form part of the essential machinery involving safety or propulsion.
- b) Lack of importance if the general living conditions are not affected adversely due to the existing deficiencies.
- c) Lack of importance if it falls out of the gamut of answerability as a result of organisational structure and policies.

d) Lack of motivation since it does not form part of the examination syllabus.

Motivation to self learning depends upon one's own aptitude. It diminishes if the learner cannot make any headway due to lack of fundamental knowledge, inability to comprehend and lack of guidance from the seniors.

Self learning motivation varies from person to person depending upon one's attitude. It also depends upon the conditions like employee and employer relationship.

The basic and fundamental knowledge in the subject matter is most essential for the very initiation of the above process. The system cannot be fully relied upon due to the diversity in the documentation, people and the environment. It may prove to be an effective support system once the personnel have acquired the fundamental knowledge.

6.1.2. The other approach is formal training based on the identified needs. This approach is more effective and has the advantage of instructor to trainee and trainee to trainee interaction for better appreciation of instructions. It also has long term benefits for the organisation. It not only brings an improvement in the performance but is also a motivating factor for the personnel and favourably changes their general attitude towards the organisation.

In addition to the above, the other factors which necessitate the need for evolving an appropriate training scheme in industrial hydraulics are:

- 1) Formulation of syllabus and its modification for the pre-sea training and post-sea training for preparatory courses is under the control of government authorities and S.C.I. does not have any control over it.
- 2) Although revision of the syllabi is expected in the near future , inclusion of the subject of industrial hydraulics is not envisaged.
- 3) Facilities for such training (oil hydraulics oriented to marine machinery) are not available in India.
- 4) Dependence on experts from abroad is detrimental to regularity of training , uneconomic and administratively difficult.
- 5) Training of a large number of personnel outside is not economically viable.
- 6) In-house courses can be tailored to suit own needs.
- 7) S.C.I. has the capability and infrastructure to develop and organise such training.

6.2. Aims of the training policy:

The S.C.I. has always considered human resources as the most valuable resources and considers investment in training and manpower development a must. One of the micro objectives of S.C.I. providing the basis for its strategic and tactical planning, inter alia emphasises:

"Development of requisite human skills and their upgradation through continuing training programmes" (2).

The training in industrial hydraulics will be part of the overall training policy. The training in this field has also been appropriately identified by the committee on the "S.C.I. Maritime Training Institute". The contents of training, level and the structure of the scheme will be related to the category of trainees, their field of responsibility and the deficiencies identified. It will be oriented towards the equipment that is fitted on board company's ships. The training in this field is proposed at two levels and through two separate courses.

6.2.1. Basic Course on Hydraulics(Off.): This course is designed for training of operators of the equipment i.e., the navigating officers. The junior engineer officers will also be trained through this course. The course structure and the trainees group structure are elaborated in Chapter VII. The course will aim at imparting essential knowledge of:

- 1) Fundamentals of oil hydraulics.
- 2) Basic working principles of different equipment under their control.
- 3) Basic function of components in the hydraulic systems and their physical identification.
- 4) Checks and tests prior to and after the use of equipment.
- 5) Routine checks and care of system against environment.

- 6) Consequences of mishandling and maloperations.
- 7) Safety devices and emergency operations.
- 8) Normal operating parameters and allowable deviations.
- 9) Economic aspects associated with the components, oil, energy etc.

The course for the petty officers will be "Basic Course on Hydraulics (P.Os.)". They will be trained separately with the course contents and the level of instructions suitable to their requirements.

6.2.2. Advanced course on hydraulics: This course is formulated for training of engineer officers who are responsible for the maintenance, overhauls, trouble shooting and repairs of the equipment. The trainees of this course also have the responsibility of ensuring that correct procedures are followed by the persons concerned with the operations of the equipment as well as to give on job training to the juniors. The course structure, detailed syllabus and the trainees group structure are elaborated in Chapter VII. The course will aim at giving essential knowledge of:

- 1) All the topics as enumerated for the Basic Course in Hydraulics in 6.2.1. above.
- 2) Working principles and constructional details of the components of hydraulic machinery.
- 3) Hydraulic circuits for different types of machinery on board company's ships.

- 4) Faults generally encountered and their rectification.
- 5) Precautions and procedures for overhauls and repairs of the equipment.
- 6) Basic electrical circuits as applicable to hydraulic equipment.
- 7) Trouble shooting procedures for different equipment.
- 8) Hagglunds' deck cranes system details, trouble shooting and repairs.
 -
- 9) Company's planned maintenance scheme for main hydraulic machinery.
- 10) Company's policy regarding procurement of spare parts and applicable consumable stores.

Reasons for repeating the topics of the Basic Hydraulic course here have been explained in para 7.2.4. chapter VII.

6.3. Methodology:

6.3.1. Theoretical training: The training through above courses will be mainly by class room lectures. Audio and visual aids will be used to facilitate the learning process. These will include some of the actual components of hydraulic systems, cut away sections, simple working models, over head projector transparencies, photo transparent slides, pictures, charts and diagrams showing constructional details, normal and abnormal running conditions.

Reading material suitable to the level of participants will be provided. It will comprise the text related to the lectures, important information from the books, machinery manuals and published articles. Procedures, precautions and lists of do's and don'ts, important conversion tables, graphs, sizing tables, diagrams of components and circuit diagrams will also be included.

Exercises, quizzes and tests suitable to the level of trainees will be given to get the direct feed back on the effectiveness of learning and to take immediately needed corrective actions and make long term modifications.

6.3.2. Practical Demonstrations: Old components of hydraulic machinery such as different types of pumps, actuators, control valves, filters, pipe fittings and couplings etc. will be used for demonstrations to explain constructional details, working principles and effects of maloperations. Cut away models of control valves and important components will be procured. A working model of a simple hydraulic power transmission system with commonly used components will be constructed. This will help the participants appreciate the causes and symptoms of deviations in normal working parameters.

Structure of Training Courses

7.1 Basic course on Hydraulics:

7.1.1. Two separate courses: The courses will be conducted separately for the officers and the petty officers and will be named as "Basic Course in Hydraulics (Off.)" and "Basic Course in Hydraulics (P.Os.)" respectively.

7.1.2. Trainees: The group of participants for the Basic Course on Hydraulics (Off.) will comprise chief officers, second officers, third officers, fourth officers and fourth engineer officers.

The participants for the Basic Course in Hydraulics (P.Os.) will be the fitters, assistants fitters, pumpmen, assistant pumpmen and the petty officers maintenance.

7.1.3. Duration of the courses: The duration of both the basic courses will be of two days. On each day there will be six lecture periods of fifty minutes each. This period includes time for screening of films as well as demonstrations in the hydraulic laboratory.

7.1.4. Course objectives: After attending the course the

participants will:

- have knowledge about the working principles of the hydraulic machinery fitted on board ships,
- have knowledge about the correct procedures, for operations of the hydraulic machinery,
- be able to use the acquired skills for improving the performance.

7.1.5. Course contents: The main topics for the Basic Course in Hydraulics (Off.) and the sequence will be:

Day I.

- 1000 - 1050 - Introduction to oil hydraulics, types of machinery on S.C.I. ships.
- 1100 - 1150 - Fundamentals of hydrostatic transmission.
- 1210 - 1300 - Hydraulic fluids, contamination control and reservoirs.
- 1400 - 1450 - Hydraulic pumps and actuators.
- 1500 - 1550 - Control valves, simple circuits, demonstrations in the lab.
- 1610 - 1700 - Accumulators. Film .

Day II.

- 1000 - 1050 - Cargo tank valves.

- 1100 - 1150 - Hatch cover operations.
- 1210 - 1300 - Steering gears.
- 1400 - 1450 - Deck machinery. Film .
- 1500 - 1550 - Deck machinery continued.
- 1610 - 1700 - Test and course evaluation.

Basic Course on Hydraulics (P.Os.): The topics for this course are similar. However the discussions will be at a lower level. Theoretical portion will be reduced by cutting down detailed explanations of circuits, construction of components, regulations on steering gears etc. More emphasis will be given to the maintenance routines of equipment, cleaning and flushing procedures, practical demonstrations of making connections of pipes and hoses. The language of instructions will normally be English but explanations in Hindi will be done depending upon the need.

7.2. Advanced Course on Hydraulics:

7.2.1. Trainees: The participants for this course will be the chief, the second and the third engineer officers. One or two engineer superintendents may also be included in the group of participants.

7.2.2. Duration : The course will be of six days duration. On each day there will be six lecture periods of fifty minutes each. In case a visit to the ship equipped with deck cranes is possible an extra day will be provi-

ded for.

7.2.3. Course objectives: After attending the course the participants will:

- have the essential knowledge of the working principles and constructional details of a majority of hydraulic machinery existing on S.C.I. ships,
- be familiar with the procedures for operations and maintenance of the hydraulic equipment,
- be able to use the acquired skills in maintaining the hydraulic machinery in good running order,
- be able to investigate the causes of failures and take precautions for avoidance in future,
- be able to guide the juniors in proper procedures for operations and care of equipment.

7.2.4. Course contents: The main topics of the course and their sequence will be as follow. The topics of the basic course have also been included in this course as the trainees have not undergone the basic course. Later on, when the participants having attended the basic course start coming for the advanced course the course contents will be modified.

Day I.

1000 - 1050 - Introduction, Development of industrial

hydraulics, hydraulic machinery on
S.C.I. ships.

- 1100 - 1150 - Fundamentals of technical measurements,
principles of hydrostatic transmission.
- 1210 - 1300 - Hydraulic fluids, their properties. Film.
- 1400 - 1450 - Hydraulic pumps.
- 1500 - 1550 - Hydraulic actuators.
- 1610 - 1700 - Accumulators and power packs.

Day II.

- 1000 - 1050 - Control valves and their applications
- 1100 - 1150 - Constructional details of control valves
- 1210 - 1300 - Control valves operations. Film.
- 1400 - 1450 - Hydraulic system elements.
- 1500 - 1550 - Hydraulic circuits.
- 1610 - 1700 - Hydraulic circuits continued. Exercises
on hydraulic circuits.

Day III.

- 1000 - 1050 - Hatch covers and tank valves operations.

- 1100 - 1150 - Deck machinery configurations.
- 1210 - 1300 - Main components constructional details.
- 1400 - 1450 - Constructional details continued.
- 1500 - 1550 - Electrical control circuits.
- 1610 - 1700 - Maintenance schedule. Test.

Day IV.

- 1000 - 1050 - Hagglunds deck cranes components layout
- 1100 - 1150 - Power units constructional details.
- 1210 - 1300 - Safety devices.
- 1400 - 1450 - Power transmission functions. Film.
- 1500 - 1550 - Control components details.
- 1610 - 1700 - Control circuit diagrams.

Day V.

- 1000 - 1050 - Control circuit diagrams continued.
- 1100 - 1150 - Control circuit diagrams continued.
- 1210 - 1300 - Twin operation of cranes.

- 1400 - 1450 - Electrical circuits.
- 1500 - 1550 - Electrical circuit continued.
- 1610 - 1700 - Trouble shooting.

Day VI.

- 1000 - 1050 - Planned maintenance schedules.
- 1100 - 1150 - Applications to control systems.
- 1210 - 1300 - Reservoirs, fluid conditioning.
- 1400 - 1450 - Pipes, hoses, fittings etc.
- 1500 - 1550 - Flushing and cleaning of systems.
- 1610 - 1700 - Test and course evaluation.

The course will commence on Monday and conclude on a Saturday.

7.3. Detailed syllabi.

7.3.1. Details of the syllabus for the basic course:

Fundamentals of oil hydraulics: Review of: creation of pressure, absolute pressure, vacuum, Pascal's law; flow in pipes, loss of pressure, conservation of energy; force, work, torque & power in hydraulic transmission systems, comparison with mechanical transmission of

power; formulae used in hydraulics.

Hydrostatic transmission: low, medium and high pressure systems; open and closed loop systems; power, control and actuator circuit groups.

Elements of transmission system: Reservoir, expansion tank, pump unit, flow control, directional control, actuator unit and return system.

Hydraulic fluids: types of fluids and application, mineral oils, function of fluid, quality requirements, main properties; effects of temperature, sources of contamination, storage and handling; maintenance of fluid quality, filtration at suction and return, pressure drop indications, bypass arrangements, maintenance of filters.

Reservoirs: construction, heat dissipation, mountings, suction and return connections, fluid level, cleaning and maintenance.

Accumulators: Function and applications, spring loaded, free piston and surge types, gas charged bladder type, charging of accumulators, control and safety arrangements.

Power units: brief description of internal and external gears pumps, balanced, unbalanced and in-travane types of vane pumps; lobe, gerotor and cam rotor pumps; fixed and variable displacement pumps; cavitation in pumps, supercharging of pumps; operating parameters, causes of deviations in parameters and maximum limits, causes of failures of pumps.

Actuators: working principles of linear actuators with single acting and double acting functions, spring returned actuators, brief details of construction and mountings; sealing arrangements; cushioning; brief descriptions of rotary actuators; gear, vane and piston types of motors; single vane, double vane, single piston and double piston types of semi-rotary actuators; operating principles, inspection and maintenance, causes of failures.

Control valves: brief details of internal valving, classification by stages of operations and number of connections, methods of actuations. Application as relief valve, pressure reducing valve and direction control valve.

Hydraulic circuits: hydraulic graphic symbols of some of the main components; elementary hydraulic circuits.

Hatch cover operations: details and lay out of common types of covers for main and tween decks; hydraulic circuits in simplified forms, operation by internal and external rams; cleating and jacking arrangements; rotary devices, maintenance of hydraulic and mechanical parts; common faults; emergency operations.

Cargo tank valves: constructional details of different types of valves, methods of actuation, hydraulic circuits for remote operations, routine checks, common faults, maintenance routines, emergency operations.

Deck machinery: brief description of constructional details of windlass, mooring winch, capstan, auto-tension winches, cargo derrick winches; pump and control units, description of motors, control valves, safety devices;

procedures for starting; operating parameters, causes of deviations; maintenance schedule for the hydraulic and the mechanical parts.

Deck cranes: types of cranes, operating features, safety devices, emergency operations, starting procedures and the checks during operations.

Hydraulic lines: piping and hoses, types of joints and couplings, correct procedures for making connections, anchoring of pipes, proper positioning of hoses, causes of failures and care against damages.

Steering gears: Details of two rams, four rams and vane type power units; control systems, follow up, non-follow up and auto-pilot operations; emergency steering arrangements; common faults and failures; requirements as per SOLAS convention regulations.

7.3.2. Details of the syllabus for advanced course:

Fundamentals of oil hydraulics: Review of - creation of pressure, absolute pressure, vacuum, Pascal's law; flow in pipes, loss of pressure, Bernoulli's equation, conservation of energy; force, work, torque and power in hydraulic transmission systems, comparison with mechanical transmission of power; speed of actuator, formulae used in hydraulics.

Hydrostatic transmission: low, medium and high pressure systems; open and closed loop systems; power, control and actuator circuit groups.

Elements of transmission system: Reservoir, expansion

tank, pump unit, flow control, directional control, actuator unit and return system.

Hydraulic fluids: types of fluid and application, mineral oils, function of fluid, quality requirements, properties like density viscosity, lubricity, stability towards oxidation, additives; effects of temperature; sources of contamination, storage and handling; symptoms of deterioration, physical and laboratory tests, grades used on company's ships, cost factor and company's policy of procurements of oils.

Filtration: micron rating, sizing, filters on the suction and return lines, bypass arrangements, pressure drop indications, maintenance of filters.

Reservoirs: construction, heat dissipation, mountings, suction and return connections, vortexing, fluid level, pressurised reservoirs, cleaning and maintenance.

Accumulators: Function and applications, spring loaded, free piston and surge types, gas charged bladder type, charging of accumulators, control and safety arrangements; power packs, applications, motor-pump units oil separation, differential pressure control.

Power units: working principles and constructional details of different types of pumps, internal and external gear type, screw type, balanced, unbalanced and intravane type, radial, inline and bent axis piston type, lobe, gerotor and cam rotor type pumps; fixed and variable displacement pumps, two stage pumps, pressure and volume combination pumps; volumetric efficiency, rating of pumps; operating conditions, cavitation in pumps,

supercharging of pumps, causes of failure, inspection and investigation, maintenance of pumps.

Actuators: working principles of linear actuators with single acting and double acting functions, spring returned, differential and telescopic cylinders, boostram and Bradbury speedram cylinders; details of construction, static and dynamic sealing, flanged end, screwed cap, tie-rod construction, methods of mounting; cushioners, stop tubes and gaters; detailed descriptions of rotary actuators, gear, balanced, unbalanced and intravane types of motors, radial, in line and bent axis piston types of motors; fixed and variable displacement type, semi-rotary actuators of single vane, double vane, single piston and double piston types; torque control, compensator control; inspection and maintenance, causes of failures.

Control valves: constructional details of internal valving, single stage double stage, two paths, four paths connections; taper plunger, adjustable orifice, spring returned, detented type; methods of actuations, manual, cam operated, pneumatic and hydraulic pilot operated. Applications as pressure control valve, relief valve, compound relief valve, balanced piston and counter balance relief valve, unloading valve, pressure reducing valve, combined relief and throttle valve, pressure control modules.

Applications as flow control valves, meter in and meter out valves, non-compensated flow control valves, flow control and check valve, pressure and temperature compensated flow control valves.

Application as directional control valves, check valve, pilot controlled check valves, pilot choke controlled deceleration valves. Servo valves, single and two stage

spool type, flapper type, jet type, electrohydraulic servo valves.

Hydraulic circuits: Hydraulic graphic symbols of I.S.O. and other standards as applicable; simple circuits and their gradual development into complicated control circuits, unloading low and high pressure circuits, automatic venting control, accumulator control, regenerative advance and retracting circuits, flow control circuits, coupled motor circuits, sequencing and braking circuits, rapid advance and deceleration circuits, torque, direction and reaction control circuits.

Hatch cover operations: The syllabus is the same as for the basic course. Construction of components and their maintenance will be covered in more detail.

Cargo tank valves: The syllabus is the same as for the basic course with more details on the constructional details.

Deck machinery: Constructional details of windlass, mooring winch, capstan, auto-tension winches, cargo winches; details of the hydraulic pump, motor, control valves, safety devices; control circuits, series operations, procedures for starting, operating parameters, maintenance schedule.

Deck cranes: types of hydraulic cranes fitted on board, names, locations and identification of parts of Hagglunds cranes, pump units for different types of cranes, constructional details of hoisting, slewing and luffing winches; hydraulic circuits for hoisting, slewing and luffing functions; details of controller, accumulator,

direction control valves, identification number and position of these on the circuit diagram; pressure distribution at different parts of the circuit; limiting and safety devices, twin operation of cranes. Electrical circuit diagrams for control and safety devices for single and twin operations of cranes. Periodical maintenance schedule, lubrication schedule, procedure for adjustment of brakes, speed adjustment, controller zero positioning, plussing adjustment for hoisting and luffing controls; trouble shooting, company's planned maintenance procedures.

Other hydraulic applications: boiler combustion control system, governing control for turbo-alternator turbine and cargo pump turbines.

Hydraulic lines: tubing and piping, types of joints and couplings, correct procedure for making connections, anchoring of pipes, proper positioning of hoses, causes of failure, care against mechanical and weather damages.

Steering gears: requirements of SOLAS regulations, typical faults on different types of units.

Organisational Aspects

8.1. Nomination of trainees:

As a normal policy the fleet personnel for all the training courses are nominated by the Fleet Personnel Department. These nominations are planned based on the schedule of courses, made in advance for every three months, and training record of the personnel. The nominated personnel are from amongst those who are on leave at that time. As a policy there are no training reserves. For the duration of training, the personnel are treated as on duty and normal service conditions of their repatriation, boarding and lodging etc. are applicable.

In order to economise on the expenses for repatriation, the Basic Course on Hydraulics will be coupled with some other short courses like course on Elementary Control Engineering for Navigating officers, Basic Fire Fighting course for petty officers, Assistant Pumpmen's Course etc. as applicable and feasible.

8.2. Physical facilities:

Both the courses will be conducted on residential basis. This will give the participants more time for after classes studies. The participants will

have a chance of interactions amongst them. Such informal discussions are beneficial for sharing their varied experiences. The facilities for conducting the courses, accomodation and boarding are available at the company's training institute.

8.2.1. S.C.I. Maritime Training Institute (MTI):

This institute has been established to meet the pressing needs of facilities for conducting specialised training courses and refresher courses for the employees of the S.C.I. Technical, commercial and management training courses in the maritime field are conducted here. These programmes are not restricted to participation by the company's personnel but are open to the personnel from other shipping companies and industries associated with shipping.

The MTI has been affiliated to the World Maritime University since March of this year. Specialised short courses developed at the IMO and the WMU will also be conducted here for participation by other nationals in the region, as well.

The courses listed in para 4.2.4. chapter IV and all the courses mentioned in para 4.2.3. of same chapter with the exception of the Radar Simulator Course are being conducted regularly at the MTI.

The MTI is located at Powai, a suburb of Bombay and is spread over an area of forty five acres. Although some of the portions at the institute are still under construction the facilities required for conducting the courses on non-residential basis have been completed.

The academic block of the institute houses the classrooms, library, spaces for laboratories, engineering workshop and simulators. The facilities for practical training in firefighting and survival at sea techniques are available at a separate block.

The residential area consists of separate hostels for crew, petty officers, junior officers and senior officers with facilities of dining hall and recreation. These facilities will be operational soon.

8.2.2. Teaching aids:

Apart from the usual facilities of the black board, 35m.m. photo slides and overhead projector transparencies will be used for lectures. 16m.m. films on hydrostatic transmission, hydraulic fluids, directional control valves and other components will be screened. Reading material will be prepared in advance and given to the participants at the time of registration.

8.2.3. Course group structure:

The number of participants in each course will be between sixteen to twenty. The composition of the groups will be such as to have a proportionate representation of navigating and engineer officers as well as an equal distribution of the senior and junior officers.

8.4. Frequency of courses:

Following factors need to be considered for deciding the frequency of courses.

- a) The trainee population: Fleet personnel falling

under the categories to be trained in the basic and advanced courses as of April 1986 are shown in the table on the next page. It does not include the superintendents who may also be trained.

Accurate estimates of the wastages and recruitments are not possible because of the vast fluctuations in the supply and demand of the personnel. The large number of personnel will demand high frequency of courses to train them as early as possible.

b) Availability of trainees: In the absence of training reserves the trainees are to be drawn from the leave reserves. The persons who are on leave after serving on board for long duration of time show reluctance to join the training course prior to expiration of their leave. This poses a problem in getting sufficient number of trainees, especially during the situations of shortages. This is the major factor governing the frequency of the courses. As more and more persons are trained the number of eligible trainees reduces, this contributes to the reduction in the frequency of courses.

c) Availability of the physical facility: In view of the availability of adequate number of class rooms and hostel accommodations at the MTI, this factor does not influence the frequency of courses at present.

* * * * *			*
* * * * *			*
	Number of eligible officers and petty officers for		
* * * * *	training in Basic and Advanced Hydraulics		*
	as of April 1988		
* * * * *			*
	<u>Basic Course on Hydraulics (Off.)</u>		
* * * * *	Chief Officers	205	*
	Second Officers	152	
* * * * *	Third Officers	286	*
	Fourth Engineer Officers	210	
* * * * *			*
	Total number of officers	853	
* * * * *			*
	<u>Basic Course on Hydraulics (P.Os.)</u>		
* * * * *	Fitters	245	*
	Assistant Fitters	164	
* * * * *	Pumpmen	53	*
	Assistant Pumpmen	58	
* * * * *	Petty Officers Maintenance	185	*
	Total number of petty officers	705	
* * * * *			*
	<u>Advanced Course on Hydraulics</u>		
* * * * *	Chief Engineer Officers	234	*
	Second Engineer Officers	275	
* * * * *	Third Engineer Officers	167	*
	Total number of officers	676	
* * * * *			*

Giving consideration to the present training activities at the MTI and the prevailing manpower situation following frequency of courses may be feasible:

Name of the course	courses per year
Basic Course on Hydraulics (Off.)	10
Basic Course on Hydraulics (P.Os.)	8
Advanced course on Hydraulics	5

8.5. Faculty:

Two lecturers attached to the training department along with two or three experts from the allied industry will constitute the faculty for these courses.

8.5.1. Selection of the lecturers: The in-house lecturers will be selected from amongst the fleet personnel. Alternatively, one of the lecturers may be designated for this assignment from those already attached to the Training Department. Both the lecturers will be senior chief engineer officers who have had experience of serving on board ships with hydraulic machinery and preferably with hydraulic deck cranes. The selection of the new lecturer

from the fleet will be according to the normal procedure followed for the appointment of the superintendents. In this case however it will be desirable that the new incumbent has a flare for teaching.

8.5.2. Training & orientation of lecturers: After the selection and, or designation of the lecturers they will be trained by attending the following:

- 1) Course on industrial hydraulics at the Vicker's School of Hydraulics, Bombay.
- 2) Training course or seminar organised by the National Productivity council in the subject.
- 3) Visit to the works of M/s. Jessop Ltd. at Calcutta, the manufacturers of the hydraulic cranes under licence from M/s. Hagglunds of Sweden.
- 4) Course on public speaking at Bombay.

8.5.3. Responsibilities of the lecturers: The lecturers will be required to perform the following duties and will be responsible for:

- 1) Development of course reading material and handouts, updating this material as required.
- 2) Preparing their lectures, the slides and drawings as needed.
- 3) Development of hydraulic laboratory.
- 4) Sharing equal portions of lecture delivery.

- 5) Each lecturer should be able to take over the duties from the other in case of emergencies.
- 6) Evaluation of the course effectiveness and reports.
- 7) Discussions with the ships officers and technical superintendents to get the feed back on the course and to assess the needs for modifications.
- 8) Modification of the course contents as needed.
- 9) Record of trained personnel and co-ordination with the Fleet Personnel Department for nominations.
- 10) During the periods when the courses on hydraulics are not in progress, these lecturers will be involved as faculty for other technical courses.

8.5.4. Visiting lecturers: Experts from the industry will be invited to lecture during the advanced course in order to get the benefit of their expertise and experience in the field. These will include an officer from the oil industry for lecture on hydraulic fluids. Officers from Vicker's school of hydraulics. Representative of M/s. Jessops Ltd. They will be given two to three lectures at each course.

8.6. Evaluation of training:

The purpose of evaluation is to determine if the objectives set forth have been achieved or not and to take corrective actions. The evaluation requires assessment of returns on the investment in any project. The same holds good for a training project as well. In case of a training project however, it may be easy to determi-

ne the investment but the returns cannot be quantified. It takes a very long time before the benefits become evident. To assess the benefits it requires a regular and proper feed back from all the departments affected with the performance. Secondly, the performance is also influenced by factors other than training such as placement of people, environmental conditions etc.

Performance depends upon the skill repertoire of the persons. If an improvement in the knowledge and skills can be achieved by training it gives a good indication on the return on investment. But the improvement in knowledge and skills will depend upon the effectiveness of the training, that is, on the course contents and their delivery. The assessment of the course effectiveness will therefore be a good indicator of the effectiveness of the whole project.

8.6.1. Course evaluation: The evaluation of the course effectiveness will be achieved by the feed back from the trainees. This will be obtained through tests at the end of the courses. In case of the advanced course a midterm test will also be given during the course. The questionnaire will be to judge the skills of the trainees with the standard set to be achieved. If the same is not achieved, it will call for an investigation of the cause and corrective action.

The purpose of constant feedback is also to find the modifications needed in the set standards. This need may arise due to changes in the equipments, new applications, or the actual requirements of standards may have been misjudged before commencement of the training. This evaluation will be achieved through a questionnaire

after the course, informal discussions with the trainees during the course and after they have been on job after training. A valuable feedback will be available from the technical superintendents of the operations departments. This will be obtained at regular intervals.

The feedback from the participants of each course will be analysed by grouping the identical remarks, comments and suggestions together to find the majority on the addressed topics. It has to be borne in mind that the feedback from the participants is highly subjective as it is an individual's own perception and depends upon his own experience, capabilities and work situation. The rule of going by the majority is a safe and good approach but it is possible that an individual's remarks or suggestions may address an important point for improvements in the training scheme even though it is not amongst the majority of comments. Such remarks will be given due weightage and views of others will also be taken to arrive at the conclusions.

Conclusions and Recommendations

Conclusions:

The Shipping Corporation of India Ltd. had a very rapid growth in the late sixties and seventies. Within a span of fifteen years, that is, between 1965 and 1980 the number of its ships increased by 450%. Its fleet also became highly diversified with ships catering to different types of cargoes. The fast expansion contributed to shortages of personnel to man the ships. This shortage of manpower was further aggravated due to, what could be called, an exodus of trained personnel to foreign shipping companies for more attractive emoluments. Many schemes were set afoot to turn out large number of trained personnel faster. This evidently could not be achieved without compromising on the duration of training and consequently on quality.

The shortage of trained personnel contributed to very fast promotions also. This did not allow the officers sufficient service time in junior ranks, who as a result lacked experience. Obviously the lack of experience with the seniors was detrimental to the guidance and training of juniors. This was a cumulative process.

Manpower shortage coupled with technological

developments brought about automation in the ships. The ships' machinery and the control systems gradually became more sophisticated. The slump in the shipping market that followed made the commercial competition stiffer, calling for faster turnaround and putting heavy demand on the efficiency and reliability. But the equipment could only be as good as the persons who handled it. The sophisticated equipment called for improved technical skills. Unfortunately, significant importance was not given to the reinforcement of skills. Neither the training curricula at the pre-sea training institutions got upgraded nor the development of refresher training to update the skills took place at the required pace.

As was the case with the electrical and electronic systems, the hydraulic power transmission and control systems increased on all kinds of ships. Because of safety against fire and explosions the hydraulic machinery has been the only replacement for the steam machinery in hazardous areas on oil and chemical tankers. Because of its many advantages, there is no doubt that application of oil hydraulics will further increase on board ships. Amongst the many advantages of the hydraulic machinery, the primary is its reliability and simplicity. But however reliable or simple a system may be, knowledge of its working principles, procedures for operations and maintenance are vital to those who operate and maintain it. That the personnel lack the needed skills, is evident from the premature failures of the equipment, delays in operations, causes of breakdowns, etc. The performance deficiencies indicate absence of self learning process from the machinery manuals and instruction books. There are many factors such as one's own attitude, interest and compulsion to learn which

influence this process. The ships' personnel are so occupied with their day to day work that time is always short. In the situations of "no punishments and no rewards" it is an individual's interest and sincerity alone that may result in self learning. These virtues cannot be generated by someone else.

In the present situation, the only solution to develop the required skills is by way of formal training of concerned personnel in the basics of oil hydraulics and its marine applications. Training is no doubt expensive, but it is an essential investment for a continued better performance in the long run. A major breakdown or an accident is far more costly. The management of the S.C.I. has rightly recognised the need for training in this field (10).

Because of the company's policy of rotation of fleet personnel on all kinds of ships, the training in this subject cannot be restricted to a few personnel only. All the persons responsible for operations and maintenance of hydraulic equipment must have the requisite training. The requirements are different and therefore training of personnel is proposed at two levels. The best way in which a technical training can be imparted is undoubtedly one that is supported by on job training. This however, is unrealistic because of economical and practical difficulties. The next best solution is through simulated conditions and demonstrations as proposed here. Cut away models and actual components will be used to help the trainees correlate theoretical knowledge with physical identifications. A simple working model using common components is proposed to be set up at the S.C.I. Maritime Training Institute,

the venue for this training scheme.

Reccomendations:

In contrast to the increase in the extent, variety and sophistication of hydraulic machinery on board ships the training of fleet personnel in the field of industrial hydraulics i.e. oil hydraulics applicable to marine machinery, has been over due. Immediate steps should be taken for selection and orientation of the lecturers, development of course material and training aids to start this training scheme at the earliest. It is recommended that one of the lecturers should be designated from amongst those already in the training department who have undergone training in the Hagglund's crane course.

There is a great diversity in the hydraulic machinery on board different ships. In the absence of standardisation it is necessary that the training is oriented to general requirements with reference to all types of machinery on board company's ships.

A visit to a ship equipped with hydraulic cranes should be arranged, if possible, for the participants of the advanced course. This may require rescheduling the course programme.

As far as possible, the persons trained in hydraulics should be posted on ships with extensive hydraulic machinery so that the efforts of training are put to use at the earliest. This will require special attention on planning and posting.

Sincere efforts will be needed for obtaining feed back from all concerned to assess the need for modifications and the effectiveness of training.

The evaluation on the comments, suggestions and remarks should not be left to the course faculty only. These should be discussed in a committee especially constituted for this purpose. The programmes for these discussions should be planned in advance.

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WORLD MARITIME UNIVERSITY
MALMOE, SWEDEN

NAVAL ARCHITECTURE AS A SUBJECT FOR THE PROPOSED MARINE
ENGINEERING DEGREE COURSE AT THE UNIVERSITY OF MORATUWA

M J A MIRAN PERERA
SRI LANKA

A paper submitted to the Faculty of the WORLD MARITIME
UNIVERSITY in partial satisfaction of the requirement for
the award of a

MASTER OF SCIENCE DEGREE
in
MARITIME EDUCATION AND TRAINING
(Marine Engineering)

The contents of this paper refelect my own personal views
and are not necessarily endorsed by the university.

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ABSTRACT

The marine engineer who is concerned with the design or operation of machinery in ships requires some knowledge of certain aspects of naval architecture and it will be found that naval architecture is included in most courses leading to a degree or some other qualification in marine engineering.

The University of Moratuwa, Sri Lanka wishes to establish a degree course in marine engineering and to have it accredited by the Institute of Marine Engineers in the United Kingdom.

It is the feeling of the governing body of the University of Moratuwa to include naval architecture as one of the subjects in the proposed degree course.

The thesis studies the importance of the naval architecture in the proposed marine engineering degree course and its relevance to the maritime industry in Sri Lanka .

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CHAPTER 1

1.1 INTRODUCTION

If you are interested in creative work, and in the possibilities offered by the profession of engineering, you might like to consider working in the marine field, and in naval architecture in particular.

-Professor J B Caldwell

Considerable reductions in manning have been brought about by the reorganizing of shipboard operation, reduced maintenance arising from better design and improved materials, and changes in the 'hotel' arrangements on board ship. Fuel is now the major cost in the shipping operation, with manning cost being second. It is not proposed to consider fuel saving but the changes in manning and their effects will be examined in detail.

The manning of a ships has been considered in three areas; deck, engine, and catering. Any reductions in deck and engine room areas will also result in reduction in the catering staff. The introduction of self serving facilities, micro wave cooking of aeroplane type frozen meals, and similar innovation could significantly reduce or eliminate the catering department, which will not be considered further.

The deck and engine departments continue to be viewed by many as separate entities, with deck officers and

engineers seemingly evolved from different species of human beings. The training scheme for each are vastly different; deck officer cadets learn something about engineering, while engineer cadets learn nothing about navigation, seamanship, or cargo work. It is nevertheless a fact that both deck and engineer officers are becoming increasingly reliant upon machines to do their work.

Does their basic training need to be much different? Specialization could occur much later in the career and dual-licensing could be practiced at least up to second engineer and second officer level. These are not new ideas. They have been tried and once again being considered and implemented. Dual licensed offers have reduced the manning of a ship to about 14. Some obstacles to further development are statutory requirements, concern about safety, the reliability of equipment and the changes needed in the education and training organisation.

The government of Sri Lanka has given a high priority for the general education and in particular for the higher education by allocating a significant budget. With the assistance of International Maritime Organisation (IMO), the Ministry of Shipping and Trading of Sri Lanka has already secured a project at the University of Moratuwa for deck and engineer officer training courses at diploma level. In addition, the university has initiated an individual plan for a marine engineering degree course, which is scheduled to commence on January 1990.

The purpose of this paper is to provide with a feasible study of Naval Architecture, as the one of the subjects in the proposed marine engineering degree course.

CHAPTER 2

2.1 General Education System in Sri Lanka

The youngsters in Sri Lanka begin their education at the age of six in grade one and progress through to grade five in primary schools. All the students are accepted into secondary schools in the sixth grade and progress through to grade ten. The instruction media is either Sinhalese or Tamil according to their domain, family situation and religion. On completion of the academic work in grade ten, the students are prepared for the Sri Lanka General Certificate of Education (GCE) Ordinary Level examination.

The successful candidates with a minimum of six passes including at least three credits at the GCE (Ordinary Level) examination are permitted further studies in colleges for a period of two years. Followed by that is the island's most competitive, (university entrance) the GCE (Advanced Level) examination.

Annually, there are about 140,000 candidates waiting to sit for the GCE (Advanced Level) examination. The minimum entry requirement for the universities as stipulated by the University Grant Commission is four passes at the GCE (Advanced Level) examination. Of that, about 5000 students are selected on merit basis or on district basis to pursue studies in the disciplines of; engineering, medicine, accounting, law, art etc. at the following universities:

- i) University of Peradeniya
- ii) University of Colombo
- iii) University of Moratuwa
- iv) University of Kalaniya
- v) University of Sri Jayawardanapura
- vi) University of Ruhuna
- vii) University of Jaffna
- viii) University of Baticalow

Admissions to an university is through fierce competition. At least two A grade and two B grade passes are required at the GCE (Advanced Level) examination to be accepted as an engineering undergraduate or as a medical student.

- 75 <= Grade A
- 65 <= Grade B < 75
- 50 <= Grade C < 65
- 40 <= Grade S

In addition, the Open University of Sri Lanka offers variety of courses including certain deciplings of engineering. Formal entry qualifications are not required here and the employees of the government and the private sector are encouraged to pursue these courses.

2.2 The University of Moratuwa and Engineer Training

The University of Moratuwa , as it is now known, has its origins in the Ceylon Technical College, Maradana as early as 1893.

The Technician courses conducted at this college were transferred to the newly established Institute of Practical Technology (occupying the the present site of the University of Moratuwa) in 1960. This Institute was found with the aid of the Canadian Government to provide full-time courses for Architects, Junior Technical Officers, Surveyors and Levellers, and Draughtman Apprentices. In addition to these, a number of part-time courses were also provided.

The "Commission of Inquiry on Technical Education" (July 1963) recommended the expansion of facilities for professional engineering education. Since only the Faculty of Engineering of the University of Ceylon, Peradeniya provided such courses at the time, it was decided to establish the Ceylon College of Technology at Katubedda utilising the resources of the Institute of Practical Technology. Assistance for this project was provided by the United Nations Development Programme through UNESCO.

Consequently, a new courses at professional level was started at this College of Technology in 1966. The existing courses (both full-time and part-time) at former Institute were also continued by the new College. The Engineering degree and Technician programmes were

designed to have an industrial bias with the inclusion of a compulsory period of in-plant training. The University of Ceylon was instituted on the 15th February 1972 by the University of Ceylon Act No. 1 of 1972' in incorporating all the existing universities in Sri Lanka and the Ceylon College of Technology at Katubedda. The Ceylon College of Technology was named University of Ceylon, Katubedda Campus.

With Ceylon becoming a Republic, later in 1972, the University was redesignated the University of Sri Lanka. The Katubedda Campus of the University of Sri Lanka provided undergraduates courses in Engineering, Architecture and Applied Science. Facilities for Post-graduate studies are provided in Town and Country Planning, Engineering, Architecture. In addition, the Campus conducts full-time and part-time courses for middle grade engineering personnel.

Further expansion took place in the 70's and in 1978 the Katubedda Campus became independent as the University of Moratuwa with three faculties:

- i) Faculty of Engineering
- ii) Faculty of Architecture and Town and Country Planning
- iii) Faculty of Physical and Applied Science

2.2.1 Faculty of Engineering

In 1981 the Faculty of Physical and Applied Science merged with the Faculty of Engineering, whose ten departments now offer four years' duration B.Sc engineering degree courses in:

- i) Civil Engineering
- ii) Electrical Engineering
- iii) Electronics and Telecommunication Engineering
- iv) Mechanical Engineering
- v) Chemical Engineering
- vi) Materials and Mining Engineering
- vii) Mineral Engineering
- viii) Computer Engineering
- ix) Textile and Clothing Technology

Admission to the Engineering courses is based on the results of the GCE (Advanced Level) examination, where passes in Chemistry, Physics, Pure Mathematics and Applied Mathematics are required, together with pre-requisites. They are a minimum of six passes including at least **three** credit passes, obtained at GCE (Ordinary Level) Examination.

There are only 250 vacancies for engineering undergraduates at the University of Moratuwa each year. Prior to their engineering course, attendance to a three month, orientation programme and an intensive English programme are compulsory to all accepted candidates. All degree courses have a common first year programme and the instruction media is English from the first year for all courses offered by the University of Moratuwa.

The undergraduate courses in Engineering are honours courses. Students are selected for the different fields of specialisation after the first year examination. From second year onwards the undergraduates are mainly following lectures in the major streams. They are expected to complete specified number of laboratory classes streamlined with lectures, and to undertake a

total of six months in-plant training with local industry. The award of the degree is upon satisfactory completion of all the examinations, a six month in-plant training with the local industry and the final year project, which is also industrially biased.

2.2.2 Engineering Technician Division

The Engineering Technician division is also under the auspices of the Faculty of Engineering of the University of Moratuwa. It conducts the following courses for the National Diploma in Technology which is in line with the Higher National Diploma (HND) in the UK;

- i) Chemical Engineering
- ii) Civil Engineering
- iii) Electrical Engineering
- iv) Electronics and Telecommunication Engineering
- v) Mechanical Engineering (both Automobile and Production)
- vi) Marine Engineering
- vii) Nautical Studies
- viii) Polymer Technology
- ix) Textile Technology

The entry requirements to the diploma programme is three passes in the GCE (Advanced level) examination and the applicants are required to appear for an entrance examination.

The NDT Course is a three-year full-time course comprising two years of academic work in the University of Moratuwa and one year in-plant training, for middle-grade technical personnel. The National Diploma in Technology certificate

is awarded on successful completion of the course. The third year is devoted to in-plant training, in government as well as in private industrial establishments, and is managed by the National Apprentice Board.

2.2.3 The Computer Centre

The University of Moratuwa Computer Centre provides a general computing service to all students irrespective of their courses at any time of the office hours. The centre provides computing facilities for about 100 students at a time on Comorde 64, IBM PC, Radio-shack etc.. And also provides occasional courses in computer appreciation, programming and systems analysis. Further, it extends its service to other universities, and to few organizations.

2.2.4 The University Library

The university library aims to provide reading material on a wide basis as feasible. It contains some 27,000 volumes mainly relating to Science, Technology and Management. In addition, a representative selection of reading material suitable for general education and recreation is also available.

More than 200 periodicals are being currently subscribed to, including major abstracting journals. Books, Periodicals, etc., not available within the university library can be borrowed through the medium of various inter-library loan service; Such as the British library, including its overseas photocopy service.

2.2.5 Training and Employment Centre

The Training and Employment Centre of the University of Moratuwa, is responsible for organisation, supervision and assessment of in-plant training of National Diploma in Technology students and Engineering undergraduates, along with the National Apprentice Board. It also extends its service to find employments, wherever possible.

The training standards for both NDT students and engineering undergraduates are being prepared by committees with representatives from the industry, the NAB and the Ministry of Education. The Institute of Engineers, Sri Lanka gives recognition for the in-plant training provided to engineering undergraduates when they apply for Corporate Membership as part of the employment experience.

2.2.6 The UNDP Project

"Merchant Marine Training" SRL/84/039/A/01/19

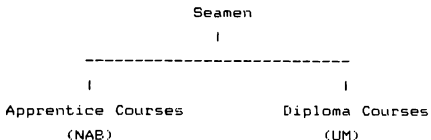
The University of Moratuwa with the assistance of International Maritime Organisation (IMO) and the Ministry of Trade and Shipping established the above two year project in January, 1987. The primary objective of the project is to establish the merchant marine training facilities in theoretical and practical training for deck officers, and its secondary objective is to upgrade the facilities for the existing marine engineering diploma course. The overall aim is to conform the standards of the courses to comply with the International Conventions of Standard Training, Certification and Watch Keeping for Seafarers (STCW 1978), and to improve productivity in national merchant marine sector by providing high quality

skilled manpower.

Support is in two parts: US\$ 1,040,000 from United Nations Development Programme (UNDP) to provide nautical and marine engineering training advisers, fellowship for the Sri Lankans to study abroad and training equipment for use in the deck officer and marine engineering officer training. The second part is a contribution by the Government of Sri Lanka and the University of Rs 14.6 million to provide new buildings, service, consumables, equipment maintenance, operating costs and the supply of technician staff.

2.3 MARINE ENGINEERING EDUCATION AND TRAINING COURSES IN SRI LANKA

The present official training system for seamen in Sri Lanka is under the administration of the National Apprentice Board (NAB) and the University of Moratuwa (UM).



2.3.1 NAB Apprentice Course

The apprentices are accepted by the NAB in the following two major streams; the craft apprentices are trained as ratings, where as the special apprentices are trained as officers. Other training facilities are provided by some shipping companies for their own purposes and requirements but these are not mainly recognised by the Ministry of Trade and Shipping.

The admission requirements are six passes in General Certificate of Education (GCE) ordinary level examination. These include science, mathematics and Sinhalese language at grade C level or above and English at grade D level or above. Only male Sri Lankan residents are considered.

	Grade A	>=	75
75	>	Grade B	>= 65
65	>	Grade C	>= 50
50	>	Grade D	>= 35

English is the language used in both training and examination. Since most of the applicants to the marine apprentice course are from general education standards with inadequate knowledge of English, the students may sometimes encounter difficulties.

The NAB special apprentice course is a four year sandwich programme. The first two years of it consist of full time attendance at heavy engineering workshops assigned by the NAB. In the third and fourth years the special apprentice have both full time tuition, advanced workshop training, and some amount of managerial training. Followed by this is the NAB final examination. Over the four year period, an apprentice must complete a guided study programme and enter the tasks undertaken in a book of the history of employment.

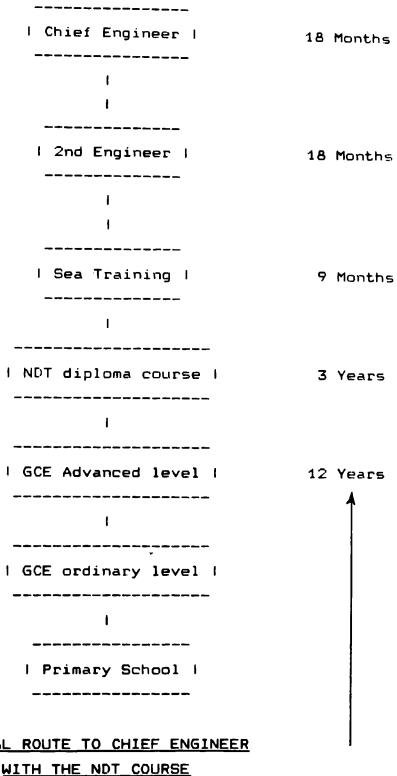
A cadet, after completion of the scheme, may embark upon a career at sea and progress through various levels of Certificate of Competency. This involves periods at sea, periods ashore undertaking preparatory courses, and subsequently end up with at Chief Engineer level.

2.3.2 The Marine Engineering Diploma Course at the University of Moratuwa

The department of Marine Engineering of the University of Moratuwa was found in 1977 to conduct Diploma courses in

marine engineering. It is a sub-department of mechanical engineering, and provides most of the nations marine engineers. Candidates from the diploma course receive a diploma in marine engineering and progress their career in a variety of ways.

On completion of the National Diploma in Technology (NDT) course in marine engineering, candidates wishing to go to sea undergo nine months sea training as engineering cadets usually on board vessels owned by the Ceylon Shipping Coporation. Thereafter, they take prescribed courses, accumulate sea experience and progress from Fifth Engineer to Chief Engineer. This sea training programme is recognised by Department of Transport, UK.



TYPICAL ROUTE TO CHIEF ENGINEER
WITH THE NDT COURSE

2.4 Mechanical Engineering Degree Course

The undergraduates assigned to the mechanical engineering department on the performance of the first year examination, and they are permitted to pursue in from second year in the major field of mechanical engineering. Thereafter, they are supposed to attend classes according to the curriculum as in the Appendix i. It is envisaged that from the second year to the fourth year the subjects offered are more convergent towards in mechanical engineering.

It is envisaged in appendix i that the mechanical engineering undergraduates are exposed to some amount of managerial experience by taking the subjects in Industrial Economics & Managements, and Industrial Engineering. On choosing the career the graduates have the opportunity of employing not only as Engineers for industries but also as Managers for enterprises, due to the overall background.

Much more emphasis also given to production engineering and automobile engineering which make our graduate to accept any mechanical engineering position irrespective of the optional subjects studied in the final year. (Appendix i)

Perhaps one of the most important features of the courses is the technical visits for about eight to ten local industries in the final year. As part of the curriculum, the students have to undertake a six month of in-plant training with the local industry after completion of

their second and third years academic work. The purpose being to provide useful practical training for each individual in order to make sure that the theoretical studies at the university are properly coupled with practical training.

The third term of the fourth year of the course, is mainly devoted to the preparatin of a written report on a selected topic that is also industrialy bias, but interwova with the theoretical knowledge gained over the four years.

CHAPTER 3

3.1 NEEDS OF THE MARITIME EDUCATION IN SRI LANKA

Over the past decade, the government of Sri Lanka has invested heavily in port development, ship building and ship repair facilities. The port of Colombo has become one of the major trans-shipment ports in the region, and the government of Sri Lanka wishes to expand its maritime industry.

A Marine Engineer who complete his recognised pre-sea training either in Sri Lanka or elsewhere embarks upon a career at sea and progress through various level of certificates of competencies. Once holding a class 1 certificate and promoted as a Chief Engineer, this officer will enjoy reasonable rewards for his efforts while remain at sea.

If however, a lifetime at sea is not that appealing, the move ashore usually results in a considerable drop in status and remuneration, and possibly even a period of unemployment. The traditional certificate of competency, while important at sea, receive little recognition of its academic and practical contents for the job ashore.

A qualified class 1 certificate holder is trained as a 'ship operator' which ensures his retention within the industry. This has resulted in mariners being ship operators with little knowledge of their industry and overemphasis on skills to the detriment of education in an academic scene.

Because the objective of the ship-officer training in Sri Lanka sea going personnel are train for the shipping companies only. There has been no formal or consistent training course in the shipping business in Sri Lanka since 1977, like charting, broking, insurance etc, which can be provided for the officers who wish to change to ashore job. The effect of the absence of these training courses will be felt in the long term rather than in the short term.

Changes have occurred to improve the academic standard of certificates of competency. Much more needs to be done. A highly qualified well trained engineer need not be lost to his industry. He may be lost to the sea but his work in a suitable post ashore will no doubt benefit the industry and probably those at sea. If the career offered more opportunities for transfer ashore with status and appropriate remuneration, then many sea going officers might well remain at sea longer, secure in the knowledge that they can come ashore when circumstances suit them.

The question of professional registration has assumed, and will continue to assume, greater importance since the Finniston inquiry into the engineering profession in 1980. Following Finniston, the engineering council was created, with a charter which empowers it to establish and maintain qualifications appropriate to the three levels of;

- i) Chartered Engineer
- ii) Technician Engineer
- iii) Engineering Technician

For each level, registration depends upon satisfying the

appropriate academic requirements, training requirements, and a period of time in a position of responsibility.

On completion of the diploma course at the University of Moratuwa or the apprentice course conducted by the NAB, the engineers hopefully end up as a Chief Engineer with a First Class Certificate of Competency. The Certificate of Competency are not, however, academic qualifications. The academic requirements for chartered status is a degree which has been accredited by an Engineering Institution (acting on the behalf of the Engineering Council). The NAB apprentice course with the certificate of competency, or the NDT course, with or without certificate of competency, is only sufficient for registration at Technician Engineer level. This means that without a degree he cannot register at the full professional level of chartered engineer with a professional institute (in this case the Institute of Marine Engineers) which, quite apart from being the cause of intense frustration, limits his career prospects ashore. It also follows that there are relatively few graduate marine engineers compared with other branches of engineering.

At the same time there has been increased opportunities for seafarers in the ashore side of the industry. Indeed, one result of the technology advanced has been to induce a transfer of jobs from ship to ashore, eg, port control or vessels traffic services. It is true that chief engineer certificates and associated experience have traditionally been the pre-requisites for the many technical positions in the port and marine authorities; but more is now required in the way of specialist knowledge and this is also influencing the direction of maritime education.

3.2 PROPOSED MARINE ENGINEERING DEGREE COURSE

Primary reasons for the establishment of marine engineering undergraduate course is for the supply of highly academically trained personnel to fulfill the needs of the maritime industry as described in chapter 3.1. A mechanical engineering undergraduate will have the option to choose his career as a mechanical or as a marine engineer. On this proposed marine engineering degree course, the governing body of the University of Moratuwa decided to offer only one subject in the third year, and three subjects in the fourth year as optionals (in chapter 3.2.1) within the existing mechanical engineering programme, and the curriculum would be kept under review for the needs of the maritime industry.

The aim of the University of Moratuwa is to have accredited the proposed marine engineering degree course by the Institute of Marine Engineers, UK and to cater the highest qualified chartered status engineers to the maritime industry in Sri Lanka.

In the accreditation process the course must be satisfy the following;

- relevant to the needs of industry and contain inputs from it
- be taught with application bias
- be formulated after discussion with industry
- contain element of administration and management practice
- contain element, involving practical experience in the fabrication, properties and use of materials

3.2.1 COURSE STRUCTURE

WEEKLY LOADING HOURS; *An academic year has 35 weeks*

FIRST YEAR

<i>Subject</i>	<i>Dept</i>	<i>Lec</i>	<i>Tut</i>	<i>Lab</i>
Mathematics I	MA	2	1	-
Mathematics II	MA	2	1	-
Physics	EE	3	1	1.5
Engineering Chemistry	CH	3	1	1.5
Building Construction	CE	1	-	2
Surveying	CE	1	-	1.5
Engineering Drawing	ME	1	-	5
Workshop Technology	ME	1	-	4
English	EN	2	-	-

SECOND YEAR (PART I)

<i>Subject</i>	<i>Dept</i>	<i>Lec</i>	<i>Tut</i>	<i>Lab</i>
Mathematics	MA	2	1	-
Strength of Materials	CE	2	1	1.5
Fluid Mechanics	CE	2	1	1.5
Theory of Electricity	EE	2	1	1.5
Applied Thermodynamics	ME	2	1	1.5
Engineering Mechanics	ME	2	1	1.5
Production Technology	ME	2	-	1.5
Machine Element and Design	ME	2	-	3

*Key to the department codes are in appendix i

THIRD YEAR (PART II)

<i>Subject</i>	<i>Dept</i>	<i>Lec</i>	<i>Tut</i>	<i>Lab</i>
Mathematics	MA	3	1	-
Industrial Economics and Management	ME	2	-	-
Strength of Materials	CE	2	1	1.5
Fluid Mechanics	CE	2	1	1.5
Applied Thermodynamics	ME	2	0.5	1.5
Electrical Technology	EE	2	0.5	1.5
Machine of Mechanics & Control Systems	ME	2	1	1.5
Naval Architecture I and Marine Engineering I	MR	2	1	1.5
Design of Machine Elements	ME	-	-	3

FOURTH YEAR (PART II)

<i>Subjects</i>	<i>Dept</i>	<i>Lec</i>	<i>Tut</i>	<i>Lab</i>
Industrial Economics and Management	ME	3	-	-
Industrial Engineering	ME	2	1	-
Marine Structures	MR	2	1	1.5
Naval Architecture II	MR	3	1	-
Marine Engineering II Project	MR	2	1	3

and ONE of the following options

Applied Thermodynamics	ME	2	1	3
Fluid and lubrication	ME	2	1	1.5

3.2.2 Justification of the Course

Ships are becoming more automated and computerised. They can not be operated and maintained with untrained personnel without proper understanding of technology. Therefore, It is a timely and far-sighted decision to establish a marine engineering degree programme at the University of Moratuwa.

Shore based jobs are becoming more available. They have to be employed with personnel with suitable educational and technical background. Over the past mariners have been trained from the scratch called the hose piped system. It has become a burden to the maritime industry with the fast development of the technology. The existing mariners can not specify the situation. It is the hope of the Ministry of Shipping, the industries and the University of Moratuwa that the proposed marine engineering programme will cater the undergraduates with adequate qualification.

Looking at the foreseeable future, it is contravertial statement among the mariners, whether these graduates will fulfil the demands of the maritime industry, and whether all the successful graduates can be absorbed by the existing maritime based industries. As primary objectives, the governing body of the University of Moratuwa already agreed to offer a marine engineering programme bias with the existing mechanical engineering programme. The proposed programme will be updated according to the needs of the industry, and the marine engineering graduates will have the opportunity to choose their career as a mechanical engineer or as a marine engineer.

The guidance and advice are always obtained by recognised universities such as The University of New Castle, UK. The University of Moratuwa is having close link with the maritime industry. The assistance is received from the industry as visiting lectures. The permanent staff members have doctoral degrees from the University of New Castle, and are qualified enough to carry out the proposed course.

As the By-Laws of the University of Moratuwa, and to have in-line with other degree courses, the marine engineering undergraduates should undertake a six month in-plant training with the local industry given in chapter 4.5 . This training period also will count as work experience (chapter 5.1.1) when they apply for the cooperative membership at the Institute of Marine Engineers.

The mechanical engineering degree from the University of Moratuwa is well accepted by the local industry. The subjects, Industrial Engineering and Industrial Economics and Managements will put our graduates at better position not only as engineers but also as managers. One of the requirements of the IMarE for cooperative membership is to engage in managerial position, that will be supported by these subjects to carry-out their managerial work with a sound knowledge.

CHAPTER 4

4.1 IMPORTANCE OF NAVAL ARCHITECTURE IN THE PROPOSED DEGREE COURSE

Ships are used for the purpose of carrying men, material, and/or weapons upon the sea. In order to accomplish its mission, a ship must possess several basic characteristics. It must float in a stable upright position, move with sufficient speed, be able to manoeuvre at sea and its restricted waters, and be strong enough to withstand the rigors of heavy weather and wave impact. To manoeuvre a ship with these features, the marine engineer must have an understanding of a ship dynamics.

With a simple knowledge of hydrostatics a marine engineer can maneuver a ship that will float upright in calm waters. However, ships rarely sail in calm water. Waves, which are the main source of ship motions in a seaway, affects the performance of a ship considerably and the success of a voyage depends ultimately on its performance in seaway. Unfortunately, however, the prediction of a ship motions, resistance and power, and structural loads in an actual seaway is such a complex problem that the marine engineer is usually forced to select on the basis of calm water performance without much consideration of the sea and weather conditions prevailing over the route on which the ship is to operate.

In the maneuvering of ships, speed is an important factor. However, there is a loss of speed while a vessel

is an under way in a sea, because of the increase in the motion resistance and loss of propellar efficiency. This results in higher fuel consumptions and there by reduce the crusing range. The heavier the seaway, the greater is the loss of speed. To overcome this loss it is often necessary to improve the resistance and propulsion characteristics of the vessels, as well as to select the machinery plant for adequate reserve power. The model tests can predict with reasonable accuracy the still water resistance and propulsion performance of a ship.

The relative importance of various aspects of ship performance in a sea way vary from ship to ship, depending on the what the operators require of the ship. The following general items must be investigated when manuvering the ship seaworthy.

- a) Excessive motions, which are undesirable since they may impair stability and cause discomfort to the crew and passengers. Also in warships, most weapon systems require a stable platform for proper funtioning.
- b) Additional stresses caused by the ship's bending or by wave impact in a seaway.
- c) Internal forces causing damages to the equipment, armament structurrs, and so forth
- d) Shipping and spraying of green water, causing equipment breakdown and degradation of the liability.
- e) Slamming
- f) Speed reduction and the conditions underwhich the propeller will start racing, thereby overloading the propeller machinery and hence increasing the fuel consumption or dropping off the crusing range.

The various problems encountered in regard to ship motion may be investigated in four different ways:

1. Analytically, that is on a theoretical basis
2. Experimentally, by means of model tests in controlled environments
3. Emperically, through stastical observations
4. Directly, as with trials of ships after they are built

Both theoretical and experimental studies help the marine engineers to dertermine the influences of various ship features on seakeeping characteristic, knowledge that is extremely valuable in manoeuvring a ship. Therefore one of the most important study in naval architecture is the investigation of ship performance in rough water. Both merchant and naval vessels must maintain a high degree of seakeeping quality in many different types of weather and still attain their mission - the merchant ship in the commercial point of view, and the naval vessel with regard to the optimum operational ability. Theoretical studies, model results, and full scale data are all necessary to provide reliable criteria.

In recent years, research on ship motion has made considerable advances in the area of theoretical development, as well as in experimental facilities. However no quantitative index has yet been found to compare the seakeeping quantities of ship, as if possible in comparing the resistance or propulsion characteristics of hull form with another, by means of simple coefficient.

The introduction of advanced marine vehicles, such as planing crafts, hydrofoil boats, and air cushion vehicles

has necessitated further studies in seakeeping in order to achieve the maximum results from the special vehicles. Intensive investigation are now underway to determine experimentally the effects of parametric variations in motions, bottom pressures, and power requirements on models of planning boats, surface effects ships (SEEs), and so on. In addition, scale effect studies on high performance vessels are being looked into to correlate test results from models of different scale and full scale trials.

(With the knowledge of naval architecture a marine engineer would be able to engage in the development of technology for measuring, predicting, and improving the various quantities that governs ship dynamics. This also includes the application of this technology to specific design, the identifications of design faults, and correction and improvement of such designs. The specific will depend on the particular design, but it is essential that the marine engineer have some means of judging the expected formance.

4.1.1 Relavance to the Maritime Industry

The development of the industry is from sail boats to motor ship as other maritime nations. Presently the Port of Colombo has become the major trans-shipment port in the region, serving ports in India, Bangladesh, Burma, Thailand and Malasiya. The fleet strength of Sri Lanka is growing larger, and the private establishments are getting into the business at a good pace. The vessels approaching the Port of Colombo are versatile, from bulk carries to newly built reefer container ships.

The government of Sri Lanka has eight container ships under the administration of Ceylon Shipping Coporation that dominates the island owned vessels.

NAME OF VESSEL	DWT	YEAR BUILT
1. M V Lanka Siri	3831	1981
2. M V Lanka Seedevevi	3831	1981
3. M V Lanka Srimathi	9700	1982
4. M V Lanka Srimani	9700	1982
5. M V Lanka Muditha	3000	1982
6. M V Lanka Mahapola	10325	1983
7. M V Lanka Athula	10600	1983
8. M V Lanka Ajitha	10600	1985

Apart from the vessels owned by the Sri Lankan enterprises, there are 62 foreign vessels under the Sri Lankan shipping registry. It is agreed with the foreign shipping owners to recruit fifty percent of the Sri Lanlan crew for their vessels. The proposed marine engineering course will able to satisfy the demands of

the foreign vessels aside from the local need, offering a sound theoretical and technical knowledge to the graduates. This hopefully will pave the way to the our graduates to employ on foreign vessels with higher remuneration.

In view of the new container terminal at the Port of Colombo, it is enlightening that the expansion is taking place in berthing facilities as well as in warehouses. A neumerious offdeck container freight station are operated by various private sector organisation that handle all inland container transpotation.

Colombo Dockyard Limited, the island largest docking facility is capable of offering its service to any type of ship under 100,000 dwt that approaching the Port of Colombo. With the knowledge of naval architecture, the graduate will complement to enhance the facilities and efficiency, and more of the small craft could be able to built at the Colombo Dock Yard.

Sri Lankan Navy has taken steps to enhance the naval strength. To make it reality, expansion in the petroal craft ought to be done, and technicaly qualified personnel have to be recruited. all the academic and technical reuirements for the navy could be satisfied by the proposed course.

The government of Sri Lanka has given a high priority to the fishing industry. The Ministry of Fishing is taking care of the local fishmen who are dominating the costal area. The fishing boat building is one of the small scale developing industies in Sri Lanka. Unfortunately, this industry is heavily depend on the foreign advice due to

the very fact of unqualified personnel.

It is the intention of the University of Moratuwa, with the inclusion of naval architecture to the proposed course to cater the industry by supplying well qualified personnel to this fastly developing fishing world.

4.2 PROPOSED SYLLABUS OF THE MARINE ENGINEERING UNDERGRADUATE COURSE

4.2.1 PROPOSED SYLLABUS FOR THE THIRD YEAR

1. Basics of Naval Architecture

- 1.1 Ship and Naval Architecture**
- 1.2 Hull form, lines, fairing**

2. Hydrostatics

- 2.1 Coefficients**
- 2.2 Flotation, stability, metacentre**
- 2.3 GM, GZ, righting moments**
- 2.4 KG, weight transactions**
- 2.5 Small angle heel, inclining experiment**
- 2.6 Suspended weights, free surface**
- 2.7 Form and initial stability**

3. Stability

- 3.1 Stability at large angle of heel**
- 3.2 Cross curves, statical stability curve**
- 3.3 Heeling moments, weights, wind, turning**
- 3.4 Criteria of adequate stability**
- 3.5 Longitudinal stability and trim**
 - 3.5.1 Movement of small masses**
 - 3.5.2 Use of MCTC**
- 3.6 Cargo handling effects on trim**
- 3.7 large weight trim effects**
- 3.8 Stability curves and trim**

4. Flooding

- 4.1 Flooding and subdivision**

- 4.2. Calculation of draught after damage
 - 4.2.1 Lost buoyancy method
 - 4.2.2 added weight method
- 4.3 Damaged stability
- 4.4 Probability of survival
- 4.5 Curves of floodable length
- 4.6 Permeability

4.2.2 PROPOSED SYLLABUS FOR THE FOURTH YEAR

1. RESISTANCE

- 1.1 Introduction
- 1.2 Composition of Resistance
- 1.3 Frictional Resistance
 - 1.3.1 Frictional resistance formula for a flat plate
 - 1.3.2 Density and kinematic viscosity
 - 1.3.3 Wetted surface area
 - 1.3.4 Equivalent flat plate
 - 1.3.5 Comment on frictional resistance
- 1.4 Residual Resistance
 - 1.4.1 The Froude's similarity law
 - 1.4.2 Viscous pressure resistance
- 1.5 Tank Test
 - 1.5.1 Analysis of the test
 - 1.5.2 frictional resistance
 - 1.5.3 Roughness correction
- 1.6 Estimation of Residual Resistance
 - 1.6.1 Taylor charts
 - 1.6.2 Yamagata charts
- 1.7 Effective Horse Power EHP

2. PROPULSION

- 2.1 Propeller
 - 2.1.1 Structur and geometry
- 2.2 Performance Characteristics
 - 2.2.1 Generation of force by propeller
 - 2.2.2 Propeller characteristics
- 2.3 Intraction of Propeller with Hull
 - 2.3.1 Wake
 - 2.3.2 Thrust deduction

- 2.3.3 Relative rotative efficiency
- 2.4 Estimation Methods of Self-Propulsion Factors
 - 2.4.1 Self-prpulsion test
 - 2.4.2 Approximate method
 - 2.4.3 Scale effect
- 3. POWERING
 - 3.1 Powers
 - 3.2 Powering
 - 3.2.1 Summary of efficiencies
 - 3.2.2 Variation of BHP
 - 3.2.3 Power curve
 - 3.2.4 Sea margin
- 4. DESIGN OF PROPELLER
 - 4.1 Propeller Design
 - 4.2 Change of Power due to the Propeller Diameter
 - 4.3 Propeller Design Chart
 - 4.3.1 Usage of the chart
- 5. CAVITATION
 - 5.1 Cavitation Phenomenon
 - 5.1.1 Physical explanation
 - 5.1.2 cavitation Tunnel
 - 5.2 Effect and Prevention of Cavitation
 - 5.2.1 Effect of cavitation
 - 5.3 Prediction of Cavitation
 - 5.3.1 Cavitation number
 - 5.3.2 Prediction method

4.2.3 Justification of the Syllabus

The work of the proposed marine engineering degree programme with Naval architecture as one of the subjects will be directed towards the preparation of undergraduates for a career involving ships and shipping, or other marine activities. The common theme in all this work are the sea and the ways in which naval architecture can be used for the marine purposes. The proposed undergraduate course recognises that this general area of interest embraces a variety of professional work:

1. design of ships or other marine vehicles
2. construction involving modern management and production methods
3. operation both of fleets and individuals units
4. Research involving scientific investigation of problems in all these areas.

With the inclusion of naval architecture as a subject in the proposed degree course, the undergraduates will be able to achieve the following;

- i) A knowledge that is concerned with the design and operation of machinery in ships
- ii) A knowledge about ship resistance and propulsion which is the main interest of marine engineering
- iii) A knowledge about ship design and calculation of stability and trim, ship motion and structural strength with emphasis on computerized application of such applicable

4.3 LIBRARY FACILITIES

4.3.1 List of Recommended Periodicals

1. Journal of Ship Research	USA
2. Royal Institute of Naval Architects	UK
3. Marine Engineers Review	UK
4. Holland Ship Buliding	Netherlands
5. Institution of Engineers and Shipbuilders	Scotland
6. International Shipbuilding Progress	USA
7. Society of Naval Architecture	Korea
8. Journal of Sound and Vibration	UK
9. North East Coast Institute of Engineers & Shipbulders	UK
10. Society of Naval Architecture	Japan
11. Naval Engineers	USA
12. Shipyard Bulletin	USA
13. Shipyard Weekly	USA
14. Naval Engineers	UK
15. New Construction (shipbuilding)	UK
16. Ship & Boat Builders	UK

4.3.2 List of Recommended Books

Principles of Naval Architecture	J P Comstock
Naval Architecture for Marine Engineers	W Muckle
Practical Solution of Torsional Vibration Problems, 5 vols	W Ker Wilson
Speed and Power of Ships	D W Taylor
Open Water Tests Seires with Modern Propoller forms	L Troost
Three Bladed Propellers	L Troost
Two and Five Bladed Propellers	L Troost
Development in Propeller Design and manufacture for merchant ships	L C Burrill
The effect of cavitation on the intera. propeller and ship's hull	J D Van Manen
Resistance of flat surfaces moving through a fluid	K E Schoenhee
Ship wave resistance	W C S Wigley
Theory of ship waves and resistance	T H Havelock
Dynamics of Marine Engineering Vehicles	R Bhattacharyya
Hydro Elasticity	R E D Bishop
What is a Classification Socity	Bureau Veritas
Mechanics of marine Vehicles	B R Clayton
Introduction to Naval Architecture	T C Gillmer
Element of Ship Design	R Munro-Smith
Basic Ship Theory	K J Rawson
Ship Design and Construction	The Soc. Nav Arch & Mar Eng.
Know your own ship	W Thomas
Dictionary of Ship types	A Dudzszus

4.4 PROPOSED ASSIGNMENTS, EXPERIMENTS AND PROJECTS

4.4.1 ASSIGNMENTS*(Complementary programmes are in Appendix ii)*

1. Storing of Ship Data on a file
2. Calculations of Water Plane Area and Centre of Flotation
3. Calculation of Cross Section Area and Immersed Volume
4. Plotting on the Computer Screen
 - i) Water Planes
 - ii) Cross Sections
5. Usage of Plotter for
 - i) Water Planes
 - ii) Cross Sections

4.4.2 Laboratory Experiments

1. Theory of model testing
2. Hull form and standard series
3. Resistance experiments comparing actual tests with standards series(60)
4. Selections of Propellers

4.4.3 Final Year Project

For the fulfilment of the course it is necessary to write a thesis with collaboration with a local industry to their requirements.

4.5 INDUSTRIAL TRAINING

As the policies of the University of Moratuwa, it is a requirement to undergo a six month in-plant training at a recognised heavy engineering workshop. It is followed by at the end of second and third years' academic work.

The following workshops are already agreed to give their support and facilities to train our undergraduates.

- a. **Ceylon Shipping Cooperation** now already provides the training facilities for the NDT diplomates and the mechanical engineering undergraduates, supported to extend their facilities to the proposed marine engineering course.
- b. **Ports Authority of Sri Lanka** is under the expansion in their container handling facilities for the two years. It is also agreed to provide the training facilities and to support our undergraduates to train in their own staff training institute which is meant for training at all levels in port operation and managements.
- c. **Ceylon Dock Yard Ltd.** is also already agreed to offer the training facilities to our graduates with much more emphasis on heavy engineering workshops.

4.6 STAFF TRAINING REQUIREMENTS

The Marine Engineering division is a sub-department within the present Mechanical Engineering Department at the University of Moratuwa.

The staff members are required to hold a postgraduate degree achieved by at least two years of research for promotion from the assistant lecturer to the lecturer grade. Assistance lecturers are provided the facility to pursue their postgraduates work mostly in overseas universities.

Presently, marine engineering division is under the supervision of two lecturers who hold doctoral degrees from the University of Newcastle and three assistant lecturers who are now at the following universities, expecting to complete their studies;

- | | |
|----------------------------------|---------|
| i. Oregan State Univ., USA | Oct, 88 |
| ii. World Maritime Univ., Sweden | Dec, 88 |
| iii. Univ. of Newcastle, UK | Sep, 89 |

Marine engineering division is offering diploma courses in marine engineering and nautical sciences. In certain areas expertise will not be available in Moratuwa for some years pending the return of seconded staff. To avoid this situation, the university is presently employed a few visiting lectures from Ceylon Shipping Cooperation and other marine oriented establishments.

It is envisaged that marine engineering division is sufficient with marine engineering lectures though it

does not have a qualified staff member in Naval Architecture. It is also proposed that at least one staff member should attain a doctorial degree in Naval Architecture.

The course is constantly being reviewed and revalidated in-line with the university policy and the needs of the maritime industry. Staff maintain close link with industry and many undertake industrial attachments to remain abreast of changes. Staff are either former sea-going officers who hold First Class certificates, or academics who hold doctorial degrees. The subject material is constantly updated, laboratory work deals with the latest equipment, projects are sometimes research related and often embrace the industry rather than simply theoretical orienterd. The development in the other countries is observed and drawn upon to improve what is done in Sri Lanka.

4.7 ROLE OF THE GRADUATE IN INDUSTRY

The maritime industry is developing as fast as electronics. It is appreciated that in order to remain competitive, new technology must be used to modernise the design and to manufacture the process and has sustained a healthy demand for well-qualified and innovative mariners.

It is already time for Agents, acting on the behalf of the the Classification Societies to recruit directly from universities because their traditional source of industry trained surveyors has dried up. There is chronic shortage of well qualified personnels in the maritime industry with a sound educational background and with a few years of relevant experience.

With the inclusion of naval architecture as one of the subjects in the proposed degree course, our graduates will have the opportunity to embark upon a well paid interesting jobs. For example; .

1. **The Colombo Dock Yard Ltd.** will employ graduates on design(as naval architects), or in production or management.
2. **The maritime related industries** associated with the design, construction and operation of marine craft and structures.
3. **Shipping companies** for technical and operational departments.

4. There are good opportunities for surveyors or research work with **Agents for Classification Societies or the Ministry of Trade and Shipping** that are concerned with the safety and integrity of ships and other marine systems.
5. **Ministry of Defence** is already willing to employ graduates for their design, technical and management work.
6. A small number of graduates will take **teaching** as their career with the intention to further education and research work.

CHAPTER 5

5.1 CONCLUSIONS AND RECOMMENDATIONS

The initiative by the University of Moratuwa to establish a degree course in marine engineering is timely and far-sighted. The focus of ship building and marine engineering is moving to the developing world in the Far East and the establishment of this course will provide professional calibre engineers in a field in which the Government of Sri Lanka anticipates expansion to become a regional centre.

As the need for the subject of the naval Architecture in the proposed marine engineering course in the University of Moratuwa is clearly defined in this research on the chapter 4.1.1, 4.2.1 and 4.7. The author can therefore conclude that there is a strong need for it and its inclusion in the syllabus. Such inclusion will further enrich the course content for the benefit of the high quality of instruction, which in turn benefit the students in particular, and the Sri Lankan industry.

5.1.1 Follow up by the University of Moratuwa

- a. The Author recommends that the inclusion of the subject Naval Architecture to be approved and supported by the policy making body of the University of Moratuwa.
- b. A letter of intent to prepare a course for submission through I.Mar.E. to satisfy stage 1 requirement for registration at the Chartered level should be sent to

Professor J C Levy, OBE, Director of Engineering Profession, The Engineering Council, 10 Maltravers St, London, WC 2R 3Er, UK.

- c. Continue the necessary action with IMarE to give recognition for the in-plant training undertaken by the engineering undergraduates, when they apply for coporative membership.
- d. Proceed with the syllabus design and submission for accreditation along guidelines as discussed, with a target date of January 1990 for the course to be offered as a third year option.
- e. Certain areas of expertise will not be available in Moratuwa for some years pending the return of seconded staff, in which case the secondment of Newcastle staff for teaching or as consultants in the installation and commissioning of the ship model towing tank, would be desirable.
- f. It is also required that the staff member should attain a Ph.D in Naval Architecture, as other staff members having their doctorial in marine engineering.
- g. Make necessary arrangements with the University of Peradeniya to use their towing tank for experiments of our undergraduates.

Appendix 1

MECHANICAL ENGINEERING PROGRAMME; WEEKLY LOADING HOURS

Each academic year consists of 35 working weeks

FIRST YEAR

<i>Subject</i>	<i>Dept</i>	<i>Lec</i>	<i>Tut</i>	<i>Lab</i>
Mathematics I	MA	2	1	-
Mathematics II	MA	2	1	-
Physics	EE	3	1	1.5
Engineering Chemistry	CH	3	1	1.5
Building Construction	CE	1	-	2
Surveying	CE	1	-	1.5
Engineering Drawing	ME	1	-	5
Workshop Technology	ME	1	-	4
English	EN	2	-	-

SECOND YEAR (PART I)

<i>Subject</i>	<i>Dept</i>	<i>Lec</i>	<i>Tut</i>	<i>Lab</i>
Mathematics	MA	2	1	-
Strength of Materials	CE	2	1	1.5
Fluid Mechanics	CE	2	1	1.5
Theory of Electricity	EE	2	1	1.5
Applied Thermodynamics	ME	2	1	1.5
Engineering Mechanics	ME	2	1	1.5
Production Technology	ME	2	-	1.5
Machine Element and Design	ME	2	-	3

THIRD YEAR (PART II)

<i>Subject</i>	<i>Dept</i>	<i>Lec</i>	<i>Tut</i>	<i>Lab</i>
Mathematics	MA	3	1	-
Industrial Economics and Management	ME	2	-	-
Strength of Materials	CE	2	1	1.5
Fluid Mechanics	CE	2	1	1.5
Applied Thermodynamics	ME	2	0.5	1.5
Electrical Technology	EE	2	0.5	1.5
Machine of Mechanics & Control Systems	ME	2	1	1.5
Production Engineering	ME	2	1	1.5
Design of Machine Elements	ME	-	-	3

FOURTH YEAR (PART III)

<i>Subjects</i>	<i>Dept</i>	<i>Lec</i>	<i>Tut</i>	<i>Lab</i>
Industrial Economics and Management	ME	3	-	-
Industrial Engineering	ME	2	1	-
Mechanics of Solids Project	ME	2	1	1.5

and THREE of the following options

Mathematics	ME	3	1	-
Applied Thermodynamics	ME	2	1	3
Automobile Engineering	ME	2	1	3
Fluid and lubrication	ME	2	1	1.5

KEY TO THE DEPARTMENT CODES

MA - Mathematics
EN - English
CH - Chemical Engineering
EE - Electrical Engineering
CE - Civil Engineering
ME - Mechanical Engineering
MR - Marine Engineering

```

; CLS
0 REM EXAMPLE 01
10 REM STORING OFFSETS
10 DIM H(7,13)
10 OPEN "E01.DAT" FOR OUTPUT AS #1
10 FOR I=1 TO 7
10 FOR J=1 TO 13
10 READ H(I,J)
10 PRINT #1,H(I,J)
10 PRINT
00 NEXT J
10 NEXT I
20 CLOSE
25 CLS
30 OPEN "E01.DAT" FOR INPUT AS #1
40 FOR I=1 TO 7
50 FOR J=1 TO 13
60 INPUT #1,H(I,J)
65 PRINT USING "###.###";H(I,J);
70 NEXT J
75 PRINT :FRINT
80 NEXT I
90 CLOSE
70 DATA 0, 0, 0,1.111,3.392,6.224,7.110,5.331,
2.291,0.580, 0, 0, 0
80 DATA 0,0.691,1.520,3.762,6.782,8.672,9.062,8.311,
6.022,3.411,1.711,1.111,0.760
90 DATA 0,0.842,1.942,4.823,7.814,9.271,9.463,8.922,
6.902,4.192,1.990,1.200,0.671
00 DATA 0,1.071,2.802,6.544,8.923,9.500,9.500,9.291,
7.711,4.942,2.122,1.000,0.250
10 DATA 0,2.172,4.523,7.945,9.364,9.500,9.500,9.412,
8.172,5.460,2.311,1.000,0.060
20 DATA 2.132,4.464,6.434,8.911,9.491,9.500,9.500,9.462,
8.510,6.040,2.762,1.200,0.111
30 DATA 4.250,6.321,7.822,9.333,9.500,9.500,9.500,9.500,
8.811,6.741,3.580,1.900,0.432

```

1. STORING SHIP DATA ON A FILE

```

10 REM EXAMPLE 02
20 REM CALCULATION OF WATER PLANE AREA
30 REM CENTRE OF FLOTATION
40 REM Cw
50 CLS
60 DIM H(7,13)
70 FOR I=1 TO 7
80 FOR J=1 TO 13
90 READ H(I,J)
100 NEXT J
110 NEXT I
120 INPUT "Water Line Number";N
130 INPUT "LENGTH OF SHIP";L
140 FOR I=1 TO 7
150 LET WA(I)=2*L/30*(.5*(H(I,1)+H(I,13))+2*(H(I,2)+
H(I,5)+H(I,7)+H(I,9)+H(I,12))+1.5*(H(I,3)+H(I,11))+
4*(H(I,4)+H(I,6)+H(I,8)+H(I,10)))
160 LET M(I)=2*(L/10)^2/3*(2.5*(H(I,1)-H(I,13))+
9*(H(I,2)-H(I,12))+6*(H(I,3)-H(I,11))+12*(H(I,4)-H(I,10))+
4*(H(I,5)+H(I,6)-H(I,8)-H(I,9)))
170 NEXT I
180 IF N>2 THEN X=1.5 ELSE X=.5
190 IF N>6 THEN Y=2 ELSE Y=1
200 PRINT
210 FOR I=1 TO N STEP 2
220 IF I=0 OR I=1 THEN W=I+1 ELSE W=I/2+2
230 PRINT USING "WA(##) = ";I;
240 PRINT USING "####";WA(W);
250 PRINT TAB(22)
260 LET CF(W)=M(W)/WA(W)
270 PRINT USING "CF(##) = ";I;
280 PRINT USING "#.###";CF(W);
290 PRINT TAB(44)
300 PRINT USING "CW(##) = ";I;
310 PRINT USING "#.###";WA(W)/2/L/H(7,6)
320 IF I=0 OR I=1 THEN I=I+1:GOTO 220
330 NEXT
340 DATA 0, 0, 0,1.111,3.392,6.224,7.110,5.331,
2.291,0.580, 0, 0, 0
350 DATA 0,0.691,1.520,3.762,6.782,8.672,9.062,8.311,
6.022,3.411,1.711,1.111,0.760
360 DATA 0,0.842,1.942,4.823,7.814,9.271,9.463,8.922,
6.902,4.192,1.990,1.200,0.671
370 DATA 0,1.071,2.802,6.544,8.923,9.500,9.500,9.291,
7.711,4.942,2.122,1.000,0.250
380 DATA 0,2.172,4.523,7.945,9.364,9.500,9.500,9.412,
8.172,5.460,2.311,1.000,0.060
390 DATA 2.132,4.464,6.434,8.911,9.491,9.500,9.500,9.462,
8.510,6.040,2.762,1.200,0.111
400 DATA 4.250,6.321,7.822,9.333,9.500,9.500,9.500,
8.811,6.741,3.580,1.900,0.432

```

2. CALCULATION OF WATER PLANE AREA AND CENTRE OF FLOTATION

```

0 REM example_03
0 REM CALCULATION OF CROSS SECTION AREA
05 REM IMMERSED VOLUME
0 DIM H(7,13)
0 DIM S(13)
0 L=150
0 OPEN "E01.DAT" FOR INPUT AS #1
0 FOR I=1 TO 7
0 FOR J=1 TO 13
0 INPUT #1,H(I,J)
00 NEXT J
10 NEXT I
20 CLOSE
30 FOR J=1 TO 13
40 LET S(J)=4/3*(.5*H(1,J)+2*H(2,J)+Y*H(5,J)+
X*H(3,J)+4*(H(4,J)+H(6,J))+H(7,J))
50 NEXT J
60 LET MA=(L/10)^2/3*(2.5*(S(1)-S(13))+9*(S(2)-S(12))+
6*(S(3)-S(11))+12*(S(4)-S(10))+4*(S(5)+S(6)-S(8)-S(9)))
70 LET V=2*L/30*(.5*(S(1)+S(13))+2*(S(2)+S(5)+S(7)+S(9)+S(12))+
1.5*(S(3)+S(12))+4*(S(4)+S(6)+S(8)+S(10)))
80 CLS
90 PRINT
00 FOR J=1 TO 13
10 B=J
20 IF J=1 THEN B=0
30 IF J=2 THEN B=.5
40 IF J=12 THEN B=9.5
50 IF J=13 THEN B=10
60 PRINT USING "SA(##.##) = ";B;
70 PRINT USING "###.##";S(J)
80 NEXT
90 PRINT
00 PRINT "VOLUME = ";INT(V);
10 PRINT TAB(30)
20 PRINT USING "L C B = #.####";MA/V

```

3. CALCULATION OF CROSS SECTION AREA AND IMMERSED VOLUME

```

10 REM EXAMPLE EX05
20 REM WATER PLANE CURVES ON THE SCREEN
30 DIM H(7,13)
40 OPEN "E01.DAT" FOR INPUT AS #1
50 FOR I=1 TO 7
60 FOR J=1 TO 13
70 INPUT #1,H(I,J)
80 NEXT J
90 NEXT I
95 CLOSE
100 CLS
110 SCREEN 9,0
120 LINE (320,0)-(320,320)
130 FOR J=1 TO 13
140 FOR I=1 TO 5 STEP 2
150 IF I=1 THEN F=1 ELSE F=2
160 P=(H(I+2,J)-2*H(I+1,J)+H(I,J))/2/F/F
170 Q=(H(I+2,J)-H(I,J))/2/F
180 R=H(I+1,J)
190 IF I=5 THEN I=7
200 IF I=1 THEN B=I-1 ELSE E=I+3
210 IF I>1 THEN B=E-4 ELSE E=I+1
220 C=(B+E)/2
230 FOR Y=B TO E STEP .1
240 Z=Y+.1
250 J1=P*(Y-C)^2+Q*(Y-C)+R
260 J2=P*(Z-C)^2+Q*(Z-C)+R
270 IF J>7 GOTO 290
280 LINE (320+20*J1,300-20*Y)-(320+20*J2,300-20*Z):GOTO 300
290 LINE (320-20*J1,300-20*Y)-(320-20*J2,300-20*Z)
300 NEXT
310 NEXT
320 NEXT

```

4.1 WATER PLANE CURVES ON THE SCREEN

```

00 REM EX06
00 REM CROSS SECTION CURVES ON THE SCREEN
00 DIM H(7,13)
00 OPEN "E01.DAT" FOR INPUT AS #1
00 FOR I= 1 TO 7
00 FOR J= 1 TO 13
00 INPUT #1,H(I,J)
00 NEXT J
00 NEXT I
00 CLOSE
10 CLS
20 SCREEN 9,0
30 FOR I=1 TO 7
40 FOR J=1 TO 11 STEP 2
50 IF J=1 OR J=11 THEN F=.5 ELSE F=1
60 IF J=11 THEN A=9:E=A+1:GOTO 190
70 IF J=1 THEN A=0:E=A+1:GOTO 190
80 A=J-2:E=A+2
90 P=(H(I,J+2)-2*H(I,J+1)+H(I,J))/2/F/F
00 D=(H(I,J+2)-H(I,J))/2/F
10 R=H(I,J+1)
20 C=(A+E)/2
30 FOR X= A TO E STEP .1
40 Z=X+.1
50 J1=P*(X-C)^2+D*(X-C)+R
60 J2=P*(Z-C)^2+D*(Z-C)+R
70 LINE (50*X,200-10*J1)-(50*Z,200-10*J2)
80 NEXT
90 NEXT
00 NEXT

```

4.ii CROSS SECTION CURVES ON THE SCREEN

```

10 REM EXAMPLE p110
20 REM USAGE OF PLOTTER FOR THE WATER PLANES
30 DIM H(7,13)
40 OPEN "E01.DAT" FOR INPUT AS #1
50 GOSUB 400
60 FOR I=1 TO 7
70 FOR J=1 TO 13
80 INPUT #1,H(I,J)
90 NEXT J
100 NEXT I
110 CLOSE #1
120 CLS
130 SCREEN 9,0
140 LINE (320,0)-(320,320)
150 FOR J=1 TO 13
160 FOR I=1 TO 5 STEP 2
170 IF I=1 THEN F=1 ELSE F=2
180 P=(H(I+2,J)-2*H(I+1,J)+H(I,J))/2/F/F
190 Q=(H(I+2,J)-H(I,J))/2/F
200 R=H(I+1,J)
210 IF I=5 THEN I=7
220 IF I=1 THEN B=I-1 ELSE E=I+3
230 IF I>1 THEN B=E-4 ELSE E=I+1
240 C=(B+E)/2
250 FOR Y=B TO E STEP .1
260 Z=Y+.1
270 J1=P*(Y-C)^2+Q*(Y-C)+R
280 J2=P*(Z-C)^2+Q*(Z-C)+R
290 IF J>7 THEN X1=5500-500*J1 ELSE X1=5500+500*J1
300 Y1=1000+500*Y
310 IF J>7 THEN X2=5500-500*J2 ELSE X2=5500+500*J2
320 Y2=1000+500*Z
330 IF J>7 GOTO 350
340 LINE (320+20*J1,300-20*Y)-(320+20*J2,300-20*Z):GOTO 360
350 LINE (320-20*J1,300-20*Y)-(320-20*J2,300-20*Z)
360 GOSUB 460
370 NEXT
380 NEXT
390 NEXT
400 REM pltest4
410 OPEN "COM1:2400,S,7,1,RS,CS65535,DS,CD" AS #2
420 PRINT #2,"IN;SP1;PA0,0,"
430 RETURN
440 END
450 REM PLOT SUB.
460 PRINT #2,"PU",X1,Y1,"PD",X2,Y2,"PU;"
470 RETURN

```

5.1 USAGE OF PLOTTER FOR THE WATER PLANES



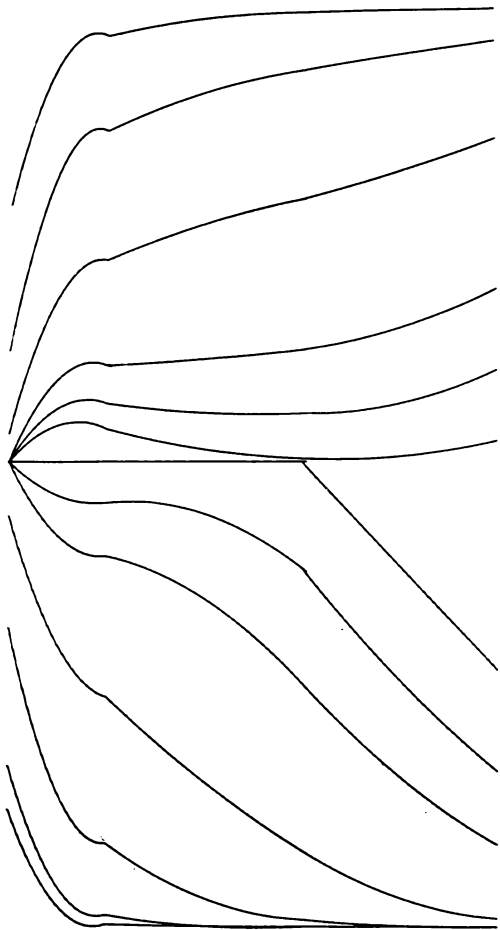
3

```

10 REM EXAMPLE p106
20 REM USAGE OF PLOTTER FOR THE CROSS SCETIONS
30 DIM H(7,13)
40 OPEN "E01.DAT" FOR INPUT AS #1
50 GOSUB 380:REM House keeping
60 FOR I=1 TO 7
70 FOR J=1 TO 13
80 INPUT #1,H(I,J)
90 NEXT J
100 NEXT I
110 CLOSE #1
120 CLS
130 SCREEN 9,0
140 FOR I=1 TO 7
150 FOR J=1 TO 11 STEP 2
160 IF J=1 OR J=11 THEN F=.5 ELSE F=1
170 IF J=11 THEN A=9:E=A+1: GOTO 200
180 IF J=1 THEN A=0:E=A+1: GOTO 200
190 A=J-2:E=A+2
200 P=(H(I,J+2)-2*H(I,J+1)+H(I,J))/2/F/F
210 Q=(H(I,J+2)-H(I,J))/2/F
220 R=H(I,J+1)
230 C=(A+E)/2
240 FOR X=A TO E STEP .1
250 Z=X+.1
260 J1=P*(X-C)^2+Q*(X-C)+R
270 J2=P*(Z-C)^2+Q*(Z-C)+R
280 X1=100+1000*X
290 Y1=3000+140*J1
300 X2=100+1000*Z
310 Y2=3000+140*J2
320 GOSUB 420
330 LINE (50*X,200-10*J1)-(50*Z,200-10*J2)
340 NEXT
350 NEXT
360 NEXT
370 REM pltest4
380 OPEN "COM1:2400,S,7,1,RS,CS65535,DS,CD" AS #2
390 PRINT #2,"IN;SP1;PA0,0,"
400 RETURN
410 END
420 REM PLOT SUB.
430 PRINT #2,"PU",X1,Y1,"PD",X2,Y2,"PU;"
440 RETURN

```

5.ii USAGE OF PLOTTER FOR THE CROSSECTIONS



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