HMAS TOBRUK

Report

223

Joint Committee of Public Accounts

Parliament of the Commonwealth of Australia 1984

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA

JOINT COMMITTEE OF PUBLIC ACCOUNTS

REPORT 223

HMAS TOBRUK

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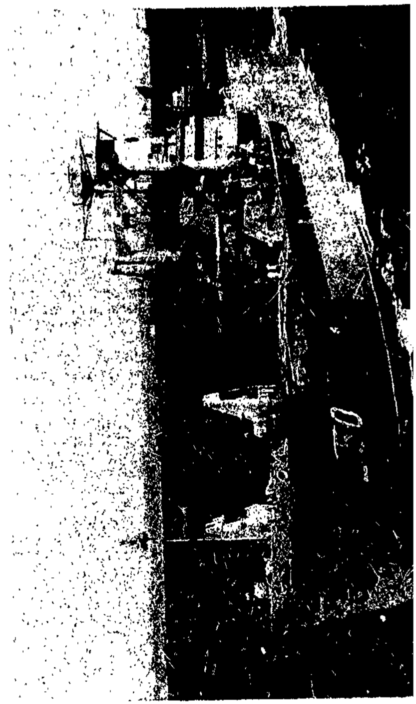
Section 8.(1) of the Public Accounts Committee Act 1951 reads as follows:

> Subject to sub-section (2), the duties of the Committee are:
>
> (a) to examine the accounts of the receipts and expenditure of the Commonwealth including the financial statements transmitted to the Auditor-General under sub-section (4) of section 50 of the Audit Act 1901;
>
> (aa) to examine the financial affairs of authorities of the Commonwealth to which this Act applies and of intergovernmental bodies to which this Act applies;
>
> (ab) to examine all reports of the Auditor-General (including reports of the results of efficiency audits) copies of which have been laid before the Houses of the Parliament;
>
> (b) to report to both Houses of the Parliament, with such comment as it thinks fit, any items or matters in those accounts, statements and reports, or any circumstances connected with them, to which the Committee is of the opinion that the attention of the Parliament should be directed;
>
> (c) to report to both Houses of the Parliament any alteration which the Committee thinks desirable in the form of the public accounts or in the method of keeping them, or in the mode of receipt, control, issue or payment of public moneys; and
>
> (d) to inquire into any question in connexion with the public accounts which is referred to it by either House of the Parliament, and to report to that House upon that question,
>
> and include such other duties as are assigned to the Committee by Joint Standing Orders approved by both Houses of the Parliament.



PREFACE

This report details the findings of the Committee's inquiry into the Department of Defence's amphibious heavy lift ship (HMAS Tobruk) project. The inquiry was commenced following the Auditor-General's critical report on the HMAS Tobruk project in March 1982. Initially the Committee planned to report on the findings of this inquiry in conjunction with its findings on other references from the Auditor-General's March 1982 Report. However, because of the magnitude and the seriousness of the problems associated with the project, the Committee decided to issue a separate report on the matter. Other items critically commented upon by the Auditor-General in his March 1982 Report were examined by the Committee and reported in the Committee's 222nd Report.

During the conduct of this inquiry the Committee found that many highly significant events and documents were not readily brought to the attention of the Committee by the Department. Rather, their existence was revealed only after prolonged investigation and probing inquiry by the Committee. The Committee was not satisfied with this aspect of the Department's conduct for it believed that a Committee of the Australian Parliament should be given a full and frank account of all relevant events and documents pertinent to the matter under consideration.

During this inquiry the Committee found that the Department's initial submission and evidence omitted any reference to the following matters:

- several severe technical problems with HMAS Tobruk's design and construction, e.g., inadequate air-conditioning, underdesign of deck mounting of forward cranes, excessive ship vibration, defective auxiliary boilers, contaminated hydraulic system, an inoperable and dangerous sewerage system, and poorly designed kit locker spaces.

- major deficiences in the Department's overall management and administration of the project.

- the tragic death of Naval Reserve Cadet Kenneth Dax and the critical findings of the subsequent Board of Inquiry and the Department's Review of that Board of Inquiry.

The Committee shares the opinion of the Review of the Board of Inquiry into the Death of Naval Reserve Cadet Kenneth Dax that

> 'With the benefit of hindsight, particularly in view of the main machinery problems being experienced, it is arguable that the ship should not have commissioned when she did, despite the pressing administrative problems inherent in a further deferral of the ceremony itself.'[1]

This report also discusses several allegations of major faults in HMAS Tobruk's construction. These allegations were received by the Committee at an in camera hearing. They were promptly communicated to the Department and the Department was given the opportunity to respond to the Committee in camera. The Department chose to discuss these matters in public. The Committee is now satisfied that these allegations may have been exaggerated. However, the Committee remains doubtful and concerned about HMAS Tobruk's watertight integrity in certain circumstances.

The Committee is most concerned about the variety of serious problems that were revealed during the course of the Inquiry. The Committee questions the failure of the Department of Defence to rectify technical problems which emerged during a project like HMAS Tobruk. The Committee would not have expected the Department to have mismanaged the acquisition of a major piece of equipment.

The Committees wishes to emphasise that it does not question the concept of, or the need for, a ship such as HMAS Tobruk. Clearly, the existence and operation of a heavy lift ship like HMAS Tobruk is of benefit to the Australian Defence Forces and the Australian community. Similarly, the Committee in reporting on the findings of this inquiry does not question the role of the Australian shipbuilding industry in Defence projects. The Committee emphasises that it does not wish to prejudice shipbuilding in Australia. It recognises the valuable contribution to the Australian economy made by Australian shipbuilding companies and their employees, and welcomes the development of this industry.

The Committee believes that the recommendations of this inquiry will go some way towards improving overall project management and administration in the Department. However, there still remains a need for project management in the Department of

1. Review of HMAS Tobruk Board of Inquiry into the Death of NRC Dax, paragraph 125.

Defence and its related organisations to be further improved substantially. With this in mind, the Committee will be undertaking a detailed and comprehensive examination into the Defence Department's overall project management and administration in 1984.

For and on behalf of the Committee,

Senator G. Georges
Chairman

M.J. Talberg
Secretary
Joint Parliamentary Committee of Public Accounts
Parliament House
CANBERRA ACT 2600
28 February 1984

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CHAPTER 1

INTRODUCTION

Historical Background

1.1 HMAS Tobruk, the most recent Royal Australian Navy amphibious ship, was commissioned on 23 April 1981. Previous RAN amphibious ships date back to World War 1.

1.2 In 1914 a P and O liner was commissioned as HMAS Berrima to serve as an amphibious transport for the Australian Naval and Military Expeditionary Force. This Force seized Papua New Guinea from Germany in a series of amphibious landings in New Britain, Bougainville and New Guinea. Since then the RAN has operated a variety of ships that were either converted to an amphibious role or were obtained second-hand from overseas.

1.3 In World War II a squadron of Landing Ships Infantry (LSI) was formed by converting the passenger ships Westralia, Manoora and Kanimbla. These ships successfully landed up to brigade size Army and Marine forces, both Australian and American, into the Phillipines, New Guinea and Borneo.

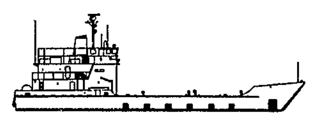
1.4 For a short period from 1945 to 1952 the RAN operated four second-hand Landing Ships Tank (LST) and then, between 1965 and 1969, HMAS Sydney was progressively converted for an Amphibious Transport (LPA) role. HMAS Sydney was paid off in 1972 after having carried many thousands of Australian troops together with their vehicles and weapons.

The Requirement for an Amphibious Heavy Lift Ship

1.5 When HMAS Sydney ended its operational service without an immediate replacement, the RAN's amphibious transport capacity was lost. However, between 1971 and 1974 six Landing Craft (Heavy) (LCH) ships were commissioned for naval service.

1.6 These LCH's are small (44.5m x 10.1m x 2m) amphibious vessels of some 503 tons displacement (fully loaded). Built by Walkers Ltd in Maryborough, Queensland, they have a complement of 16 and can carry three medium tanks. Although versatile they have a limited load and oceangoing capability. Their range is 3000 miles at 10 knots. (refer to Diagram 1 below)

Diagram 1 - HMAS Balikpapan (LCH No. L126)
(Scale 1 : 600, Source - Jane's Fighting Ships 1982-83)



1.7 The Australian Defence Force recognised a need for a vessel capable of lifting and carrying heavy equipment as well as being able to accommodate a large number of troops. The ship was also required to operate amphibious craft and helicopters for ship to shore movement.

1.8 In 1975 the Cabinet determined that the national defence required a ship of this configuration.

1.9 Three options were considered by the Department of Defence to meet the amphibious lift requirement -

1.
- an amphibious assault ship, or
- an amphibious cargo ship, or
- two amphibious heavy lift ships (LSH) based on the design of the United Kingdom landing ship logistic (LSL) class of the Sir Bedivere type.

1.10 A single LSH was selected as a core force element which, according to evidence given before the Committee 'was more cost effective than producing an Australian unique design'.[1]

1.11 On 9 March 1976 the Minister for Defence announced that the LSH would be named HMAS Tobruk. The contract for the ship's construction was awarded on 21 November to Carrington Slipways Pty Ltd., of Tomago NSW. 1977. The construction cost was estimated to be some $36m (at February 1977 prices) and a delivery date was set for 21 June 1980.

Basic Design and Capabilities of HMAS Tobruk.

1.12 HMAS Tobruk's design is based on the Landing Ships Logistic (LSL) class operated by the Royal Fleet Auxiliary of the Royal Navy. Tables 1A and 1B, below, summarize the major characteristics of the LSL class and include those of HMAS Tobruk.

1.13 HMAS Tobruk is 'an update of the British Sir Bedivere group whose design has been modernised and modified to meet Australian conditions'.[2]

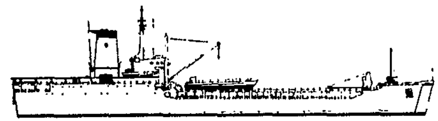
1.14 The ship (outlined in Diagram 2 below) is of a roll-on/roll-off hull design with bow doors and bow ramp and a combined stern door ramp. Between bow and stern doors is the Tank Deck on which a squadron of battle tanks can be carried or any other equivalent size mix of Army vehicles and guns.

1.15 Two combined ramp/hatches connect the Tank Deck to the Upper Vehicle Deck which can be used as either a stowage for wheeled vehicles and artillery, as a helicopter flight deck, or to carry containerised cargo. This deck is also fitted with cranes forward and aft to handle general cargo or to lift vehicles over the side.

1. In camera Minutes of Evidence, p. 3
2. HMAS Tobruk Commissioning Ceremony Booklet, p. 7

1.16 On either side of the Tank Deck are troop messes which may be used for a variety of purposes, from moving troops to evacuating civilians. Aft there is a dedicated helicopter flight deck.[1] Beneath this deck is an eight bed sick bay.

Diagram 2 - HMAS Tobruk (LSH No. L50)
(Scale 1 : 1200, Source - Jane's Fighting Ships 1982-83)



1.17 The LSL design, upon which HMAS Tobruk is based, is capable of landing troops or embarking personnel, vehicles and equipment in a variety of ways without dependence on a port. It is designed to:

- beach itself and unload through its bow doors;
- position its own side-carried pontoons to form a causeway to which it can marry its bow ramp;
- 'swim' amphibious vehicles from its stern door;
- launch and recover fully loaded landing craft via port and starboard davits;
- bring landing craft to the stern door to drive out vehicles;
- bring landing craft alongside to receive equipment and stores craned out of the ship using its own equipment; or
- use its helicopters for ship-to-shore operations.

1. Refer Illustration 2 and Diagram 2

TABLE 1A - Summary : Amphibious Logistic Landing Ships (LSL's)

Ship	Builder	Launch Date	Commissioning Date	Days Between Launch and Commissioning	Tonnage Full Load	Tonnage Light Load	Dimensions (m) Length	Dimensions (m) Beam	Dimensions (m) Draft
HMS SIR LANCELOT	*Fairfield* (Glasgow, UK)	25 June 1963	16 Jan. 1964	206	5550 tons	3370 tons	115.8 wl. 125.1 oa.	19.6	4.3
HMS SIR GALAHAD	Alex Stephen (Glasgow, UK)	19 April 1966	17 Dec. 1966	243	5674 tons	3270 tons	115.8 wl. 125.1 oa.	19.6	4.3
HMS SIR BEDIVERE	Hawthorn Leslie (Hebburn-on-Tyne, UK)	20 July 1966	18 May 1967	303	5674 tons	3270 tons	115.8 wl. 125.1 oa.	19.6	4.3
HMS SIR TRISTRAM	Hawthorn Leslie (Hebburn-on-Tyne, UK)	12 Dec. 1966	14 Sept. 1967	277	5674 tons	3270 tons	115.8 wl. 125.1 oa.	19.6	4.3
HMS SIR GERAINT	Alex Stephen (Glasgow, UK)	26 Jan. 1967	12 July 1967	168	5674 tons	3270 tons	115.8 wl. 125.1 oa.	19.6	4.3
HMS SIR PERCIVALE	Hawthorn Leslie (Hebburn-on-Tyne, UK)	4 Oct. 1967	23 March 1968	171	5674 tons	3270 tons	115.8 wl. 125.1 oa.	19.6	4.3
HMAS TOBRUK	Carrington Slipways (Tomago, Australia)	1 March 1980	23 April 1981	419	5709 tons 5800 tonnes	3562 tons 3619 tonnes	127 oa.	18.3	4.9

TABLE 1B - Summary (continued) : Amphibious Logistic Ships (LSL's)

Ship	Main Engines	Guns	Speed	Complement	Troops	Cranes	Other Comments
HMS SIR LANCELOT	2 Denny Sulzer diesels, 9520 bhp	2x40mm (not normally carried)	17 knots	68	340-534	1x20 ton, 2x4.5 ton	prototype ship, still in service
HMS SIR GALAHAD	2 Mirrlees 10-cyl diesels 9400 bhp	2x40mm (not normally carried)	17 knots	68	340-534	1x20 ton, 2x4.5 ton	hit and abandoned 8 June 1982 off Falkland Islands, later towed to sea and sunk, replacement ordered 'as soon as design is ready'
HMS SIR BEDIVERE	2 Mirrlees 10-cyl diesels 9400 bhp	2x40mm (not normally carried)	17 knots	68	340-534	1x20 ton, 2x4.5 ton,	still in service
HMS SIR TRISTRAM	2 Mirrlees 10-cyl diesels 9400 bhp	2x40mm (not normally carried)	17 knots	68	340-534	1x20 ton, 2x4.5 ton	damaged 8 June 1982 off Falkland Islands, remained afloat as accommodation ship with prospect of repair at a later date
HMS SIR GERAINT	2 Mirrlees 10-cyl diesels 9400 bhp	2x40mm (not normally carried)	17 knots	68	340-534	1x20 ton, 2x4.5 ton	still in service
HMS SIR PERCIVALE	2 Mirrlees 10-cyl diesels 9400 bhp	2x40mm (not normally carried)	17 knots	68	340-534	1x20 ton, 2x4.5 ton	still in service
HMAS TOBRUK	2 Mirrlees Blackstone KDMR8 diesels 9600 bhp	2x40mm (as fitted)	17 knots (normally restricted to 15 knots cruising)	130 (approx)	350-550	1x70 ton, 2x4.25 ton	designated LSH - heavy lift ship, still in service, an update of the 'Sir Bedivere' LSL class

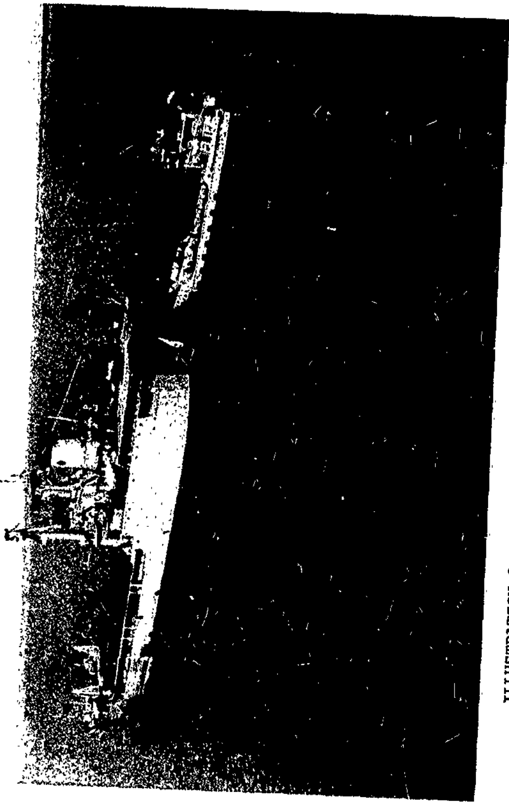


ILLUSTRATION 2 - HMAS Tobruk (L50) and HMAS Brunei (L127) at *Shoalwater Bay*, Qld (RAN official photograph)

1.18 The official roles of HMAS Tobruk are to participate as required in:

- providing logistic support for forces deployed:
  - .. in defence of Australia and its Territories;
  - .. for contingency plans;
  - .. for United Nations operations;
  - .. on joint and single Service exercises; and
  - .. on civil aid and disaster relief operations;
- carrying out seaborne support operations for:
  - .. strategic and tactical movement; and
  - .. the lodgement of a force;
- moving defence aid cargoes; and
- providing an administrative movement capability for Service cargoes.[1]

Conduct of the Inquiry

1.19 In his Report presented to Parliament on 24 March 1982, the Auditor-General commented upon the following aspects of the Department of Defence Amphibious Heavy Lift Ship (HMAS Tobruk) Project:

- control over production;
- modifications;
- quality assurance and contractual matters;
- government furnished equipment;
- landing craft vehicular and personnel; and
- cost escalation.[2]

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1. Minutes of Evidence 17 September 1982
2. The Auditor-General's detailed comments are reproduced at Appendix A

1.20 Overall, the Auditor-General concluded the major unsatisfactory issues arising from the audit were:

- departmental procedures failed to clearly specify lines of responsibility within the Department to ensure that weight monitoring was achieved;

- inadequate consideration was given by departments responsible for framing the contract to ensure that certain important contractual conditions could be enforced, if necessary by penalty provisions;

- insufficient quality assurance control was exercised to ensure that the specified Naval requirements for design construction and material would be fully met; and

- unsatisfactory administrative processes led to delays in issuing Government Furnished Equipment to the contractor.[1]

1.21 In addition to the above comments on the Heavy Lift Ship Acquisition project, the Auditor-General also commented on 18 other Department of Defence matters in his March 1982 Report.

1.22 On 12 July 1982 the Committee sought submissions from the Department of Defence on the following Auditor-General's comments -

- the Amphibious Heavy Lift Ship Acquisition

- Mobile Radio Terminals

- Helicopters for FFG-07 Class Guided Missile Frigates

1.23 The Committee also sought submissions from other Departments on several other matters raised by the Auditor-General in his March 1982 Report.

1.24 On 17 August 1982 the Department of Defence provided submissions on the above three items for the Committee's consideration. Similarly, other Departments provided submissions for the Committee's consideration.

1.25 The Committee subsequently decided to proceed to public hearings only on the Amphibious Heavy Lift Ship Acquisition (HMAS Tobruk) item.

1. pp. 34 to 35, Auditor-General's Report, March 1982

1.26 Five public hearings were held[1] as well as five days of <u>in camera</u> hearings. The Committee had three inspections of HMAS Tobruk and inspected the shipyards of Carrington Slipways Pty Ltd, HMAS Tobruk's builder[2].

1.27 Between the first public hearing on 17 September 1982 and the second public hearing on 5 August 1983 the term of the Thirteenth Public Accounts Committee expired with the dissolution of Parliament and the Federal election. In May 1983 the Fourteenth Joint Parliamentary Committee of Public Accounts was established.

1.28 The Fourteenth Committee examined the work undertaken by its predecessors on items previously selected from the Auditor-General's March 1982 Report. It resolved to continue consideration of these items.

1.29 The Committee decided to issue a separate report on HMAS Tobruk because of the significance and magnitude of its findings. All other items for which submissions were called for are reported in the Committee's 222nd Report titled ' The Auditor-General's Report : March 1982'.

Continuation of the Inquiry in 1983.

1.30 Soon after the establishment of the Fourteenth Public Accounts Committee in May 1983 new evidence was received indicating the need for a continuation and expansion of the Committee's Inquiry into HMAS Tobruk.

1.31 This evidence revealed that there were major problems and significant events in the Tobruk project <u>NOT</u> brought to the Committee's attention by the Department during the September 1982 public hearing nor included in the Department's submission of 17 August 1982. These included, amongst other things, the tragic death of a 14 year old Naval Reserve Cadet Kenneth Dax on board HMAS Tobruk on 16 December 1981.

1.32 On 25 May 1983 the Committee informed the Department of its decision to continue its Inquiry into HMAS Tobruk. The Committee requested a further submission from the Department commenting on the Department's management of the Tobruk project, addressing in particular the controls exercised over production and the design changes made to the ship, and the death of NRC Dax.

1.33 The Department was also asked to comment on and provide the Committee with the following documents:

- HMAS Tobruk Board of Inquiry into the Death of Naval Reserve Cadet Kenneth Dax, and

- Review of HMAS Tobruk Board of Inquiry Into the Death of Naval Reserve Cadet Kenneth Dax.

1. Refer to Appendix D for details
2. Refer to Appendix E for details

1.34 Part 1 of the Department's further submission was received on the 23 June 1983. Part 2 was received eight days earlier on 15 June 1983.[1] The Board of Inquiry Report and Review of the Board of Inquiry Report were received from the Minister for Defence on 9 June 1983.[2]

1.35 The Review of the Board of Inquiry Report proved to be a very significant document and is at Appendix H of this Report. The copy contains certain deletions so as not to identify, by name or rank, individuals (both Service personnel and civilian public servants) who have no opportunity to respond to criticisms of them in the Review Report. The Committee requested and received (on 2 August 1983) a further copy of the Review of the Board of Inquiry Report without such deletions.[3]

1.36 Research of the above material led to the construction of a detailed 'Chronology of Events' at Table 2 below.

1.37 This chronology, together with the two submissions from the Department of Defence[4] and the Review of the Board of Inquiry Report[5] prompted the Committee to hold a further series of hearings[6] and inspections[7] during 1983.

1. Refer to Appendix C for details
2. Refer to Appendix I
3. ibid
4. Refer to Appendix B and C
5. Refer to Appendix H
6. Refer to Appendix D
7. Refer to Appendix E

TABLE 2

CHRONOLOGY OF EVENTS

Aug 1973	ABR1921 'Instructions for HMA Building, Undergoing Modernization, Conversion or Extended Refit' issued by the Department of Defence (Navy Office) to replace MOD UK BR 1921 previously issued
Aug 1975	Cabinet approval of LHS (Heavy Lift Ship) project (initial project cost $41.7m, at April 1975 prices)
1976	Army Office advises Navy Office that weight of embarked troops will be 2500kg
9 Mar 1976	Minister for Defence announces LHS to be named HMAS Tobruk
Sep 1976	Tenders called for HMAS Tobruk's construction
Feb 1977	Administrative Services invites tenders for HMAS Tobruk's four landing craft
23 Mar 1977	Navy Office does preliminary assessment of Carrington Slipways' quality control system
May 1977	Programmed date for letting HMAS Tobruk's construction contract (not met)
Jul 1977	Defence requests Administrative Services to negotiate a contract for HMAS Tobruk's four landing craft with a UK company
15 Sep 1977	UK Company advised Administrative Services that HMAS Tobruk's Landing Craft will have reserve buoyancy and be stable if filled with water; they will, however, have a loll of 6 degrees
21 Nov 1977	Commonwealth signs contract with Carrington Slipways for HMAS Tobruk at a construction cost of $36m, at February 1977 prices
Jan 1978	UK company advises Administrative Services that HMAS Tobruk's landing craft will conform with swamping requirements
Sep 1978	Carrington Slipways advise Navy Office that computer estimates of HMAS Tobruk show it will be overweight,[1]

1. Refer to Appendix E

Sep 1978	First steel cut at shipyard
Oct 1978	Navy Office becomes aware that Carrington Slipways is using steel plates thicker than original imperial specification, construction continues
7 Feb 1979	HMAS Tobruk's keel laid down
16 Feb 1979	Correspondence between members of Navy Office re strong disagreement as to working relationships and responsibilities at dockside, Navy's Overseer's role clarified 'to ensure specific standards are met'
May 1979	UK company finds unsatisfactory result when simulated swamping tests done on HMAS Tobruk's landing craft as measured against RAN two compartment swamping criteria, Defence and Administrative Services advised
26 Sep 1979	Ascertained that HMAS Tobruk embarked troops will weigh 3400kg (not 2500kg as previously advised)
10 Jan 1980	Carrington Slipways submit claim to Defence for 105 'excusable delay' days
6 Feb 1980	Defence advises UK company that further simulated swamp tests on HMAS Tobruk's landing craft not required as Defence will analyse the problems
18 Feb 1980	Commanding officer (in command at time of accident) commences 'stand by ship during build'
1 Mar 1980	HMAS Tobruk launched at Tomago, NSW
21 Jun 1980	Original handover date of HMAS Tobruk (not met)
16 Dec 1980	HMAS Tobruk's maiden voyage, port engine refuses to start ahead
Jan 1981	Defence does weight tests, ascertained that HMAS Tobruk 297 tonnes (8.9% overweight)
19 Jan 1981	'Final Installation Inspection' of HMAS Tobruk sewerage system attempted but 'aborted' because of failure

19-22 Jan 1981	'Setting to work' of HMAS Tobruk sewerage system attempted at sea but abandoned due to several midship tank overflows, faulty pumps and alarms
23 Feb 1981	Defence accepts Carrington Slipways claim of 105 'excusable delay' days (submitted on 10 January <u>1980</u>)
Mar 1981	Audit seeks clarification from Defence of policy on HMAS Tobruk fuel usage because of concern about ship weight increase
Mar 1981	Defence advises Audit that HMAS Tobruk fuel policy only promulgated in March 1981 and was an oversight
17-19 Mar 1981	Further trial of HMAS Tobruk sewerage system attempted in presence of Navy Overseer but very unsatifactory
19 Mar 1981	End of Defence approved 'excusable delay' contract period of 271 days from original handover target of 21 June 1980
Apr 1981	Practical swamp test by UK company on craft similar to HMAS Tobruk's landing craft unsuccessful
6 Apr 1981	HMAS Tobruk's Marine Engineer Officer (MEO) resigns, reasons include dissatisfaction with management of build, incoming MEO is granted his rank 6 months ahead of normal time
11 Apr 1981	Carrington Slipways hand over HMAS Tobruk to RAN (293 days late) against original contract, 22 days late against amended contract, 'Report of Inspection of Ship Prior to Acceptance into Service in HMA Fleet' read for first time (but not signed) - sewerage system not listed as deficient
23 Apr 1981	HMAS Tobruk commissioned, major sewerage spill occurs in forward tanks
May 1981	Defence formally advises Administrative Services of HMAS Tobruk's weight problems and comments on Administrative Services not instructing Carrington Slipways about contract performance

14 May 1981	Second reading of HMAS Tobruk's 'Report of Inspection of Ship Prior to Acceptance into Service in HMA Fleet' but Commanding Officer refuses to sign because of 76 pages of deficiencies, repeat of second reading now necessary
18 May 1981	Major sewage spill aboard HMAS Tobruk in Sydney, extensive system damage and expensive repairs but no investigation. Results, described as 'flood, uninhabitable'. HMAS Tobruk and Fleet Marine Engineer Officers view spill, Fleet Medical Administrative Officer reports to Fleet headquarters his concern for safety
11-12 Jun 1981	HMAS Tobruk's Project Design Manager addresses problem of sewerage vents during ship visit (only instance of direct involvement of the Navy Design Branch at shipyard)
10-16 Jun 1981	Carrington Slipways fit non return valves to forward sewerage tanks, improve switches and set chlorination units to work
23 Jul 1981	RAN formally accepts HMAS Tobruk for operational service into the Fleet
31 Jul 1981	'Report of Inspection of Ship Prior to Acceptance into Service in HMA Fleet' read again and signed by the Commanding Officer - sewerage system still not listed as deficient (Repeat of 2nd Reading)
Aug 1981	HMAS Tobruk's project cost now $59.2m (42% increase), construction cost now $49.4m (37% increase), all increases due to escalation and modifications
14 Aug - 11 Sep 1981	Carrington Slipways and other contractors do rectification work during 'Post Shakedown Availability', not regarded as shipbuilder liability
19 Aug 1981	Navy modifies HMAS Tobruk's sewerage vent pipe (thought critical to Dax death), work undertaken by contractor in Brisbane to specifications provided by Naval Design Branch
15 Sep 1981	Defence General Overseer and Superintendent of Inspection East Australian Area writes to Director-General Naval Production about former problems with Carrington Slipways formal quality control processes concerning HMAS Tobruk

6 Oct 1981	HMAS Tobruk Commanding Officer writes to Director of Fleet Maintenance with details and problems surrounding the duties of 'Personnel Standing by Ships Building'
4 Nov 1981	Piping Systems Handbook received by HMAS Tobruk but not issued, remains in store until after Dax death
10 Nov 1981	Troops disembarked at Melbourne from HMAS Tobruk after Exercise Kangaroo 81
23 Nov 1981	Chief Shipwright for HMAS Tobruk leaves HMAS Tobruk project, new Chief Shipwright received no prior training related to HMAS Tobruk
Dec 1981	Audit asks Defence to comment on Audit observations
prior to 14 Dec 1981	Exhaust fan (of less than specified diameter) serving head 3DZ4 where NRC Dax gassed removed for repair
14 Dec 1981	Sewage gassing of Naval Reserve Cadet Kenneth Dax occurs at 3DZ4 Heads.
16 Dec 1981	Dax dies in hospital
17 Dec 1981	Fleet Commander convenes Board of Inquiry, Coroner's post mortem conclusion is Dax died of cerebral oedema
19 Dec 1981	Board of Inquiry Report completed, sent to Fleet Flag Office Commanding HMA Fleet
13 Jan 1982	Deputy Chief of Naval Staff (having received an advance copy) directs that Board of Inquiry Report be reviewed by Director-General Fleet Maintenance
22 Jan 1982	Deputy Fleet Commander forwards with comments Board of Inquiry Report to Deputy Chief of Naval Staff
Feb 1982	Audit seeks further comment from Administrative Services on HMAS Tobruk contract
24 Mar 1982	Auditor-General's March 1982 Report comments on HMAS Tobruk project (viz overweight, contract enforcement, quality control, administrative delays)
19 May 1982	Review of Board of Inquiry Report completed

3 Jun 1982	Director-General Fleet Maintenance forwards Review of Board of Inquiry Report to Deputy Chief of Naval Staff via Chief of Naval Technical Services
4 Jun 1982	Acting Director-General Naval Design comments on Review of Board of Inquiry Report to the Deputy Chief of Naval Staff
15 Jun 1982	Chief of Naval Technical Services comments on Review of Board of Inquiry Report to Deputy Chief of Naval Staff
21 Jun 1982	Deputy Chief of Naval Staff issues directions in respect of recommendations of the Review of Board of Inquiry
12 Jul 1982	Public Accounts Committee (PAC) seeks submission from Defence Department on Auditor-General's March 1982 Report reference to HMAS Tobruk project
17 Aug 1982	Submission on HMAS Tobruk received by PAC
24 Aug 1982	PAC resolves to hold public hearings and inquire into HMAS Tobruk project
17 Sep 1982	Public hearing and inspection held on board HMAS Tobruk at Garden Island Dockyard, Sydney; Dept. makes no reference to: . death of NRC Dax . Board of Inquiry Report . Review of Board of Inquiry Report . design related problems past and current on board ship . project management problems
11 May 1983	Fourteenth PAC formed, resolves to continue investigation into HMAS Tobruk
25 May 1983	PAC seeks supplementary submission from Defence Department on all matters <u>not</u> referred to by the Department at public hearing on 17 September 1983
9 Jun 1983	Copy (with deletions) of Board of Inquiry Report and Review of Board of Inquiry Report received by PAC from Minister for Defence
15 Jun 1983	Part 2 of Defence Department supplementary submission received by PAC
23 Jun 1983	Part 1 of Defence Department supplementary submission received by PAC

7 Jul 1983	PAC seeks copy (without deletions) of Board of Inquiry Report and Review of Board of Inquiry Report from Minister for Defence
2 Aug 1983	Copy (without deletions) of Board of Inquiry Report and Review of Board of Inquiry Report received by PAC from Minister for Defence
Aug 1983	In Camera briefing
5 Aug 1983	Inspection of HMAS Tobruk and Public hearing held in Brisbane
7 Sep 1983	Public hearing held in Canberra
14 Sep 1983	Public hearing held in Canberra
18-19 Sep 1983	Inspection of HMAS Tobruk by PAC during operations at Shoalwater Bay, Qld and en route to Melbourne
9 Oct 1983	Inspection of Carrington Slipways Pty Ltd and Ramsay Fibreglass at Tomago, NSW, by PAC
Oct 1983	In camera hearings
9 Nov 1983	Public hearing held in Canberra
Dec 1983	In camera hearing

CHAPTER 2

THE ORIGINAL REFERENCE - EXCESS WEIGHT

The Auditor-General's Comments

2.1 In his March 1982 Report the Auditor-General noted that HMAS Tobruk's lightship[1] weight was 3619 tonnes, 297 tonnes or 8.9% above the contract specified lightship weight of 3322 tonnes[2]. The contract weight specifications included allowances for the extensive RAN design changes discussed in Chapter 6 of this Report.

2.2 During the ship's construction, steel plates of the required imperial measurement thickness used in the original 1960's U.K. design were not readily available in Australia. Thicker metric plates were used by the contractor without seeking prior Navy Office approval. Navy Office became aware of the problem in October 1978.

2.3 In the previous month the contractor advised Navy Office that its computer estimates for the weight monitoring program had indicated the lightship weight was critical and that it would be exceeded. Examination by Navy Office of the contractor's main structural drawings confirmed this view. The Navy Office advised the contractor that it was essential for the lightship weight to be met and that this could be achieved by using steel of direct Imperial to Metric conversion.

2.4 An increase in weight above specification was disclosed by departmental displacement checks and inclining tests conducted in January 1981. At this time the ship was very nearly complete having been launched on 1 March 1980 and undertaken its maiden voyage on 16 December 1980.

2.5 It was too late to exercise any worthwhile weight control in the structural area. Three months after this discovery HMAS Tobruk was handed over to the Navy (on 11 April 1981).

2.6 In general the Auditor-General noted that, in the Navy Office, directions for monitoring the weight of vessels under construction were not specified definitively in any standing instruction. The construction specification for the ship defined the responsibility of the shipbuilder to continuously monitor the weight during the construction and progressively report to the Department.

2.7 In summary, the audit of production control disclosed (amongst other things):

- departmental documentation lacked sufficient detail in assigning functional responsibilities for weight monitoring within Navy Office

1. Ship's weight (not including fuel,water or ammunition)
2. Refer to Appendix A

- difficulty was experienced in comparing the contractor's advised computer estimates of the ship prefabricated unit weights with Navy Office design weight calculations because of differences between the contractor and Navy Office weighing systems

- the shipbuilding contract did not include penalty provisions where the contracted agreed weight was not achieved

The Department's Submission

2.8 In its submission of 13 August 1982 the Department agreed with the Auditor-General's findings.[1] It stated that:

> a new Defence Navy Instruction on weight monitoring in new ship construction has been promulgated.

Contractor Weight Control Procedures

2.9 The Committee discussed the Auditor-General's comments on Tobruk's excess weight with the Department at its public hearings on 17 September 1982 and 7 September 1983. It also raised the matter with the contractor at a public hearing on 14 September 1983.

2.10 The Committee heard evidence that weight monitoring of the ship was a responsibility of the contractor under the contract. The contract called for the contractor to produce a quality control plan. One element of the quality control plan was weight control procedures.

2.11 The Committee observed that throughout the Department's specifications for HMAS Tobruk, weight control and weight saving measures were stressed.

2.12 At section 1.2.8 (v.1) of the specifications it is stated that:

> High tensile steels to Lloyds AH and DH qualities are to be used during construction to give weight saving, together with a high standard of strength and robustness.

2.13 Later in section 1.10 (v.1) the specifications stipulate:

> Weight control during construction of this ship is of the utmost importance. The shipbuilder is required to keep this continually under review and when working drawings are prepared, all proposals are to be clearly analysed with a view to weight control.

1. Refer to paragraph 11 of Appendix B

2.14 Under the heading of 'Ship Characteristics', Volume 2 of the ship's specifications says, (at section 1.3.3):

> Scantlings[1] as shown on appropriate design guidance drawings have been selected to ensure minimum weight....

2.15 Further, in section 1.8 of volume 2 of the ship's specifications where weight control procedures are outlined, the following subsection (1.8.81) emphasizes the importance of controlling weight:

> It is mandatory that the Ship Design Criteria stated in this Chapter be adhered to. It is essential, therefore with particular respect to stability, trim, strength, speed, endurance and deadweight capacity, that a weight control and monitoring programme be implemented.

2.16 Before signing the contract on 21 November 1977 the Department assessed the contractors quality control systems for a variety of aspects, including weight control monitoring.

2.17 The Department found that the contractors quality control systems:

> did not completely satisfy the Australian Standard (AS 1822).... However we became convinced that his intentions to produce the quality were sound .... it was not until some time after signing the contract .... that he reached the Australian Standard.[2]

2.18 Evidence was given to the Committee that when the Department carried out its own quality assurance it 'discovered late (in the project) rather than early that the vessel was overweight'.[3] However this evidence contradicts the Auditor-General's statement that:

> In September 1978 the contractor advised Navy Office that its computer estimates for the weight monitoring program had indicated the lightship weight was critical and it would be exceeded. Examination by Navy Office of the contractor's main structural drawings confirmed this view. According to departmental records the quality assurance reports indicated that the steel ordered by the contractor met the contractor's requirements, but did not draw attention to the fact that the steel ordered was heavier than the United Kingdom specified material.[4]

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1. Set of standard dimensions for parts of the ship structure
2. Minutes of Evidence, 17.9.82
3. ibid
4. Report of the Auditor-General, March 1982, p.29

2.19 The Department made the first assessment of the contractors quality control system on 23 and 24 March 1977. The contract was signed on 21 November 1977. It was not until 1980 when the final version of the quality control plan was approved in all elements. In 1979, during finalisation of this approval process the Department discovered that the contractors weight control procedures were not sufficient.

2.20 By this time the ship had been launched and it was not possible to introduce weight reduction measures.

2.21 The Committee was told that:

> at the monthly progress meetings... the shipbuilder always disputed that there was any increase in weight .... there was a mathematical argument right up to the time the design and production people, with the ship in the water, were actually able to prove who was right and who was wrong.[1]

Conversion from Imperial to Metric Measurements

2.22 The Department told the Committee that, had the contractor insisted on imperial standards being used, it would have cost him between 10% and 25% (at 1981 prices) more per tonne of steel. As the shipbuilder was operating on a fixed price contract the Department considered that such a cost increase would have been unfair. It would have necessitated the steel manufacturer developing a separate production line in order to fill the requirement.

2.23 The shipbuilder recognised that the steel plate was thicker than specified but decided the additional thickness was acceptable under the commercial standards to which the ship was being built. These standards are discussed in the next section of this Chapter.

2.24 The Department gave evidence that it would not have been cost effective for the Navy to convert HMAS Tobruk's design drawings and specifications from imperial to metric measurements as the time involved to effect the amendments would have delayed further the procurement of the ship.

2.25 A departmental representative said:

> We decided that we would use a British design and not change from the imperial standard to metric. We made a technical judgement. We believed that what the contractor offered us in the way of weight control would be adequate. We were not aware until twelve months or six months afterwards[2] that what the shipbuilder had

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1. Minutes of Evidence, 17.9.82
2. i.e. after construction of HMAS Tobruk had commenced

ordered from BHP was that extra bit thicker, which would throw up the weight. By then most of it had been fabricated.[1]

2.26 The Committee notes that the booklet for HMAS Tobruk's commissioning ceremony states:

> the original British design had to be considerably modified, every working drawing had to be converted from imperial measurements to metric....

2.27 The Committee also notes that clause 54 of the contract for HMAS Tobruk stipulates that:

> ... all dimensions and units on plans and drawings, and all references to measurements and quantities in any communication with the Commonwealth shall be in metric units.

2.28 Furthermore Volume 1 of the Department's specifications for the ship states, at section 1.25:

> 1.25.1 Materials and equipment for use in the construction of the Amphibious Heavy Lift Ship shall be in metric sizes.
>
> 1.25.2 Many Design and Design Guidance Drawings provided in the tender documentation will be in imperial units because of previous association with the U.K. LSL design. However Shipbuilder working drawings to be developed from these drawings are to be in SI metric form in accordance with AS10000 for the construction of the LSH.
>
> 1.25.3 All gauges, instruments, controls and draught-marks, throughout the ship shall be calibrated in SI metric units.
>
> 1.25.4 Tenders are to indicate the extent of the materials and equipment (if any) not able to comply with the shipbuilding requirement for conversion to metric.

2.29 The Department's specifications for the ship also state, at section 2.2.6/7 (the Development of Shipbuilder Working Drawings):

> 2.2.6 For construction of the LSH in an Australian shipyard, the shipbuilder will need to develop Working Drawings to achieve the specified design requirement by:

1. Minutes of Evidence, 17.9.82

> a. Strict compliance with design drawings
>
> b. ....
>
> c. Conversion from imperial to metric units
>
> 2.2.7 The provision of design guidance drawings for information and clarification does not absolve the Shipbuilder in any way from the responsibility of meeting the functional and design requirements stated in the specification.

2.30 In evidence to the Committee, both the Department and the contractor described the conversion to metric scantlings as 'a soft conversion to the metric equivalent'.[1]

2.31 The shipbuilder ventured the opinion that:

> It would be impossible to completely redesign the ship to keep the weight down and go for metrics. It would have meant changes to frame spaces and changes to all sorts of things throughout the ship and it was not considered that it would have been an advantage. It was thought that the implications of the steel weight, when it was being converted in the initial stage, was that some scantlings would be closer than they were, but in the final analysis it did not turn out that way.[2]

Naval and Commercial Standards

2.32 The Committee noted that contractual procedures for HMAS Tobruk were related to building a ship to commercial standards. The specifications called up the Lloyds standards on which the U.K. predecessors of this ship were built.

2.33 The Department said 'the Lloyds standards do not in themselves go into very great detail about weight <u>per se</u>'.[3]

2.34 Generally, the Department expected that naval vessels would be required to operate in conditions in which normal merchant ships do not operate. Therefore the construction of naval vessels is to different criteria. However, these criteria depend on whether the vessel is a front line warship, such as a destroyer, or an auxiliary ship like HMAS Tobruk. The Committee notes that some parts of HMAS Tobruk were built to more stringent naval standards.

1. Minutes of Evidence, 17.9.82 and 14.9.83
2. Minutes of Evidence, 14.9.83
3. Minutes of Evidence, 17.9.82

2.35 Section 1.6 of Volume 1 of HMAS Tobruk's specifications states:

> 1.6.1 Concept of Standard : the standard required for the build of the Amphibious Heavy Lift Ship (LSH) is that of Lloyds Rules and Regulations and certain RAN Standards ....
>
> 1.6.1.1 (a) Hull and Machinery - to the requirement of Lloyds Rules and Regulations and associated codes of practice.
>
> (b) Electrical - to the requirement of Lloyds Rules and Regulations and associated codes of practice
>
> (c) Accommodation and Habitability - to RAN standard
>
> (d) Flight Deck and Upper Vehicle Deck Flying Arrangement - to RAN standard
> (e) Weapon Fit - to RAN standard
> (f) Fire Fighting - to RAN standard
> (g) Damage Control - to RAN standard
> (h) Life Saving - to RAN standard
> (i) Communication - to RAN standard
> (j) Shock - to RAN standard
> (k) Painting - to RAN standard
>
> 1.6.1.2 .... the shipbuilder is provided with both LSL and RAN drawings as design and guidance information for development by the Shipbuilder into Working Drawings. In producing schemes, plans or working drawings ... and in particular in meeting the current Lloyds requirement, the Shipbuilder is not to lower any standard given ....

2.36 The Committee also notes that where the ship's contract and specification conditions allowed the builder a choice in the selection of materials and/or processes, Australian standards were preferred.[1] If there is a conflict between Lloyds Rules and Regulations and Naval specifications, the ships specifications state that Naval specification requirements shall take precedence provided the Lloyds standards are not reduced.[2]

1. s.1.6.1.6, v.1 HMAS Tobruk specifications
2. s.1.6.1.4, v.1 HMAS Tobruk specifications

2.37 Generally, the Department described HMAS Tobruk as being built to 'a partially improved commercial standard'.[1] It was also stated at the same hearing that the Department 'had not built ships to commercial standards and we did not have the same degree of expertise in building ships to commercial standards as perhaps we see it would have been good to have.'

2.38 In a later hearing a departmental representative said:

> In a fully designed naval ship we would look for a much higher level of structural watertight integrity of the ship than we would look for in other ships or that commercial liners look for. What is an acceptable standard? We bought this ship in the full knowledge of what we had, that it was designed to Lloyds standards and to meet the requirements of the international regulations for safety of life at sea; it is designed that way and it meets those standards. They are lesser standards than we would have in our own design of a naval ship.[2]

2.39 The Department also gave evidence that controls over the HMAS Tobruk contract were not as great as those exercised by Australia in the United States FFG contract.[3] The Committee notes the Auditor-General's comment, in his March 1982 Report, that the Australian built Fremantle Class Patrol Craft are also overweight.

2.40 In reply to a question on why the Department used commercial specifications for the major parts of HMAS Tobruk, a Departmental representative said 'It is cheaper'.[4]

2.41 Section 1.16.3 (v.1) of HMAS Tobruk's specifications:

> Because of the large proportion of commercial construction standards involved, the LSH is not uniform with the majority of RAN ships in regard to in-service support needs and in particular fittings.

2.42 The Committee acknowledges that for reasons of maintaining the UK design integrity and minimising cost HMAS Tobruk was not built to full naval standards. The appropriateness of this decision is canvassed in Chapter 6. However, it still remains that the Department exercised less stringent control over the commercial standards used for construction.

Weight Criticality and Operational Capability

2.43 During the Inquiry the Committee was told that there were two main reasons for the Department being conscious of HMAS Tobruk's weight. These were:

1. Minutes of Evidence, 17.9.82
2. Minutes of Evidence, 9.11.83
3. Minutes of Evidence, 7.9.83
4. Minutes of Evidence, 17.9.82

2. whether HMAS Tobruk was 'weight critical'; and

- whether HMAS Tobruk's 297 tonnes excess weight would adversely affect its operational capability.

2.44 It was explained to the Committee that the term 'weight critical' referred to the longitudinal strength of a vessel. If the light ship weight exceeds the weight critical value a vessel's longitudinal strength is jeopardised - it may, in effect 'break it's back'.[1]

2.45 Subsequent to the launching of HMAS Tobruk the Department tested the ship for weight criticality. A Departmental representative told the Committee '...we satisfied ourselves that the additional weight ... was not so great as to cause the ship to be weight critical'.[2] The Committee accepts this explanation.

2.46 However, the matter of excess weight affecting operational capability is a more subtle question.

2.47 The Department advised the Auditor-General that the implications of HMAS Tobruk's increased weight were:

- a steeper beach gradient being required for self beaching operations; and
- additional fuel consumption when the ship maintains cruising speed, thus reducing (marginally) the ship's range.

2.48 In evidence to the Committee the Department said HMAS Tobruk's 8.9% weight increase above specification 'was sufficient to cause the Department to look closely at the reasons for which it existed and to look closely at the ramifications'.[3]

2.49 The contractor stated 'it is not unusual for a ship to go overweight .... (although) .... nine percent (sic) would possibly be on the high side'.[4]

2.50 During public hearings into the matter the Department generally argued that HMAS Tobruk's excess weight was not important, as either:

- it only slightly increased the gradient of beaches where HMAS Tobruk could beach; and/or
- the flexibility of the ship enabled it to use any one of five methods for ship-to-shore discharge of personnel and equipment, of which beaching was only one method.

1. Minutes of Evidence, 17.9.82
2. ibid
3. ibid
4. Minutes of Evidence, 14.9.83

2.51 The Committee acknowledges that the design concept of HMAS Tobruk incorporates several methods of ship to shore discharge. However it remains that HMAS Tobruk:

- is severely restricted in the number of Australian beaches where it can beach because of it's excess weight, and
- is not as flexible in its ship to shore operations as it is designed to be because of problems with other methods of discharge eg. port and starboard davits are inoperable because of a contaminated hydraulic system,[1] the landing craft are unsuitable[2] and there are restrictions on the use of the stern door during rough sea conditions.[3]

2.52 The Committee notes that in the first paragraph (1.1.1) of volume 1 of HMAS Tobruk's specifications it is stated:

> The Royal Australian Navy requires a versatile, general purpose amphibious ship with a heavy lift and <u>beaching capabilities</u> to provide both strategic and tactical sea lift capability for the Australian Defence Force (emphasis added)

2.53 Later, in the second volume of HMAS Tobruk's specifications it is stated (under the heading Beaching Role, (s.1.4.5)

> The ship shall be capable of direct beaching at varying displacements up to 4454 tonnes with a trim by the stern (to be at minimum commensurate with the beaching condition but shall be not greater than equivalent keel slope of 1 in 50)

2.54 In evidence before the Committee the Department stated that, after assessing HMAS Tobruk's weight, it recognised the effect of the ship's increased draft and recommends that the ship beach on a gradient of not less than one in 42.[4]

2.55 A former Captain of HMAS Tobruk stated

> That is not to say that it is not possible to beach the ship on a gradient that is one in 42. It would depend on a considerable intermix of different factors. Many Australian beaches are within this

1. Refer to Chapter 5 for discussion
2. Refer to Chapter 4 for discussion
3. Refer to Chapter 5 for discussion
4. The gradient or slope of a beach increases as the denominator in the gradient measure decreases, hence a beach with a slope of 1:42 is steeper than a beach with a gradient of 1:50. A gradient 'greater than 1:42' would be 1:25 or 1:30

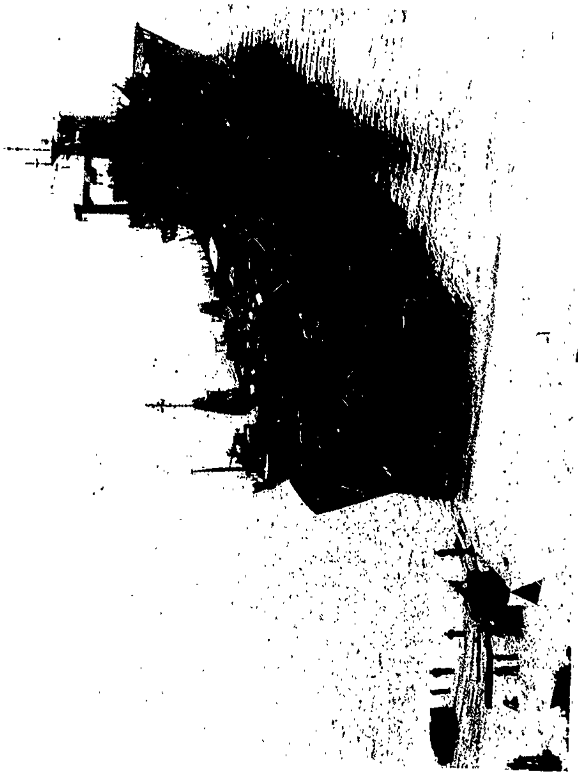

ILLUSTRATION 3 - HMAS Tobruk, beached at Jervis Bay, ACT (RAN official photograph)

gradient of one in 42 and many beaches within our particular strategic area of interest, in which I would expect the ship to operate, have that beach gradient of greater the one in 42.[1]

2.56 The Department said that other factors - such as wind, sea, tide across the front of a beach, currents and distribution of the ships 1,900 tonnes of liquid load (fuel, fresh and salt water, ballast) - are of greater operational significance than the difference in beach gradients of one in 42 and one in 50.

2.57 During the public hearing on 7 September 1983 a Departmental representative disclosed that:

> It was recognised from the beginning that there were a number of places where she would not be able to beach herself. On the other hand, a survey of the Australian coast indicated that there were a number of places she could. She has done a bow direct discharge in Jervis Bay. She could do a direct bow discharge in Port Stephens. There are places on the west coast. There is a proposed amphibious training area over on the west coast of Australia where she could beach directly. So it is a facility that should be made use of when it can be.

2.58 Later at the same hearing another departmental representative told the Committee:

> The ability to beach is a bonus, if you like.... The ability to discharge over the beach was one which was developed in the course of bringing forward the staff requirement and it is an additional bit of flexibility which has been built into the ship. It was never intended to be the primary means of discharging this ship or, to my knowledge, similar ships of this type. There are many areas in the world where, as I said earlier, the physical configuration of the beach is such that discharge over the shore may not be a possibility.

2.59 The Committee remains concerned however with the observation made by HMAS Tobruk's Joint Evaluation Working Party on the ship's beaching capability. In its Trials and Evaluation Report[2] *HMAS Tobruk's Joint Evaluation Working Party stated:*

> Technically, HMAS Tobruk can trim and beach upon a gradient of 1:42, which results in a water depth of about two metres at the end of the ramp. In

1. Minutes of Evidence, 17.9.82
2. Part 1, paragraph 59

practical terms, the maximum water depth should not normally exceed one metre, which requires a limiting beach gradient in the region of 1:25 to 1:30. This severely limits the ships beaching capability in the general Australian Environment.

2.60 The Committee agrees with this statement of HMAS Tobruk's Joint Evaluation Working Party.

2.61 The Committee notes the Department's calculation of the additional fuel expenditure to be incurred because of HMAS Tobruk's excess weight. The Department estimates that, based on a 25 year ship life and subjective judgement about how long the ship would maintain an operating speed of 15 knots, the additional fuel expenditure over the period would be approximately $200,000.

2.62 It is noted that this estimate may be conservative for HMAS Tobruk's specifications require a ship service life of 30 years.[1]

2.63 The Auditor-General notes that negotiations took place during 1981 between the contractor and the Commonwealth for recovery of compensation in respect of the overweight ship. The contractor denied that it was liable under the contract and negotiations were unsuccessful.

2.64 The Committee notes that HMAS Tobruk has never carried a cargo of maximum permitted weight (1211 tonnes). Between April 1981 and June 1983 the ship had however completed 10 voyages where the maximum volumetric capacity was used (7 of these were for Australian Defence Force exercises). Since commissioning, the vessel has undertaken only 2 voyages where more than 60% of the maximum permitted cargo weight was carried.

2.65 Generally, HMAS Tobruk has operated between the ports of Sydney, Melbourne, Brisbane, Jervis Bay and Shoalwater Bay. It has also visited Darwin, Townsville, Wyndham, Kemp Beach and Port Alma.

2.66 The ship has undertaken three overseas voyages:

- between 16 February 1982 and 30 April 1982 HMAS Tobruk assisted in the deployment of the Australian contingent of the Multi National force and Observers to Sinai;
- between 20 May 1982 and 10 June 1982 HMAS Tobruk undertook two Defence co-operation Programme Tasks to Tonga and Vanuatu
- during March 1983 HMAS Tobruk also voyaged to Singapore and Penang on an RAAF Support Task

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1. Paragraph 1.1.4, v.1, HMAS Tobruk specifications

Weight and Design Changes

2.67 The Auditor-General reported that, of HMAS Tobruk's 297 tonnes excess weight, 21.5 tonnes (7.2%) was attributable to approved design changes.

2.68 The Department gave evidence to the Committee that it was fully aware of the weight penalty that would be incurred with such changes. It was thought however that such design changes considerably enhanced the ships capability.[1]

2.69 The Department also stated that:

> the builder, apart from making it (the ship) a little overweight, saved a lot of weight in other places and put in, out of his own good shipbuilding sense, a lot of modern ideas'.[2]

2.70 The Committee acknowledges such actions of the shipbuilder but concludes that HMAS Tobruk would be an even better product if the hull was built to correct weight specification.

Other RAN Vessels

2.71 The Committee heard evidence that other RAN vessels under construction also suffer weight problems like HMAS Tobruk. The auxiliary oil replenishment ship HMAS Success and the patrol boat HMAS Fremantle were cited by the Department as examples.

2.72 It is noted that both these ships, like Tobruk, are 'first-off' vessels.

2.73 In its Industry Position Paper,[3] the Australian Shipbuilders Association comments on contracts for first-of-class vessels as follows:

> There appears to be a need for two separate contractual arrangements. The first arrangement should encompass the construction of a single vessel or the lead vessel of a class. The experience gained from the construction of a lead vessel, would provide valuable background against which a separate arrangement could be negotiated for follow on vessels. By implementing such arrangements the financial/commercial interest of both the Government and the contracting yard can be fully protected.

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1. These design changes are discussed in Chapter 6
2. Minutes of Evidence, 17.9.82
3. Refer to Appendix G

2.74 The Department stated to the Committee that:

> weight control is a very expensive operation and you can get any level of weight control that you desire if you really want to pay for it.[1]

2.75 The Committee questions the accuracy of this statement. In the case of HMAS Tobruk, there is little doubt that the ship's excess weight resulted from a lack of enforcement of contract weight control procedures by the Department and not because of the need for an expensive weight monitoring system.

2.76 The Committee notes that the contracts for patrol craft have been changed to tighten up weight control procedures with the contractor.

2.77 In respect of HMAS Success (AOR) the Department said that it had considered a $150,000 weight control system but:

> decided that the requirement for such a tight system was not justified. We therefore proposed an alternative system. The contractor and ourselves have come to an agreement over a satisfactory weight control system for the AOR.[2]

2.78 The Committee notes this reference to the HMAS *Success* contract and may follow it up in a later inquiry on general project management within the Department.[3]

Conclusions and Recommendations

2.79 The Committee concludes that:

- the Department did not allocate sufficient resources to developing quality assurance programs for monitoring, amongst other things, the weight control procedures of the contractor's quality control system. With hindsight it was a poor decision of the Department to sign the contract for the ships construction when it did. The Department knew of the need to upgrade the contractor's quality control system and should have accurately assessed the difficulty and duration of this task;

- the Department misled the Committee in giving evidence that it (the Department) 'discovered late rather than early that the vessel was overweight'.[4] The Auditor General reported that in September 1978, the month the first steel was cut at the shipyard, the contractor advised Navy Office that the ship would be overweight and Navy Office confirmed this view. This instance appears to be another example of poor consultation across the functional boundaries of the Department;[1]

- HMAS Tobruk's unauthorised weight increase was due to the Department not ensuring that the contract specifications were met;

- the Department did not give adequate consideration to the commercial practicalities of converting HMAS Tobruk's specifications from imperial to metric measurements;

- the Department did not recognise, in a timely manner, the adverse consequences of a 'soft conversion' from imperial to metric measurements of the specifications for HMAS Tobruk's steel plate;

- given the magnitude and obvious implications of converting the ship's design from imperial to metric measurements, the Department should have monitored more closely the contractor's conversion processes and materials acquisition. In this respect the Department was derilict in carrying out it's contract supervisory role;

- by contracting for HMAS Tobruk to be built to a mix of commercial and RAN specifications the Department may have saved on the capital costs of the project at the expense of incurring high ship maintenance costs;

- as a result of not being built to specifications HMAS Tobruk's beaching capability has been significantly reduced. While the Committee acknowledges that the ship's flexibility allows it to discharge cargo by other means, it remains that the ship would be more flexible and useful if it was able to beach at its specified gradient;

- there is little purpose in building a specialised beaching design vessel such as HMAS Tobruk if the resultant ship can only use the specified design feature in a secondary role under restricted conditions;

- HMAS Tobruk's excess weight does not jeopardise the ship's longitudinal strength; and

- the Department's performance in managing the weight control aspects of the local ship construction contracts is poor. HMAS Success, HMAS Tobruk and the *Fremantle Class Patrol Craft* have all been allowed to be constructed with excess weight.

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1. Minutes of Evidence, 17.9.82
2. ibid
3. Further reference to the Inquiry into Defence Project Management is contained in Chapter 7
4. Minutes of Evidence, 17.9.82

1. This aspect is analysed in Chapter 6

2.80 The Committee recommends that:

- the Department develop, in consultation with the Australian shipbuilding industry and other groups, standardized techniques for assessing the weight of vessels. Effort should be directed towards developing a range of agreed methods (with differing costs and accuracies) for objectively determining the weight of a vessel during construction and at the time of its commissioning;

- for future contracts the Department either:

  - ensure that a contractor's quality control system meets the appropriate Australian standard at the time of signing the contract, or

  - if, at the time of signing the contract, the contractor's quality control system is judged not to meet the relevant Australian standard but is thought to be able to do so at a later date, a development plan for the contractors quality control system should be incorporated into the contract specifications by the Department;

- the Department ensure that development of a contractors quality control system is carried out as promptly as possible. Contract progress payments should be linked to stages in such a development plan; and

- the Department should investigate and assess the utility of the contracts proposal of the Australian Shipbuilders Association in conjunction with the Department of Defence Support and the Attorney-General's Department.

CHAPTER 3

THE ORIGINAL REFERENCE - QUALITY ASSURANCE AND CONTRACTUAL MATTERS

Terminology

3.1 The concepts of quality assurance and quality control discussed in this Report are those defined by Australian Standard 1057-1971 'Terms Used in Quality Control'.[1]

3.2 The Committee understands the term quality assurance to mean 'all activities and functions concerned with the attainment and proof of the required quality'.[2] In the case of the HMAS Tobruk contract, responsibility for quality assurance rests with the Department via its Naval Quality Assurance Representative, the General Overseer and Superintendent of Inspection East Australia Area (GOSIEAA).

3.3 The Committee understands the term quality control to mean 'a management system for the establishment, attainment and maintenance of the quality requirements'.[3] The HMAS Tobruk contract specifications state that quality control is the shipbuilders responsibility.

The Auditor-General's Comments

3.4 Among the 'major unsatisfactory issues' with which the Auditor-General concluded his March 1982 Report was that:

> insufficient quality assurance control was exercised to ensure that the specified Naval requirements for design, construction and materials would be fully met.[4]

3.5 Elsewhere in his Report the Auditor-General said, in reference to control over production, 'the Department was not advised in a timely manner of the results of quality assurance inspections'.

3.6 The Auditor-General also commented that the Department proposed to increase the resident quality assurance staff in shipyards to avoid difficulties of the type encountered in the HMAS Tobruk project. For major projects this staff would report directly to the Quality Assurance Authority.

3.7 The use of outside contractors for quality assurance work was also being investigated by the Department.

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1. Incorporating Amendment No.2, 1976
2. AS 1057, defn 1.3
3. AS 1057, defn 1.5
4. Refer Appendix 1

Contract Specifications

3.8 The Committee noted that HMAS Tobruk's contract specifications required the shipbuilder to operate a quality control program in accordance with Australian Standard 1822 'Suppliers Quality Control System-Level 2'[1].

3.9 This Standard, 1822 'Level 2', is one of three distinct suppliers quality control systems laid down by the Standards Association of Australia.

3.10 The Association describes the three systems in decending order of complexity as follows:

.. Level 1 (AS 1821) specifies requirements which would normally be applied to contracts where the customer considers quality control to be essential in all phases. This system would be particularly suitable where the technical requirements are expressed principally in terms of performance and the supplier may be required to design and develop, as well as manufacture, assemble and test the supplies and services;

.. Level 2 (AS 1822) established requirements for a less stringent system than that specified in AS 1821 for Level 1. These requirements would normally be applied to contracts where the main function of quality control is directed towards the manufacture, assembly and test of the supplies and services;

.. The requirements of Level 3 (AS 1823) are less extensive than those prescribed for Levels 1 and 2. This system is applicable where conformance to contract requirements can be established by inspections carried out on the finished product and, where appropriate, at specific intermediate stages of production.[2]

3.11 In respect of quality assurance, section 1.6.3 v.1 of *HMAS Tobruk*'s specifications state that the conditions of TI364 (1974) 'The Requirements of Naval Quality Assurance' must be compiled with by the contractor.

3.12 Section 1.6.3.2 v.1 of the ship's specifications states:

> The purpose of the Naval Quality Assurance activity shall be to obtain evidence by quality audit and quality control surveillance (including product audit) to assure that the quality of work

1. Volume 1, s.1.6.2 HMAS Tobruk Specifications
2. AS 1821 to AS 1823 - 1975, pp.5,6)

> performed by the shipbuilder in fulfilment of the contract complies with stated requirements before acceptance.

3.13 Also section 1.24.1 of the ship's specifications states that:

> the shipbuilder shall provide shipyard office accommodation for the 4 (four) overseeing staff during construction of the vessel.

The Department's Submission

3.14 In its second submission to the Committee's Inquiry[1] the Department made the following points:

. one (1) on site Navy officer acted as representative for the General Overseer and Superintendent of Inspection East Australia Area (GOSIEAA),

. the GOSIEAA representative performed the duties of the Departments Quality Assurance Representative with direction to monitor programs and report to GOSIEAA Head Office in Sydney,

. GOSIEAA Head Office support was provided on an 'as required' basis,

. conflict arose between GOSIEAA and the RAN Trials and Assessing Unit (RANTAU) over their respective roles in the ship inspection and trials process, and

. the established procedure for handling inspection reports was not sufficiently reactive to a fixed price commercial build.

3.15 The Department also said:

> By the time an inspection had been completed and a report written, circulated and considered, matters on which Navy Office decisions had been sought had, in most cases, been overtaken by events as shipbuilder's work could not normally cease during the Navy Office consideration process. It has been recognised that there is a requirement to tailor an inspections organisation and reporting process to meet the needs of fixed-price contract construction in commercial shipyards and ABR1921 'Instruction for HMA Ships - Building' is currently under review to reflect this requirement.

1. *Refer to Appendix C*

3.16 The Committee is astounded by these statements. It would appear that the Department damns the efficacy of its own decision making process with the above explanation.

The Review of HMAS Tobruk Board of Inquiry Into the Death of NRC Kenneth Dax

3.17 During the course of this Inquiry the Committee analysed the findings and conclusions of the Review of the HMAS Board of Inquiry into the Death of Naval Reserve Cadet Kenneth Dax.[1]

3.18 This Review is a comprehensive document. It comments not only on the tragic circumstances and physical conditions which led to the death of NRC Dax but also on the Department's overall management and administration of the Tobruk project. In this and later Chapters references to the Review's findings on general departmental management, overall ship design and project administration are used to support the Committee's analysis. Specific comment on the death of NRC Dax and the question of compensation is in Chapter 8 of this Report.

3.19 The Committee supports the view of the Deputy Chief of Naval Staff that the author of the Review 'is to be commended for the depth and breadth of the review and the attention to detail which he has demonstrated'.[2]

3.20 Comment is made in this Chapter on the Review's findings on quality assurance and quality control.

3.21 Paragraph 83 of the Review states:

> Navy was represented on site during the build by GOSIEAA, whose officers audited (the Contractor's) quality control procedures. GOSIEAA representatives have advised (the author) that (the contractor's) performance in this field was unsatisfactory and the towards the end of the build GOSIEAA officers had virtually to revert to overseeing.

3.22 At Annex H of the Review, the General Overseer and Superintendent of Inspection, East Australia Area says:

> Although it was a contractual requirement for the contractor to operate a quality system to the level of AS 1822, and it was assessed that he had established such a system, in practice it was difficult to get the contractor to give more than lip service to this requirement. In particular, during the final few weeks of the construction period the contractor abandoned formal quality

1. Refer to Appendix H
2. ibid., Letter 21 June 1982

> control practices and in effect, GOSIEAA staff, in nominating defects for correction, were carrying out the QC function. However if this had not been done the ship would not have been completed to the standard it was in the given time. In the event, of course, it is considered that a very satisfactory ship was handed over by the contractor.

3.23 The Committee questioned the contractor about this matter during a public hearing on 14 September 1983. The contractor replied:

> I will tell you what we did towards the end, with the co-operation of GOSIEAA and in hindsight that has been turned against both them and ourselves; the paperwork system which was involved for quality control inspection was quite involved with the setting to work notice and that sort of thing. We decided for expediency towards the end that we would have co-operation between the GOSIEAA inspectors and ourselves, our own inspection people, and shorten the system to allow the ship to be finished on time.

3.24 Later in the same hearing the contractor stated:

> Our relationship with GOSIEAA and the ship's officers, I believe, was at a high level right throughout the contract. The standby crew had certain restrictions placed on them which are expressed in Annex I (of the Review of the Board of Inquiry Report). Towards the end of the contract in order to meet the delivery goal discussions were held with GOSIEAA and this introduced this idea of co-operation. The second-in-charge of GOSIEAA agreed that to reduce the amount of paperwork, and the procedures backwards and forwards, the GOSIEAA representatives and our people would co-operate in the inspection procedures in order to progress it more quickly and achieve the final result and that has been interpreted that they had virtually to revert to overseeing. Towards the end of any contract the items that possibly have been outstanding because of differential interpretations on it all come to a head.

3.25 The Committee believes GOSIEAA's conclusion (cited above) re 'a very satisfactory ship' does not accord with the findings of the Review, the Auditor-General and the Committee's findings generally. GOSIEAA's conclusion is at odds with the Review's statement, at paragraph 125 that:

> with the benefit of hindsight, particularly in view of the main machinery problems being experienced, it is arguable that the ship should not have been commissioned when she did, despite the pressing administrative problems inherent in a further deferral of the ceremony itself.

3.26 The Committee acknowledges and supports the Review's critical comments on the role of the General Overseer and Superintendent of Inspection East Australia Area, and the RAN Trials and Assessing Unit (RANTAU). In particular it notes the following Review comments:

> The arrangements under which the ship was built by the contractor excluded direct oversight by Navy.... Navy was represented on site during the build, by GOSIEAA, whose officers audited the contractors quality control procedures. GOSIEAA representatives have advised that the contractor's performance in this field was unsatisfactory and that towards the end of the build GOSIEAA officers had virtually to revert to overseeing. The dissatisfaction felt by the standby crew, with the situation, (was) strongly expressed (in correspondence).[1]

> Although the ship was apparently not to be built formally under the terms of ABR 1921, Instructions for HMA Ships Building, Undergoing Modernisation, Conversion or Extended Refit (Aug 1973), GOSIEAA had been identified by Navy Office as the authority responsible for ITTs (inspections, tests and trials), as in ABR 1921 Art 2107. RANTAU assistance was used by GOSIEAA to the extent felt to be possible in a ship not built to normal naval standards - a source of some difficulty and confusion for RANTAU. It is understood that disagreements arose between GOSIEAA, RANTAU and the ship's staff to the extent that working relationship were strained.[2]

1. Review of HMAS Tobruk Board of Inquiry Into the Death of NRC Dax, paragraph 83
2. ibid., paragraph 84

> The total management system under which the ship was built, commissioned and set to work.... was complex and tended to isolate the standby crew from their ship before commissioning, thereby inhibiting self-teaching and on-the-job training. This was a source of particular difficulties for the ship. After commissioning, the ship's company found themselves beset by difficulties. In addition to the normal problems of getting to know their new ship and of working up an inexperienced crew (without benefit of formal technical training, at least) they were distracted by major engineering problems, affecting main propulsion performance and reliability, particularly.[1]

> Compounding the engineering problems were difficulties imposed by warranty considerations, necessitating the multilateral involvement of the Project Staff, GOSIEAA, the Shipbuilder, his Main Machinery Contractor, Sub Contractors, the Administrative Authority (and in some aspects his delegate, Commander Australian Amphibious Squadron), and finally the ship itself. It is small wonder that in this complicated situation, the Administrative Authority's normally close involvement with a fleet unit's material problems, particularly during safety inspections and the workup period, may have been reduced.[2]

> The notion that GOSIEAA should not provide an overseeing service is practicable only where it can be assured that the contractor has an adequate quality control organisation, and this does not appear to have been so in TOBRUK's case.[3]

> RANTAU needs clear guidelines in the way of trials schedules and standards to be met. The schedule for the sewerage system was inadequate, given the brevity of the design guidance provided for the contractor. What seems to have been necessary was a schedule of tests to ensure a working system, not merely to ensure that the specified design guidance criteria had been incorporated.[4]

1. Review of HMAS Tobruk Board of Inquiry Into the Death of NRC Dax, paragraph 111
2. ibid., paragraph 112
3. ibid., paragraph 124a
4. ibid., paragraph 124b

The shipbuilder's Quality Control and Overseeing arrangements appear to have been unsatisfactory and were the source of dissatisfaction and criticism by the standby crew and GOSIEAA. The standard was not good enough for GOSIEAA's involvement to have been restricted to quality assurance.[1]

An Inspection, Tests and Trials (ITT) Programme existed but RANTAU felt compromised by the requirement that the ship was not to be built to normal naval standards. RANTAU's involvement in ITT was too limited.[2]

3.27 It is apparent that the conclusions of the Review of the Board of Inquiry on quality control and quality assurance are reflected in other departmental correspondence initiated during the ships construction.

3.28 The Committee notes that in his January and February 1981 'Monthly Activities Report' the Senior Officer standing by HMAS Tobruk comments 'progress on the ship towards completion continues to be slow and most disappointing'. Similar sentiments are echoed in the Senior Officer's Monthly Reports from August 1980 onwards, for example:

Aug 1980 Overall progress on the ship has been slow and it appears that this may be because of a reduction in employees on the project. The planned trials programme has commenced hesitantly but is already behind schedule.

Sep 1980 Progress on the ship during the month has been very slow.... the main reason for the lack of progress appears to have been because of the company's emphasis on two other vessels, both of which have now left the shipyard.

Oct 1980 Progress for the month has only been fair.

Nov 1980 Progress during the month was disappointing. Although many compartments are now nearing completion, the shipbuilder continues to fall behind schedule and programmed dates for final inspections and trials are seldom met. In addition the cleanliness of the ship is still unsatisfactory.

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1. Review of HMAS Tobruk Board of Inquiry Into the Death of NRC Dax, paragraph 162hh
2. ibid., paragraph 162ii

3.29 The reports of HMAS Tobruk's Army Detachment Commanding Officer also show a similar growing dissatisfaction with the quality and progress of the ship's build. The Army Detachment was raised on 24 March 1980, soon after HMAS Tobruk's launching on 1 March 1980. It comprised 15 men. During HMAS Tobruk's fitting out the Army detachment operated from an off-site office at the nearby RAAF Base at Williamtown, NSW.

3.30 In the Army Detachment Commander's Progress Report of 18 June 1980 it is noted that:

> the standard of ship construction is considered to be high within the constraints of a fixed price contract.

3.31 Later, in his Report of 17 October 1980, the Army Detachment Commander says:

> The resulting pressure on sub-contractors and workers to meet delivery dates has caused a downturn in the quality of work. In many areas short cuts are being taken and this is evidenced by the long list of rectification items found on preliminary inspections prior to final acceptance of compartments.

3.32 Finally, in his Report of 4 February 1981 (HMAS Tobruk was commissioned on 23 April 1981) the Army Detachment Commander states:

> As reported previously the quality of work on the ship continues to be less than satisfactory. This is caused by contractural pressures to finish the ship without penalty clauses being invoked. Although many of the defects are of a minor nature they occur in most compartments of the ship and their numbers reflect ignorance of the ship specification. If these defects are not rectified prior to handover of the ship to the Navy it must be assumed that, in the long term, the operational capability of the ship will be affected.

On Site Representation.

3.33 In its submission of June 1983 the Department stated, at paragraphs 40 and 41:

> Many factors contributed to the difficulties encountered on this project. Some of the more significant ones were:
>
> (a) insufficient onsite resources to adequately manage a shipbuilding project of this magnitude; and

(b) insufficient level of specialist management expertise and supporting staff from the functional areas which was compounded by a lack of continuity in personnel.

For current projects the level of onsite staff has been increased significantly, however, these have not been matched with increases in the levels of support staff required. The matter is being pursued further with the Department's Establishment Inspection Branch.

3.34 During an in camera hearing in August 1983 a Departmental representative admitted:

> In the case of 'Tobruk', our expectation that the necessary assurance in regard to quality could be achieved with a minimal number of staff at the shipbuilder's yard - that is, one person - was unreasonable in hindsight. The situation which I have just reported is at variance with the experience of other navies building naval vessels at commercial yards. We endeavoured to apply national engineering practice to shipbuilding and that called for the shipbuilder to reach a certain standard of quality. At the time of placing the contract we assessed that he could reach that standard of quality. We did not provide enough staff on base to ensure that he attained that standard of quality until later in the building process.

3.35 Later, during a public hearing in August 1983 the Departmental representative amended this response saying:

> In fact, the residential staff was increased halfway through by an assistant technical officer joining, again, another civilian employee of the department. They were assisted by regular visits from specialists in the Sydney area, who used to go up from Sydney to Newcastle for one or two or sometimes three days a week, but not every week. That has proven to be, for many reasons which I went into (previously), quite inadequate and it is not a thing which we are pursuing either in HMAS Success or in the present contract with the Carrington Slipways or indeed in any future contract we have. We will have a considerably greater number resident, dependent upon the complexity of the contract. As I have said, we know that there was not enough people or enough experience to do the (HMAS Tobruk) task adequately.

3.36 With such a low level of departmental on-site representation during HMAS Tobruk's construction it is probable that many of the ships inspection tests and trials were not oversighted as effectively as they should have been. In his Monthly Activities Report for January 1981, soon after HMAS Tobruk's maiden voyage on 16 December 1981, the ship's Commanding Officer commented on the Basin and Initial Sea Trials saying:

> Although both sets of trials were considered satisfactory, the manner and thoroughness of those conducted left a lot to be desired. Inadequate documentation, lack of thoroughness of examinations and a rushed programme are the major areas of concern. The conduct of these trials are yet another example of 'good commercial practice' falling short of naval practice.

3.37 The Committee notes with some concern the following comments made by a senior departmental officer in a letter of 6 October 1983 to the Association of Draughting Supervisory and Technical Employees:

> Nevertheless the Department does accept that the Management arrangements and the number of Field Representatives resident at the shipyard was not sufficient to provide an adequate level of <u>management visibility</u> for a Naval ship being constructed by a Commercial shipbuilder, unfamiliar with Defence requirements. Both the Department and the contractor underestimated their respective tasks and did not have the depth of expertise applied to these tasks now seen to be necessary with hindsight. The requirement for <u>visibility</u> has already generated changes within the Department towards more dedicated Project Management teams. (emphasis added).[1]

3.38 The Committee completely rejects this view. The Committee believes it is not just the 'visibility' of management which is important but the efficiency and effectiveness of management in carrying out its designated roles.

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1. The Association of Draughting Supervisory and Technical Employees (ADSTE) had written to the senior departmental officer expressing their concern at critical statements made by another senior departmental officer in evidence during a public hearing of the Committee. The statements were critical of HMAS Tobruk's quality control and quality assurance, ADSTE members are on the staff of the GOSIEAA who was responsible for HMAS Tobruk's quality assurance.

Conclusions and Recommendations

3.39 The Committee concludes that:

- the Department's explanation that 'by the time an inspection had been completed and a report written, circulated and considered, matters on which Navy Office decisions had been sought had, in most cases, been overtaken by events as shipbuilder's work could not normally cease during the Navy Office consideration process' is completely unacceptable and an indictment on the efficiency of the Department;
- the number of on-site departmental representatives at the shipbuilders yard was grossly inadequate;
- the level of on site departmental expertise and experience was inadequate given the task at hand. The Department was negligent in that it did not even meet the level of resident overseeing staff as laid down (by itself) in section 1.24.1, v.1 of HMAS Tobruk's specifications;
- it is not a matter of the 'visibility' of resident departmental quality assurance staff which is important in a project like HMAS Tobruk. It is important that there be skilled departmental quality assurance staff on site in sufficient numbers to efficiently and effectively fulfil the quality assurance function; and
- there is a need to review the efficiency and effectiveness of the organisation of the General Overseer and Superintendent of Inspection East Australia Area, this issue will be addressed by the Committee during its Inquiry into Defence Project Management in 1984.

3.40 The Committee recommends that:

- the Department in all future projects ensure that as part of the on-site resident team a resident quality assurance team, of a size commensurate with the scale and complexity of the contract, be present throughout the project; and
- members of all future on-site resident departmental quality assurance teams have adequate skills and expertise and a clear understanding of the Department's policy on quality assurance.

CHAPTER 4

THE ORIGINAL REFERENCE - LANDING CRAFT VEHICULAR AND PERSONNEL

Background

4.1 HMAS Tobruk has a complement of two Landing Craft Vehicular and Personnel (LCVP). They are small boats carried on the port and starboard side of the ship's bridge structure and can be seen on Illustrations 1, 3 and 4 (the port LCVP in illustration 4 overleaf is designated T2).

4.2 Volume 2 section 5.9.4.1 of HMAS Tobruk's specifications state that these LCVP's have the following approximate dimensions:

length - 12 metres
beam - 3.5 metres
weight - 5 tonnes (light)
8 tonnes (loaded)

4.3 The LCVP's are simple craft. They have an open well deck which carries troops or small vehicles, a bow door which flaps down, an aft engine room, points for lifting the craft up to HMAS Tobruk's davits and a jet propulsion plant. They are constructed of fibreglass.

The Auditor-General's Comments

4.4 In his March 1982 Report the Auditor-General made several critical comments on the Department's procurement and testing of HMAS Tobruk's two LCVP'S.

4.5 He noted that the 1977 tender schedules and naval staff requirement specified the acquisition of a craft with a proven hull design which would remain afloat and upright when filled with water. The contract for the LCVP's did not stipulate the specific swamp testing required to ensure these characteristics.

4.6 In January 1978 the UK contractor advised the Department that the craft would conform with the swamping requirements of the Tenders Schedule. However in May 1979 the contractor's simulated swamp test (using mathematical and computer modelling techniques) disclosed that the LCVP would remain afloat but turn upside down when both compartments were swamped. In February 1980 the Department resolved to undertake its own analytical model calculations. A practical test on similar craft done by the UK contractor in April 1981 confirmed the company's earlier (May 1979) analysis.

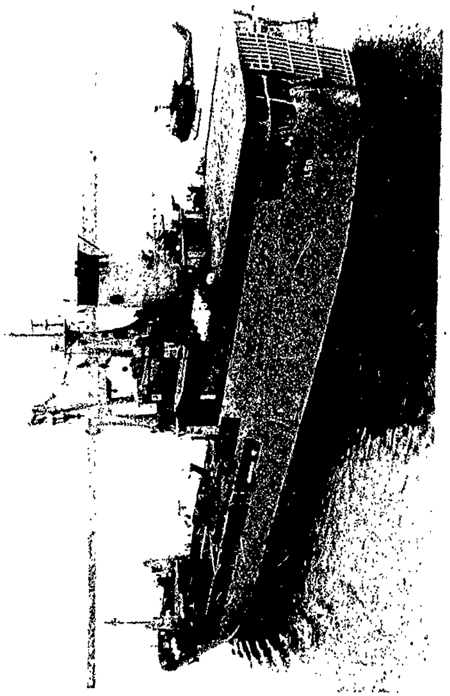

ILLUSTRATION 4 - HMAS Tobruk with helicopters
(RAN official photograph)

4.7 The Auditor-General reported that the LCVP's have lost some of their planned capability because of:

- a potential swamping hazard,
- a 26% understatement of the weight of armed troops to be embarked by the LCVP'S, and
- a slight increase in the weight of LCVP's above contract specifications.

4.8 The procurement contract for the LCVP's stated that the weight of the 34 fully armed troop was 2500 kg (based on the advice of the Army Office during 1976). It was ascertained during 1979 that the weight of the personnel was understated by 900 kg. Thus restrictions have had to be placed on the number of armed personnel (a reduction of 47%)[1] to be lifted/lowered in an LCVP. As a result alternative embarkation procedures have been adopted. However, the LCVP's hoisting system has no clutch slipping arrangements to regulate the speed of LCVP lowering to the sea. Hence, troops can only be lowered under very favourable sea conditions.

4.9 HMAS Tobruk's configuration also allows troops to disembark by scrambling net, accommodation or jumping ladder or through the bow or stern doors.

The Department's Submission

4.10 In its submission of August 1983 the Department stated:

> It is agreed that difficulties were encountered in respect of the swamp testing called for in the Naval Staff Requirement and further definition is required. Pending resolution of an RAN swamp testing policy for these craft, users have been advised of restrictions necessary when used in heavy surf. Although the advice as to weight of fully armed troops was incorrect the overall effect on ability to transport troops is negligible as the occasions when lifting or lowering by davits in a loaded condition would be minimal.'[2]

Davit Hoist of the LCVP's

4.11 During its public hearing on 17 September 1982 the Department stated that although there were four Australian tenders for the HMAS Tobruk's LCVPs, only the tender from the United Kingdom met the Navy's requirement. The HMAS Tobruk Project Director said:

> One of the most important requirements was a craft that we could davit hoist and the United Kingdom ship firm was the only one that offered a craft

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1. Auditor-General's Report, March 1982, p.34
2. Refer to Appendix B

that had already been davit lifted that we could see. It had to be a proven craft that was already in existence.

4.12 The Committee heard evidence from a former HMAS Tobruk Commanding Officer that to lower the LCVP's from the ship's davits with a fully equipped platoon would be a most unusual circumstance. The preferred method of loading troops and equipment into the LCVP's was to have the craft alongside the ship and use scrambling nets and/or ladders such as an accommodation ladder or a crane. The officer stated that he 'did not know why the requirement was written for LCVPs to be lowered from the davits with such a loading of troops'.[1]

4.13 The Department stated that it became aware of the error in the weight of embarked troops while the ship was being built in 1979. It tested the LCVP's on the davits 'with 12 times the weight of 34 troops (using) pig iron blocks' and found the stength of the davits satisfactory.

4.14 During evidence heard at in camera and public hearings in August 1983 the Committee was told that the hydraulic motors on the davits were a continuing problem for the ship. The davit hydraulic motors are the drive mechanisms for the wire ropes used to raise and lower the LCVP's. The problem with the davit hydraulic system is that it is contaminated, for reasons which have not at the time of writing this Report yet been established.

4.15 It appears that problems originating early in HMAS Tobruk's construction have contributed to the continuing failure of the davit hydraulic motors. Throughout HMAS Tobruk's Senior Officer's Monthly Activities Reports (filed during the ship's construction) there are adverse comments pertaining to the hydraulic system, for example:

May 1980	Unfortunately cleanliness of compartments is considered to be below acceptable standard and there is clear evidence of foreign matter being allowed to gather in pipework and paint being sprayed on items such as valve threads.
Jun 1980	An item which has been completed is the installation of the LCVP davit hydraulic system and flushing out of this system is now in hand.
Jul 1980	Setting to work of the LCVP davit hydraulics is continuing but due to mechanical problems, the Harbour Acceptance Trials for this equipment are overdue.

1. Minutes of Evidence, 17.9.82

Aug 1980	There continues to be problems in the setting to work of the LCVP davits hydraulics ..... the standard of cleanliness in the ship previously reported continues to be a course for concern.
Sep 1980	The three new and bigger motors for the hydraulic pumps have arrived and are being fitted. The davits continue to present a problem in that they are presently unable to lift any load even approximating that of an LCVP.
Nov 1980	Harbour Acceptance Trials of the LCVP davits were carried out.
Feb 1981	Further modifications have been undertaken to the LCVP Davit's Hydraulic System. These comprised enlarging the oil storage tanks, adding an inlet filter, changing the position of the Port/Starboard changeover valve and modifying the pump. This work is not yet complete.
Mar 1981	The davit hydraulic pump has been changed for a larger version....

4.16 As at August 1983 there have been five failures of these motors since commissioning. Presently both davits are unserviceable. Illustrations 1, 3 and 4 in this Report were taken early in the ship's life soon after commissioning and hence the LCVPs are shown on the davits. Illustration 2 is a more recent photograph and it can be seen that the ship's LCVPs are not on the davits.

4.17 The contaminated system in HMAS Tobruk will need a thorough cleaning in order to reach the required standard and there will be a delay while spares from the United Kingdom are acquired.

4.18 The Committee is concerned with this delay and notes that marine hydraulics technology is well known and relatively straightforward in the engineering industry. The Department has been dilatory in devising a remedy for such an apparently straightforward problem.

Operational Capability of the LCVP's

4.19 At the September 1982 public hearing a representative from the Army Office said that prior to the procurement of the LCVPs the only view the Army Office had of them was that:

.... they were basically ship's boats designed to cater for the ship all the time to move the crew around as required. The fact that they would be small landing craft as such was a bonus to Army and there was little they could carry ashore. Possibly at some time they would be very useful. Mainly their role is as ship's boats.

4.20 The Committee understands that the Department has advised HMAS Tobruk's Commanding Officer that the swell of the surf level in which the boats can operate should now be reduced by 35% because of the LCVP's swamping possibility.

4.21 The Department stated that the LCVP's can satisfactorily carry a Land-Rover and trailer or a 105 millimetre gun if required but were not the main method of getting troops to the shore.

4.22 The Department confirmed that HMAS Tobruk's LCVP's, when fully loaded, and when both compartments (the well deck and engine room) are filled with water, the craft will overturn but remain afloat. A departmental officer said:

> In that regard these LCVP's share that characteristic with the thousands of small landing craft which were used during wars in the last half century. There is nothing peculiar about that. When fully swamped they will overturn. With one compartment flooded - either the well deck or the engine room - the craft will not only float but remain upright. There is a school of thought which says that the role of these craft is such that we can follow the widespread practice of the past and not require them to stand up to the requirments of the swamp test that they remain upright with both compartments flooded. Notwithstanding that, we have nearly completed some design work which can provide extra buoyancy high on the well deck, which will improve the stability when the well deck is flooded, or some modifications to the engine compartment to prevent the engine compartment being flooded when the well deck is swamped.[1]

It was also stated that:

> Since entering service in Australia, these craft have not achieved the operational performance claimed for them during maintenance trials in the United Kingdom. This casts some doubt on the trial figures achieved. It appears that the engine is not sufficiently powerful to get the craft to plane. However, new LCVP's are planned for 'Tobruk'. The present ones will be transferred to

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1. Minutes of Evidence, 5.8.83

> the new fleet oiler now under construction at Vickers Cockatoo, where their role will be less demanding.[1]

4.23 The Committee notes that the Trials and Evaluation Report on HMAS Tobruk made several adverse comments on the utility of the LCVP's. It doubted the ability of the craft to manoeuvre Naval Lighterage Equipment because of the craft's lack of knee pads, fragility, shallow draft and lack of sufficient power. These doubts were reinforced from experience gained in LCVP operations. The Joint Evaluation Working Party's Trials and Evaluation Report concluded (at paragraph 63):

> The LCVPs have proved generally unsatisfactory due to their low speed, unreliability and light construction. Acquisition of a more reliable and robust type of LCVP should be considered.

4.24 The Committee notes that the Flag Officer Commanding HM Australia Fleet (the Fleet Commander), in his Report on HMAS Tobruk Trials and Evaluation Programme of 28 March 1983 states that among HMAS Tobruk's 'other important technical problems' are problems with the LCVP's. He notes:

> LCVPs have had engine failures, GRP buckling and some ramp securing arrangement failures. The trial has indicated that the reliability of this craft is not satisfactory and much work is yet to be done to bring the craft to an acceptable operational state.

Conclusions and Recommendations

4.25 The Committee concludes that:

- the Department's tender specifications for HMAS Tobruk's LCVPs were deficient and not correctly oversighted by the Department when the contract for the LCVPs was awarded;

- the Department's statement that it tested the LCVP's on the davits 'with 12 times the weight of 34 troops (using) pig iron blocks', and found the strength of the davits satisfactory, conflicts with the Auditor-General's concern that the weight of LCVP embarked troops was understated by 900 kg resulting in the Department placing restrictions on the number of armed personnel lifted/lowered in on LCVP;

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1. Minutes of Evidence, 5.8.83

- initial problems with HMAS Tobruk's davit hydraulic system point to problems with supervision and oversight of the contractors quality;

- the Department has been dilatory in devising a remedy for HMAS Tobruk's contaminated hydraulic system;

- continuing problems with HMAS Tobruk's davit hydraulic system, point to a lack of expertise with hydraulics in the Department or inefficient systems in the Department to rectify defects in well known engineering technology;

- although the Department states that HMAS Tobruk's LCVP's are not the main method of getting troops ashore, problems with other methods (eg. beaching) or restrictions with other methods (eg. operation of the stern door only during calm sea conditions) compounds the significance of the davit problem;

- HMAS Tobruk's landing craft vehicular and personnel are unsatisfactory in their design, operational capability and safety; and

- the LCVP's design and specifications were poorly determined and the decision to purchase them was completely unsatisfactory.

4.26 The Committee recommends that:

- the Department proceed as soon as possible with rectification work on the LCVP's to improve their buoyancy, such work should be completed before the craft are transferred for use on HMAS Success;

- replacement LCVP's for HMAS Tobruk should be procured as soon as possible and be available before the scheduled refit of the ship;

- replacement LCVP's should be acquired to improved specifications developed with the hindsight of the problems experienced in the original craft; and

- preference be given to Australian contractors who tender for the replacement LCVP contract and the rectification contract for existing LCVP's.

CHAPTER 5

DESIGN AND MODIFICATIONS

Background

5.1 In this Chapter several unsatisfactory aspects of HMAS Tobruk's design, and modifications made to that design, are examined. While much of the analysis concentrates on the disclosure of design problems it should not be interpreted as a complete or comprehensive discussion of the detail surrounding HMAS Tobruk's design faults. Only major areas of concern to the Committee have been discussed below.

5.2 As discussed in Chapter 1, HMAS Tobruk is a modified variant of the 1960's UK RN Sir Bedivere LSL class of vessel.[1]

5.3 During its inquiry the Committee sought to establish why the Department chose to purchase and substantially modify an old overseas design. In a public hearing on 7 September 1983 the following rationale was given by a departmental respresentative:

> ...one must consider what sort of ship the Australian Navy needed to meet its requirements. A number of possible material solutions to the Naval Staff requirement were considered and it was decided that the Sir Bedivere class from the United Kingdom had the main attributes that we were looking for in our ship. It was about the size of ship that carried the sort of Army military load that the Defence Force wanted to carry. It had about the right speed. It was about the right size. The tonnage load was about right. It had the characteristics of the various means of off-loading the military load ashore. The range was about right also. As a result, that ship was taken as a basic design rather than entering into a completely new design.
>
> Having made the decision that that was the base on which we were to build, the individual changes that were necessary to meet our full requirements then had to be incorporated into the design. Overseas equipment and the difficulty with spares were common problems. We have a lot of overseas equipment right throughout our Navy and to varying degrees they can pose problems in the logistic support. Sometimes it is a lot better than the support we can get from local suppliers, I might add. If one looks at our main combatant ships, the guided missile destroyers and the FFGs that are now coming into the inventory, one sees that it is all overseas equipment, with a couple of minor

1. Refer Tables 1A and 1B

exceptions. Generally speaking, the equipment in our warships, particularly our combatant equipment, is all designed and procured overseas. All the weaponry, a lot of the electronics and the engines are all overseas designed. That is a characteristic of our ships as they exist right now - it is right through the Navy.

5.4 The Committee believes that, in principle, there is nothing inherently wrong with taking an old ship design and changing it. Engineering development is based on experience and research. It is this principle that sets engineering standards and codes of conduct.

5.5 However unless the original design is duplicated completely, and therefore the old technology and the requirements/specifications of the previous user accepted, then great care must be exercised with design modifications and translations.

5.6 The Committee sought independent specialist advice on the practicalities of adopting and modifying an old ship design to produce a new first of class vessel. One well qualified adviser of many years standing in the Australian industry, and overseas, ventured the following opinion:

> My experience is that you have to treat it as being the same as a completely new design. You must set up a complete design team and you must go into it in great detail. You cannot accept any individual component as being exactly the same as it was done 15 years ago. Naturally, your requirements will change - it is characteristic of clients - and indeed their requirements usually change after they have finished establishing their requirements, so that you must, firstly set your requirements as firmly as possible and then set a dedicated design team to work to re-engineer the job completely. You cannot just do sections of it; you must do the entire system because any engineered project is completely interactive. That is just a basic principle - you must go into it completely. It is always a great mistake to think that you can save money by starting off with the design.

5.7 The Committee notes the general observation of the Joint Evaluation Working Party Report on HMAS Tobruk Trials and Evaluation Programme, as follows:

> 'The LSH design is based upon that of a 21 year old United Kingdom LSL. If in the future, consideration was to be given to the construction of a similar ship-type for the Defence Force, the ship's design should be updated to reflect experience gained with HMAS Tobruk in the Australian environment and latest developments in technology'.[1]

5.8 The Committee heard evidence that there were inherent problems in purchasing ships' designs from abroad when it came to assessing the potential for Australian industry participation in the construction of such vessels. It was told that, in many relevant fields, Australia does not have the depth of industry or intrinsic management capability to participate in such work. Buyers must look towards overseas expertise, materials and equipments, identify them and take proper management and administrative actions to control and acquire such items.

5.9 The Committee is concerned by such statements, given the present domestic economic circumstances, but it acknowledges that for much of the previous decade there had been no warship building activity in Australia. During this time scale - 1971 to 1977 - some of the skills extant in naval technical activities associated with shipbuilding were eroded by departure, reassignment of people or simply loss of practice by head office and field officers. However a small number of local shipyards retained their capability to undertake RAN projects.

Departmental Design Modifications

5.10 Old designs engender confidence because of the belief that 'at the end of the day' an organisation believes it will have something that works because a similar thing has already been produced and is in operation. The Committee believes that this may be false economic reasoning as often, in the long run, the cost of modifying an existing complex design is greater than starting from scratch. It is very dependent on assembling and managing a collection of skilled design people.

5.11 The redesign of the original LSL Sir Bedivere class of vessel to produce the LSH HMAS Tobruk involved the Department making the following major design changes:

- replacement of the original 20 ton crane with a 70 tonne derrick/crane and supporting structure associated with hoisting and lowering Army landing craft carried on the ships vehicle deck;
- reinforcement of the vehicle deck structure to permit Chinook class helicopters to operate from the ship;

1. Joint Evaluation Working Party Report on HMAS Tobruk Trials and Evaluation Programme, p.19

- reinforcement and lengthening of the aft flight deck structure to permit up to Sea King class helicopters to operate from the ship;
- installation of a sewage plant and holding tanks to meet International Maritime Consultative Organisation requirements;
- carriage of landing craft vehicle personnel (LCVP) in port and starboard davits;
- use of two 4.25 tonne FAVCO cranes as the original deck cranes were no longer available;
- use of inflatable life rafts, a dinghy and a utility boat instead of the original four life saving boats;
- installation of a diving workshop, aircraft workshop/office, enlarged laundry, emergency generator compartment, damage control HQ, canteen;
- upgraded accommodation for RAN crew and Army personnel;
- increased air conditioning requirements;
- provision of a main galley to serve RAN crew and the troop cafeteria; and
- a complete change of the ships external communications outfit to allow for the RAN communications system and a joint communications centre.

5.12 In addition the ship's electrical system was heavily modified. A 115 volt single phase supply was installed in lieu of a 230 volt single phase supply for lighting and power. Automatic emergency lanterns and amenity sockets were provided. The 440 volt distribution system was modified to cater for RAN equipment changes such as the 70 tonne derrick/crane, sewerage plant pumps and LCVP davit winches. The rating of the ship's main generators was increased from 400 to 550 kilowatts.

5.13 Prior to the completion of the Shipbuilders Estimating Package the RAN design was further developed to incorporate the following major facilities:

- a joint operations room;
- a flight control office;
- a fuelling probe reception on the port side;

- a trunked hatch from the flight deck to the tank deck for palletized cargo;
- an incinerator compartment adjacent to the galley and compactor unit on the quarter deck aft;
- lengthening of the stern ramp to aid marriage of LCH bow ramps;
- redesign of fo'c's'le deck to cater for 40/60 Bofors guns port and starboard and to simplify the method of mooring to a buoy and towline reception;
- increase the height of the funnel to overcome problems with gases over the flight deck and the bridge;
- selection of Mirrless Blackstone K Major engines coupled to David Brown reduction gearing;
- provision of refuelling facilities in the after flight deck area;
- selection of Ulstein 90 TV-400 bowthruster in lieu of Voith Schneider as fitted in the original LSL design; and
- a second gyro compass.

5.14 The Departments submission of June 1983 also states:

> With the development of the detailed design and working drawings by the shipbuilder, a further 104 design change proposals were considered. Of these, 92 were approved for incorporation during construction. During the later stages of construction, some further changes to update the UK design were also incorporated.

5.15 It is noted that the net value of the design changes incorporated during construction, after allowing for increases and decreases, was $1.512m which represented 65% of the modification funds provided in the approved project cost estimate.

5.16 The Committee also notes that the Department expects its total obligation program as at 1983/84, in respect of HMAS Tobruk's new equipment and stores, to be $2.684 million. These funds cover payments for conversions and modifications to the ship. In the explanatory notes accompanying the Department's Budget estimates for 1983-84 the following data is given in respect of HMAS Tobruk:

	$m
Value of Obligations Undischarged 1.7.83	1.727
Value of New Obligations to be made 1983/84	0.957
Total Obligation Program	2.684

Design Guidance

5.17 The Review of the Board of Inquiry is critical of the design guidance provided to the shipbuilder by the Department. At paragraph 74 it comments that the sewerage system design guidance provided was 'minimal, consisting of a schematic and general instructions included in specifications attached to the contract'. The provision of such design guidance is part of the overall contracting process.

5.18 Initially a ship to be built is defined in the ship specifications and associated drawings. Where a shipbuilder wishes to depart from the requirements of the ship specification and associated drawings, he is required to submit his proposals under the change procedures described in the construction contract. No change may be incorporated without the specific approval of Commonwealth officers duly appointed for the purpose of approving such changes.

5.19 The Department's approach to ship design was described as follows:

> A (departmental) designer will work up the main components of a design resulting in a contract design. That is the design on which one goes to the contractor to have him bid a price for it and then formulate a contract. The shipbuilder then has to take that design and work out for himself his own detailed drawings of all of the detail of the design, such as where the actual pipes run given a schematic of what you want to connect with a pipe from A to B. He works up the detailed design of where those pipes will go, what pipe length he will work with, what arrangements suit his facilities in the yard, how he is going to build the ship - all of these things are his business to work up that detail as to how he is going to incorporate the overall design into the practice procedures and so on that he has in his own yard. We call up from the shipbuilder documents called key build approval drawings and the shipbuilder, having worked up his detailed design, resubmits that nominated key build approval drawing to the Navy for approval.[1]

5.20 The Committee understands that for HMAS Tobruk only a very limited number of shipbuilders detailed design drawings were nominated as 'key build approval drawings'.

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1. Minutes of Evidence, 7.9.83

5.21 Detailed systems drawings for HMAS Tobruk's sewerage system were not included in the Department's list of key build approval drawings.

5.22 During the project changes were made to the Departments initial guidance drawing for HMAS Tobruk's sewerage system, to improve and simplify it. It appears however that at the time such changes were made not all of the details describing components to be incorporated were understood by the Department.

5.23 In its submission of June 1983 the Department commented:

> In retrospect, Navy's approval of the first change and development of the second change may have been ill-advised and, as indicated in the Review of the Board of Inquiry, they were contributing factors (among a number of others) in the Dax incident.

5.24 The Committee notes the Department's comments at paragraphs 34 and 35 of its June 1983 submission.[1]

Design Related Problems

5.25 As the Committee's inquiry progressed through 1983 it became apparent that HMAS Tobruk had suffered a series of major problems since commissioning.

5.26 A departmental representative made the observation that:

> ....teething problems, sometimes severe ones, are normal during the early stages of a new ship's life, and it is not unusual for much of the warranty period to be devoted to the correction of shortcomings in the build. This is particularly so in ships built to warship standards - unlike 'Tobruk' in some respects.[2]

(a) Air Conditioning

5.27 Except for its tropical trials, HMAS Tobruk's air conditioning plant was accepted by the Navy's General Overseer prior to commissioning while the ship was alongside in harbour during a period of relatively cool temperatures. When the ship began operating in earnest the airconditioning proved inadequate and major manufacturing and installation inadequacies were discovered.

5.28 The manufacturer became involved in lengthy negotiations on rectification and there were disagreements between the subcontractor, the shipbuilder and the Navy as to

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1. Refer to Appendix C.
2. Minutes of Evidence, August 1983

cause and liability. Parts of the system have been re-engineered by the shipbuilder at his own expense and some inadequate materials have been replaced. Since the warranty had expired the replacement costs were the Department's.

5.29 The Committee examined the specifications for the ship's air conditioning. It notes that while the specifications set out desired equipment, performance characteristics, location and fitting, there is no requirement for inspection tests and trials to be carried out within the equipment's warranty period. The specification only stipulates that the airconditioning installation 'be tested on completion .... and results obtained in accordance with design requirements.'[1]

5.30 The Committee notes with concern the Fleet Commander's comment (made on 28 March 1983) on HMAS Tobruk's air conditioning:

> ....the long term solution may well be to remove the existing system and replace it. This solution would be very expensive but may be the best one in the long term[2]

5.31 The system was finally accepted by the Navy in July 1983, subject to ambient temperature trials proving satisfactory. At the time of writing this Report the results of these trials are unknown.

5.32 The Committee notes that part of a $500,000 Advance to the Minister for Finance 1982/83 funding application by the Department was used to fund a requirement for increased motel accommodation rather than ship's accomodation for the crew of HMAS Tobruk because of ship airconditioning system breakdowns.

(b) Engine Control System

5.33 HMAS Tobruk's main engines are controlled during manoeuvring by a pneumatic system. This system has been a source of difficulty since before the ship was commissioned. It was particularly distracting for the ship's crew during the period immediately following commissioning of the ship.

5.34 HMAS *Tobruk's* first Commanding Officer made the following comments to the Committee on this problem:

> As a new vessel, first of class and first naval warship built by that yard, I was expecting that I would have problems with main propulsion units. I may say that during the period that I was in command we probably used more tug hours than would normally have been expected to be used by a vessel

1. HMAS Tobruk Specifications, v.2, paragraph 6.11.19
2. HMAS Tobruk Trials and Evaluation Program - Report by Fleet Commander 28.3.83

> so that I always had assistance available to me should things go wrong. I experienced main engine problems from the word go. In the first move out of the shipyard the port engine refused to start ahead and, with the use of tugs, the bow thruster and the starboard engine I controlled the ship and successfully navigated it down the Hunter River from the Hexham Bridge down to Newcastle. We subsequently had problems in the Port of Newcastle and during sea trials.
>
> Over the period that I was in command of the ship once commissioned between April and December 1981 I had occasion .... to signal the Fleet Commander to say that I regretted that I could not go into a port and I could not meet my commitments because I no longer had confidence in the controls of the main engines. That occurred the first time when I was in the Port of Brisbane, having come up the river with the assistance of tugs and gotten the ship alongside; we were loading cargo preparing to go to an exercise, Kangaroo 81, and at that stage of the game, in consultation with my engineers, I deemed that the control problem had got beyond us and that I was not prepared to take the vessel to sea. As a result of that the cargo was off-loaded on the wharf; the necessary experts were provided and some curative work took place on the control mechanisms.
>
> We then went into the next series of exercises during the trial and evaluation period. Outside Port Alma I stopped to test main engines before entering the Port; I could not get both engines to react as they should have reacted, and because of that I went to anchor.[1]

5.35 The Committee understands that the problem stemmed mainly from the ship's compressors. The Committee heard evidence that:

> The discharge temperature of the air is high and the compressors take their air supply from the engineroom, where there is a high temperature, high humidity and high oil vapour content. The result is moisture and oil in the compressed air, with consequential corrosion and fouling of the sensitive elements.[2]

5.36 Some of the main engine control system problems experienced by the ship came from 'initial ad hoc system changes'[3] which were necessary to accommodate the different

1. Minutes of Evidence, 5.8.83
2. ibid
3. ibid

engines used from those used in the Sir Bedivere class which were no longer available. Remedial steps have been taken to improve filtration and cleanliness and as a result there has been an increase in reliability. Further remedial measures have been identified by the Department and some underdesigned components were replaced at the subcontractor's expense in August 1983.

5.37 The Committee also notes the Fleet Commanders observations on HMAS Tobruk's main engine control system. In his report on HMAS Tobruk's Trials and Evaluation Programme the Fleet Commander observed:

> Of the major problems, this has been potentially the most hazardous. The control system had two serious problems; they were firstly, a lack of adequate drain point filters and secondly, a mixture of ferrous and non-ferrous pipes. The combination of this mixture led to corrosion of the pipework and the resultant loose particles caused by corrosion passed unfiltered through the system causing damage to components and blocking control orifices. Immediate rectification was made more difficult because the drawings were inadequate.

5.38 The use of dissimilar metals is commented on in Volume 1, s.1.12.3 of HMAS Tobruk's specifications:

> Direct contact of dissimilar metals is to be avoided and such installations are to be in accordance with the method given in the Specification.

5.39 The Committee is concerned that HMAS Tobruk's quality assurance project staff and on site supervisors did not adequately inspect the construction of the air conditioning system and ensure that dissimilar metal components were correctly installed.

(c) Deck Mounting of Forward Cranes

5.40 HMAS Tobruk has experienced difficulties with the mounting arrangements of the two forward 4.25 tonne FAVCO cranes. The cranes themselves have performed satisfactorily and are different from the original LSL design cranes as the original UK forward cranes were not available. The cranes are located at the forward end of the ship's cargo area.[1]

1. Refer Illustration 3

5.41 During a routine load test in Brisbane in 1982 cracking was discovered on the deck around the base of the cranes, at a test load of eight tonnes. The cracks were welded and a reduced load limit of two tonnes was applied to enable them to be used during HMAS Tobruk's Tonga relief assistance mission.[1]

5.42 The Committee was told that 'the problem was that the footings of the strength members had been underdesigned'.[2] The Committee was concerned to read the Fleet Commander's comment on this problem:

> The FAVCO cranes were merely welded to the deck with little strengthening or support. Cracks soon developed and required reinforcement from below.[3]

5.43 Remedial measures have been taken by a contractor in Brisbane and the Committee understands the cranes have since performed satisfactorily, with all restrictions removed.

(d) Ship Vibration

5.44 A Departmental representative told the Committee:

> HMAS Tobruk exhibits vibration in excess of that normally encountered in a warship. Investigation suggests that it is caused by the propeller being sited too close to the hull and rudder. When the problem was queried in the United Kingdom, the advice given was that it is an inherent problem in the Sir Bedivere class. This was not revealed at the time of procurement of the class design package. However, the vibration is tolerable and is not considered likely to reduce the ship's life.[4]

5.45 The Committee notes with concern the Fleet Commander's conclusions, made in his report on HMAS Tobruk's Trials and Evaluation Programme that:

> From commissioning, HMAS Tobruk has been subject to excessive noise and vibration levels. The effects have been felt by hull and machinery. The problem appears to emanate from a variety of sources and collectively will be difficult to overcome since it is a combination of machinery generated and structure generated noise. By far the worst sources of noise affecting habitability

1. Minutes of Evidence, 5.8.83
2. Minutes of Evidence, 5.8.83
3. HMAS Tobruk Trials and Evaluation Program - Report by Fleet Commander 28.3.82, p.13
4. Minutes of Evidence, 7.9.83

is the air exhaust noise emanating from the generator exhaust blowers which function when the ship is operating at normal speeds. Internal fittings in accommodation areas, recreation areas and offices which are of modular construction, contribute to the overall noise level. Many large components such as lockers and bunks are made from sheet metal which at sea creak and rattle and amplify an already noisy environment.

The problem will be a difficult one to solve and is being examined by the design sections of Navy Office. A survey has been conducted revealing that many of the areas are approaching levels which are noise dangerous. For personnel living in such an environment there could be long term health implications.[1]

5.46 On 13 March 1981 a representative of the RAN Trials and Assessing Unit, in a letter to the Department's Canberra Navy Office commented on vibrations during HMAS Tobruk's Contractor's Sea Trials held in January 1981 as follows:

> The most noticeable aspect of the ship is the obstreperous background when the ship is underway, but more noticeably at maximum speeds.

5.47 In evidence before the Committee the Department stated that HMAS Tobruk's crew undertook hearing tests every six months as opposed to the Navy's usual requirement of annual hearing examinations. It was also stated that '....this vibration problem is not unique to Tobruk. It has existed in the Royal Navy LSHs for the 18 years that they have been running'.[2]

5.48 The Department also stated that:

> One of the major features may be the propeller revs themselves and we have the same as the British, although a different engine. It is a different engine running at different revs but the shaft speed and the propellers are the same, and the British have a problem. As far as I know the British have not done anything major in altering that machinery line on their existing ships but, and importantly, I mention that they are heading towards building a new ship or ships to replace the losses of the Falklands and the informal advice is that they will have to look at a different engine, for a start because the old engines are not available. How they will come out

1. HMAS Tobruk Trials and Evaluation Programme - Report by Fleet Commander, p.12
2. Minutes of Evidence, 5.8.83

> in that new ship now that they have got to change the propulsion prime mover, whether they will change their shafting arrangement of propeller revs, propeller size and so on, remains to be seen. But I suspect that they are looking at that. The informal advice is that they are looking at that with one particular aim, and that is to drop the shaft revs down. Dropping shaft revs down is good. It makes the ship quieter; you may be able to get a slightly better performance propeller. You have, of course, to change all the arrangements, the whole form down at the back end, to be able to accommodate it but I suspect the Brits are looking at that for their new ships.[1]

5.49 Members of the Committee were on board HMAS Tobruk on the 18 and 19 August 1983. During this period the ship travelled from Shoalwater Bay offshore en route to Melbourne. On average a cruising speed of 15 knots was maintained. However, for the purposes of a visiting team of vibration analysts on board from the Department of Defence Support, the ship maintained a maximum speed of 17 knots for a limited time . At both speeds Committee members noted high levels of vibration occuring in parts of the ship.

5.50 On 15 February 1984 the Department forwarded the following interim report on progress with investigations into the noise and vibration problems experienced in HMAS Tobruk:

> HMAS TOBRUK suffers from vibration problems characteristic of a shallow-draught vessel designed for amphibious operations. The propeller is tucked well up under the stern and the clearance of the propeller from the hull is kept to a minimum. This situation is conducive to the transmission of propeller-generated vibrations to the hull.
>
> In conformity with the original design of the ship being largely to commercial rather than naval standards, most of the main machinery and equipment in the ship is hard-mounted to the ship's hull, rather than being resiliently mounted. This is a potential source of noise and vibration in the hull.
>
> As designed and built, the insulation of the machinery spaces is largely thermal insulation rather than acoustic installation. The thermal insulation provides limited attenuation of noise from the machinery spaces to the adjacent areas of the ship.

1. Minutes of Evidence, 9.11.83

Although subjective opinions have been expressed to the PAC that noise and vibration levels are acceptable and are not significantly worse than in other naval ships, it is believed that improvements can be made, subject to the availability of funds.

In 1983, Navy Office tasked Garden Island Dockyard with the conduct of noise and vibration surveys of the ship, to investigate the causes of high noise and vibration levels found, and to propose remedial measures. Progress on the work has been slow due to competing priorities and demands of other fleet support work for the limited specialist resources available at Garden Island.

The investigation work by Garden Island Dockyard to date has been concentrated mainly on noise, and has resulted in the undertaking of improvements to the balancing of some of the fans in the air conditioning system. This is being examined further, noting that much of the distribution air trunking is behind linings and panelling, and any remedial work is likely to be very expensive. Another problem area identified in these studies is in the sections of the ship adjacent to the main machinery casings.

The next step in the Garden Island work will be the conduct of vibration measurements covering overall hull vibration, natural frequencies of hull vibration, structural vibration in way of the propellers, hull pressures due to propeller/hull interaction, local vibration problems including that in the main machinery intake and uptake ducting and the possible requirement for acoustic booths around significant noise generators. Garden Island plans to commence these investigations within the next two months.

Remedial measures derived from the Garden Island studies will be considered for the programme of work for the ship in its first main refit commencing in late 1985. Priorities for any remedial work will have to be assessed closer to the time, against competing demands for the very limited funds expected to be available for the refit.

(e) Auxiliary Boilers

5.51 Although HMAS Tobruk is a diesel powered ship, she has two auxiliary boilers which are used to provide steam for the distillation of fresh water and for heating and cooking. Both

boilers have been unserviceable for much of the time since HMAS Tobruk was commissioned, mostly due to a lack of spares. The furnace brick work collapsed at the end of 1981 and the boilers were inoperable for a large part of 1982 awaiting spares. HMAS Tobruk currently uses other means of obtaining fresh water supplies e.g. dockside mains, ballast.

5.52 A Departmental representative commented:

> Part of the early problems may have been attributable to operator error. But we have an overall impression that the boilers may be not quite man enough for the job.[1]

5.53 One consequence of this problem is that several items of HMAS Tobruk's galley equipment cannot be used e.g. 6 steam coppers and other steamers.

(f) Landing Craft and Davits

5.54 Comment on the problems experienced with HMAS Tobruk's landing craft vehicular and personnel, and their associated davits, is contained in the previous Chapter of this Report.

(g) The Sewerage System

5.55 The many serious problems with the design, installation, modification, quality control, quality assurance, management and rectification of HMAS Tobruk's sewerage system serve to characterise the Department's approach to the Tobruk project generally.

5.56 The Committee viewed the problems with the sewerage system very seriously because:

- of the death of a 14 year old Naval Reserve Cadet; and
- information about this death and the many problems associated with the sewerage system was not mentioned or alluded to by the Department in its initial submission to the Committee's inquiry nor during the first hearing of the inquiry.

5.57 Because the sewerage system is detailed and complex the following explanation is reproduced to aid understanding.[2]

> The sewerage system comprises six collection tanks and two holding tanks. Two of the collection tanks are located for convenience within the holding tanks and these are the tanks which were involved in the accident (see Diagram 3 overleaf). The tanks are symetrically arranged around the ship's

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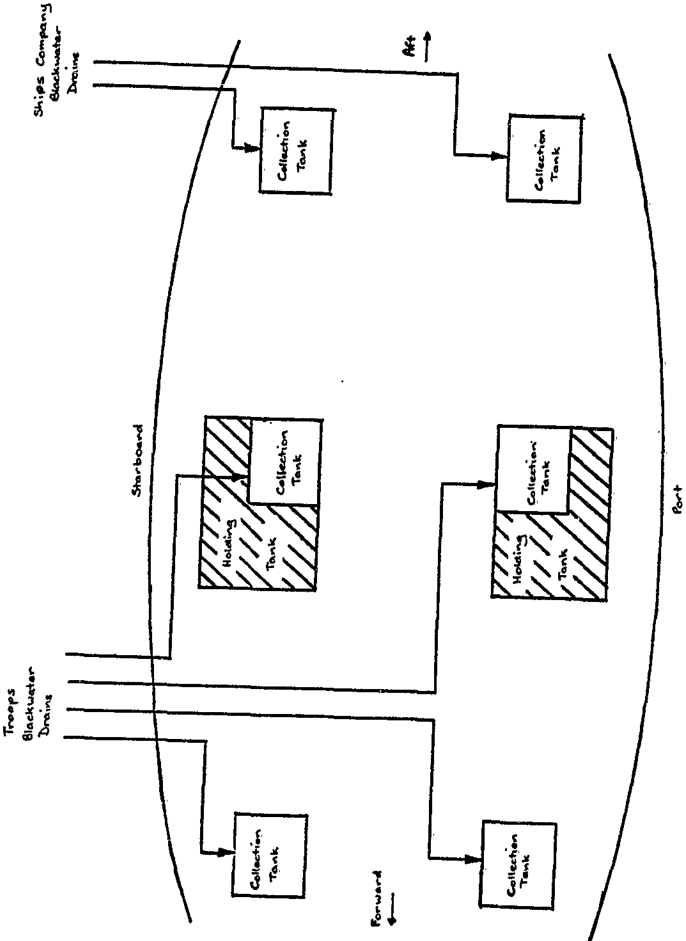
1. Minutes of Evidence, 5.8.83
2. This explanation was heard as evidence during a public hearing on 5 August 1983 in Brisbane

DIAGRAM 3 - General Outline of HMAS Tobruk's Sewerage System



centre line and, in effect, form two similar interconnected systems. I shall consider only one system and, in passing, would mention that it was the port side system which was involved in the accident (the death of NRC Dax). It could have been either. Bathroom, laundry and galley drains, called greywater drains, go directly to the holding tanks while the toilet, or heads' drains, called blackwater drains, were to go to the collection tanks in the first instance. The design also called for all ship's company blackwater drains to go to the aft collection tanks, leaving the other four for embarked troups. This would allow the four tanks designated for troops' use to be shut down when there are no troops on board. Since the accident (death) it has been established that several ship's blackwater drains were directed by the shipbuilder to the midships collection tanks, including the port midships tank involved in the accident. This would mean that the tank would slowly collect human wastes and generate gases of decomposition without the ship being aware of it.

Turning now to the tanks in question (see Diagram 4) as is typical of the entire system, we have the various heads pans, discharging via U-bends and water-seals to the collection tank. Just like toilet pans in one's own home, the blackwater drain needs an air escape on it acting as a siphon breaker, to stop the water-seal from being sucked out by the venturi effect of water passing by in the combined blackwater drain. In these pans in HMAS 'Tobruk' the water-seal is only 17 millimetres deep, in order to minimise the amount of flush water necessary to overcome the seal when flushing away waste. The collection tank also has an air escape on it to compensate for the inflow from the blackwater drains. These blackwater drains can, of course, be directed straight overboard without passing through the sewerage treatment plant at all and this would always be the case in the open sea, outside the 12-mile limit specified by the International Maritime Organisation. The midships collection tanks' air escapes were originally intended to go directly to the upper deck but because of their proximity to the holding tank air escapes, approval was given to combine them in the interests of simplicity (see Diagram 5). It is now believed that this modification contributed to the accident. The sewerage is pumped from the collection tank to the holding tank via a macerator, or chopping blade, which ensures that there are no lumpy solids passed across to the holding tanks. There are, of course, up to three macerator pumps discharging to each of the holding

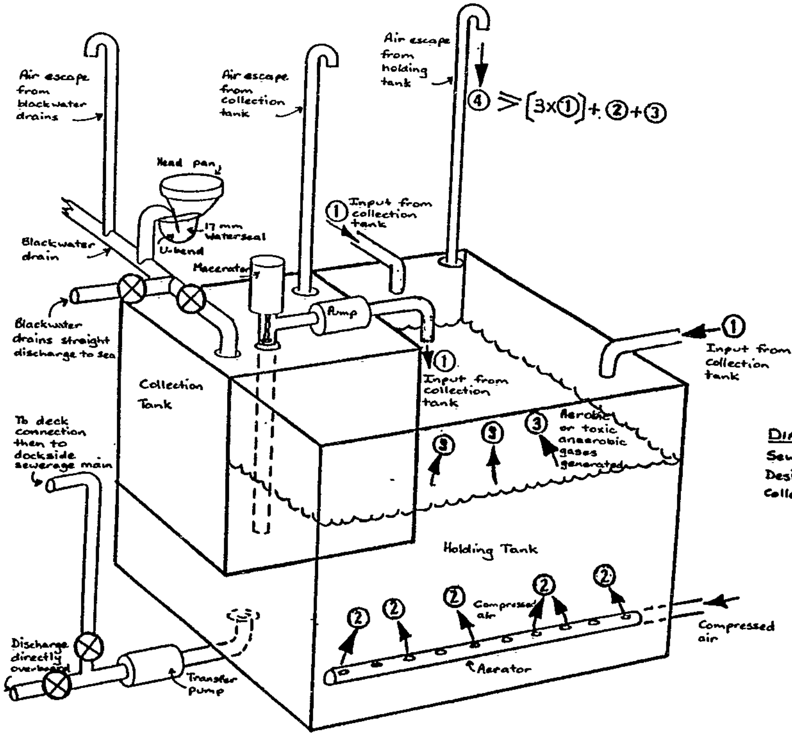


DIAGRAM 4: HMAS Tobruk's Sewerage System: Original Design of Holding and Collection Tank

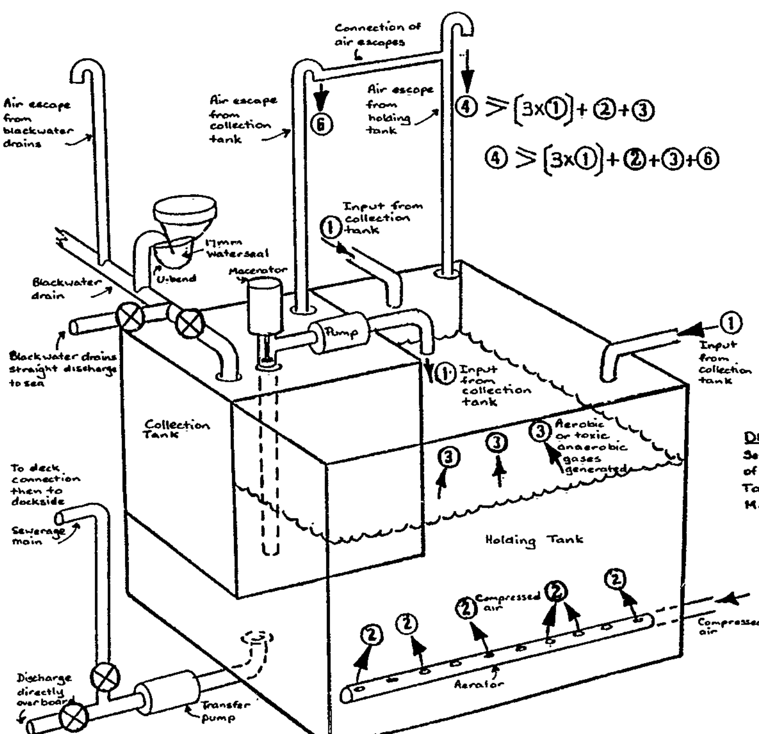


DIAGRAM 5-HMAS Tobruk's Sewerage System: Operation of Holding and Collection Tank after First Design Modification tanks at any one time. There is a requirement that the contents of the holding tanks should be constantly aerated with compressed air being supplied from a special compressor in the engine room. If copious quantities of air are not supplied constantly the chemistry of the microbiological decomposition which occurs in the holding tanks will be changed from aerobic to anaerobic. Gases are generated in both circumstances but they are different gases and are almost certain to be toxic when decomposition occurs in the absence of free oxygen. As I indicated earlier, the ship did not fully understand the plant and only operated the aerator compressor intermittently. The holding tank also has an air escape, which as originally designed, had to cope with the volume of air displaced by the discharge of up to three macerator pumps, plus the aerating air itself, plus the volume of product gases being generated within the decomposing sewerage.

Our calculations showed that the holding tank vent pipe did have sufficient capacity to cope with three times the inflow of the macerator pumps plus the aerating air plus the generated gases without raising the pressure in that tank significantly, or at all (ie. 4>(3x1)+2+3 on Diagrams 4, 5 and 6). The first modification that occurred was to connect the vent pipe from the port macerator tank to the port holding tank vent pipe so that the port holding tank vent pipe had the additional duty (no.6 on Diagram 5) which had previously been the duty of the macerator tank vent. Our calculations showed that this combined vent pipe is still big enough to cope with the addition of that displaced vapour or gas or air without creating an overpressure in the tank (ie. 4>(3x1)+2+3+6 on Diagrams 5 and 6). That first modification, of course, occurred during building. The next modification dates from August 1981. In this case, that same vent pipe had been connected to it a similar combined vent from the other side of the ship (see 7 on Diagram 6). The two then ran together up the starboard kingpost. So in effect, the new piece of pipe had to cope with twice the load that the individual tanks had to cope with earlier and our calculations have shown that it could not do so without a back pressure building up inside the vapour space of the holding tank (ie. 4<(3x1)+2+3+6+7 on Diagram 6). That pressure then had a path of course up to the atmosphere but if it were sufficient - and it was - it was able to track

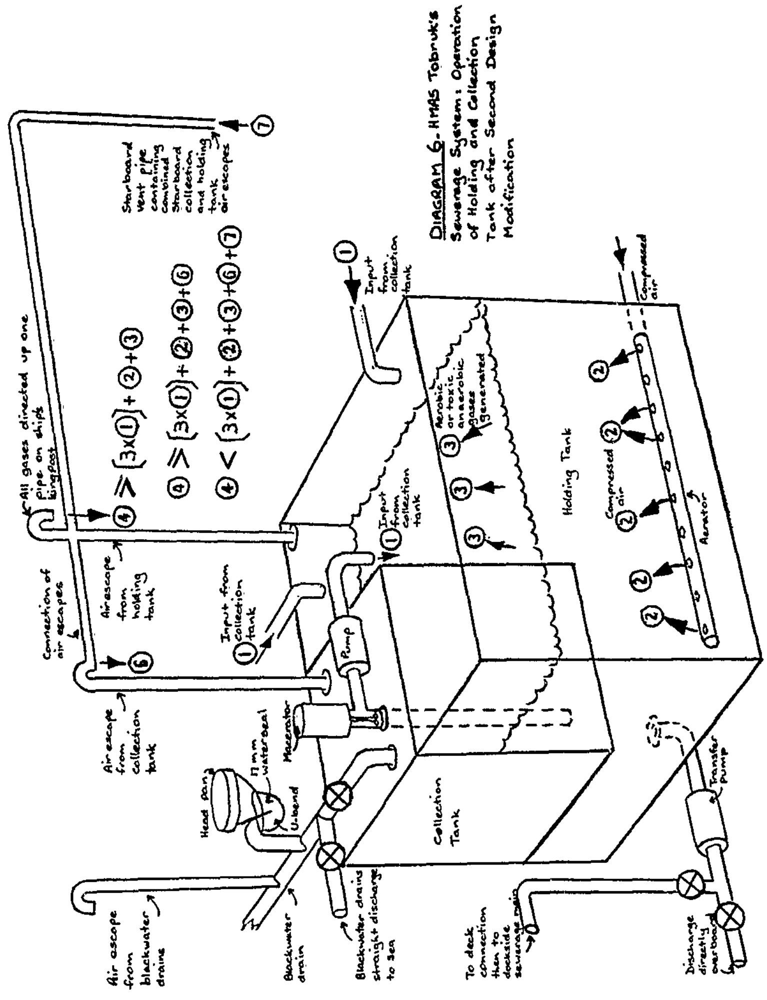


DIAGRAM 6. HMAS Tobruk's Sewerage System: Operation of Holding and Collection Tank after Second Design Modification

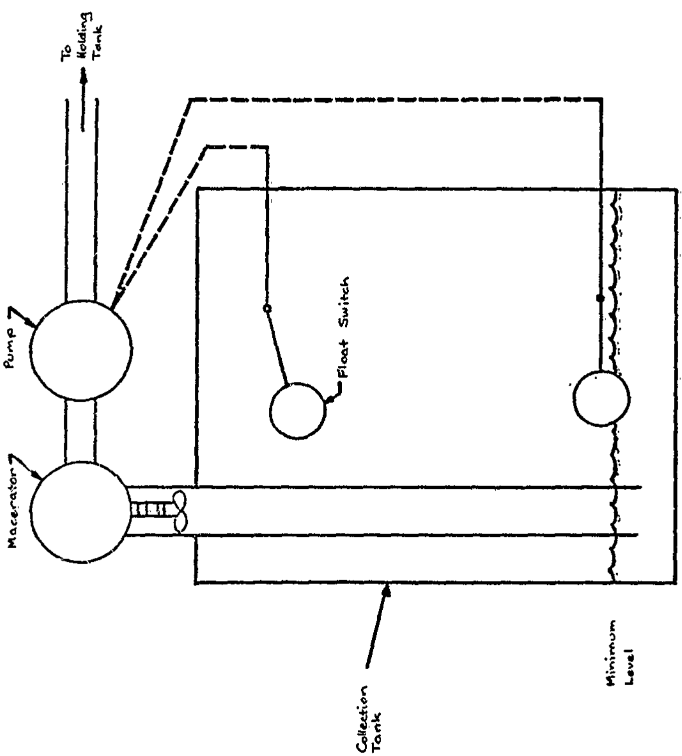


DIAGRAM 7. HMAS Tobruk's Sewerage System: Float Switch Operation

back along that path to the macerator tank and from the macerator tank back through the blackwater drain and bubble out past a 17-millimetre seal. That 17 millimetres, of course, is the critical pressure.

The result is now believed to have been that a back pressure did build up in the holding tanks and thence, via the earlier air escape piping as I have described to the midships collection tank. This pressure would have been sufficient to overcome the 17-millimetre water-seal and bubble through it into the heads compartment itself which was where Naval Reserve Cadet Dax was found. There are two issues which I mentioned in passing which ought to be amplified. Firstly, the matter of siphon breakers on the individual heads pans or group of pans without which the action of heads flushing elsewhere in the same part of the system could possibly suck out a water seal in the adjacent pan. An investigation since the accident has revealed that these essential siphon breakers were not installed by the shipbuilder, in some cases, in sufficient proximity to the heads pans concerned. Thus it is possible that there was an effective escape route for gases via or from the collection tank which was not dependent upon the holding tank air pressure reaching the 17-millimetre equivalent pressure I mentioned a while ago. It is also possible that water-seals could have been lost by evaporation during long periods of disuse such as could have been the case with the troops' heads when there were not troops embarked. The same easy gas path would have been presented to gases seeking to escape via or from the associated collection tank.

Secondly, I have mentioned float switches and their later replacements which control the macerator pumps. Diagram 7 illustrates how the float switches work. The important thing to notice is that the switch shuts off the pump electrically before it completely empties the tank in order to avoid running the pump dry and damaging it. In the case of the port midships collection tank, over a tonne of sewage would be left behind with two relevant effects. Firstly, anaerobic conditions must develop since there is no provision for aeration of this tank at all. Thus poisonous gases would generate here regardless of whether the air escape pipe modifications had been done. Were there no water-seals in one or more of the heads pans above the tank, there would be an easy and direct path to the heads compartment itself, where

Naval Reserve Cadet Dax was found. The generation of gases, given that the vent of that tank is correctly in place - and is so - would not, of itself, have generated sufficient gas to blow out the seal. It would be if the seal was not there that that leakage path would exist. Also, the residue of about one tonne of sewage would act as a seeding material for the faster development of anaerobic decomposition than would otherwise occur. Its effect seems likely to ensure the presence of toxic gases in collection tanks at all times except when they have been deliberately washed out and gas freed, as has been the case since the accident.

5.58 In addition to the above, a Departmental representative gave the following precis of events surrounding the operation of HMAS Tobruk's sewerage system:

> The sewerage system has been a source of trouble for the ship since January 1981, when the shipbuilder first began to test it, long before commissioning. Further untoward incidents, in the form of overflows of some of the various tanks in the system, occurred on the day of commissioning - that is, 23 April 1981 - and on 18 May while the ship was in Sydney Harbour. The trials schedule did not specify a full scale test of the system in its normal operating condition. Instead, it was necessary only for the shipbuilder to demonstrate that the more important components functioned correctly - for example, that the aerating compressor operated at the correct output; that the chlorinator functioned; that the pumps pumped; and that the pump switches worked at the right levels; and so on. As it happens, these latter switches did not stand up to the test. They tended to stick in the salt water and sewage environment and they certainly caused the spill on commissioning day. The cause of the spill in May 1981 was never formally established and the shipbuilder did not accept liability for the consequential damage. However, he ultimately replaced all pump switches, added tank contents gauges and digital readouts, and he improved the alarm system which gives warning of high tank levels.
>
> Following the fatal accident in December 1981, it has been established that the ship had not been operating the plant correctly and did not really know how to. It stank; foul smells escaped from the tanks, it was thought, from the upper deck outlets from the various tank air escapes and the smells were then drawn back into the ship through the ventilation and air conditioning inlets. Following the spill in May 1981, the ship complained of the smell which they said was not dispelled by the chemicals stipulated for use in the chlorinator and they sought help. The purpose of chlorination is to sterilise, not deodorise, and there are circumstances when the chlorinator need not be used at all. The ship does not appear to have understood this fact. It was following this complaint from the ship that an air escape pipe modification was designed and subsequently incorporated in August 1981. The modification, which joined the air escapes from the port and starboard holding tanks together and led them to the top of the starboard kingpost - which is one of the two masts associated with the 70-tonne derrick - was intended simply to remove the smell away from occupied parts of the ship. Smells persisted, however, and the ship appears to have continued to search for a solution, in the form of a chemical deodorising agent. This was the situation up until 14 December 1981, the day of the accident involving Naval Reserve Cadet Dax, since when the entire plant has been shut down, cleaned out and made inoperable pending a design review and modification.[1]

5.59 The Committee notes that HMAS Tobruk's sewerage plant is still inoperable at the time of writing this Report.

5.60 Extensive critical comment on the ship's sewerage system is to be found in the Review of the Board of Inquiry Report at Appendix H of this Report (refer in particular to paragraphs 35 to 95 of the Review).

(h) Kit Locker Spaces

5.61 At the commencement of public hearings in 1983 the Committee was told by a departmental officer that:

> We made a substantial change to (the size of) the ship's crew as compared with the British (LSL class). This meant significant changes and rearrangement of sleeping spaces, kit locker spaces, dining areas, galleys, bathrooms, laundry, canteen, life-saving equipment, stores and so on, directly related to the accommodation change.[2]

1. Minutes of Evidence, 5.8.83
2. ibid

5.62 The Committee is concerned to note a conclusion of the Joint Evaluation Working Party in its Report on HMAS Tobruk's Trials and Evaluation Programme that:

> One problem .... is the size of the lockers in the soldiers' mess decks. Soldiers large packs will not fit into the lockers and have to be stowed on the decks in their respective messes, which is unsatisfactory, a damage control hazard, and in some situations presents a personal safety hazard.[1]

5.63 In addition the Joint Evaluation Working Party found that no provision had been made for the stowage of personal weapons in the embarked force's mess decks.

5.64 The Committee observes that analysis of the major HMAS Tobruk problems (a) to (h) listed above shows that they are related to either:

- departmental changes made to develop the LSH design, or
- inherent problems in the original UK LSL design not addressed by Australian modifications.

Allegations of Major Design Faults

5.65 During October 1983 it was alleged to the Committee that HMAS Tobruk had several serious major faults over and above those discussed in this Report. The Committee carefully considered this matter and decided that it should discuss these allegations with senior Service and civilian members of the Department in order to establish the validity of the allegations.

5.66 The Committee has satisfied itself that the person who made the allegations was in a position to comment from experience gained on the HMAS Tobruk Project.

5.67 On the 7 November 1983 the Chairman of the Committee wrote to the Minister for Defence and the Secretary of the Department informing them of the Committee's desire to discuss these allegations. Details of the allegations were given in these letters. The following comments were also made by the Chairman in these letters:

> 'The Committee fully appreciates the sensitive nature of these matters. However, it is the view of the Committee that these and other related matters should be inquired into in public because of their seriousness and the potential danger to HMAS Tobruk personnel. You may wish to express a view on these matters to me before the hearing next Wednesday'.

1. Joint Evaluation Working Party Report on HMAS Tobruk Trials and Evaluation Programme, p.12

5.68 The Chairman received a letter from the Secretary of the Department on 8 November 1983. The Secretary noted that 'the Department of Defence will, as always, be glad to co-operate fully with your Committee'. At the commencement of the public hearing the Chairman reiterated the Committee's view that these allegations raised sensitive matters and gave the senior officers representing the Department an opportunity to inspect a document discussing the allegations before the document was tabled and discussed in public by the Committee.

5.69 The Chairman also gave the Department's representatives an opportunity to, if they so wished, make a case to the Committee as to why the Committee should not examine the allegations in public. The departmental officers concerned subsequently agreed to the following allegations being discussed in public.

(a) Lack of Watertight Integrity Following Damage

5.70 *It was alleged that:*

> Tobruk has a central tank deck with a row of Army troop messes on either side but there is no watertight integrity between the troop messes and the central tank deck. If the ship is holed at the waterline the messes may flood into the tank deck. Because of the resultant 'free surface water' Tobruk may be inherently unsafe and may roll over. The ability of transverse bulkheads (between the troop accommodation areas on 3 Deck and the central tank deck) to contain and regularize flooding is severely doubted. The troop messes cannot be shut off. Tobruk is more vulnerable to being holed at the water-line because it has only a 'single skin' down its sides. Modern merchant ships of this type have a 'double skin' down the sides. There is no effective compartmentalization on board HMAS Tobruk. Similar British designs have watertight hatches.

5.71 In evidence before the Committee the Department rebutted this allegation. With the use of a model of HMAS Tobruk a departmental representative demonstrated that there was watertight integrity between the troop messes and the central tank deck. The main longitudinal bulkhead between these areas is watertight.

5.72 Although the Committee was satisfied that this allegation could not be substantiated, it is not satisfied that HMAS Tobruk will have watertight integrity when the ship incurs damage under certain circumstances.

5.73 At a public hearing on 9 November 1983 a departmental representative gave evidence to the Committee that:

> ....if the damage is not constrained to one compartment and goes across two compartments, we have got trouble. But I started off by saying that this ship was designed as a one-compartment ship; it is not designed to take any extensive flooding over a number of compartments.

5.74 This problem was further examined by the Committee with the Department during an in camera hearing.

5.75 The Committee understands that the probability of the ship sustaining the type of damage likely to bring the ship's watertight integrity into question is very low. Nevertheless the Committee remains concerned with this problem.

5.76 A departmental spokesman assured the Committee that the problem was being researched as a matter of priority and that remedial action would be taken if necessary.

(b) Aft Door Flooding

5.77 It was alleged that:

> By the nature of its design HMAS Tobruk is vulnerable to catastrophic flooding through the aft ramp door. If, for any reason it fell open, or if as in the case of 'Straitsman', it was erroneously opened during operations, and the ship was ballasted down, water could flood the central tank deck (and subsequently the side troop messes) making the ship unstable and liable to sink. The bow doors of Tobruk are backed up by a ramp which acts as a secondary bulkhead but there is only one stern door, which is held up by two chains with a chain stopper arrangement.

5.78 The Department, in reply to the above allegation, demonstrated to the Committee that:

- HMAS Tobruk's design bore no relation to the design of the M V Straitsman;
- water would have to flood up the rear ramp of HMAS Tobruk in order to reach the tank deck;
- the ships tank deck was specially designed to cope with dispersing the massive amount of water which comes from the tank deck overhead fire sprinkler system;

- if water did stay in the tank deck the ship would remain stable because of longitudinal watertight bulkheads;
- RAN training should prevent any erroneous opening of the aft door;
- RAN training is very conscious of the requirements for damage control;
- there are positive locking arrangements separate from the lifting arrangements for the aft door.

(c) Fire Hazard

5.79 It was alleged that:

> HMAS Tobruk has a large amount of wood in her structure. All the internal linings are secured on to wooden battening. Although the ship's internal panelling is flameproof navyboard - a special laminex coated silicate marine board - it is secured by nails or power screws on to wooden battening throughout the ship. A major fire could start behind this lining and be fuelled by the wooden structure which supports it. Tobruk's internal panelling does not seem to be surviving the vibration inherent in the vessel. In addition, Tobruk's superstructure is aluminium. In a major fire aluminium fittings, holding up cables and other structures, will melt or lose strength and generally contribute to the general disturbance of the fire and the damage.

5.80 In reply to this allegation the Department stated that not all of HMAS Tobruk's internal linings were secured to wooden battening.

5.81 A departmental spokesman said:

> The use of timber grounds for the securing of insulation or panelling is very, very common practice. In our Navy it has been the practice for a very long time and in the commercial world it is usual practice. More recently the scene has changed. In the most recent ships that we are getting, the FFG's - of which we have four being built, the last two coming out of the US and two more to be built in Australia, hopefully - that practice is not adopted. The battening is metal. Mind you, a lot of it is aluminium and one might question that; nonetheless it is not timber in

> those FFGs. But virtually every other ship that we have and a vast majority of the ships floating around the world at the moment are so built.[1]

5.82 The Department admitted that ship vibration does cause the screws securing some of the ships internal panelling to work loose. It was stated that:

> There is a problem in that area. We are working to overcome that by using a different size of screw, which at the moment appears to be satisfactory. It is the sort of thing you would have seen on board the ship. Some of these things work loose when it is not into the grounds but into the other boards in some areas. And that is a problem which we are handling on board.[2]

5.83 In relation to the potential for a fire hazard the Department gave evidence that, in a war environment 'flammable material in excess of what is normally required on board'[3] is removed. The Department also commented that:

> Whether you would go to the extent of ripping off the panelling from the side of ship and the deckheads is another matter. It would be a matter of the time you had available and you would work towards it.[4]

5.84 On the question of the use of aluminium in HMAS Tobruk's superstructure, a departmental spokesman said:

> We have said that there is a lot of aluminium right through our ships and right through the ships of a lot of navies. In our new guided missile frigates coming from the United States all of the superstructure is aluminium. Some people feel more strongly about it than others. The Americans have used aluminium superstructures commonly and so have we in changes to our ships. The British have used it but to a much lesser extent, and as a general principle they say they would not use it and their new designs have steel superstructures. The fact is that aluminium in fire loses its strength and fittings can fall down or whatever, but nonetheless it is a useful structural material. The stability of ships dictates that if you do not save weight in using

1. Minutes of Evidence, 9.11.83
2. ibid
3. ibid
4. ibid

> aluminium you have to give up weight high up in the ship on other things which could be combat systems, radar, masts or something else. Our position on it generally in the use up there in the superstructure is that we would avoid it if we could.'[1]

(d) Troop Door Fire Safety Hazard

5.85 It was alleged that:

> HMAS Tobruk's troop doors - fireproof doors which separate compartments - may constitute a major personnel hazard. These doors are roller shutters, like garage doors, and are kept up by fusible links. It appears that the only way these doors may be raised is by having at least two people, one on either side. This situation may be inherently dangerous in a fire.

5.86 The Department gave evidence that HMAS Tobruk's fireproof troop doors are roller shutters and kept up by fusible links. There are of two sizes of these doors - three feet wide and five feet wide.

5.87 It was claimed in rebuttal that

> One man can open the narrow door and lift it quite readily. Two men are required for the bigger door but they need not be on either side of the door. Two men can lift it from the same side and it does not matter which side they happen to be on. I would also remark that ships have an ongoing damage control organisation. There is a headquarters. There are usually outstations depending on the preparedness of the ship's company at the time. There are communications. There are often patrols out. The likelihood of somebody being on the wrong side of a big door alone, where two people would be required to lift it, and being there without anybody being available to help him, is remote. Of course if the ship were closed up at action stations there would be passive damage control teams distributed around the ship. It is not an empty ship. It is not a situation where you would expect to find a single person alone.[2]

1. Minute of Evidence, 9.11.83
2. ibid

(e) Use of PVC Piping Externally

5.88 It was alleged that:

> *HMAS* Tobruk has PVC piping constantly exposed to the external environment. The ship has a pre-wetting system which washes the ship down for radioactive fallout. This system uses piping made out of normal PVC household piping and may split because of chemically bonded joints. It is in an air-exposed environment and may be subject to rapid ultraviolet degradation.

5.89 During an in camera hearing in December 1983 a departmental spokesman confirmed that there was some plastic piping up above HMAS Tobruk's main deck and that it was recognised that some of the piping is highly smoke emitting during combustion.

5.90 However the departmental spokesman noted that this piping was in the open air and, as far as the Department had been able to ascertain, no PVC piping was internal to the ship.

5.91 Evidence was given that PVC piping was used for the pre-wetting system because of the piping's lightness. It was recognised that the material deteriorated under ultraviolet light however the Department was not aware of the precise composition and UV vulnerability of the piping material.

5.92 A departmental witness commented on the possibility of risks associated with UV deterioration of the piping saying:

> The only risk you have there is that, if it deteriorates and it cracks, you may not get the spray where you want to get it, or you will get less spray in the areas where you want to get it and the water spurting out somewhere else. The system - as with all systems in ships - is open to inspection and there are routines for getting those sorts of systems inspected. We have no reports at the moment of any observed deficiencies in that system.

5.93 The Department agreed to supply the Committee with more information about the use of external PVC piping in HMAS Tobruk. As at the date of this Report this information has not been received.

(f) Ship Propeller Problem[1]

5.94 It was alleged that:

> The original UK 15 year old design on which Tobruk is based is understood to incorporate a slow speed *Mirrlees engine coupled to a matching propeller.* HMAS Tobruk, after design modificaiton by the Defence Department, uses a medium speed Mirrlees engine but, it is alleged, coupled to the 'original' propeller as per the original UK design. This is thought to waste approximately 600 horsepower because the propeller is not designed to match the medium speed engine. Although it appears that the Department purchased a Mirrlees engine of the same horsepower from the same maker *as specified in the original* 15 year old UK design, they are two different engines with different harmonics and transmission system. One is a slow speed directly coupled engine, the other is a medium speed, 16-cylinder V configuration. HMAS Tobruk's excessive vibration, which the Department is currently analysing and testing, may stem from this problem.

5.95 The Department replied to this allegation by saying that although *HMAS Tobruk did use a medium speed Mirrlees engine* the higher revolutions were reduced to the original revolutions of the earlier design by the use of reduction gearing in the transmission system. Thus the propeller shaft speeds of HMAS Tobruk would be the same as the UK design to which the propeller is matched.

Conclusions and Recommendations

5.96 The Committee concludes that:

- in principle, there is nothing inherently wrong with purchasing an old ship design and changing it;
- the Department's design modifications were of such an extensive nature that either, they were beyond the Department's available design expertise to specify sufficient detail and oversight construction, or that the design expertise in the Department was not adequately applied to the project;
- the problems experienced by HMAS Tobruk since commissioning are not minor teething problems. Their number and significance suggest that HMAS

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1. Refer also to the discussion on excessive vibration earlier in this chapter

Tobruk has experienced a higher than expected amount of major problems when compared to what should be the outcome of a well managed project;

- comparing the problems of HMAS Tobruk with those of other contemporary RAN vessels such as HMAS Cook, Success, Parramatta, Ipswich, Cessnock, Stuart and Adelaide may be spurious. Differing design and construction methods have been used, the functional roles of these ships are different and generally the financial, industrial and political environment surrounding their construction have varied. Some of these ships have also had or are having severe problems and the Department's management of their construction has also been criticized by the Auditor-General;
- many of the major problems HMAS Tobruk has suffered since its commissioning stem from design related causes;
- the ship's existing airconditioning system is unsatisfactory and in need of replacement in the long term;
- HMAS Tobruk's air conditioning system should have been inspected, tested and trialled within it's warranty period;
- problems with the ship's engine control system, partly attributable to the use of a mixture of ferrous and non-ferrous pipes, contravene the contract specifications on dissimilar metals;
- HMAS Tobruk's quality assurance project staff and on site supervisors did not adequately inspect the construction of the air conditioning system and ensure that dissimilar metal components were correctly installed;
- the initial design of HMAS Tobruk's deck mountings for its forward FAVCO cranes was not satisfactory, given the loads the cranes were expected to handle the need for robust reinforcement from below should have been anticipated;
- the problem of HMAS Tobruk's excessive vibration has not been resolved;
- technical reports detailing HMAS Tobruk's excessive vibration were not made available to the Committee;
- the ship's excessive vibration may constitute a longterm health hazard to the crew;

- the cause of the ship's excessive vibration should have been diagnosed when purchase of the LSL design was considered and attempts made to redesign the LSH class of vessel to minimise the problem;
- there is little doubt that HMAS Tobruk's excessive vibration will increase the ship's maintenance costs and reduce it's life;
- problems with HMAS Tobruk's auxiliary boilers typify the difficulties of procuring spare parts from overseas manufacturers;
- HMAS Tobruk's auxiliary boilers should have been built for endurance and thoroughly tested under warranty;
- the many serious problems with the design, installation, modification, quality control, quality assurance, management and rectification of HMAS Tobruk's sewerage system serve to characterise the Department's poor approach to the Tobruk project generally;
- the large number of critical conclusions and recommendations of the Review of the Board of Inquiry into the Death of NRC Dax are indicative of the magnitude of mismanagement in the Department;
- HMAS Tobruk's sewerage system was not adequately understood by the department's designers, the contractor's designers and installation staff, the ship's company and the department's maintenance personnel during the build of the ship;
- although no one person can be identified as having acted in such a way to cause NRC Dax's death it appears that the contractor's and the Department's lack of understanding about HMAS Tobruk's sewerage system, and the departmental design changes made to HMAS Tobruk's sewerage system, were most significant contributory factors;
- HMAS Tobruk's poorly designed kit locker spaces have led to the development of a potential safety hazard in the form of congested troop passage ways when troops are on board;
- the shipbuilder's detailed systems drawings for HMAS Tobruk's sewerage system should have been included in the list of key build approval drawings to be submitted to the Department for approval in principle; and

- *HMAS Tobruk*, under certain circumstances, may have a lack of watertight integrity.

5.97 The Committee recommends that

- detailed systems drawings for sewerage systems be included in future key build approval drawings to be submitted by a shipbuilder for approval in principle by the Department;
- the Department institute a formal evaluative research program into the design of currently available ship sewerage systems;
- departmental documentation controlling proposed design changes be amended so that consideration of the safety implications of design changes becomes a mandatory and formalized part of the design approval process;
- the Department proceed as a matter of urgency to thoroughly research questions surrounding HMAS Tobruk's potential for lack of watertight integrity and initiate corrective action as soon as possible if needed;
- the Department research the risks associated with HMAS Tobruk's external PVC piping;
- the Department complete its investigation into the sources of *HMAS Tobruk's* excessive vibration and take action to reduce this vibration to more desirable levels during the ship's next major refit;
- rectification of *HMAS Tobruk's* many serious technical problems (as detailed in this Report) should be carried out in advance of the scheduled refit. In the meantime consideration should be given to the operation of the ship to ensure its safety; and
- departmental management effort should concentrate on making the Australian shipbuilding industry both efficient and effective, significant problems with locally built ships will not be overcome until this objective is attained.

CHAPTER 6

PROJECT MANAGEMENT

Background

6.1 Recently the Auditor-General, in his September 1983 Report, undertook a review of 10 Departmental projects and concluded:

> This Office considers that the Department's project management practices for major projects covered by this review were unsatisfactory, contributing to:
>
> - significant additional costs to the Commonwealth (incurred and prospective);
> - the need for scarce resources to be engaged in rectifying project problems, and;
> - diminution of the Defence capability through untimely delivery of equipment and facilities and through equipment and facilities not meeting technical performance objectives.
>
> While recognising the complexitites of the planning and forecasting task and the need for appropriate reconsideration and readjustment of Defence priorities in the light of financial constraints and changing circumstances, Audit believes that the projects referred to above demonstrate problems of a kind which skilled project management should be able to avoid.
>
> Audit is not in a position to recommend specific remedial action although it seems that organisational complexities may in part be the underlying cause. Audit is of the view that urgent action is needed so that all issues within the control of the Department are fully recognised and appropriate measures taken to contain lead times, ensure adherence to specified service requirements and minimise cost escalation.[1]

6.2 The Committee is most concerned about these conclusions of the Auditor-General.

6.3 Furthermore the Committee is most concerned about the Australian Shipbuilders Associations's remark that 'those yards with current or recent experience of defence contracts in

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1. Report of the Auditor-General, September 1983, p. 38

particular have reported great difficulty in dealing with the Australian Government as a client'.[1]

6.4 In it's Industry Position Paper, 'the Australian Shipbuilding Industry and It's Prospects in the 1980's' [2], the Association commented:

> negotiating teams representing (the Australian) Government appear to lack a common purpose at all times. In addition they lack overall expertise in resolving and negotiating issues;
>
> in dealing with (the Australian) Government lines of communication are very complex and as a result the achievement of a final decision in respect of an aspect of a contract is most difficult; and
>
> when contractual problems arise the experience of individual yards is that there appears to be no system for a satisfactory resolution of the matter in question.

6.5 The Association concluded:

> from their experience of Governments as clients, Association members are in agreement that:
>
> .. State Government contracts are generally satisfactory from a commercial viewpoint;
>
> .. Australian Government contracts are generally unsatisfactory from a commercial viewpoint;
>
> the Association is firmly of the view that there is an urgent need for the Australian Government to modify its contractual arrangements to ensure that they are fair and equitable and adequately protect the commercial interests of individual yards.

6.6 The Committee is also mindful of the general dissatisfaction with Defence Department project management recently expressed to the Committee by the members of the Defence Manufacturers Council of the Metal Trades Industry Association .

6.7 During the course of this Inquiry the Committee became increasingly aware of the need for greater organisational efficiency in the Defence Department's project management.

1. Appendix G, s.10
2. Refer to Appendix G

6.8 The Committee has announced it will be undertaking a review of the Defence Department's project management methodology in 1984. In delivering the key note address on 'Accountability and the Task Ahead' at the 1983 Conference of State and Federal Public Accounts Committees, the Vice-Chairman of the Committee, Mr A. Cadman, M.P., announced:

> The Committee feels that while the recommendations of its Tobruk Report will go some way towards improving project management and contract administration in the Department of Defence there remains an urgent need to critically review the methodology of defence project management. As part of its 1984 program the Federal Public Accounts Committee will be conducting a major inquiry into project management within the Department of Defence. That Department currently has approximately 150 projects underway worth an estimated $7,000 million with expenditure of $750 million last financial year. The precise terms of reference for this Inquiry are yet to be announced but it is probable that they will be wide ranging. At this stage the Committee is considering using the construction of HMAS Success as a case study for this inquiry.

6.9 The Committee feels that, in this Report, it is able to make only limited observations on the overall management of the HMAS Tobruk project pending its inquiry into Defence Department project management this year.

6.10 For the purposes of this Report the Committee has adopted the definition of project management used by the Auditor-General in his September 1983 Report as follows:

> Project management is a systematic process of planning, review and utilisation of resources aimed at achieving a product with certain technical performance objectives, on time and within cost. It is a means of achieving a project's objectives rather than an end in itself. Project management is an all-encompassing term embracing the consideration of all aspects of a project from inception to ultimate completion.

6.11 It is noted that the general approach to project management in the Commonwealth Government has come under the scrutiny of the House of Representatives Standing Committee on Expenditure in its May 1980 Report on 'Alternative Delivery Systems for Commonwealth Public Works'.

HMAS Tobruk Project Management Team Structure

6.12 In its June 1983 submission the Department describes it's approval to project management as being 'based on co-ordinative management and teams are structured with a mixture of dedicated project staff and specialist staff drawn from the functional areas'[1].

6.13 The LSH project management team and its relationship to the functional area of the Department is shown overleaf at Table 3.

6.14 The team, based in Canberra, comprised:

- Project Director,
- Deputy Project Director,
- Project Design Manager,
- Project Production Manager,
- Project Integrated Logistic Support Manager,
- Project Financial Advisor,
- Army and RAAF Project Advisers.

6.15 Also in the team was a liaison officer from the Defence Industry and Materiel Policy Division. This Division is responsible for policies relating to the development of defence industry, including Australian industry participation in defence equipment purchases and stocking of defence material. As well, it is responsible for resource co-ordination, source definition and monitoring overall performance in acquisition of major and minor capital equipment.

6.16 The Department's submission also mentions 'a number of nominated Project Liaison Officers responsive to the Project Director for project-related tasks, but remaining responsible to their functional heads for the integrity of their work'[2] as being part of the team.

6.17 The Project Director has a direct functional responsibility to the Chief of Naval Materiel. The Office of the Chief of Naval Materiel is responsible for:

- ensuring the timely submission of projects for Naval equipment to the various processes of analysis and presentation up to the point of Government decision;
- co-ordinating the development of Navy's new proposals for major equipment from the point of their endorsement within Navy through to introduction into service;

1. Refer Appendix C, paragraph 3
2. Paragraph 4i of Appendix C

- the management of all minor Naval capital equipment projects; and
- overall direction of the Supply Branch - Navy in accordance with approved policies.

6.18 The Project's Production Manager and Finance Advisor, while described as being 'responsive' to the Project Director (through the Deputy Project Director), have a direct functional responsibility to the Director of Naval Ship Production. The Director of Naval Ship Production is generally tasked with technical/engineering aspects of planning, contracting, construction, cost estimating, trials and delivery in relation to RAN ship acquistion.

6.19 The Director of Naval Ship Production has a direct functional responsibility to the Director-General of Naval Production. The Director-General of Naval Production is charged with the overall supervision and control of Naval construction, modernization and conversion projects including installation of specified Naval equipment in shore establishments.

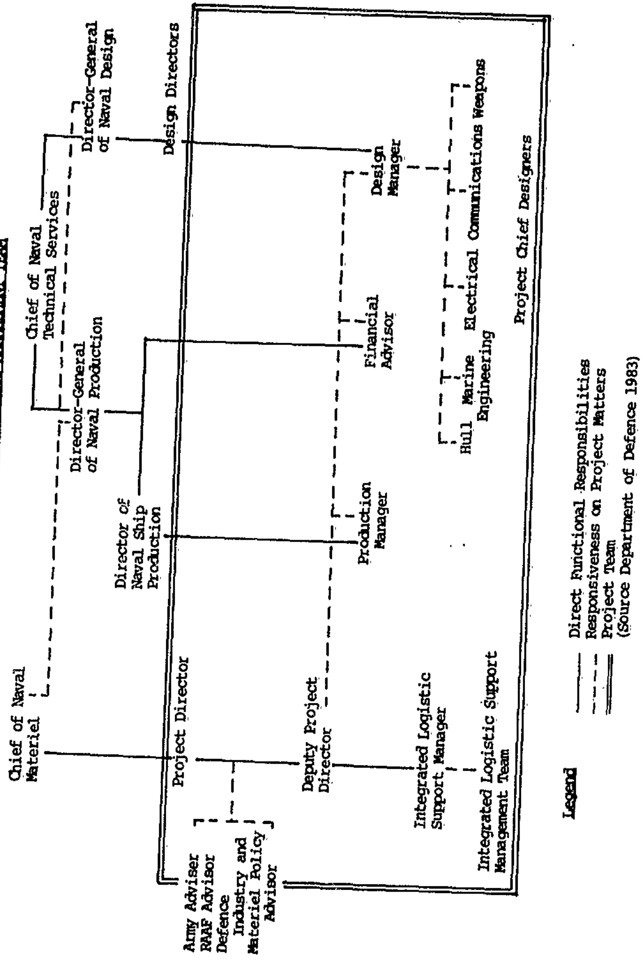
6.20 Similarly, the Project Design Manager is described as being 'responsive' on project matters to the Project Director but has a direct functional responsibility to the Director-General of Naval Design via several Design Directors. There are Naval Design Directors for:

- forward design (ship projects),
- electrical design,
- naval ship design,
- marine engineering design,
- weapons design,
- combat data systems,
- communications design.

6.21 The Director-General of Naval Design is tasked with the design of new ship, submarines, support ships and craft and their associated systems and equipment including the design aspects of modernization and conversion. He also provides advice on materials engineering and is responsible for Navy standardisation.

6.22 As Table 3 shows, both the Director-General of Naval Production and the Director-General of Naval Design have a direct functional responsibility to the Chief of Naval Technical Services and are 'responsive' to the Chief of Naval Material.

TABLE 3
AMPHIBIOUS HEAVY LIFT SHIP (LSH) PROJECT MANAGEMENT TEAM



6.23 Overall the Naval Technical Services Division is tasked with

- the *design, construction, repair and maintenance* of ships, submarines, support craft and equipment, *the repair and maintenance of aircraft;*
- the determination of maintenance policies, engineering and quality assurance standards, *monitoring the inspection* policy and procedures of Naval armament and explosive stores; and
- the policy control and higher level management of Naval dockyards.

6.24 In additon to the above, the General Overseer and Superintendent of Inspection East Australia Area (GOSIEAA) exercised the delegated functions of:

- providing overseeing services, technical advice and guidance to the contractor;
- progressing, monitoring and rectifying the physical and financial aspects of orders;
- providing representation at all inspections, tests or trials; and
- performing the quality assurance function.

6.25 These functions were carried out by a single on site GOSIEAA representative at the ship's contractors, with the Head Office of GOSIEAA in Sydney providing additional itinerent support as required. Comments on the adequacy of on site representation are provided in Chapter 4.

Directions for Change

6.26 Consideration of the above command chain shows that responsibilities and task definitions, although often having complex interdependancies, are, in theory, distinct recognizable and understandable. However in practice this approach to management does not appear to work so well.

6.27 The Committee acknowledges that the management of a ship's build is a complex, detailed and often difficult task in a Department where there are many concurrent projects in operation and given financial constraints.

6.28 The Committee believes that there may be two approaches to improving this situation:

- improve the existing management approach; or
- change the essential nature of the project management as currently practiced.

6.29 No matter which of these approaches is followed or experimented with there may also be other institutional factors concerning personnel which the Department should address. These factors, considered later in this Chapter, involve:

- the turnover of project personnel;
- retention of skilled and experienced personnel in the Services generally; and
- familiarisation of ship's staff.

Improvements To the Existing Management Approach

(a) Consultation Across Functional Boundaries

6.30 The Committee observed that, in a number of instances during the HMAS Tobruk project, functional rigidity appeared to have either resulted in a low level of consultation (during construction) between the project team and specialised areas or the unplanned exclusion of advice from some specified areas.

6.31 An example of the former effect of functional rigidity is the poor communication between the Project Officer and the Design Branch which occurred when HMAS Tobruk's sewerage system suffered severe setting-to-work problems. Instead of consultation occurring with the Design Branch over the design requirements, the GOSIEAA based process of correction continued to concentrate on component failures and not the design integrity.

6.32 An example of the latter effect of functional rigidity is the involvement of the Fleet Maintenance Branch in the analysis of problems only after the ship was commissioned. The Fleet Maintenance Branch is responsible for formulating and co-ordinating policy on the maintenance of ships, support ships and craft and equipment fitted in Naval dockyards and other shore establishments. It issues detailed instructions for technical operation and maintenance. The Fleet Maintenance Branch appears to have had little involvement in the project during its initial formulation and construction phase yet the Branch has a large bank of expertise stemming from its analysis and solving of ships' post commissioning problems.

(b) Systems Approach to Problem Solving

6.33 The Review of the Board of Inquiry Report[1] details several instances where a systems approach to problem solving should have been used but was not. As the Review says, at paragraph 136, '....groups were more concerned with overcoming the symptoms than with the disease itself'.

6.34 A systems approach appears not to have been used to diagnose the myriad of problems that emerged with Tobruk's sewerage system until the Review of the Board of Inquiry was undertaken. Similarly it also appears that the ship's engine control problems stemmed from 'initial ad hoc changes'[2] made to the ship to accomodate engines different from the Sir Bedivere class on which HMAS Tobruk is based.

6.35 One technique that is available to the Department to improve its overall approach to management is simulation modelling. The Department currently has many large scale management systems and subsystems, each of considerable complexity. They share the following characteristics:

- large numbers of variables, some of which are qualitative and intangible;
- high degrees of interaction between variables, and between subsystems - within time frames and over time, including lags and feedback loops;
- prevalence of random variables;
- conditional or branch situations; and
- a dynamic or time factor.

6.36 These management system characteristics appear suitable for the development of simulation models.

(c) Role and Authority Delineation

6.37 During the construction and post commissioning phases of the HMAS Tobruk project there appears to be several instances where it was not clear which office had the role and/or authority to either initiate, undertake or authorize an action. However general responsibilities and overall duties of all offices and officers in the Department appear to be clearly specified.

6.38 Interdependancy and overlapping of various roles appears to have made it unclear as to which office or officer should exercise authority and/or responsibility for some actions during the project.

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1. Refer to Appendix H
2. Minutes of Evidence, 5.8.83

6.39 For example during the test and trials of HMAS Tobruk the roles of the General Overseer and Superintendent of Inspection East Australia Area representatives and those of the RAN Trials and Assessing Unit were perceived to overlap. This subsequently caused disagreements on site.

6.40 Immediately prior to sea trials the position, the status and responsibilities of the ship's Commanding Officer were not clearly defined. For example, the shipbuilder found he could not take action on the advice of the Commanding Officer and his staff on the placement of some equipment. Similarly during the earlier period when the Engineering Officer was HMAS Tobruk's Senior Officer he was specifically excluded from meetings about the ship which other Navy representatives attended at the shipbuilder's yard, he was denied access to documentation and his advice went unheeded. These two matters were raised in a letter from the Commanding Officer of HMAS Tobruk to the Fleet Commander on 6 October 1981.[1]

6.41 Another example occurred with the responsibility for post commissioning completion of the ship and rectification work. The Review of the Board of Inquiry commented, at paragraph 126:

> Just what is to be done with a commissioned ship which has not yet been completed has to be decided and the ground rules published. This is a task of great complexity, involving inputs from functional areas not previously involved, like the Fleet Maintenance Branch and the Fleet Commander.[2]

6.42 It also commented further, at paragraph 131:

> The Project Office retained some responsibility for TOBRUK at least until the end of the warranty period but delineation of the project/functional interface has not been clear. In the absence of a published transition policy the interface has been marked by uncertainty and some reluctance on the part of functional areas to become involved. Although (Navy Office, Canberra) received information copies of most relevant traffic there appears to have been a generally held view that, because of continuing problems with equipments under warranty, the ship remained under procurement and therefore with the Project Office. The Fleet Maintenance Branch which could by now have become usefully involved, does not appear to have been consulted on the sewerage problems, nor taken any initiatives. The Design Branch involvement appears to have been limited to a ship visit by the Project Design Manager following the serious spill on 18 May 1981.[3]

1. Refer to Annex I of Appendix H
2. At Appendix H
3. ibid

6.43 This led the Review to conclude, at paragraph 169(p):

> that the Chief of Naval Technical Services and the Chief of Naval Materiel be jointly tasked with the development of a general policy document for the transition of ships and craft from procurement to maintenance. The document should provide the basic format for 'transition reports' to be produced in future by relevant project directors.[1]

6.44 This conclusion was made on 19 May 1982. The Department, in Part 2 of its submission[2] stated that 'action as at 1 June 1983 is slow due to a complex subject'. The Department's submission of June 1983 comments:

> '....a need exists to more clearly define and establish the arrangements for the preparation of a formal package of data to be included in the formal transfer of responsibility for ship to the Fleet. This is currently under review with the intention of adding to ABR 5069 and ABR 1921.

6.45 The Committee will be examining the mechanisms for the delineation of authority and determination of operational roles in the Department during its inquiry into the Department's project management in 1984.

(d) Documentation

6.46 During the course of its inquiry the Committee found many aspects surrounding the provision and management of HMAS Tobruk project documentation to be unsatisfactory. In particular the provision of system handbooks and warranty/guarantee information was poor and untimely. Design documentation was discussed in the previous Chapter.

6.47 The Review of the Board of Inquiry Report[3] makes several comments on the lack of documentation, or delay in its provision, by the shipbuilder e.g. paragraphs 96 to 103 of the Review. Paragraph 96 reads:

> The provision of documentation by the shipbuilder to Navy has lagged badly and even at the present time there is a shortfall in as-fitted drawings. A

1. Refer to Appendix H
2. Refer to Appendix C
3. Refer to Appendix H

steady trickle of documentation has continued since commissioning which indicates that the cover and extent of general technical information available to the ship at the time of the accident was poor.

6.48 It is noted that the Fleet Commander agreed with this view[1].

6.49 At the public hearing on 14 September 1983 the shipbuilders confirmed that they lagged in the provision of system manuals and detailed parts lists for the ship. The shipbuilders found it difficult to get such technical information from their suppliers and employed consultant handbook specialists to compile ship documentation.

6.50 The Department's June 1983 submission (part 2) states that'action is 95% complete' on the recommendation of the Review of the Board of Inquiry that:

> the Chief of Naval Technical Services (Director General Naval Production) be tasked with listing all remaining Tobruk documentation shortfalls and prosecuting delivery.'[2]

6.51 The Committee understands that, at the time of preparing this Report, material shortfalls in HMAS Tobruk's documentation remain. The Committee is most concerned that, twenty one months after the Review of the Board of Inquiry into the Death of NRC Dax recommended that action be taken to overcome documentation shortfalls, HMAS Tobruk still lacks basic documentation.

(e) Warranties/Guarantees

6.52 The Committee is concerned about the delay in providing warranty/guarantee information on HMAS Tobruk equipment.

6.53 The Commonwealth's contract with the shipbuilder provides, at clause 34(4) that:

> the Shipbuilder as early as possible, but in any case prior to the completion of the vessel, shall submit to the Commonwealth a statement showing all guarantees and warranties obtained from suppliers and a copy of each such guarantee or warranty shall upon receipt be forwarded immediately by the Shipbuilder to the Commonwealth.

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1. Refer Review of the Board of Inquiry into the Death of NRC Dax, paragraph 170(f) of Appendix H
2. Paragraph 159u, Review of Board of Inquiry into the Death of NRC Dax

6.54 A study of departmental signals and correspondence reveals that as late as 12 May 1981, after the ship had been handed over and commissioned, HMAS Tobruk's Project Director, Commanding Officer and crew had not received such a list of guarantees and warranties.

6.55 The consequences of this are shown in Table 4 below. The warranty/guarantee situation was complex, understandably because of the mix of equipment. There were 18 different types of warranty/guarantee periods covering many thousand pieces of equipment.

6.56 Towards the end of the project it became very important for the Project Director, Commanding Officer and crew to have full knowledge of warranty/guarantee conditions and periods so that rectification work could be undertaken without jeopardising the Commonwealth's contractual position. Table 4 below shows that by the time a complete list of warranties/guarantees was provided many of the warranties/guarantees had expired.

6.57 Among the above items of equipment on which the warranty/guarantee period had expired were machinery air intake filters, deck cranes, diving compressors, welding plants, roller shutters/grills, aluminium doors, mast fittings and installation, wind speed and direction equipment, garbage compaction, broadcast/intercom/telephone systems, main air compressors, refrigerators, electric drills and power tools, emergency lanterns, filter elements. Many of these pieces of equipment have been linked to the faults discussed in the previous Chapter.

Changing the Structure of Departmental Project Management

6.58 The Committee has given much thought to alternative structures for the management of projects in the Department.

6.59 In the case of the HMAS Tobruk project it appears that, in addition to the factors mentioned above, there was insufficient authority delegated to the Project Director and on site departmental representatives.

6.60 It may be that the findings of the project management simulation modelling, mentioned at (b) above, will suggest changes to be made to the Department's project management structure.

6.61 During public hearings departmental representatives acknowledged that they had debated the philosophies of project management. Two opposing philosophies were mentioned - having a senior officer act as a project co-ordinator versus having somebody with ultimate responsibility/authority for project decisions - co-ordination as compared to line operation.

TABLE 4

HMAS TOBRUK SUPPLIERS GUARANTEES AND WARRANTIES

Period of Warranty Guarantee	No. of Purchase Orders* Applicable	Expiry Date	Warranty of Guarantee or Period (months) Remaining After Notification to Project Director (after 12 May 1981)**
12 months from commissioning ship	119	Apr 82	11
12 months from ship handover	49	Apr 82	11
12 months from commissioning equipment	2	Sep 81	4
	3	Nov 81	6
	2	Dec 81	7
	3	Mar 82	10
	1	May 82	12
12 months from delivery date of equipment	1	Aug 80	expired
	1	Oct 80	expired
	2	Jan 81	expired
	1	Oct 81	5
12 months from receipt of equipment	1	Sep 80	expired
	2	Nov 80	expired
	1	Mar 81	expired
	1	Apr 81	expired
	2	Jun 81	1
	1	Sep 81	4
12 months from installation of equipment	1	Jan 81	expired
	1	Feb 81	expired
	1	Jul 81	2
12 months F.O.B. despatch from U.K. of equipment	1	Nov 80	expired
12 months from despatch of equipment	1	Nov 80	expired
6 months from commissioning of ship	7	Oct 81	5

TABLE 4 (continued)

Period of Warranty Guarantee	No. of Purchase Orders* Applicable	Expiry Date	Warranty of Guarantee or Period (months) Remaining After Notification to Project Director (after 12 May 1981)**
18 months from despatch or 12 months from commissioning of ship (whichever earlier)	1	Oct 80	expired
18 months from despatch or 12 months from ship handover (whichever earlier)	1	Jan 80	expired
2 years from despatch of equipment	1	Sep 81	4
12 months after first use of equipment	2	Jan 82	8
6 months from commissioning equipment	1	Apr 81	expired
3 months from delivery date of equipment	1	Feb 80	expired
6 months from receipt of equipment	2	May 80	expired
12 months from invoice date	1	Sep 80	expired
	1	Oct 80	expired
12 months after commissioning of equipment or 18 months after delivery of equipment (whichever lesser)	1	Aug 81	3

NOTE

* A purchase order can cover many items of equipment

** on 12 May 1981 the HMAS Tobruk Project Director wrote to the Director Naval Ship Production seeking 'to ensure that the ship is fully informed of all items under guarantee/warranty', it is surmised that this information was supplied to the Project Director in the same month as his request (if not then the estimate in column 4 above is conservative)

Personnel Factors

6.62 The Committee became aware of these other matters for concern during its inquiry into HMAS Tobruk's project management. These matters appear to be part of the institutional framework of the Department. They are:

- a high turnover of project personnel;
- evidence of a sub-optimal retention of skilled Service personnel in the Department generally; and
- insufficient ship's staff familiarisation.

6.63 It is apparent that the high turnover of HMAS Tobruk project and related personnel, contributed to the difficulties experienced throughout the project.

6.64 The Department, in its June 1983 submission, states:

> In the four years between the letting of the contract and HMAS Tobruk being handed over to the RAN, the LSH Project had some eleven personnel changes in the positions of Production Manager, Design Manager and Integrated Logistic Support Manager. Each change brought varying modes of operation in the respective fields, varying interpretation of detail and placed different emphases on different aspects. Also, there were two GOSIEAA's and two Deputies in this period. The shipbuilder had to adjust to a number of variations of modus operandi and delays occurred which may have been avoided had there been fewer changes in personnel.

6.65 The Review of the Board of Inquiry Report[1] discusses personnel factors at paragraphs 108 to 115 and 162 (rr)(ss). Among the matters discussed therein is the resignation of HMAS Tobruk's Marine Engineering Officer 17 days before the ship was commissioned and his replacement with a person receiving no pre-commissioning training related to HMAS Tobruk. The Review also notes that the ship's Chief Shipwright at the time of NRC Dax's death, had relieved his predecessor only three weeks earlier. He had received no pre-commissioning training also.

6.66 Paragraphs 42 to 44 of the Department's June 1983 submission[2] detail problems with HMAS Tobruk's staff familiarisation and training. These problems are linked to the turnover of project staff discussed above.

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1. Refer to Appendix H
2. Refer to Appendix C

6.67 The Department should ensure that all future ships' staff receive adequate pre-commissioning training, regardless of whether the ship concerned is fitted with commercial and/or Naval systems.

Conclusions and Recommendations

6.68 The Committee concludes that:

- for the HMAS Tobruk project, the Department's formal lines of direct functional responsibility reduced the responsiveness and interaction of project team personnel with the other specialised personnel in the Department;
- the manager of a departmental project should be given greater authority and responsibility for the overall administration and management of the project;
- personnel from the Department's Fleet Maintenance Branch should have become involved in the HMAS Tobruk project earlier than they did;
- the Department did not ensure that the contractor provided, in a timely manner, HMAS Tobruk system handbooks and 'as fitted' drawings;
- either, the Department did not allocate sufficient draughtsmen/engineers to the task of examining HMAS Tobruk's 'key build approval drawings' or the Department generally had an insufficient number of design draughtsmen/engineers;
- the shipbuilder did not comply in a timely manner with the provision of information on HMAS Tobruk's equipment warranties and guarantees as specified in the ship's contract;
- there may be grounds for instituting a line approach to the management of major projects instead of having a Project Director act as a co-ordinator. The Committee will be following up this point during its inquiry into the Department's overall project management in 1984;
- in respect of warranties and guarantees the Department neglected its contract supervision duty to ensure that the contractor supplied the Department with warranty/guarantee information in a timely manner;

- the Department should have simplified and standardised the warranty/guarantee terms, conditions and periods for HMAS Tobruk's equipment through the use of appropriate contract clauses and specifications; and

- the high turnover of personnel related to the HMAS Tobruk project was unsatisfactory and detrimental to the outcome of the project.

6.69 The Committee recommends that:

- the Department investigate and trial (in different parts of the Department) the use of simulation models to improve its management information systems. The Committee may follow this matter up during its inquiry into the Department's project management in 1984;

- the Department accord a high priority to the development of a policy for the transition of ships and craft from procurement to maintenance. The existence of such a policy will benefit the management of projects currently in hand e.g. HMAS Success;

- the Department, as soon as possible, clarify the duties of personnel standing by ships under construction;

- personnel from the Department's Fleet Maintenance Branch be included in Naval Project Management Teams;

- the development of ship's systems documentation should be an ongoing process commencing, in outline, at the commencement of a ship's construction. The preparation of handbooks should not be treated as a discrete activity at the end of a ship's build but should be thought of, and carried out as, an activity which is done continuously through the build and refined during the ship's service;

- the Department, for future ship construction contracts, ensure that system handbooks and 'as fitted drawings' be produced in a timely manner. The preparation and development of such documentation should be treated as an on-going task commencing early in the build;

- for all future capital equipment contracts the Department ensure that the major contractor compiles a register of equipment guarantees and

warranties and copies that register, in a timely manner, to the Department on an ongoing basis throughout the contract period;

- the Department inspect, test and trial equipment within its warranty/guarantee period;

- the Department, for future major equipment contracts, specify the period of equipment warranties and guarantees. The range of warranty/guarantee periods should be kept to a minimum;

- The Department explore ways in which it might promote officers through various civilian grades or Service ranks while keeping them on the same departmental project and/or position; or if an officer retires he/she might be retained as a civilian on the project. The Committee will be addressing this issue further in its inquiry into departmental project management in 1984; and

- the Department investigate immediately the development of a line approach to the management of major projects. The elements of this approach should include sufficient delegation of authority and continuity of resources for the project manager to plan, review and use resources to achieve an end product that meets specified technical performance objectives, is on time and within budgeted cost. The Committee will be examining this matter during its inquiry into the department's overall project management in 1984.

CHAPTER 7

THE DEATH OF NAVAL RESERVE CADET KENNETH DAX

Introduction

7.1 The Committee has conducted its Inquiry into HMAS Tobruk pursuant to the Committee's duty as described in section 8(1)(ab) of the Public Accounts Committee Act 1951.[1] The Committee also believes that it has a duty, as described in section 8(1)(b) of its Act, to report to Parliament on matters concerning the Department's treatment of, and compensation for, the family of NRC Dax.

7.2 On 14 December 1981 NRC Dax was gassed in troop heads onboard HMAS Tobruk and died in the Royal Brisbane Hospital on 16 December 1981. He was 14 years of age.

7.3 On 17 December 1981 the Fleet Commander ordered a Board of Inquiry to be convened on board HMAS Tobruk. Two days later the Board of Inquiry's Report was completed and transmitted to the Fleet Commander. Subsequently the Fleet Commander referred the Board of Inquiry Report to the Deputy Chief of Naval Staff who, on 13 January 1981, directed that the Board of Inquiry Report be reviewed. The Review of the HMAS Tobruk Board of Inquiry into the Death of NRC Kenneth Dax was completed on 19 May 1981.

7.4 The Review of the Board of Inquiry Report commented on the Board of Inquiry Report as follows:

> The report is brief and is in the nature of a resume of events. Whilst it could be criticised for 'situating the appreciation' (its exclusion of poisoning as a cause of death led inevitably from the line of questioning pursued; as did its conclusion that the (sewerage) system in TOBRUK is inherently dangerous), Board of Inquiries do suffer time and information restrictions from which Navy Office is relatively free. Suffice to say, the factors contributing to Naval Reserve Cadet Dax's death are manifold and the Board of Inquiry has not explored them adequately. Had it been more inquisitive it might have provoked a different response from the Coroner (who has accepted the Board of Inquiry findings without formal inquiry) and perhaps from the Fleet Commander, but it is unlikely that it would have materially reduced Navy Office work in the conduct of this review.[2]

1. Refer to page (iv) of this Report
2. Review of HMAS Tobruk Board of Inquiry into the Death of NRC Dax, paragraphs 10 and 11

7.5 The Committee questions the utility of the Board of Inquiry Report and is concerned at the shortcomings of the Board of Inquiry Report exposed by the Review of the Board of Inquiry Report. The Committee finds the explanation, conclusions and recommendations of the Review of the Board of Inquiry Report logical and consistent with other evidence heard or taken during this inquiry.

7.6 In particular the Committee notes the Review's recommendation, at paragraph 168, as follows:

> In summary, whilst the following individual errors of judgement have been identified and are to be criticised, it is not considered appropriate to apportion blame for NRC Dax's tragic death, between the persons concerned. Too little was known about marine sewage treatment, on all sides, for the latent dangers to be appreciated, and it is recommended that the following personnel and organisations be informed accordingly, by personal letter from Deputy Chief of Naval Staff, to be drafted by Director of Naval Legal Services and Director-General of Fleet Maintenance:
>
> a. The (title of person deleted),[1] who approved guidance drawing A000077 (Issue 2) which cross-connected the holding tank and midships macerator tank vent pipes;
>
> b. The (title of person deleted), who approved sewerage tank vent pipe extensions, to remove the smell from occupied areas, knowing that anaerobiosis had developed;
>
> c. Carrington Slipways Pty Ltd who had incorrectly re-routed some ship's company heads drains, apparently without drawing Navy's attention to the change;
>
> d. (title of person deleted), who authorised a departure from the published requirement for continuous aeration of the contents of holding tanks;
>
> e. (titles of persons deleted), neither of whom sought outside help specifically to determine why the plant was foul smelling. Nor did they unilaterally decide to shut down the plant pending further assistance;
>
> f. (title of person deleted), who did not instigate a formal investigation into the circumstances of the 18 May 81 spill, ...

1. Titles of persons have been deleted here because the Service personnel and civilian public servants concerned do not have an opportunity to respond to criticism of them in the Review of the Board of Inquiry Report. For further explanation refer to Appendix I.

g. The (title of person deleted), who did not convene a Board of Inquiry .... to investigate the circumstances of the same spill.

7.7 The Review of the HMAS Tobruk Board of Inquiry into the death of Naval Reserve Cadet (NRC) Kenneth Dax[1] comprehensively details the sequence of events immediately surrounding his tragic death[2]. While NRC Dax's death was accidental, this type of death should not have been possible in an effective and efficient organisation. In this respect the Review of the Board of Inquiry identifies sections of the Department of Defence which have deficiencies. However the Department is to be commended for carrying out the Review of the HMAS Tobruk Board of Inquiry into the Death of Naval Reserve Cadet Kenneth Dax and for having provision to carry out such a Review.

7.8 Although NRC Dax was killed by exposure to a faulty onboard sewerage system, his death resulted from a systems failure which commenced with the Department's design of and subsequent modifications to the sewerage system, lack of proper understanding by the ship's crew as to how to maintain it in a proper chemical balance and their failure to understand the lethal potential of the system in that state, and a lack of understanding by the shipbuilder of the system's general design and operation.

Application for Compensation and Information

7.9 Mr and Mrs Dax have sought to claim compensation from the Commonwealth for the loss of their son. It is understood that Mr and Mrs Dax's motive for making this claim was to establish a precedent for other parents in similar circumstances in the future.

7.10 The events surrounding this compensation claim are significant in that they:

- raise important matters of compensation principles involving ex gratia payments; and
- illustrate the attitude of the Department towards the release of this type of information.

7.11 An outline of Mr and Mrs Dax's efforts to gain information about their son's death and to apply for compensation are detailed in the following chronology.[3] This chronology should be read in conjunction with the chronology at Table 2 of this Report.

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1. Refer to Appendix H
2. Review of HMAS Tobruk Board of Inquiry into the Death of NRC Dax, paragraphs 19 to 34
3. Refer to Table 5 below

TABLE 5

CHRONOLOGY OF DAX FAMILY CORRESPONDENCE

Date	Letter/Item
16.12.81	NRC Dax dies
?.12.81	from Fleet Commander notifying death
17.12.81	Fleet Commander convenes Board of Inquiry (BOI)
19.12.81	BOI Report Completed
?.01.82	from CO HMAS Tobruk, invitation to visit ship
13.01.82	Deputy Chief of Naval Staff (DCNS) directs that BOI report be reviewed
10.02.82	to Defence Department requesting to be informed of BOI findings
16.02.82	to Fleet Commander acknowledging his previous letter
20.02.82	to DCNS, questions about circumstances of death
01.03.82	from Fleet Commander, very brief explanation of BOI findings
08.03.82	from DCNS, acknowledging receipt of 20.02.82 letter
11.03.82	from DCNS, brief explanation of death
21.03.82	from DCNS, some general answers to questions posed 20.02.82
?.05.82	visit by Naval Officers, brief explanation given
19.05.82	Review of BOI report completed
23.05.82	to DCNS,
12.06.82	to Naval officers who visited on ?.05.82 requesting information on death
21.06.82	DCNS issues directions in respect of Review of BOI report recommendations
pre.08.82	to Member for Fisher requesting representation to Minister for Defence re compensation, representation made, matter passed onto Minister for Social Security
09.08.82	Minister for Social Security replies to Member for Fisher on compensation (application unsuccessful) letter later copied to Dax family
26.08.82	from DCNS, more replies to questions of 12.06.82, Review of BOI conclusions referred to
10.09.82	DCNS forwards copy of Review of BOI report to Qld Coroner
14.09.82	to DCNS requesting copy of Review of BOI report
01.10.82	from DCNS, decline to release Review of BOI report
08.10.82	to DCNS request to reconsider his decision of 01.10.82
13.10.82	to Commonwealth Ombudsman seeking access to Review of BOI report and reasons for compensation rejection decision
25.10.82	from DCNS, copy of BOI report

29.10.82	Minister for Defence to Member for Fisher rejecting ex gratia payment
?.11.82	Department presents commemorative lectern to NRC Dax's school
26.11.82	to DCNS and Naval officers thanking them for lecturn
29.11.82	from Member for Fisher enclosing copy of Minister for Defence's letter of 29.10.82
30.11.82	to DCNS, questions on BOI report (forwarded 25.10.82)
23.01.83	to Naval Association of Australia, requesting assistance to approach Department for information and compensation
?.02.83	from Naval Association of Australia 'regret interference would receive a very abrupt result from powers that be'
03.02.83	to Prime Minister re information and compensation
06.02.83	to Shadow Minister for Defence re information and compensation
09.02.83	to Qld Coroner request for all reports, documents held
11.02.83	from Shadow Minister for Defence, if elected case will be reviewed and different action
15.02.83	from Qld Coroner copies of Coroner's report and pathology report
28.02.83	from DCNS, looking at Review of BOI report to see if any information relevant to convey to family
02.03.83	to DCNS request information
17.03.83	letter of 03.02.82 referred by PM&C Department to Department of Defence
31.03.83	from Leader of the Opposition, special award is within capacity of Minister for Defence
09.05.83	from Minister for Defence, copy of Review of BOI report, rejection of claim for ex gratia payment
?.07.83	telephone call from Minister for Social Security explaining details of ex gratia payment $3550
04.08.83	to Minister for Social Security rejecting ex gratia payment
16.08.83	from FASFIN Defence, cheque for ex gratia payment
16.08.83	to Minister for Social Security formally rejecting ex gratia payment on grounds of principle
22.08.83	to Minister for Social Security returning ex gratia cheque and asking for reconsideration.

(Correspondence/representations are continuing)

7.12 While the above chronology is not exhaustive it does indicate the difficulty the Dax family experienced finding out the events surrounding their son's death.

7.13 Among the recommendations of the Review of the Board of Inquiry Report was a recommendation that a Leading Seaman be nominated for a bravery award.[1] The Committee understands that the Dax family had earlier written to the Department suggesting such an award. The Committee was disappointed to see that the Department chose to inform the Dax family of the award's presentation only after the award ceremony was held.

7.14 The Committee believes that after the occurrence of a Service death the spouse (or family if appropriate) of the deceased should be able to gain full knowledge of the circumstances surrounding the death if they so desire. Such information should be withheld only where it could reasonably be expected to cause serious damage to national security.

7.15 The Committee does not accept that there were valid grounds for the Department declining promptly to provide Mr and Mrs Dax with full information of the circumstances surrounding the death of their son.

7.16 It is noted that often the Department referred to the Board of Inquiry Report and the Review of the Board of Inquiry Report as being 'highly technical' and as such not readily understood by laypersons. There are aspects of both reports which are technical, but for the most part both reports are succinct and clear in their argument.

7.17 In the Dax case many Departmental resources would have been saved, and much mental anguish on the Dax family's side, if the Department had made available information on the full circumstances surrounding the death of their son.

The Question of Compensation

7.18 Following the death of their son, Mr and Mrs Dax made representations to the Commonwealth for the award of an ex gratia payment. The Committee understands that in seeking such a payment Mr and Mrs Dax wished to establish a compensation precedent for other parents in such circumstances in the future.

7.19 The Compensation (Commonwealth Government Employees) Act 1971 does not provide for compensation in the case of Naval Reserve Cadets without dependants. Thus the Dax request entailed consideration of an 'act of grace' payment by the Commonwealth.

7.20 The act of grace provisions of the Audit Act 1901 enable the Commonwealth to make payments that could not otherwise be legally made - i.e. where the proposed payments are not payable in pursuance of the law or under a legal liability. The

1. Review of HMAS Tobruk Board of Inquiry Into the Death of NRC Kenneth Dax, paragraph 169(g)

authority to approve act of grace payments is provided under section 34A of that Act. That provision allows an authorised person to direct that an amount 'be treated as properly payable' to someone by the Commonwealth. The Act merely requires the authorised person to be satisfied that special circumstances exist that make it reasonable to make payment.

7.21 Because of the extremely wide (*indeed, unlimited*) power to expend public funds that this provision confers, the authority to approve such payments is closely kept. The 'authorised person' is the Minister for Finance or a person appointed by him for the purpose. Appointees have been confined to the Secretary, the two Deputy Secretaries and the First Assistant Secretary Accounting and Supply Division of the Department of Finance.

7.22 Moreover, the appointees operate within very strict limitations and in practice most claims are referred to the Minister for decision. Also, while an 'authorised person' has complete discretion in determining requests, they are subject to the statutory procedural limitations that, in respect of:

- an amount exceeding $25,000 proposed to be paid to a recipient as a single amount; and
- amounts aggregating more than $5,000 per year proposed to be paid to a recipient by way of periodical payments;

the authorised person must first consider a report on the matter furnished by a Committee of specified Permanent Heads or their deputies. The Permanent Heads specified in the legislation are the Secretary to the Department of Finance, the Secretary to the Department of Administrative Services and the Comptroller-General of Customs.

7.23 Consideration of an act of grace payment is not regarded as an alternative to the operation of arbitral processes. Only where a case cannot otherwise legally or justly be considered and determined is it thought appropriate for an act of grace payment to be considered.

7.24 The Committee understands Mr and Mrs Dax's application for an act of grace payment was judged against general principles currently applied in determining such requests.

7.25 Those broadly-stated principles are that it may be appropriate to make an act of grace payment in the following circumstances:

- where a public servant or other person acting on behalf of the Government has, in the exercise of his/her duties, given incorrect advice (or taken some other incorrect action) which has led the claimant to taking a course which was to his/her financial detriment;
- where the matter in respect of which a payment is sought is covered by specific legislation but application of the legislation would produce a result that was unintended, anomalous, inequitable, unjust or otherwise unacceptable in the particular circumstances;
- where the matter in respect of which a payment is sought is not covered by legislation but it is intended to introduce legislation and for special reasons it is considered desirable in the particular case to apply the benefits of the proposed legislation prospectively by act of grace;
- where in a particular case there are other special circumstances which led to the conclusion that there is a moral obligation on the Commonmwealth to make a payment.

7.26 It is understood that, in October 1982, the Minister for Defence determined that he was unable to recommend that an ex gratia payment be made as there were no special circumstances arising in the case to merit a special award.

7.27 The Minister for Defence also noted that such an ex gratia payment may be a circumvention of subsection 43(2) of the Compensation (Commonwealth Government Employees) Act 1971 which excludes compensation payments where there are no dependants. The Minister referred the question of amending this legislation to the then Minister for Social Security.

7.28 Following the election of a new Government in March 1983 Mr and Mrs Dax's case was reviewed. On 9 May 1983 the Minister for Defence advised the Dax's that the position remained unchanged and that no ex gratia payment would be made.

7.29 Between May and August 1983 the Minister for Social Security examined the case and decided there were grounds to recommend the award of an ex gratia payment.

7.30 Although research showed that no Commonwealth Act provided for compensation payments in cases like the Dax's it was decided that the Queensland Workers Compensation Act 1916 could provide a yardstick for determining the size of the ex gratia payment. The Queensland Act provided for a payment of a lump sum, equal to approximately 10% of the maximum death benefit under the Act, to the parents of a minor leaving no dependants. Equating this approach to the Compensation Act of the Commonwealth the lump sum payable was determined as $3550.

7.31 A cheque for this amount was forwarded to Mr and Mrs Dax on 16 August 1983. This was subsequently returned by the Dax family.

Conclusions and Recommendations

7.32 The Committee concludes that:

- the amount of $3550 is not an adequate amount to be paid for compensation to Mr and Mrs Dax given the circumstances;
- a more adequate act of grace payment should be made to Mr and Mrs Dax;
- the provisions of the Queensland Workers Compensation Act provided a guide for compensation but its provisions were not relevant to the Dax case;
- in this instance the Board of Inquiry Report and the Review of the Board of Inquiry Report are not so technical nor confidential that they should have been withheld from the Dax family; and
- the Department did not sympathetically respond to the Dax family's request for information.

7.33 The Committee recommends that:

- the Dax case be reviewed by the Department in conjunction with the Departments of Finance and Social Security, as a matter of priority, to determine an adequate amount to be paid for compensation to Mr and Mrs Dax. Among the factors to be considered by this review should be the horrible circumstances of the death, the age of the deceased, his volunteer Service status and the particular departmental problems of the HMAS Tobruk project as discussed elsewhere in this Report;
- when a person dies in Service the deceased's spouse (or family if appropriate) be informed of, as soon as possible, the full circumstances surrounding the death of the deceased;
- the Auditor-General be informed of and supplied with, in a timely manner, unedited Board of Inquiry Reports and Reviews of Board of Inquiry Reports;

- the <u>Compensation (Commonwealth Government Employees) Act 1971</u> be revised and amended as soon as possible to provide for adequate compensation payments in circumstances like the Dax case, or that appropriate legislative changes be made.

CHAPTER 8

THE SHIPBUILDER - CARRINGTON SLIPWAYS PTY LTD

Background

8.1 Throughout this inquiry into the Auditor-General's reference on HMAS Tobruk the Committee has been aware that the focus of its inquiry should be on the Department of Defence's administration and management of the LSH project. The Committee has sought to establish the reasons for shortcomings in the construction of HMAS Tobruk and in doing so it took evidence from the shipbuilders, Carrington Slipways Pty Ltd and inspected the company's shipyards at Tomago, NSW.

8.2 The Committee believes that much of the future of shipbuilding in Australia depends on the ability of the Defence Department and those who contract with the Defence Department to produce vessels of high standard and quality. The Committee wishes to reiterate a comment made by one of its Members during a public hearing on 14 September 1983:

> '.... this inquiry should not be seen as an attack on the local shipbuilding industry here in Australia. I think in some sectors it has been inferred that it may have been. What we are seeking to do is implement mechanisms that will expedite the efficient construction of shipping, so that these ships can be constructed in a minimum of time according to the highest quality standards that are available.'

8.3 It is recognised that Carrington Slipways Pty Ltd is a successful builder of ships in Australia. In recent years the company has constructed many tugs and some specialised vessels. Following the completion of HMAS Tobruk the Department of Defence placed a contract with Carrington Slipways Pty Ltd in January 1983 for the construction of two prototype catamaran minehunters for the RAN.

8.4 The Company is well regarded in the industry and makes a contribution to the local economy through its employment of some 446 people (as at December 1982) and requirements for materials.

General Difficulties Experienced by the Company

8.5 It appears that two main problems were experienced by Carrington Slipways during the HMAS Tobruk project.

8.6 The company was slow in developing it's quality control system up to a satisfactory level. The result of this is discussed elsewhere in this Report.

8.7 An equally significant problem for the company was communicating with the Department during the project. Difficulties were experienced because of:

- the complexity of the communication chain;
- the structure and terminology of Commonwealth Government contracts and Departments;
- a response lag to queries by the company greater than that previously experienced with private clients;
- changes in Service and civilian project personnel employed by the Defence Department;
- limited delegated authority held by on-site departmental personnel leading to the company not being able to resolve many problems;
- ambiguity in the contract specifications;
- problems in securing materials and technical details from overseas suppliers.

These problems are commented on elsewhere in this Report.

8.8 The Committee notes the comment of the Fleet Commander in his report on HMAS Tobruk's Trials and Evaluation Programme:

> From the commissioning of TOBRUK a number of deficiencies quickly became apparent. These were mainly design related and a number of shortcoming still exist. Some deficiencies were noticed towards the end of the construction phase but for reasons related to contract, as well as design difficulties, rectification before acceptance and commissioning could not be achieved. In all fairness to the builder he produced what he was required to produce and responded well to rectification of faults which were discovered during the warranty period.

The Shipbuilder and Specific Problems of the HMAS Tobruk Project

8.9 Throughout previous chapters of this Report there is discussion of the shipbuilder's involvement in the problems of the HMAS Tobruk project. Although the Department of Defence is primarily responsible for these problems the shipbuilder, as the project's prime contractor, must inevitably share some of this responsibility.

8.10 It is clear from the discussion in Chapter 2 of this Report that the shipbuilders, although informing the Navy Office of the likelihood of HMAS Tobruk being overweight, commenced building the ship in the same month they notified the Navy Office, September 1978.

8.11 From the outset of the project the shipbuilder experienced problems in developing his quality control procedures. These matters are discussed in Chapter 3 of this Report. Only later in the project did the firm develop its quality control systems with enchanced ADP facilities. Despite this it appears that in the final months of the project the shipbuilder had to depart from negotiated quality control and quality assurance procedures.

8.12 While Carrington Slipways were not responsible for HMAS Tobruk's landing craft they did install the davit hoist hydraulic system as discussed in Chapter 4. The evidence there suggests that the standard of cleanliness during the ship's construction contributed to the contamination of the davit hydraulic system.

8.13 Of the many design related problems discussed in Chapter 5 it is the design, installation and testing of HMAS Tobruk's sewerage system which is most significant. Several critical modifications were made to the ship's sewerage system by the Department's Naval Design Branch. All available evidence suggests that the Department, the shipbuilder and the ship's crew did not understand the design and operation of the ship's sewerage system.

8.14 Also, the shipbuilder did not adequately document several of the ship's systems.

Carrington Slipways Pty Ltd's Reaction to the Review of the Board of Inquiry

8.15 Because the Committee has decided to append the Review of the Board of Inquiry at Appendix H of this Report, and as Carrington Slipways Pty Ltd is mentioned in the context of the prime contractor throughout the Review the Committee believes that the response of Carrington Slipways Pty Ltd to the Review should also be included in this Report.

8.16 On 25 May 1983 the Managing Director of Carrington Slipways Pty Ltd (CSPL) wrote to the Department, thanking the Department for forwarding a copy of the Review on 9 May 1983 and making the following comments:

Paragraph 5 of the Review:

> The contributing factors which led to NRC Dax's death are complex, largely because they stem from a shipboard system - Sewage Collection, Holding and Transfer (CHT) - which is new to the RAN, designed by outside agencies (the Shipbuilder in consultation with Mono Pumps), and installed in a contract built ship (Carrington Slipways P/L-CSPL) to commercial standards. Comprehensive 'as fitted' information was not available to the ship, nor to Navy Office, at the time of the accident.

> CSPL Comment:

>> States that the system 'which is new to R.A.N. - designed by outside agencies (the shipbuilder in consultation with Mono Pumps)'. This statement is not entirely correct. During Questions and Answers, five (5) questions and answers related to the sewerage system and detailed answers were provided by Navy. Navy nominated Mono Pumps because they had installed such a system in 'Yarra', Ref. Q.111 and Minutes of Technical Conference on 11th November, 1976.

Paragraph 39 of the Review:

> Exceptionally, the forward macerator tanks receive both blackwater and greywater drains, thereby simplifying the pipe system runs to the holding tanks much further aft. Design guidance specified otherwise but this departure from guidance is not a factor in NRC Dax's death.

> CSPL Comment:

>> We do not agree with the second sentence. Design Guidance Drawing A000077 required both blackwater and greywater drains to go direct to the forward macerator tanks.

Paragraph 52 of the Review:

> Each of the forward and aft macerator tanks has its own separate vent but the midships tanks do not: instead they join into the vent lines from their associated holding tanks.

These midships macerator tanks are sited within but separate from their associated holding tanks and this close proximity undoubtedly accounts for the decision to marry the vent lines, which was done in accordance with a design guidance amendment provided in Navy Office drawing No A000077 (Issue 2). It is certain that the marrying of the vent lines was a major factor in NRC Dax's death.

CSPL Comment:

> Marrying of vent lines was not an amendment. Navy spelled out this requirement during Questions/Answers during Contract/Tendering Period, Ref. Q.44. As stated, Design Guidance Drawing A000077 also indicates marrying of these vents.

Paragraph 53 of the Review:

> The net effect of paras 49 and 52 was to vent all four midships tanks up a single vent pipe, to the top of the starboard kingpost. As discussed later, at para 89 there was some evidence that the vent system may have been inadequate and the matter was further explored. Calculations which have been made tend to prove that the first modification, to combine the holding and midships macerator tank vents in pairs port and starboard, although inherently dangerous for other reasons, do not overload the vent pipe capacity but the second modification, to combine the port and starboard pairs into a single pipe, increased the back pressure beyond the capacity of the water seals in the heads bowls (para 56 below), thereby leading directly to Dax's gassing and death.

CSPL Comment:

> The modification to connect port and starboard midship macerator tanks and port and starboard holding tank vents was designed by Navy Office and the installation arranged, supervised and paid for by Navy. C.S.P.L. had no input.

Paragraph 54 of the Review:

> All blackwater drains to the macerator tanks rely on water seals ('P' traps, 'U' bends etc) to isolate the compartments from which they drain (ie heads), from the atmospheres within the relevant tank ullages. (Similar arrangements are used in the most recent RN designs). Greywater drains also use 'P' traps and 'U' bends but they are backed up by non-return valves. Exceptionally amongst the blackwater drains, non-return valves were fitted between the forward macerator tanks and related WC bowls only, in June 1981. The work was done by CSPL, presumably following their experience of an earlier sewage spill from the forward macerator tanks. There is no knowledge on board of why a similar modification was not made to the midships and aft systems but had its significance been appreciated at the time and the modification, or something like it, been extended throughout the ship, the accident involving NRC Dax could well have been avoided.

CSPL Comment:

> Design guidance did not indicate requirement for non-return valves however, under 'at sea' conditions the movement of the ship caused the surge of sewage from the forward macerator tanks up through the toilets on 3 deck. C.S.P.L. were notified of this defect and undertook to fit non-return valves to the lines leading to the macerator tank. At the time it was not considered necessary to fit non-return valves in any other lines.

Paragraph 40 & 71(a) of the Review:

> Navy Office design guidance was that all permanent ship's company heads should drain to the aft macerator tanks, leaving the midships and forward tanks for embarked troops only, thereby enabling them to be shut down for long periods, see para 10 of folio 30. Following the accident, it has been established that a small number of ship's company heads actually discharge to the midships macerator tanks. The relevance of this departure from guidance will be discussed later.

The identified shortcomings in the sequence mentioned in the review are:

a. Some ships company heads discharge to the midships macerator tanks, preventing their isolation when troops are not embarked. This lost any significance it might otherwise have had for Dax because of the holding tank cross connection and because the ship could not readily flush out macerator tanks after use.

CSPL Comment:

Y-ARD Sewerage Arrangement Diagrammatic Drawing No. 138-605H SRI is in accord with Navy Guidance Drawing A000077, However, Y-ARD Sewerage Arrangement Drawings Sheets 2, 3 and 4 deviate from Diagrammatic by showing some of the ship's company heads discharging to midships macerator.

Reason for this departure from guidance is not known and was not 'picked up' by C.S.P.L.

Paragraph 74 of the Review:

The detailed design was carried out by the shipbuilder (CSPL) and his subcontractor (Mono Pumps) with drawing office assistance from Y-ARD (UK). The design guidance provided to the shipbuilder by Navy was minimal, consisting of a schematic and general instructions included in specifications attached to the contract. It did little more than indicate:

a. That a CHT type of system was required.

b. That only the aft macerator tanks were for ship's company use; the remaining four tanks being for embarked troops use only.

c. That both blackwater and greywater drains should be capable of being directed either overboard or to macerator and holding tanks.

d. Air agitation of holding tanks was to be provided, at a stated air flow.

e. Flame proofing of holding tank air vents was required.

f. Tank cleaning arrangements were to be provided (hose connections for macerator tanks; fixed flooding arrangements for holding tanks).

g. Chlorination of holding tanks was to be provided.

CSPL Comment:

Once again the statement is made 'the detailed design was carried out by the shipbuilder (C.S.P.L.) and his sub-contractor (Mono Pumps) with drawing office assistance from Y-ARD (U.K.)'. We can only repeat that Navy provided a considerable amount of guidance information to enable the detailed design to be completed.

Paragraph 78 of the Review:

One departure from design guidance which did occur and which was potentially dangerous though not significant in Tobruk's accident, was the routing of several blackwater drains from ships company heads to macerator tanks intended for embarked troops use only.

CSPL Comment:

This paragraph criticises the shipbuilder for failure to recognise the possible defects and assumes that 'a reputable shipbuilder to be considered competent to design and build a viable plant'. We should point out that C.H.T. systems are not common in todays shipbuilding practice.

Paragraph 94 of the Review:

Further rectification work was undertaken as arranged by CSPL during the Post Shakedown Availability (PSA) in Brisbane 14 Aug - 11 Sep 1981, this work taking the form of modifications etc, not regarded as a contractor liability. It included the marrying and extension of the holding tank vents up the starboard kingpost, the supply and installation of contents gauges and the restoration of spaces contaminated by the May 81 spill. The PSA work was carried out by local contractors under the supervision of GOSIEAA.

CSPL Comment:

> This paragraph incorrectly suggests that C.S.P.L. undertook rectification work in the form of modifications to the vent system. We refer to our comments under paragraph 53 above. Further to paragraph 124, Navy's criticisms of C.S.P.L.'s quality control organisation was partly justified. C.S.P.L. have taken note of these minor shortcomings and are determined that they will not be repeated in any future Contracts

Paragraph 125 of the Review:

> With the benefit of hindsight, particularly in view of the main machinery problems being experienced, it is arguable that the ship should not have commissioned when she did, despite the pressing administrative problems inherent in a further deferral of the ceremony itself. Commissioning per se should alter nothing but in practice it does. A ship's company with morale to be considered, is introduced; the command assumes a direct responsibility hitherto denied it and the Fleet Commander acquires an asset to be programmed.

CSPL Comment:

> Comment is made on the main machinery problems 'it is arguable that the ship should not have been commissioned when she did'.
>
> There were some machinery problems during trials, however, the vessel was handed over in a satisfactory condition. Following handover, further defects did become evident which were only highlighted with continuous running of the main machinery and were expertly attended to by the machinery suppliers.

Paragraph 155 of the Review:

> Except in the case of the aft pair of macerator tanks, macerator motors and transfer and discharge pumps and associated valves are located in unventilated compartments below mess decks and passageways, accessible only through bolted-on manhole covers. This quite unsatisfactory arrangement invites either the disregard of rules governing entry to confined spaces, or poor standards of inspection and maintenance of machinery.

CSPL Comment:

> The report states that the macerator tank motors transfer and discharge pumps and associated valves are located in unventilated compartments below mess decks and passageways. This is totally incorrect. The forward macerator machinery compartment is exhausted by Exhaust Fan No. EF4, the midship macerator machinery compartment is exhausted by Exhaust Fan No. EF5. The requirement for this ventilation is clearly indicated in Q. & A.'s answer to Q.44 and also Specifications Volume 2, para. 6.11.9.7. (d) and (e).'

Concluding Comments

8.17 As discussed in Chapter 6 of this Report in 1984 the Committee will be inquiring into project management in the Department of Defence. One of the projects which the Committee may address is the RAN Minehunter Catamaran project. A division of Carrington Slipways Pty Ltd has the prime carriage of this project.

8.18 The Committee, in reporting on the findings of this inquiry does not question the role of the Australian shipbuilding industry in Defence projects. The Committee does not wish to prejudice shipbuilding in Australia. It recognises the valuable contribution to the Australian economy made by Australian shipbuilding companies and their employees.

CHAPTER 9

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The Original Reference - Excess Weight (Refer Chapter 2)

9.1 The Committee concludes that:

- the Department did not allocate sufficient resources to developing quality assurance programs for monitoring, amongst other things, the weight control procedures of the contractor's quality control system. With hindsight it was a poor decision of the Department to sign the contract for the ships construction when it did. The Department knew of the need to upgrade the contractor's quality control system and should have accurately assessed the difficulty and duration of this task;
- the Department misled the Committee in giving evidence that it (the Department) 'discovered late rather than early that the vessel was overweight'.[1] The Auditor General reported that in September 1978, the month the first steel was cut at the shipyard, the contractor advised Navy Office that the ship would be overweight and Navy Office confirmed this view. This instance appears to be another example of poor consultation across the functional boundaries of the Department;[2]
- HMAS Tobruk's unauthorised weight increase was due to the Department not ensuring that the contract specifications were met;
- the Department did not give adequate consideration to the commercial practicalities of converting HMAS Tobruk's specifications from imperial to metric measurements;
- the Department did not recognise, in a timely manner, the adverse consequences of a 'soft conversion' from imperial to metric measurements of the specifications for HMAS Tobruk's steel plate;
- given the magnitude and obvious implications of converting the ship's design from imperial to metric measurements, the Department should have monitored more closely the contractor's conversion processes and materials acquisition. In this respect the Department was derilict in carrying out it's contract supervisory role;

1. Minutes of Evidence, 17.9.82
2. This aspect is analysed in Chapter 6

- by contracting for HMAS Tobruk to be built to a mix of commercial and RAN specifications the Department may have saved on the capital costs of the project at the expense of incurring high ship maintenance costs;
- as a result of not being built to specifications HMAS Tobruk's beaching capability has been significantly reduced. While the Committee acknowledges that the ship's flexibility allows it to discharge cargo by other means, it remains that the ship would be more flexible and useful if it was able to beach at its specified gradient;
- there is little purpose in building a specialised beaching design vessel such as HMAS Tobruk if the resultant ship can only use the specified design feature in a secondary role under restricted conditions;
- HMAS Tobruk's excess weight does not jeopardise the ship's longitudinal strength; and
- the Department's performance in managing the weight control aspects of the local ship construction contracts is poor. HMAS Success, HMAS Tobruk and the Fremantle Class Patrol Craft have all been allowed to be constructed with excess weight;

9.2 The Committee recommends that:

- the Department develop, in consultation with the Australian shipbuilding industry and other groups, standardized techniques for assessing the weight of vessels. Effort should be directed towards developing a range of agreed methods (with differing costs and accuracies) for objectively determining the weight of a vessel during construction and at the time of its commissioning;
- for future contracts the Department either:
  - ensure that a contractor's quality control system meets the appropriate Australian standard at the time of signing the contract, or
  - if, at the time of signing the contract, the contractor's quality control system is judged not to meet the relevant Australian standard but is thought to be able to do so at a later date, a development plan for the contractors quality control system should be incorporated into the contract specifications by the Department;

- the Department ensure that development of a contractors quality control system is carried out as promptly as possible. Contract progress payments should be linked to stages in such a development plan; and

- the Department should investigate and assess the utility of the contracts proposal of the Australian Shipbuilders Association in conjunction with the Department of Defence Support and the Attorney-General's Department;

The Original Reference - Quality Assurance and Contractual Matters (Refer Chapter 3)

9.3 The Committee concludes that:

- the Department's explanation that 'by the time an inspection had been completed and a report written, circulated and considered, matters on which Navy Office decisions had been sought had, in most cases, been overtaken by events as shipbuilder's work could not normally cease during the Navy Office consideration process' is completely unacceptable and an indictment on the efficiency of the Department;

- the number of on-site departmental representatives at the shipbuilders yard was grossly inadequate;

- the level of on site departmental expertise and experience was inadequate given the task at hand. The Department was negligent in that it did not even meet the level of resident overseeing staff as laid down (by itself) in section 1.24.1, v.1 of HMAS Tobruk's specifications;

- it is not a matter of the 'visibility' of resident departmental quality assurance staff which is important in a project like HMAS Tobruk. It is important that there be skilled departmental quality assurance staff on site in sufficient numbers to efficiently and effectively fulfil the quality assurance function; and

- there is a need to review the efficiency and effectiveness of the organisation of the General Overseer and Superintendent of Inspection East Australia Area, this issue will be addressed by the Committee during its Inquiry into Defence Project Management in 1984;

9.4 The Committee recommends that:

- the Department in all future projects ensure that as part of the on-site resident team a resident quality assurance team, of a size commensurate with the scale and complexity of the contract, be present throughout the project; and

- members of all future on-site resident departmental quality assurance teams have adequate skills and expertise and a clear understanding of the Department's policy on quality assurance;

The Original Reference - Landing Craft Vehicular and Personnel (LCVP) (Refer Chapter 4)

9.5 The Committee concludes that:

- the Department's tender specifications for HMAS Tobruk's LCVPs were deficient and not correctly oversighted by the Department when the contract for the LCVPs was awarded;

- the Department's statement that it tested the LCVP's on the davits 'with 12 times the weight of 34 troops (using) pig iron blocks', and found the strength of the davits satisfactory, conflicts with the Auditor-General's concern that the weight of LCVP embarked troops was understated by 900 kg resulting in the Department placing restrictions on the number of armed personnel lifted/lowered in on LCVP;

- initial problems with HMAS Tobruk's davit hydraulic system point to problems with supervision and oversight of the contractors quality;

- the Department has been dilatory in devising a remedy for HMAS Tobruk's contaminated hydraulic system;

- continuing problems with HMAS Tobruk's davit hydraulic system, point to a lack of expertise with hydraulics in the Department or inefficient systems in the Department to rectify defects in well known engineering technology;

- although the Department states that HMAS Tobruk's LCVP's are not the main method of getting troops ashore, problems with other methods (eg. beaching) or restrictions with other methods (eg. operation of the stern door only during calm sea conditions) compounds the significance of the davit problem;

- HMAS Tobruk's landing craft vehicular and personnel are unsatisfactory in their design, operational capability and safety; and

- the LCVP's design and specifications were poorly determined and the decision to purchase them was completely unsatisfactory;

9.6 The Committee recommends that:

- the Department proceed as soon as possible with rectification work on the LCVP's to improve their buoyancy, such work should be completed before the craft are transferred for use on HMAS Success;

- replacement LCVP's for HMAS Tobruk should be procured as soon as possible and be available before the scheduled refit of the ship;

- replacement LCVP's should be acquired to improved specifications developed with the hindsight of the problems experienced in the original craft; and

- preference be given to Australian contractors who tender for the replacement LCVP contract and the rectification contract for existing LCVP's;

Design and Modifications (Refer Chapter 5)

9.7 The Committee concludes that:

- in principle, there is nothing inherently wrong with purchasing an old ship design and changing it;

- the Department's design modifications were of such an extensive nature that either, they were beyond the Department's available design expertise to specify sufficient detail and oversight construction, or that the design expertise in the Department was not adequately applied to the project;

- the problems experienced by HMAS Tobruk since commissioning are not minor teething problems. Their number and significance suggest that HMAS Tobruk has experienced a higher than expected amount of major problems when compared to what should be the outcome of a well managed project;

- comparing the problems of HMAS Tobruk with those of other contemporary RAN vessels such as HMAS Cook, Success, Parramatta, Ipswich, Cessnock, Stuart and Adelaide may be spurious. Differing design and construction methods have been used, the functional roles of these ships are different and generally the financial, industrial and political environment surrounding their construction have varied. Some of these ships have also had or are having severe problems and the Department's management of their construction has also been criticized by the Auditor-General;

- many of the major problems HMAS Tobruk has suffered since its commissioning stem from design related causes;

- the ship's existing airconditioning system is unsatisfactory and in need of replacement in the long term;

- HMAS Tobruk's air conditioning system should have been inspected, tested and trialled within it's warranty period;

- problems with the ship's engine control system, partly attributable to the use of a mixture of ferrous and non-ferrous pipes, contravene the contract specifications on dissimilar metals;

- HMAS Tobruk's quality assurance project staff and on site supervisors did not adequately inspect the construction of the air conditioning system and ensure that dissimilar metal components were correctly installed;

- the initial design of HMAS Tobruk's deck mountings for its forward FAVCO cranes was not satisfactory, given the loads the cranes were expected to handle the need for robust reinforcement from below should have been anticipated;

- the problem of HMAS Tobruk's excessive vibration has not been resolved;

- technical reports detailing HMAS Tobruk's excessive vibration were not made available to the Committee;

- the ship's excessive vibration may constitute a longterm health hazard to the crew;

- the cause of the ship's excessive vibration should have been diagnosed when purchase of the LSL design was considered and attempts made to redesign the LSH class of vessel to minimise the problem;

- there is little doubt that HMAS Tobruk's excessive vibration will increase the ship's maintenance costs and reduce it's life;

- problems with HMAS Tobruk's auxiliary boilers typify the difficulties of procuring spare parts from overseas manufacturers;

- HMAS Tobruk's auxiliary boilers should have been built for endurance and thoroughly tested under warranty;

- the many serious problems with the design, installation, modification, quality control, quality assurance, management and rectification of HMAS Tobruk's sewerage system serve to characterise the Department's poor approach to the Tobruk project generally;

- the large number of critical conclusions and recommendations of the Review of the Board of Inquiry into the Death of NRC Dax are indicative of the magnitude of mismanagement in the Department;

- HMAS Tobruk's sewerage system was not adequately understood by the department's designers, the contractor's designers and installation staff, the ship's company and the department's maintenance personnel during the build of the ship;

- although no one person can be identified as having acted in such a way to cause NRC Dax's death it appears that the contractor's and the Department's lack of understanding about HMAS Tobruk's sewerage system, and the departmental design changes made to HMAS Tobruk's sewerage system, were most significant contributory factors;

- HMAS Tobruk's poorly designed kit locker spaces have led to the development of a potential safety hazard in the form of congested troop passage ways when troops are on board;

- the shipbuilder's detailed systems drawings for HMAS Tobruk's sewerage system should have been included in the list of key build approval drawings to be submitted to the Department for approval in principle; and

- HMAS Tobruk, under certain circumstances, may have a lack of watertight integrity;

9.8 The Committee recommends that

- detailed systems drawings for sewerage systems be included in future key build approval drawings to be submitted by a shipbuilder for approval in principle by the Department;

- the Department institute a formal evaluative research program into the design of currently available ship sewerage systems;

- departmental documentation controlling proposed design changes be amended so that consideration of the safety implications of design changes becomes a mandatory and formalized part of the design approval process;

- the Department proceed as a matter of urgency to thoroughly research questions surrounding HMAS Tobruk's potential for lack of watertight integrity and initiate corrective action as soon as possible if needed;

- the Department research the risks associated with HMAS Tobruk's external PVC piping;

- the Department complete its investigation into the sources of HMAS Tobruk's excessive vibration and take action to reduce this vibration to more desirable levels during the ship's next major refit;

- rectification of HMAS Tobruk's many serious technical problems (as detailed in this Report) should be carried out <u>in advance</u> of the <u>scheduled</u> refit. In the meantime consideration should be given to the operation of the ship to ensure its safety; and

- departmental management effort should concentrate on making the Australian shipbuilding industry both efficient and effective, significant problems with locally built ships will not be overcome until this objective is attained;

Project Management (Refer Chapter 6)

9.9 The Committee concludes that:

- for the HMAS Tobruk project, the Department's formal lines of direct functional responsibility reduced the responsiveness and interaction of project team personnel with the other specialised personnel in the Department;

- the manager of a departmental project should be given greater authority and responsibility for the overall administration and management of the project;

- personnel from the Department's Fleet Maintenance Branch should have become involved in the HMAS Tobruk project earlier than they did;

- the Department did not ensure that the contractor provided, in a timely manner, HMAS Tobruk system handbooks and 'as fitted' drawings;

- either, the Department did not allocate sufficient draughtsmen/engineers to the task of examining HMAS Tobruk's 'key build approval drawings' or the Department generally has an insufficient number of design draughtsmen/engineers;

- the shipbuilder did not comply in a timely manner with the provision of information on HMAS Tobruk's equipment warranties and guarantees as specified in the ship's contract;

- there may be grounds for instituting a line approach to the management of major projects instead of having a Project Director act as a co-ordinator. The Committee will be following up this point during its inquiry into the Department's overall project management in 1984;

- in respect of warranties and guarantees the Department neglected its contract supervision duty to ensure that the contractor supplied the Department with warranty/guarantee information in a timely manner;

- the Department should have simplified and standardised the warranty/guarantee terms, conditions and periods for HMAS Tobruk's equipment through the use of appropriate contract clauses and specifications; and

- the high turnover of personnel related to the HMAS Tobruk project was unsatisfactory and detrimental to the outcome of the project;

9.10 The Committee recommends that:

- the Department investigate and trial (in different parts of the Department) the use of simulation models to improve its management information systems. The Committee may follow this matter up during its inquiry into the Department's project management in 1984;

- the Department accord a high priority to the development of a policy for the transition of ships and craft from procurement to maintenance. The

existence of such a policy will benefit the management of projects currently in hand e.g. HMAS Success;

- the Department, as soon as possible, clarify the duties of personnel standing by ships under construction;

- personnel from the Department's Fleet Maintenance Branch be included in Naval Project Management Teams;

- the development of ship's systems documentation should be an ongoing process commencing, in outline, at the commencement of a ship's construction. The preparation of handbooks should not be treated as a discrete activity at the end of a ship's build but should be thought of, and carried out as, an activity which is done continuously through the build and refined during the ship's service;

- the Department, for future ship construction contracts, ensure that system handbooks and 'as fitted drawings' be produced in a timely manner. The preparation and development of such documentation should be treated as an on-going task commencing early in the build;

- for all future capital equipment contracts the Department ensure that the major contractor compiles a register of equipment guarantees and warranties and copies that register, in a timely manner, to the Department on an ongoing basis throughout the contract period;

- the Department inspect, test and trial equipment within its warranty/guarantee period;

- the Department, for future major equipment contracts, specify the period of equipment warranties and guarantees. The range of warranty/guarantee periods should be kept to a minimum;

- The Department explore ways in which it might promote officers through various civilian grades or Service ranks while keeping them on the same departmental project and/or position; or if an officer retires he/she might be retained as a civilian on the project. The Committee will be addressing this issue further in its inquiry into departmental project management in 1984; and

- the Department investigate immediately the development of a line approach to the management of major projects. The elements of this approach should include sufficient delegation of authority and continuity of resources for the project manager to plan, review and use resources to achieve an end product that meets specified technical performance objectives, is on time and within budgeted cost. The Committee will be examining this matter during its inquiry into the department's overall project management in 1984;

The Death of Naval Reserve Cadet Kenneth Dax (Refer Chapter 7)

9.11 The Committee concludes that:

- the amount of $3550 is not an adequate amount to be paid for compensation to Mr and Mrs Dax given the circumstances;
- a more adequate act of grace payment should be made to Mr and Mrs Dax;
- the provisions of the Queensland Workers Compensation Act provided a guide for compensation but its provisions were not relevant to the Dax case;
- in this instance the Board of Inquiry Report and the Review of the Board of Inquiry Report are not so technical nor confidential that they should have been withheld from the Dax family; and
- the Department did not sympathetically respond to the Dax family's request for information;

9.12 The Committee recommends that:

- the Dax case be reviewed by the Department in conjunction with the Departments of Finance and Social Security, as a matter of priority, to determine an adequate amount to be paid for compensation to Mr and Mrs Dax. Among the factors to be considered by this review should be the horrible circumstances of the death, the age of the deceased, his volunteer Service status and the particular departmental problems of the HMAS Tobruk project as discussed elsewhere in this Report;
- when a person dies in Service the deceased's spouse (or family if appropriate) be informed of, as soon as possible, the full circumstances surrounding the death of the deceased;

- the Auditor-General be informed of and supplied with, in a timely manner, unedited Board of Inquiry Reports and Reviews of Board of Inquiry Reports;
- the Compensation (Commonwealth Government Employees) Act 1971 be revised and amended as soon as possible to provide for adequate compensation payments in circumstances like the Dax case, or that appropriate legislative changes be made.

Report of the Auditor-General

upon
audits, examinations and inspections
under the Audit and other Acts March 1982

5. DEPARTMENT OF DEFENCE

5.3 Amphibious Heavy Lift Ship Acquisition

Background

In August 1975 Cabinet approved a procurement project to provide a versatile amphibious ship able to carry and land forces and their equipment including tanks, helicopters, bulldozers etc., if necessary without the use of a port.

Tenders were called for ship construction in September 1976, and a contract was let in November 1977. The commissioning date was set at 21 June 1980, with the ship to be named HMAS *Tobruk* and to be classified as a Heavy Lift Ship (LSH).

The LSH project also included the acquisition of 4 Landing Craft Vehicular and Personnel (LCVP) from funds provided for the project. The acquisition of the LCVPs was not part of the November 1977 shipbuilding contract.

The contractor handed over the LSH to the Royal Australian Navy (RAN) on 11 April 1981 and the vessel was commissioned on 23 April 1981. The RAN formally accepted HMAS *Tobruk* for operational service with the Fleet on 23 July 1981.

The audit consisted of a detailed analysis of the planning and implementation phases of the project with particular emphasis on departmental management exercised from Navy Office, Canberra.

The audit indicated that the planning and tendering/contracting processes were carried out in a regular and satisfactory manner.

Control over production

In summary the audit of production control disclosed:

- departmental documentation lacked sufficient detail in assigning functional responsibilities for weight monitoring within Navy Office
- the Department was not advised in a timely manner of the results of quality assurance inspections
- difficulty was experienced in comparing the contractor's advised computer estimate of the ship prefabricated unit weights with Navy Office design weight calculations because of differences between the contractor and Navy Office weighing systems as specified for HMAS *Tobruk*
- the shipbuilding contract did not include penalty provisions where the contracted agreed weight was not achieved

- supplies of some Government Furnished Equipment to the shipbuilder were not timely, contributing to delays in the shipbuilder's program
- Navy Office and contractor delays, design changes, clarification of standards used in the ship construction specifications and modifications caused extensions to the contract delivery date
- the Department has not met contractual requirements with respect to the timely determination of the extent of excusable delay, and
- ambiguity in the wording of Ship Construction Specification necessitated additional costs of $60 960 for the LCM8 Landing Craft cradles.

The lightship weight of HMAS *Tobruk*, modifications to the basic design during construction and cost escalation were subjected to detailed examination.

The LSH design was based on that of the Royal Navy's *Sir Bedivere* class updated with a number of Australian machinery and equipment additions. The contract specifications stipulated a lightship weight of 3322 tonnes, which included allowances for RAN design changes. Navy Office reviewed the contractor's computerised weighing/ calculation system during tender evaluations and was satisfied that although the system differed from RAN's procedures the the contractor's procedures were appropriate for commercial practices and acceptable. Audit noted however that directions for monitoring the weight of vessels under construction were not specified definitively in any standing instruction.

The specification for the construction of the ship defined:

- the extent of Commonwealth responsibility for the design and performance of the vessel, and
- the responsibility of the shipbuilder to continuously monitor the weight during construction and progressively report to the Department.

In September 1978 the contractor advised Navy Office that its computer estimates for the weight monitoring program had indicated the lightship weight was critical and it would be exceeded. Examination by Navy Office of the contractor's main structural drawings confirmed this view.

According to departmental records the quality assurance reports indicated that the steel ordered by the contractor met the contractor's requirements, but did not draw attention to the fact that the steel ordered was heavier than the United Kingdom specified material.

During LSH construction, steel plates of the required Imperial measurement thickness used in the *Sir Bedivere* class design were not readily available in Australia, and thicker plates were used by the contractor without seeking prior Navy Office approval. Navy Office became aware of the problem in October 1978. It promptly advised the contractor that it was essential the lightship weight be met and this objective could be achieved by using steel of direct Imperial to Metric conversion.

Minutes of a meeting held in 1979 between representatives of the Department and the contractor to discuss weight monitoring and to ensure weight reductions would occur during the construction of the ship disclosed the shipbuilder had relied upon computer calculations in respect of structural weight calculations but structural units had not been check weighed. The contractor had encountered problems in respect of the procurement of and installation of a 40 tonne weigh-bridge and other weight monitoring devices. At that time it was estimated that approximately 85% of the total structure was completed and it was too late to exercise any worthwhile weight control in the structural area. For other construction areas of the ship weight control was possible.

Displacement checks and inclining tests conducted by the Department disclosed that in January 1981 HMAS *Tobruk's* lightship weight was 3619 tonnes, an increase above specification of 297 tonnes (8.9%). Of the increase, 275.5 tonnes was attributed to the heavier plates and other the contractor increases and 21.5 tonnes to approved design changes.

Effect of lightship weight being exceeded The Department advised that the implications of the increased weight of the LSH were:

- a steeper beach gradient being required for self beaching operations, and
- additional fuel consumption when the ship maintains cruising speed thus reducing the ship's range (the degradation of fuel consumption and range was, however, said to be marginal).

This Office sought clarification on whether the LSH fuelling policy approved during March 1981, whereby a full load of fuel could not be embarked was the result of the LSH being overweight. The Department advised that the fuel bunkering policy setting out the amount of fuel which may be loaded into the LSH is an operational aspect which was not related to the ship being overweight. The fuelling policy was determined having regard to the prospective use of the ship in Australian waters and such journeys required less fuel to be carried in comparison to the prospective range of the LSH maintaining cruising speed with a full load of fuel.

The Department advised that the LSH was never intended to be capable of achieving a beaching gradient with a full load of fuel. The fact that the fuelling policy was only promulgated in March 1981 was an oversight and not the result of any change in operational capability.

This Office notes an inconsistency in the latest departmental attitude on the results of the LSH being overweight with the concern expressed earlier about the essentiality of achieving the specified lightship weight.

In May 1981 the Department advised the Department of Administrative Services (DAS), (the Contracting Authority for the Commonwealth), concerning the LSH being overweight together with the implications thereof. The Department of Defence commented that weight control was the responsibility of the contractor and DAS had not previously been instructed to direct the contractor to correct the overweight trend. The Department also referred to quality assurance audits which had not been sufficiently stringent because of inadequate staff resources.

Negotiations took place during 1981 between the contractor, the Department of Defence and DAS for recovery of compensation in respect of the overweight ship. The contractor denied that it was liable under the contract.

Modifications

Examination of selected modifications costing in excess of $50 000 revealed that:

- associated contract amendment requests were processed satisfactorily with regard to funds availability, cost variation investigation, approval by competent authority and necessity for and desirability of the design modification, and
- the specification did not stipulate unequivocally that the shipbuilder was to provide cradles for carriage of two Army LCM8 Landing Craft necessitating separate tendering for the supply of cradles at a cost of $60 960.

The Department advised that prior to the placing of the LSH contract it was acutely aware of the need to minimise and control modification during construction. Against this background, existing procedures were further developed and coupled with other approval procedures resulted in LSH modification costs being less than half the initial estimate. For the LSH project these procedures had been most effective in controlling modifications and equivalent procedures have been introduced for other contracts.

The Department said that the LSH contract package consisted of 4 volumes of schedules, 3 of which were the technical specification. These documents contained approximately 600 pages of technical data compiled by at least 6 specialised Directorates. Ambiguity and contradiction are difficult to avoid in the *first of a class* technical documentation but a continuous effort is made to detect such errors prior to the issue of documents to the contractor. Further improvement can be expected with the exercising of greater emphasis on quality engineering within the Naval Technical Services Division.

Quality assurance and contractual matters

In December 1981, the Department was asked to comment on audit observations on weight monitoring quality assurance and utilisation of the contracting authority.

The Department advised that a consolidated instruction was currently being collated from Naval Technical Services design and production inputs, into a comprehensive document. The first draft for circulation within Department of Defence and DAS is expected to be available towards the end of February 1982. In the draft document the line of responsibility for each activity has been defined. Although individual persons are not listed, the responsibility of specific Navy Office directorates will be identified.

To avoid certain difficulties encountered with the LSH project the Department proposed to increase the resident quality assurance staff in the shipyard and for major projects this staff would report directly to the Quality Assurance Authority. The use of outside contractors for quality assurance work was also being investigated.

The Department advised that it is looking at ways to ensure that timely formal notification is given to DAS on pending contractual problems. Improved liaison between Navy and DAS regarding clarification of contractual problems should flow from the recently reintroduced quarterly project meeting as distinct from the monthly production meetings.

The Department also stated that the liaison between DAS and Navy for the LSH project was satisfactory and although Navy did not formally advise DAS until May 1981 of the full details of the weight problem, DAS was aware of the problem through its attendance with Navy at monthly progress meetings and other discussions. DAS was formally advised when all normal liaison with the shipbuilder failed to produce the product Navy considered was required under the contract.

In February 1982, this Office sought further comment from DAS concerning the contractual matters set out above.

For future contracts the Department of Defence in conjunction with DAS will investigate the feasibility of penalty clauses. It will be more than likely that incentive clauses would be preferred and the proposed instruction for weight monitoring reflects this approach.

Current contract documents and the Quality Assurance and Application procedures clearly identify that prior approval of the Department is required before a shipbuilder substitutes other materials in lieu of that set out in the shipbuilding specification. The relating of milestone payments to quality and concession procedures approvals is being considered as one method of enforcing conformance by the shipbuilder. The presence of resident Quality Assurance staff should ensure that the shipbuilder adheres to the contractual requirements for obtaining concessions from the shipbuilding specification.

The strategy to be adopted regarding the timely receipt of drawings and the vetting of such drawings depends to a large extent on the availability of in-house resources and the type of contract. The LSH contractor was responsible for the detailed drawings based upon the Baseline Design. These were passed to Navy for information. Any deviation from the Baseline should have been detected by the contractor's quality control procedures and the Navy resident Quality Assurance Staff.

Government Furnished Equipment

The Department was asked about proposed remedial action concerning delays in the provision of Government Furnished Equipment (GFE).

It advised that the GFE supplied to the shipbuilder for installation on HMAS *Tobruk* constituted about 7% of the total equipment fit. For subsequent new construction projects, an EDP monitoring system has been developed by the Production Branch to ensure accurate and detailed monitoring of delivery of all GFE and associated logistic support. Discussions were in hand with the Supply Branch with a view to establishing a *lay apart* store within the Naval Supply Centre (NSC) to enable items of GFE to be held against new construction projects avoiding the possibility of these items being issued to other units of the Fleet, as has occurred in the past.

Late acceptance

The programmed date for letting the LSH construction contract was May 1977 and the contract was let in November 1977, with the resultant program slippage of 6 months.

The handover date specified in the shipbuilding contract for the LSH was 21 June 1980. The actual handover occurred on 11 April 1981, a slippage of 293 days. The Department has approved excusable delay of 271 days to 19 March 1981. Twenty-two days liquidated damages will be deducted from final moneys owed to the contractor.

The contractor has attributed project slippage to industrial disputes, poor performance of subcontractors, delays in deliveries of major contractor equipment and GFE and, design modifications. Also contributing to the slippage were discussions between the Navy Office and the contractor in approving generator size changes (over 3 months) and modifications in pontoon lifting equipments (21 days extension to the delivery date).

The shipbuilding contract required the Commonwealth to determine the extension that it considers reasonable within 28 days after application by the shipbuilder for an extension of time to deliver the vessel. The contractor's claim dated 10 January 1980 for 105 days excusable delay was not decided upon by the Department until 23 February 1981. The delays in determining extension were attributed to incomplete information provided by the contractor and differences of opinion between Navy and the contractor's technical experts as to the validity of the contractor's claims for excusable delay. More practicable contract clauses are being developed for future contracts.

Landing Craft Vehicular and Personnel (LCVP)

Tenders were invited in February 1977 by the Department of Administrative Services (DAS) for the supply of 4 LCVPs for the LSH. The Tender Schedules and the

Naval Staff Requirement specified the acquisition of a craft with a proven hull design. In July 1977 DAS was requested to negotiate a contract with a UK company to include the necessary improvements required by the Navy Office. Although mentioned in the Tender Schedule, the procurement contract between the Commonwealth and the company did not stipulate the specific swamp testing required to ensure the LCVP prototype and follow on craft complied with the Naval Staff Requirement that the craft would remain afloat and upright when filled with water.

In January 1978 the company advised the Department that the tendered craft would conform with the swamping requirements of the Tender Schedule.

In May 1979 the company, with the approval of the Department, completed a simulated swamp test using mathematical and computer modelling techniques in lieu of a practical test with a RAN LCVP. The computer analysis disclosed that the LCVP would remain afloat but would turn upside down when both compartments (that is the engine room and main cargo deck) were swamped. A practical swamp test initiated by the company during April 1981 confirmed the craft would remain afloat and upright with adequate reserves of buoyancy if the main cargo deck only was filled with water.

In February 1980 the Department resolved that because of uncertainties of the mathematical swamp test calculations and delays these would cause to the follow on LCVPs, the company would be advised that further swamp tests or calculations were not required as the Department would determine the swamped and flooded characteristics of the LCVPs. The Directorate of Naval Design undertook to have analytical model calculations prepared. At the date of preparation of this Report this work has not been completed.

Since the LCVP will be used during rough and smooth sea conditions and passage via surf to and from beaches the apparent conflict of which swamp test criterion is to be followed must be settled. The mathematical trials conducted in the United Kingdom during 1979 disclosed that the craft would not comply with the swamping policy set out in the Tender Schedule.

In reply to Audit representations on the swamping policy and characteristics of the constructed landing craft the Department advised that the craft were accepted from the supplier in the knowledge that further evaluation of the swamped characteristics was necessary. This evaluation is continuing, but due to other pressing demands on staff it has not been finalised. It is expected that the evaluation will find an amount of additional fixed buoyancy will be required to make the LCVP accord with departmental standards.

Although the Department has yet to define the extent of any hazard which the LCVPs may present, prospective users are being advised of the potential hazard so that they can regulate craft operation accordingly. No operating restrictions have been imposed other than those decided upon by the users depending upon prevailing conditions.

LCVP utilisation and loss of planned capability

The original requirement for the LCVP and davit was to lift and lower the LCVP from the davit head with 34 fully armed troops embarked. The procurement contract for the LCVP stated the weight of the 34 fully armed troops was 2500 kg (based on the advice of the Army Office during 1976). It was ascertained during 1979 that the weight of the personnel was understated by 900 kg. The lifting capability of the davits is insufficient to raise and lower 34 fully armed troops together with the LCVP crew, stores, etc. Restrictions have therefore been placed on the number of armed personnel (a reduction of 47%) to be lifted/lowered in the LCVP. As a result alternative embarkation procedures have been adopted.

A further operational capability review revealed the intentions of the Naval Staff Requirement and Tender Schedules were to procure an existing proven craft. It was necessary for Navy Office to reconfigure much of the tendered craft apart from the basic hull. Changes increased the tendered craft weight by 40%. The contract weight for the LCVP was 5841 kg. However, a 16% weight increase occurred during the course of construction of the prototype (to 6776 kg). Departmental records indicated that the increase in weight of the prototype craft was attributable to the lack of quality control by the contractor, limited RAN on the spot project advice during the design phase and the dependence by the contractor on telex and memoranda concerning Navy requirements during the design and building phase.

It is understood that the follow on LCVP's have been accepted for operational use as there is only a 3% variation from the contract weight. The prototype LCVP has been stationed at HMAS *Moreton* for use as a training vesel for amphibious operations.

The Audit view is that Navy Office should have detected earlier the significant understatement of the estimate of 70 kg for a fully armed soldier as that weight would represent the weight of an average unarmed serviceman.

The Department advised that although 34 troops cannot be lowered from deckedge in an LCVP this does not mean the ship has a reduced operational capability to disembark troops. As the LCVPs have no slipping arrangement troops would only have been lowered under very favourable conditions. Under any other circumstances and indeed, apart from the initial trip when the craft was being lowered, troops would disembark by scrambling net, accommodation or jumping ladder or through the bow or stern doors.

Cost escalation

The initial project cost approval was $41.7 million at April 1975 prices and the initial construction contract cost $36.0 million. These costs were compared with the project cost estimate of $59.2 million at August 1981 prices and the most recent construction contract cost estimate of $49.4 million at August 1981 prices, with the conclusion that the rate of cost escalation compared favourably with concurrent inflation rates.

The Department has stated that HMAS *Tobruk* was the first and largest major warship built since World War II to a fixed price contract in a commercial yard. It was the contractor's first effort at meeting Naval requirements. Moreover, the occurrence during the construction period of fiscal inflation and industrial turbulence, and the introduction of metrication during that period did not assist in the efficient and timely construction of the vessel. The Department maintained that despite the overrun, the performance of this contract compared more than favourably with any other effort in recent times in either naval and commercial shipyards.

Conclusion

The major unsatisfactory issues arising from the audit are:

- departmental procedures failed to clearly specify lines of responsibility within the Department to ensure that weight monitoring was achieved
- inadequate consideration was given by departments responsible for framing the contract to ensure that certain important contractual conditions could be enforced, if necessary by penalty provisions
- insufficient quality assurance control was exercised to ensure that the specified Naval requirements for design construction and material would be fully met, and

- unsatisfactory administrative processes led to delays in issuing items of GFE to the contractor.

The Department has indicated that in future acquisitions of this kind special attention will be given to the above matters.

APPENDIX B

Department of Defence Submission of 13 August 1982

JOINT COMMITTEE OF PUBLIC ACCOUNTS
Inquiry Into the Auditor-General's Report, March 1982
Submission by the Department of Defence

AMPHIBIOUS HEAVY LIFT SHIP ACQUISITION

ITEM 5.3

INTRODUCTION

1. The Auditor-General's Report for March 1982 at paragraph 5.3 refers to the acquisition of the Amphibious Heavy Lift Ship (LSH) for Navy. The report commented on the planning and implementation phases of the project with particular emphasis on departmental management exercised from Navy Office, Canberra.

2. The report whilst indicating that the planning and tendering/contracting processes were carried out in a regular and satisfactory manner and the rate of cost escalation compared favourably with current inflation rates also disclosed the following:

- departmental procedures failed to clearly specify lines of responsibility within the Department to ensure that weight monitoring was achieved;
- inadequate consideration was given by departments responsible for framing the contract to ensure that certain important contractual conditions could be enforced, if necessary, by penalty provisions;
- insufficient quality assurance control was exercised to ensure that the specified Naval requirements for design construction and material would be fully met; and
- unsatisfactory administrative processes led to delays in issuing items of Government Furnished Equipment (GFE) to the contractor.

3. The report also commented adversely on the capability of the associated Landing Craft Vehicular and Personnel (LCVP).

BACKGROUND

4. The acquisition of a specialised heavy lift ship for amphibious operations was approved by the Government in August 1975 at an estimated project cost of $41.7m in April 1975

prices and subsequently confirmed in the context of the 1976/77 Budget.

5. Tenders for the construction of the LSH based upon the British SIR BEDIVERE Class design were invited from Australian shipbuilders in September 1976. The ship design was updated by introducing Australian machinery and equipment items. British specifications, drawings and documentation employing the imperial System of measurements were used during the tender period and subsequently in the construction of the vessel to facilitate as far as possible the efficient construction to commercial shipbuilding standards.

6. Following an exhaustive evaluation of tenders a contract to construct the LSH was awarded to Carrington Slipways Pty Ltd (CSPL) of Tomago, New South Wales in November 1977. The contract specifications stipulated a lightship weight of 3,322 tonnes with delivery of the vessel on or before 21 June 1980.

7. In relation to weight monitoring, the Department judged during tender evaluation that CSPL's computerised weighing/calculation system conformed to normal commercial practices and it was therefore considered acceptable despite the fact that it differed from the RAN's procedures. The contract placed the responsibility on the Contractor to continuously monitor the weight of the vessel during construction and to submit regular weight reports to the Department.

8. During construction of the vessel, steel plate of the required Imperial measurement thickness used in the SIR BEDIVERE class design was not readily available in Australia, and consequently metric plate was used by the shipbuilder without the prior approval of Navy Office. This was the main cause of the overweight problem. Navy Office became aware of this action in October 1978.

9. However by the time the circumstances which contributed to the shipbuilder's problems were identified and their effects analysed approximately 85% of the total structure was complete and it was considered to be too late to exercise any significant weight reduction measures. Displacement checks and tests conducted in January 1981 disclosed that the lightship weight was 3,619 tonnes, an increase above specification of 297 tonnes or 8.9%.

10. The ship was delivered on 11 April 1981, a slippage of 293 days from that specified in the construction contract. However, of this slippage, some 271 days were agreed between the Commonwealth and the shipbuilder to be caused by matters beyond the reasonable control of the shipbuilder.

DEPARTMENTAL COMMENT

Procedures failed to clearly specify lines of responsibility within the Department for weight monitoring

11. On this matter the Auditor-General's comment is agreed. In an endeavour to ensure that formal lines of responsibility are followed in weight monitoring, particularly in Navy Office directorates, part of a new Defence Navy Instruction on weight monitoring in new ship construction has been promulgated.

Inadequate consideration in framing the contract to ensure certain conditions could be enforced

12. The contract for the construction of the LSH was originally drafted by the Department of Defence along the lines of a standard format provided by the former Department of Industry and Commerce (Shipbuilding Division). The subsequent refinement of the contract was undertaken jointly by the Departments of Defence and Administrative Services, with consultation from the Crown Solicitor's Office.

13. The contract included procedures to be followed by the contractor during construction in matters such as deficiencies and omissions in minor details found in the specification. It was expected by the Departments responsible for framing the contract that the contractor would conform to these procedures. The contract did not provide specific mechanisms to enforce these procedures other than under the "cancellation" clause of the contract.

14. Penalty clauses are not normally included in ship construction contracts. However, in future shipbuilding contracts, the Department considers that the possible use of contract penalty and incentive provisions related to quality requirements and the like, should provide appropriate motivation for the contractor to meet the contract requirements.

15. The Department is also planning to include penalty and incentive provisions applicable to weight control in its next and subsequent major RAN ship building contracts which, if accepted by the contractor, should overcome the problems experienced with the LSH contract. In this context the Department is taking steps for the wording in Ship Construction Specifications to be framed in such a way that contractors unfamiliar with Navy requirements should not be in a position that the intent of the specification or reference is unclear.

Insufficient quality assurance control exercised

16. In addition to the introduction of penalty and incentive provisions to encourage contractors to meet the

Commonwealth's quality and other requirements which are capable of prior determination, the Department is planning to increase quality assurance staff for new ship construction at shipbuilders' facilities. For major projects this staff would report directly to the Quality Assurance Authority.

17. The Quality Assurance Authority staff of Navy has been strengthened. More experienced officers have been recruited and further additional training given to Quality Assurance staff. All potential contractors are now subject to assessment against current Australian Quality Assurance standards as a preliminary to the award of a contract; such assessment also continues after contract award.

18. The additional staff, increased training and the improved contractual arrangements are expected to ensure that the naval requirements for design, construction and material will, in future, be met.

Processes led to delays in issuing GFE to the Contractor

19. To obviate the type of delays highlighted by the Auditor-General in relation to issuing items of GFE the Department has developed and introduced an Electronic Data Processing monitoring system including an 'earmark' facility to ensure accurate and detailed monitoring of delivery of all GFE and associated spares, operator training and documentation. The monitoring system will be used on subsequent new construction projects and should provide sufficient protection for items procured in aid of those projects in the future.

LCVP

20. It is agreed that difficulties were encountered in respect of the swamp testing called for in the Naval Staff Requirement and further definition is required. Pending resolution of an RAN swamp testing policy for these crafts, users have been advised of restrictions necessary when used in heavy surf. Although the advice as to weight of fully armed troops was incorrect the overall effect on ability to transport troops is negligible as the occasions when lifting or lowering by davits in a loaded condition would be minimal.

Summary

21. HMAS TOBRUK was the first and largest major warship built since World War II to a fixed price contract in a commercial yard. It was Carrington's first effort at meeting Naval requirements. Moreover, the construction occurred during a period of high economic inflation and industrial unrest.

22. Notwithstanding the problems considered above and particularly those associated with converting material sizes from Imperial to Metric measurement, the Department considers that the contractor's performance overall compares favourably with other efforts with which it has had experience.

13 August 1982

APPENDIX C

Department of Defence Submission of 23 June 1983, Parts 1 and 2

JOINT COMMITTEE OF PUBLIC ACCOUNTS
Inquiry into the Auditor-General's Report, March 1982
Re-opening of 1982 Inquiry
Submission by the Department of Defence: Part 1

AMPHIBIOUS HEAVY LIFT SHIP ACQUISITION (HMAS TOBRUK)

ITEM 5.3

INTRODUCTION

1. The Auditor-General's Report for March 1982 at paragraph 5.3 refers to the acquisition of the Amphibious Heavy Lift Ship (LSH) for Navy. The Report commented on the planning and implementation phases of the project with particular emphasis on Departmental management exercised from Navy Office, Canberra.

2. Upon advice from the Chairman of the Joint Committee of Public Accounts on 25 May 1983 that it has been decided to re-open the Inquiry into HMAS TOBRUK, the following comments have been prepared with respect to the Department's management of the project, addressing in Section 1 the controls exercised over production and the design changes made to the ship and in Section 2 comments as they relate to the Navy Office Review of the Board of Inquiry Into the Death of Naval Reserve Cadet Dax, recognising that a number of production aspects have been previously addressed in the Defence submission to the Committee in 1982.

DEPARTMENTAL COMMENT

SECTION 1

LSH Project Management of Construction

3. Project management within Navy has evolved from experience gained from the early 1970s when it was recognised that a dedicated team was required to handle the procurement of ships for the then Department of the Navy. Project management within the Department is based on co-ordinative management and teams are structured with a mixture of dedicated project staff and specialist staff drawn from the functional areas.

4. The LSH project management team established to undertake the coordinative management task for the project comprised:

a. Project Director;

b. Deputy Project Director;

c. Project Design Manager;

d. Project Production Manager;

e. Project Integrated Logistic Support Manager;

f. Project Financial Adviser;

g. Project Advisers (Army, RAAF);

h. Defence Industry and Materiel Policy Division Liaison Officer; and

i. a number of nominated Project Liaison Officers responsive to the Project Director for project-related tasks, but remaining responsible to their functional heads for the integrity of their work.

5. The above project management team organisation and its relationship to the functional area is shown in Figure 1 (attached).

6. The Project Production Manager was responsive to the Project Director and responsible to the Director of Naval Ship Production (DNSP) for, inter alia, "the planning and oversight of the construction of the ship, including preparation and review of ship acquisition costs".

7. In accordance with the Ship Specification and definition therein, the General Overseer and Superintendent of Inspection (GOSI) was delegated the functions of:

a. Providing overseeing services, technical advice and guidance to the Contractor with particular regard to the interpretation of the Naval requirement as required and as requested by the ordering authority; to progress, monitor and certify the physical and financial aspects of orders on behalf of the ordering authority.

b. Representation at all inspections, tests or trials carried out on the ship and/or equipment by the shipbuilder.

c. Performing the responsibilities of the Quality Assurance Representative to ensure that orders placed on the shipbuilding contractor were completed to the specified standards and in accordance with the Specification.

8. To carry out these functions, GOSI provided an on-site Navy representative in the shipyard as a Progress Officer (redesignated 18 months later as Resident Naval Overseer) with directions to monitor progress and report to GOSI Head Office. GOSI Head Office support was provided on an 'as required' basis to undertake overseeing duties and inspections.

9. The inspection process called up in the Contract was to be in accordance with Australian Standard AS 1822 which required the shipbuilder to establish a quality control system under which the shipbuilder was to construct the ship in accordance with quality standards and methodologies (Quality Plan) approved by the Department. Monitoring of contractor compliance to this Quality Plan was carried out by GOSI. This method of Quality Assurance was adopted in order to make the shipbuilder responsible for meeting the quality requirements, and for GOSI to monitor and audit the shipbuilder's performance. Wherever possible, this system is now applied to Defence equipment construction contracts and is similar to that being applied by the US Navy to the construction of RAN FFGs at Todd Seattle.

Inspections, Tests and Trials

10. A programme of the required Inspections, Tests and Trials (ITT) was provided to the shipbuilder in Chapter 3 of Volume 1 of the Ship Production Specification. The programme required the shipbuilder to undertake certain mock-up inspections, advanced installation inspections, progress inspection, installation inspection, setting to work and testing and tuning for most equipments and systems. In addition Harbour Acceptance Trials and Sea Acceptance Trials programmes were developed.

11. All ITTs were witnessed by the GOSI organisation either by the resident GOSI staff at the Shipbuilder's Yard or by GOSI Head Office staff from Sydney. From time to time where the more important ship's systems and naval operational equipments were involved, the RAN Trials and Assessing Unit (RANTAU) was represented. As a general rule after each series of ITTs were carried out, a meeting was held with the Shipbuilder to discuss the trial results and shortcomings and deficiencies noted for rectification by the shipbuilder.

12. There were a number of difficulties encountered with the (then) new method of ensuring the quality of the finished ship by requiring the shipbulder to conform to the requirements of AS1822. Some of these difficulties were:

a. the shipbuilder commenced the contract with an inadequate understanding of the Navy's inspection requirements;

b. the shipbuilder's quality control staff had difficulty adjusting their mode of operation to meet Navy's inspection process;

c. conflict between GOSI East Australia Area (GOSIEAA) and RANTAU over their respective roles in the inspection and trials process; and

d. the established procedure for handling inspection reports not being sufficiently reactive to a fixed price commercial build.

By the time an inspection had been completed and a report written, circulated and considered, matters on which Navy Office decisions had been sought had, in most cases, been overtaken by events as shipbuilder's work could not normally cease during the Navy Office consideration process. It has been recognised that there is a requirement to tailor an inspections organization and reporting process to meet the needs of fixed-price contract construction in commercial shipyards and ABR1921 'Instruction for HMA Ships - Building' is currently under review to reflect this requirement.

13. From the experience gained in the TOBRUK contract, the on-site representation for subsequent contracts (Fleet Underway Replenishment Ship and Minehunter Catamaran Projects) has been strengthened, including a dedicated quality team responsible direct to Canberra through the Director of Naval Ship Production.

Project Staff

14. Throughout the duration of the contract, several changes effected in project staff contributed to the difficulties. In the four years between the letting of the contract and HMAS TOBRUK being handed over to the RAN, the LSH Project had some eleven personnel changes in the positions of Production Manager, Design Manager and Integrated Logistic Support (ILS) Manager. Each change brought varying modes of operation in the respective fields, varying interpretation of detail and placed different emphases on different aspects. Also, there were two GOSIEAAs and two Deputies in this period. The shipbuilder had to adjust to a number of variations of modus operandi and delays occurred which may have been avoided had there been fewer changes in personnel.

Progress Meetings

15. Following award of the contract to Carrington Slipways Pty Ltd on 21 November 1977, a pre-construction meeting was held at the Shipbuilder's premises on 15 December 1977 under the following agenda headings:

a. General Overseer and Superintendent of Inspection East Australia Area (GOSIEAA)/Director of Naval Ship Production (DNSP) functions and responsibilities.

b. Carrington's organisation/project team.

c. Lines of communication.

d. Production plan.

e. Quality Control/Quality Assurance plan.

f. Purchasing plan.

g. Government Furnished Information and Government Furnished Equipment.

h. Progress meetings and reports.

16. Thereafter, commencing in February 1978, progress meetings were held each month to discuss the progress of the contract items. These meetings were chaired by GOSIEAA and every endeavour was made to ascertain from the Shipbuilder his difficulties and to then marshall the Department's resources to resolve those problems where they lay in the Commonwealth area of action. The minutes of these meetings, together with the formal monthly Report of Progress TM206, provided an historic record of the project construction activities.

Design Changes

17. In the redesign of the MOD(N) LSL - RFA 'SIR BEDIVERE' by Navy Office to incorporate modifications to suit RAN special requirements, the following major changes were agreed:

a. General:

(1) 70 Tonne Safe Weight Load (SWL) derrick/crane and supporting structure associated with hoisting and lowering Army landing craft (LCM8), carried on vehicle deck;

(2) Vehicle deck structure reinforced to permit up to Chinook helicopter to operate from the ship;

(3) flight deck structure reinforced and lengthened to permit up to Sea King helicopter to operate from the ship;

(4) sewage plant and holding tanks to meet International Maritime Consultative Organization (IMCO) requirements;

(5) carriage of Landing Craft Vehicle Personnel (LCVP) in davits Port and Starboard;

(6) Inflatable Life Rafts (ILR's) plus Gemini type dinghy and utility boat;

(7) diving workshop;

(8) aircraft workshop/office;

(9) enlarged laundry;

(10) emergency generator compartment;

(11) accommodation for RAN crew and Army personnel plus increased air conditioning requirements;

(12) one main galley serving RAN crew and troops' cafeteria;

(13) damage control HQ;

(14) canteen; and

(15) RAN communications system and joint communications centre.

b. Electrical:

(1) 115 volt, 1 phase supply in lieu of 230 volt, 1 phase supply for lighting and low power;

(2) installation of automatic emergency lanterns and amenity sockets;

(3) modifications to 440 volt distribution system to cater for RAN equipment changes such as 70 tonne derrick/crane, sewage plant pumps and LCVP davit winches;

(4) increase in rating of main generators from 400 to 500 kilowatts; and

(5) installation of second gyro compass.

18. As the RAN design was further developed in Navy Office prior to completion of the Shipbuilders Estimating Package (SEP), the following major facilities were also agreed for incorporation:

a. Joint Operations Room;

b. Flight Control Office;

c. Probe reception port side;

d. Trunked hatch from flight deck to tank deck for palletized cargo;

e. Incinerator compartment adjacent to galley and compactor unit on quarter deck aft;

f. Lengthened stern ramp to facilitate marriage of LCH bow ramp;

g. Redesign of fo'c's'le deck to cater for 40/60 Bofors P&S and simplify method of mooring to a buoy and towline reception;

h. Selection of Mirrlees Blackstone K. Major engines coupled to David Brown gearing;

i. Provision of refuelling facilities in the after flight deck area;

j. Selection of Ulstein 90 TV-400 bowthruster in lieu of Voith Schneider as fitted in LSL thus effecting considerable cost saving.

19. With the development of the detailed design and working drawings by the shipbuider, a further 104 design change proposals were considered. Of these, 92 were approved for incorporation during construction. During the later stages of construction, some further changes to update the UK design were also incorporated. Design change control was accomplished by the use of the standard Navy TG144 procedure which requires each change proposal to be separately documented.

20. The TG144 procedure stipulates the steps to be followed to approve changes and obtain the necessary approval for the additional funds. Proposed changes require the recommendation/concurrence/approval (as necessary) of the Project Director, appropriate Design Director, Director of Naval Ship Production, Director General of Naval Design, Director General of Naval Production, Assistant Secretary, Naval Technical Services and Deputy Chief of Naval Materiel. For modifications involving more than $25,000, the endorsement of Chief of Naval Materiel and Chief of Naval Staff was also required.

21. The nett value of the design changes incorporated during construction, after allowing for increases and decreases, was $1.512m which represented 65% of the modification funds provided in the approved project cost estimate.

22. New ship construction programmes normally allow a contingency of 8-10% of shipbuilder's costs for design changes. For the LSH, the cost of modifications was well under what might be considered normal for Australian or overseas ship-builders. This lends support to the Department's view that the design strategy and change control procedures were satisfactory.

Ship Completion and Acceptance

23. Before a ship is accepted into RAN service, the shipbuilder is required to provide a final accounting of all items of the ship that do not meet the quality or contractual requirements. Form TI338 (first and second reading) sets out in documented form List 1 items (see Form TI338 attached) that are outstanding at the date of acceptance of the ship which, it is agreed, are to be completed by the shipbuilder at no additional charge to the Australian Government. This form also provides for the development of a List 2 which records items requiring further attention but which are not the responsibility of the shipbuilder.

24. Many of the deficiencies noted at ITT meetings were not completed by the shipbuilder at the time the ship was offered for acceptance. This led to an extensive list of incomplete work being included in the first reading of the TI338. Many of these outstanding items were rectified subsequently.

25. The first reading of TI338 took place on 11 April 1981 at which time the ship was provisionally accepted by Navy with an extensive large list of deficiencies which did not immediately affect the ship's operation. Deficiencies of the sewerage CHT system did not appear on the TI338. The shipbuilder undertook to complete all the outstanding List 1 items whilst TOBRUK was undertaking work-up exercises out of Newcastle and later during the Post Delivery Availability (PDA) which is a period in which the ship is made available to the shipbuilder for this purpose. TOBRUK was commissioned on 23 April 1981 but it was not until 31 July 1981 that the final (second) reading of TI338 took place and the ship was finally accepted by Navy. At that time there were still 50 outstanding items to be rectified by the shipbuider or by Navy personnel. In the latter case a deduction of moneys due to the shipbuilder was made for work carried out by Navy personnel.

26. In essence, the HMAS TOBRUK was delivered with a slippage against the Contract Acceptance Date (CAD) of only 22 days. Aluhough the TI338 list was large and did not address the sewerage system, many items were not of a significant nature. At present the Contractor has corrected all but 3 items (ie: helo start/servicing system, air-conditioning system and bonding and earthing) all of which are being actively pursued and are expected to be resolved by September 1983.

SECTION 2

Production and Design Comments Specifically Related to The Navy Office Review of the Board of Inquiry Into the Death of Naval Reserve Cadet Dax

27. The following comments address specific areas of the Navy Office Review of HMAS TOBRUK Board of Inquiry into the death of Naval Reserve Cadet (NRC) Kenneth Dax and relate to production control and design change aspects.

Inspections, Tests and Trials (ITT)

28. There are existing procedures and formal documentation in the form of the TI338 List 1 for shipbuilder responsible items or List 2 for other items for recording outstanding trials or trials deficiencies. However, it would appear in the case of the Sewerage System that these procedures were not implemented. This has highlighted the need for Departmental officers to exercise greater responsibility and caution during the transition stage leading up to Harbour and Final Acceptance Trials. This is especially the case for List 2 items with a safety implication.

29. It is also now appreciated that greater care must be exercised by the Department in establishing those outstanding trials or trials deficiencies (ITT) which have an operational safety implication and for which no deviation from contract, drawings or specification will be permitted irrespective of the type of contract.

Design

30. The ship to be built is defined in the Ship Specification and associated drawings. Where a shipbuilder wishes to depart from the requirements of the Ship Specification and associated drawings, he is required to submit his proposals under the change procedures described in the construction contract. This condition stipulates that no change may be incorporated without the specific approval of Commonwealth officers duly appointed for the purpose of approving such changes. Under the change procedure and using associated drawings as the contractual base, the shipbuilder is then required to develop his own detailed design drawings for the construction of the ship.

31. A limited number of the more important shipbuilder's detailed design drawings are nominated in the contract as 'Key Build Approval Drawings' and are required to be submitted to Navy Office for approval in principle before the ship is built. 'Approval in Principle' of these drawings does not absolve the shipbuilder from his responsibility for producing a satisfactory and acceptable product in conformance with the contract.

32. In the case of the sewerage system in TOBRUK, the contractual requirements were included in the Ship Specification in the form of a statement of requirements and a guidance (schematic) drawing. At the time, it was considered that the shipbuilder's detailed systems drawings for the sewerage system did not warrant inclusion in the list of Key Build Approval Drawings.

33. A change to Navy's initial guidance drawing for the sewerage system was made during technical discussions prior to the award of the construction contract and a second change was made by Navy as a result of a complaint raised by the Ship after acceptance into Service. These changes were made in the interests of simplifying and improving the system. At the time these changes were agreed, it appears that not all of the details describing components to be incorporated were understood by Navy. In retrospect, Navy's approval of the first change and development of the second change may have been ill-advised and, as indicated in the Review of the Board of Inquiry, they were contributing factors (among a number of others) in the Dax incident.

34. Two further points are worthy of note:

a. The shortcomings in the system may have been corrected if the shipbuilder's detailed systems drawings for the sewerage system had been included in the list of Key Build Approval Drawings to be submitted to Navy for approval in principle.

b. Investigations into the matter since the Dax incident have revealed cases where the shipbuilder departed from his own working drawings in the actual installation. In this regard, doubt must be cast on the shipbuilder's quality control, and Navy's audit of the shipbuilder's quality.

35. The following actions have been taken as a result of the matter:

a. A detailed review of the sewerage installation in TOBRUK has been undertaken. A detailed series of necessary and prudent changes is expected to be available in August 1983. (Pending these changes, the system in TOBRUK has been closed down).

b. A review of the process of approving design change drawings has been made, principally directed at raising the level and qualifications of the officer approving changes to drawings.

c. Where appropriate in future projects, detailed systems drawings for sewerage systems will be included in Key Build Approval Drawings to be submitted by the shipbuilder for approval in principle by Navy.

d. Efforts are being made to improve the level of Navy's design expertise in sewerage systems, subject to staff limitations.

e. Sewerage systems in other ships are being investigated to ensure that they are safe.

f. A trial of a new type of sewerage system will be undertaken, commencing in late 1983, following installation in HMAS FLINDERS. This may lead to significant changes in the method of treating effluent in HMA Ships.

g. Greater attention will be given to shipbuilder's quality assurance and quality control, and Navy's audit of shipbuilders' activities in these areas, to ensure that ships are constructed to approved drawings and specifications.

Design Changes

36. With regard to design changes, the present system of control using TG144 procedures is considered adequate except that the existing formal documentation should be amended to include a more extensive section addressing safety implications. This would alert those involved to possible implications and provide further assurance that the safety factors have been thoroughly resolved.

Responsibility after Commissioning

37. On Commissioning, the total responsibility for operating, maintaining and safety of the ship and ship fitted equipment passes from Chief of Naval Technical Services to the Fleet Commander/Ship's Captain. This also includes the responsibility for reporting warranty items. The repair of warranty items would then be coordinated in this case by the GOSIEAA who in turn establishes a liaison between the ship and the contractor and manages the contractual implications.

38. However, it is evident within the Department that although the requirement for transition planning and transferring responsibilities relating to the introduction of equipment into service is generally understood and is stated in the existing policy for project management (ABR 5069 and ABR 5245), a need exists to more clearly define and establish the arrangements for the preparation of a formal package of data to be included in the formal transfer of responsibility for ships to the Fleet. This is currently under review with the intention of adding to ABR 5069 and ABR 1921.

Project Directors Responsibilities

39. The Review of the Board of Inquiry tends to be critical of the Project Director for not liaising with the Design Division. With the current project management system, this criticism could also have been extended to other functional groups and in particular GOSIEAA and the Navy Office Production Division.

40. Many factors contributed to the difficulties encountered on this project; Some of the more significant ones were:

a. insufficient onsite resources to adequately manage a shipbuilding project of this magnitude; and

b. insufficient level of specialist management expertise and supporting staff from the functional areas which was compounded by a lack of continuity in personnel.

41. For current projects the level of onsite staff has been increased significantly, however, these have not been matched with increases in the levels of support staff required. The matter is being pursued further with the Department's Establishment Inspection Branch.

Ship's Staff Familiarisation and Training

42. Paragraph 166 of the recommendations in the Review of the Board of Inquiry refers to a management system that placed an unproven system in the hands of an untrained and inexperienced ship staff and left it there. The chain of events that led to the use of relatively untrained and inexperienced ship staff was that a small nucleus of ship's engineering staff joined the ship after launch approximately 15 months prior to ship completion, and comprised an Engineering Lieutenant Commander together with a Chief Petty Officer and a number of technically trained sailors. Because of the shipbuilder's needs, little access to equipment and systems was allowed to the engineering standby staff and it was not until towards the end of the build period that ship standby staff were allowed to become familiar with the equipment and systems they were to operate.

43. These arrangements were not considered to be significantly different to the conditions under which previous naval ships have been constructed in Australia except that Pre-Commissioning Training (PCT) is normally arranged to assist ship staff. In the case of HMAS TOBRUK, PCT was not undertaken principally because of time constraints and the thought that the fitted commercial systems would be simpler when compared with naval systems with which the crew would normally have been familiar.

44. The situation was not improved by the resignation of the Marine Engineering Officer (MEO) who stood by the ship during build and left the ship 17 days prior to commissioning. The principal engineer onboard was then replaced at the last stages by a MEO unfamiliar with TOBRUK's equipments and systems.

CONCLUSIONS

45. Generally the control exercised over production and design changes made to the ship under the conditions of a commercial fixed price contract were considered satisfactory having regard to the resources available and allocated. A number of improvements in these controls have

been developed for inclusion in more recent contracts especially in the area of increased site representation of departmental progressing and quality assurance staff and more positive contractual clauses to ensure the shipbuilder's conformance to the conditions of contract.

46. There is also the need for Navy to more clearly define those drawings considered to be Key Build Approval Drawings for each contract and to ensure that ITT specifications address possible risk and safety implications.

47. Additionally there is the need for more emphasis to be placed on the compilation of the TI338 List 2, this being the recording of items requiring further attention, but not the responsibility of the shipbuilder.

48. Finally, a formal procedure for the transfer of Project Responsibility to the Fleet on commissioning needs to be developed and included in ABR 1921 and/or ABR 5069.

LSH Reference Documents Attached:

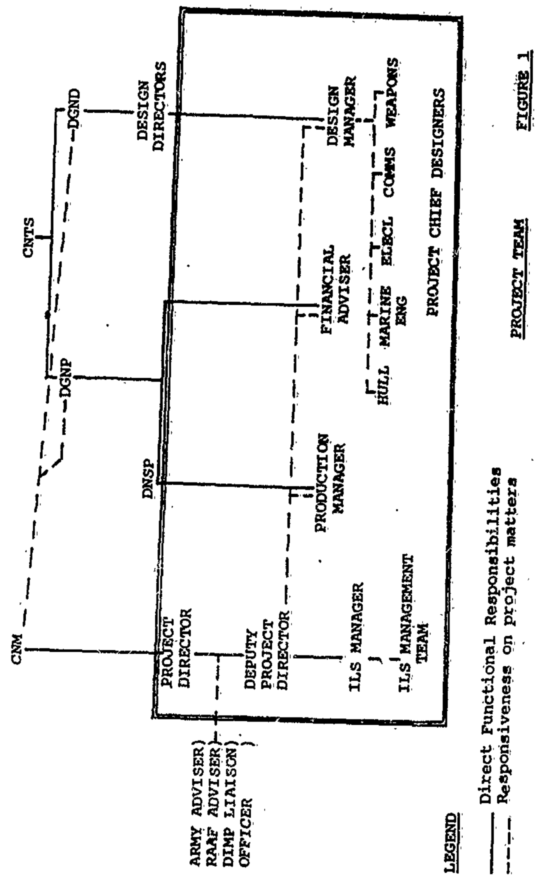
Figure 1

TG144

TM206

TI338

AMPHIBIOUS HEAVY LIFT SHIP (LSH) PROJECT MANAGEMENT TEAM



PROJECT TEAM

FIGURE 1

COVER SHEET

TG144A (1972) DNSP 2

Proposed Design Change Identification No. (DNSP Use)

NEW CONSTRUCTION, MODERNISATION OR CONVERSION
PROPOSED DESIGN CHANGE TO SPECIFICATION

● **SECTION A** *Navy Office Use Only*

Ship(s) and/or Project

DGNP

The proposed Design change is submitted for consideration *(brief description/name/title of proposed Design Change)*

The relevant sections of Part 1 have been completed where possible (Signature/designation and date)

/ /

● **SECTION B**

DGND

Relevant File No.

/ /

The proposed Design change described in Part 1 has been approved for investigation. The proposal is forwarded for preliminary investigation and completion of the relevant sections of Part 2.

(Signature and Date)

DGNP

● **SECTION C**

DGNP

The proposed Design Change has been investigated by the Naval Design Directorate and is

☐ RECOMMENDED

☐ NOT RECOMMENDED — that this Design Change be undertaken at this time

☐ subject to time and cost implications

The relevant sections of Part 2 have been completed where possible (Signature and Date)

DGND / /

PART 1 — ASSESSMENT OF THE PROPOSED DESIGN CHANGE
(To be completed by the Authority initiating the proposal)

A. Brief description of this proposed Design Change

B. Name or identification of ships being constructed, modernised or converted for which this Design Change is proposed

C. If applicable, existing Navy Office identification of this proposed Design Change *(ie, Modification No., A and A No. etc)*

D. Reason why the Design Change is proposed

E. Justification for the proposed Design Change *(indicate)*

1. ☐ Essential to ships operational efficiency
2. ☐ Essential from a safety aspect
3. ☐ Essential to overcome design shortcomings
4. ☐ Existing design does not comply with approved requirements
5. *Considered desirable to achieve* ☐ better performance ☐ increased reliability ☐ reduced maintenance ☐ improved economy

Resulting in a change in ☐ staff requirements ☐ approved ship characteristics

7. Comments:

F. Comments on features of the proposed Design Change which vary from the Approved Ship Characteristics

G. Effect on ship performance if the proposed Design Change is not introduced

H. Details of additional equipment, stores, operators, materials, test equipment and spare gear which it will be necessary to carry on the ship, held at base or in the dockyard if the proposed Design Change is implemented

Item	Detail

I. Details of currently specified equipment, stores, operators, materials, test equipment and spare gear planned to be carried on the ship, held at base or in the dockyard which will become redundant if the proposed Design Change is implemented

Item	Detail

J. Availability of equipment, material, stores etc. necessary for the introduction of the proposed Design Change

K. Provide the following information for each item of currently specified equipment and/or stores that would no longer be required if the proposed Design Change is implemented.

ITEM					
Number not ordered					
Number on order					
Number received but not installed					
Cost of cancellation					
[illegible] ber suitable for use elsewhere in ships					
Number suitable for return to stores/base					
Estimated salvage value					

L. Estimated cost to implement the Design Change

Labour	Stores	Equipment			TOTAL
					$

M. Identification of other proposed Design Changes being considered on which this Design Change is dependent.

N. Earliest date considered implementation could commence

/ /

O. Suggested date/programme for implementation of proposed Design Change

Date	Programme

P. Other relevant considerations

TG146
(1974)
DNMP 2

DESIGN EVALUATION OF THE PROPOSED DESIGN CHANGE

PART 2
(To be completed by the Design and/or Directorates involved in the evaluation)

A. Description of new specifications that will be required and/or existing specifications that will be required to be changed if the proposed Design Change is approved

B. Description of new drawings and/or changes to existing drawings that will be required if the proposed Design Change is approved

C. Description of the equipment schedules that will require changes if the proposed Design Change is approved

D. Description of hand books and manuals that will require changes if the proposed Design Change is approved

E. Indicate what additional workshop facilities, if any, would be required if the proposed Design Change is implemented

F. Describe the variations to planned maintenance requirements

G. Describe variations in trials requirements

H. Any other comments relevant to this proposed Design Change

I. Signature of responsible authority carrying out Design Evaluation

/ /19

TG148 (1972) DNSP 2

PROJECT EVALUATION OF THE PROPOSED DESIGN CHANGE

PART 3

(To be completed by the Naval Ship Production Branch in conjunction with DNEP and SEO(NP))

A. Time implications of the proposed Design Change

1. Delivery time for additional in-aid items *(to be obtained from DNEP)* — *months*
2. Estimated time required by shipbuilder from date of authority to proceed to completion of the work involved in implementing the proposed Design Change — *weeks*
3. The approved project completion date is — / /
4. It is estimated that the project completion date WILL/WILL NOT BE delayed for the following reasons

5. If this Design Change is authorised:

   (a) Completion date for the project will be — / /

   (b) The project cost will be INCREASED/DECREASED by an estimated — $

B. Equipment procurement details to be provided to DNSP by DNEP

Recommended supplier of equipment

Recommended installation contractors

Expected lead time from date of approval and authorisation of the Design Change to date of placing the order	
Expected lead time from date of placing order to date of delivery of equipment at shipbuilders premises	

Other applicable details of procurement

C. Action taken by DNSP in processing consideration of the proposed Design Change

Date	Action

D. Action recommended to DGNP by DNSP

DGNP

It is recommended that

1. This proposed Design Change be

☐ authorised for incorporation in the ship(s)

☐ not authorised for incorporation in the ships at this time for the following reasons:

☐ authorised for incorporation in the ships on a 'fit for but not with' basis.

2. The proposed Design Change be submitted to the following authorities for decision

☐ Naval Board ☐ 3NM ☐ Others *(name)*

3. The following other action be taken

☐ details of this proposal be forwarded to DGDM for consideration for incorporation after commissioning

☐ the proposed Design Change be submitted to the following authorities for concurrence prior to the action of Para D. 2.

Signature

DNSP / /

TM 206 Rev ... 78 DNSP ...

Department of Defence

SHIP CONSTRUCTION MODERNISATION AND CONVERSION PROGRESS REPORT

Report Number	File Number

Ship	Report for Month Ending	Shipbuilder

NOTES.

1. Reports to be furnished monthly for the period up to the end of the month from commencement of fabrication or construction until vessel is complete. Additional pages to be attached if space insufficient for full report.
2. Where the shipbuilder is HMA Naval Dockyard, 2 copies of the report and all attachments are to be forwarded to the Director of Naval Ship Production, Navy Office, Canberra ACT 2600, to arrive at Navy Office by *the 21st day of the following month.*
3. Where the shipbuilder is other than HMA Naval Dockyard, 3 copies of the report and all attachments are to be forwarded to the Progress Authority to reach him by the 14th day of the following month.
4. If dates given in paragraphs 7 to 12 vary from those given in last report, previous date and reasons for change are to be stated in paragraph 13.

● Paragraphs 1 – 17 to be filled in by Shipbuilder

1. Remarks on Progress of Fabrication, Erection, Construction, Fitting Out and Trials

a. Hull

b. Mechanical

c. Electrical

d. Weapons

2. List Late Activities Which May Delay Completion of Vessel

Activity No	Description

3. Reason for Stoppage of Each Activity Which May Delay Completion of Vessel *(As listed in paragraph 2)*

4. Identification of Outstanding Equipment Which Could Cause Delay in Completion of Vessel
a. Government Furnished Equipments (GFE)

b. Shipbuilders *(Contractors)* Furnished Equipments (CFE)

5. General Managers/Contractors Comments on Overall Project Progress

6. Return of Total Weights Worked into Hull up to Present Date

Description	Tonnes During Month	Tonnes Total to Date	Remarks
Hull Structure			
Propulsion			
Electric Plant			
Communication & Control			
Auxiliary Systems			
Outfit and Furnishing			
Armament			
Totals			

PLANNED OR ACHIEVED DATES

7. Contract Placed		8. Commence Fabrication	
Planned	Achieved	Planned	Achieved
9. First Portion on Blocks		10. Launching	
Planned	Achieved	Planned	Achieved
11. Commence Sea Trials		12. Completion	
Planned	Achieved	Planned	Achieved

13. Date Changed *(Items 7 – 12)* and Reason for Change

14. Draft of Vessel at End of Month

For'd	Metres	cm
Aft	Metres	cm

15. Average Number of Shipbuilders Workmen Employed on Vessel *During Past Month*

Planned	Achieved	Planned Next Month

16. List of Construction Progress Photographs Forwarded With This Report

Photo No	Date	Description	Photo No	Date	Description

17. Signature
☐ General Manager of dockyard or representative
☐ Contractor or representative
/ /

• Paragraphs 18–23 to be completed by the Progress Authority (where applicable). Two copies of the completed form and attachments to be forwarded to the Director of Naval Ship Production, Navy Office, Canberra ACT, 2600 to reach Navy Office by the 28th of the month

18. Date Shipbuilders Monthly Report Received by Progress Authority
/ /

19. Date Progress Report Forwarded to Navy Office
/ /

20. Report on Delivery Status
a. Government Furnished Equipments (GFE)

b. Shipbuilders *(Contractors)* Furnished Equipment (CFE)

21. Comments on Rate of Progress During Past Month in the Following Areas

a. Hull

b. Mechanical

c. Electrical

d. Weapons

22. General Comments on Overall Project Progress

23. Signature – Progressing Authority or Representative	24. Date Report Received by DNSP / /

Department of Defence

TI338 (1973)

REPORT OF INSPECTION

HMAS...

Tick appropriate box

☐ Built
☐ Modernised
☐ Converted
☐ Extended Refit

By...

PRIOR TO ACCEPTANCE FOR SERVICE IN HMA FLEET

Date and place of inspection...

....

....

This Report Comprises:–

List 1 - .... pages

List 2 - .... pages

INSTRUCTIONS:

Copies of this form are to be prepared for distribution as follows:-

1. New Construction - Contract Built Ship (ABR 1921 Refers)
   a. 2 copies to Navy Office (1 for Navy Office Copy of Ships Book)
   b. 1 copy to NOC of the Area
   c. 1 copy to the GM of the Dockyard at which the ship will be refitted
   d. 1 copy to be retained by GOSI
   e. 1 copy to ship for insertion in Captains Ship's Book
   f. 1 copy to RANTAU

   \- HMA NAVAL DOCKYARD BUILT SHIP

   As for above, less copy to GOSI.

2. Modernisations, Conversions, Extended Refits. (ABR 1921 Refers)
   The requirement for Form TI338 to be raised will depend on the nature and extent of the work involved in the project. The Project Directive for each modernisation, conversion or extended refit will state whether or not Form TI338 is to be rendered. If required distribution will be as in 1 above.

If space is insufficient for inclusion of all items in Lists 1 and 2, additional serially numbered pages are to be inserted. The number of pages is to be shown in this form.

REPORT OF INSPECTION – LIST 1

T1 338-1
(1973)

Items outstanding at the date of inspection which it has been agreed will be *completed by the shipbuilder* at no additional charge to the Australian Government.

It is agreed that List 1 Items (comprising .... pages) will be completed by the Shipbuilder at no additional charge to the Australian Government.	Shipbuilder *(Signature)*

REPORT OF INSPECTION – LIST 2

T1 338-2
(1973)

Items outstanding at the date of inspection which it has been agreed should be carried out, but which will be deferred to a *refit after completion.*

REPORT OF INSPECTION – CERTIFICATION

T1338-3 (1973)

Certificate of Officers Responsible for Supervision of the Work

We whose names are hereunto subscribed to certify that in our respective departments the work upon this ship has been truly and faithfully completed, excepting only those items listed, in accordance with approved drawings and specifications and that the approved program of inspections, tests and trials for the ship has been completed.

OIC RANTAU	Engineer Overseer or Superintending Mech. Engineer
Hull Overseer or Superintending Naval Architect	Weapons Engr. Overseer or Superintending Weapons Engr.
Electrical Overseer or Superintending Electrical Engineer	General Overseer or General Manager

Certificate of Directors Responsible for Specifying Work

We whose names are hereunto subscribed do certify that in our respective departments this ship is, except for the items listed, complete and properly fitted to carry out her functions as specified in the Staff Requirements.

DSD	DCSD
DMED	DWSD
DESD	DIRECTOR-GENERAL NAVAL DESIGN
DNSP	DIRECTOR-GENERAL NAVAL PRODUCTION

Certificate of Ships Officers

We concur that this ship is, except for the items listed, satisfactorily completed for commissioning for service in H.M.A. Fleet.

Navigation and Direction Officer	Gunnery Officer
Torpedo and Anti-Submarine Officer	Communications Officer
Engineer Officer	
Boatswain	Shipwright Officer
Weapon Electrical Engineer Officer	Captain

Forwarded for the information of the Naval Board Concurring. – Chief of Naval Technical Services *(Signature)*

/ /

PUBLIC ACCOUNTS COMMITTEE

LIST OF PUBLIC HEARINGS*

Date	Place	Witness(es)
17 September 1982	Sydney	Department of Defence
5 August 1983	Brisbane	Department of Defence Carrington Slipways Pty Ltd
7 September 1983	Canberra	Department of Defence Carrington Slipways Pty Ltd
14 September 1983	Canberra	Department of Defence Carrington Slipways Pty Ltd
9 November 1983	Canberra	Department of Defence

* In addition to the hearings listed above, the Committee has had 5 days of 'in camera' hearings.

APPENDIX E

PUBLIC ACCOUNTS COMMITTEE

LIST OF INSPECTIONS

Date	Place	Inspection
17 September 1983	Sydney	HMAS Tobruk at Garden Island Dockyard
5 August 1983	Brisbane	HMAS Tobruk at Newfarm (Dalgety No.1 Wharf)
18-19 September 1983	Rockhampton to offshore Brisbane	HMAS Tobruk at Shoalwater Bay, then offshore (en route to Melbourne)
9 October 1983	Newcastle	Carrington Slipways Pty Ltd, and Ramsay Fibreglass, at Tomago

APPENDIX F

PUBLIC ACCOUNTS COMMITTEE

LIST OF WITNESSES AND OBSERVERS

Witnesses at Public Hearings*

Department of Defence

Lieutenant-Colonel R.J. Boyle,	former Army Office Trials Officer, HMAS Tobruk
Rear-Admiral R.R. Calder, AM,	Chief of Naval Technical Services (CNTS)
Mr H.H.G. Dalrymple,	Director-General Naval Design (DGND)
Captain K.A. Doolan,	former Commanding Officer, HMAS Tobruk
Commodore D.G. Holthouse,	Director-General Fleet Maintenance (DGFM)
Commander G.A. Morton,	Commanding Officer, HMAS Tobruk
Mr G.E. Nicholls,	Assistant Secretary Naval Technical Services (ASNTS)
Mr F.V. Shadbolt,	Director-General Naval Production (DGNP)
Commander P.J.M. Shevlin, AM,	former Project Director Heavy Lift Ship Project (HMAS Tobruk)
Mr T.E. Sullivan,	First Assistant Secretary, Financial Services and Internal Audit Division (FASFIN)
Commander R.A.K. Walls,	former Commanding Officer, HMAS Tobruk, currently Commander Australian Amphibious Squadron
Rear-Admiral G.J.H. Woolrych, AO,	former Deputy Chief of Naval Staff (DCNS), currently Flag Officer Commanding HM Australian Fleet

Carrington Slipways Pty Ltd

Mr J.W. McPhee,	Contracts Co-ordinator
Mr D.J. Moir,	Contracts Director
Mr J.A. Laverick,	General Manager and Director

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* Several persons, including most of those listed above, also gave evidence to the Committee at 'in camera' hearings.

Observers

Mr A. Agafonoff	Department of Finance
Mr J. Chandler	Department of Finance
Mr R. Donaldson	Public Service Board
Mr L. Fraser	Auditor-General's Office
Mr A. Lawrence	Auditor-General's Office
Mr D. Lennie	Auditor-General's Office
Mr J. Louttit	Department of Finance
Mr A. Newton	Public Service Board
Mr J. Quirk	Public Service Board
Mr J. Stewart	Public Service Board
Mr M. Watson	Auditor-General's Office
Mr H. Whitton	Public Service Board

APPENDIX G

'The Australian Shipbuilding Industry and Its Prospects in the 1980's : An Industry Position Paper', the Australian Shipbuilders Association

AUSTRALIAN SHIPBUILDERS' ASSOCIATION

The Australian Shipbuilding Industry and it's prospects in the 1980s

AN INDUSTRY POSITION PAPER
DECEMBER 1982

M.D. Stockton,
Secretary
Australian Shipbuilders' Association,
Industry House,
BARTON A.C.T. 2600
Tel. (062) 732311

Foreword

This paper was commissioned by the Australian Shipbuilders' Association. Membership of the Association as at 1st December 1982 comprised the following companies:

- Australian Shipbuilding Industries (W.A.) Pty. Ltd., Fremantle, W.A.
- Carrington Slipways Pty. Ltd., Newcastle, N.S.W.
- Colan Shipbuilders Pty. Ltd., Adelaide, S.A.
- 'K' Shipyard Construction Company, Fremantle, W.A.
- Lloyd's Ships Pty. Ltd., Bulimba, Queensland.
- James McLarty and Son, Fremantle, W.A.
- North Queensland Engineers & Agents Pty. Ltd., Cairns, Queensland.
- Ocean Shipyards, Fremantle, W.A.
- State Dockyard of New South Wales, Newcastle, N.S.W.
- Tamar Steel Boats Pty. Ltd., Launceston, Tasmania.
- Vickers Cockatoo Dockyard Pty. Ltd., Sydney, N.S.W.

Preparation of the paper was undertaken by:

J.W. Andrew
Applied Research and Advocacy Pty. Ltd.
Canberra, A.C.T.

Contents

Introduction

The following paper, prepared on behalf of the Australian Shipbuilders' Association presents a broad overview of the local shipbuilding industry, as well as a detailed analysis of the current situation of the industry represented by the Association.

As well as being of material assistance to individual members of the Association in preparing their separate strategies to meet future trading conditions, it will also be of interest to other parties with a direct interest in this industry. Amongst these, it is anticipated that this report will be of direct interest to the Australian Government and the Department of Defence. Other parties which will have an interest in the report will be various State Governments as well as local shipowners.

The report also isolates a number of problems that will confront the industry in future periods, and recommends courses of action. It is anticipated that these problems and the courses of action will be separately discussed by the industry and the parties identified above.

SECTION 1.

Overview Of The Industry

Government Policy

The first systematic approaches by Government to the development of an Australian Shipbuilding Industry commenced in 1947. At that time, the experience of entering into World War II with a very small industry had a significant impact on the policy approaches of the Government of that time.

During 1947 assistance by subsidy, which was first introduced in 1940, was extended. The subsidy was calculated separately for each ship but was intended to offset the differences between locally built ships and those built in the U.K. At that time the U.K was the major world shipbuilder and hence the most likely source of Australian purchases. The maximum level of subsidy was set at 25% of Australian construction costs.

Policy statements made in Parliament during the initial period of the operations of this scheme indicate that the major consideration was the matter of defence. By adopting a subsidy scheme, rather than a tariff, the Government demonstrated that it was also concerned to avoid adding to the costs of shipping operators.

The subsidy scheme was supported by a scheme of import control which prevented ships being imported, except with the approval of the Minister of Shipping and Transport.

The level of assistance extended to the industry was reviewed by the Tariff Board in 1955, 1959 and 1963.

As a result of the 1955 review assistance to the industry by way of subsidy was continued, but the maximum level of subsidy was increased from 25% to 33⅓% of local construction cost.

In its 1959 report the Board recommended that the subsidy be continued and that the maximum rate of 33⅓% be retained. It also suggested that special measures were required to encourage demand and extend the scope for new tonnage to be built in local yards if the Government's shipbuilding policy objectives were to be achieved.

In its 1963 report the Board again stressed that unused capacity continued as the principal problem facing the local shipbuilding industry.

Despite the fact that import controls were being administered in such a way that little demand was being lost to overseas yards, the industry continued to operate at less than 50% capacity. To increase demand the Board recommended that the tonnage limitation for subsidised ships be reduced from 500 tons gross register to

1

100 tons gross register and that non trading vessels be allowed to come within the subsidy scheme.

At the time of the 1971 Tariff Board inquiry, the main features of the assistance scheme were;

- Ships and other floating structures exceeding 200 tons gross register for use in Australian waters were eligible for subsidy.
- The level of the subsidy was still assessed on a vessel by vessel basis to equate the cost of prices available from U.K. yards, up to a maximum of 33⅓% of Australian costs.
- The importation of new and second hand ships was controlled by the Minister for Shipping and Transport.
- The construction of ships under 200 tons gross register was assisted by customs duties on imported vessels, the most common rate being a general rate of 40%.

Following the 1971 Tariff Board report, the Government accepted recommendations calling for changes in the level and methods of assistance to the industry. For vessels over 200 tons gross register it was announced that;

- Subsidy would apply to vessels constructed in Australia. Initially the maximum subsidy level was set at 45%. The level of the subsidy was to be decreased over a 5 year period to a maximum level of 25%.
- All shipbuilders were eligible for subsidy assistance.
- Import controls on new and secondhand vessels were to continue. For vessels of 200 tons gross register or less, import duties at a level of 35% general rate were to apply.

In December 1973 the Minister for Secondary Industry and Supply announced revisions to the above policy. These embraced the following;

- A revision in the rate of phase down of subsidy from 45% to 25%
- The extension of the subsidy to vessels of 150 tons gross register, or in the case of fishing vessels, a minimum length criterion of 70 feet was introduced
- The subsidy was extended to vessels operated under the Australian flag in international trade.
- The subsidy was extended to cover modifications of existing vessels where the cost exceeded $0.5 million. The level of the subsidy to apply in this instance was 25%.
- A registration system was introduced for participating yards

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- The concept of the recapture provision of subsidy paid was also introduced at this time.

In 1976, following the change of Government, the Minister for Industry and Commerce announced that for the time being the measures outlined above would be maintained.

Later in 1976, as a result of continuing difficulties being experienced by the industry, the question of assistance for the industry was again referred to the IAC, the successor body to the Tariff Board.

In handing down its report the Commission concluded that;

- The type of vessel produced by BHP Whyalla and the State Dockyard were not of primary defence significance.

- The production of vessels at these two yards was not economic and that it appeared probable that the production of such vessels would cease.

The Government announced acceptance of the Commission's recommendations in 1977. The key recommendations were as follows;

- That the current level of subsidy, together with announced phasing arrangements to be completed by 1980, should not be varied.

- That the control of imports of new and secondhand vessels exceeding 6,000 tons gross register be abolished.

In the light of the orientation of this report to large vessels, the Commission also suggested that the matter of assistance for vessels less than 6,000 tons gross register be referred back to the Commission. This step was taken during mid 1977.

As a result of this inquiry, the current package of industry assistance was implemented. The key elements of this policy are·

- The conversion of the subsidy scheme to a system of bounty payments based on construction costs.

- The phasing down of the level of bounty from a rate of 27.5% to 20% by 30th June 1986.

- The maintenance of import controls on second hand vessels.

- Vessels in excess of 150 gross construction tons or fishing vessels in excess of 21 metres in length, be eligible for bounty payments.

As part of this report, the Commission drew attention to the fact that the requirements of the Department of Defence fell within the size range produced by the industry

The Department indicated that this sector of the industry would be that most likely to require expansion in a defence emergency and therefore the maintenance in the industry of the current range of skills and technology and their continual upgrading would be in the defence interest.

The Department indicated that it was also concerned for the future viability of firms outside the shipbuilding sector which provide support to both commercial and naval yards and for the continued training in Australia of naval architects if commercial shipbuilding were to cease. Lack of this infrastructure would have a serious effect on Australia's capacity to continue with naval shipbuilding.

Commentary

The foregoing paragraphs outline the development of Australian Government Shipbuilding policy over the past 40 years.

This period witnessed many changes in the thrust of policy which was initially aimed at fostering the development of the industry. However through the late 1970's the aim of the policy was significantly redefined. Part of the redefinition was orientated towards phasing down the activity geared towards the construction of large vessels and at the same time fostering the development of the industry now perceived to be closely aligned with defence requirements.

During the 1970's the concept of economic efficiency rather than technical efficiency was introduced and used as an aid to the evolution of industry assistance policies.

This concept is embodied in the current assistance arrangements for the industry in its existing form.

With regard to the negative aspects of the current policy, the aims of Government have been achieved. The following yards, which were orientated to the construction of larger vessels, have closed;

Walkers Ltd.
Evans Deakin Ltd.
Whyalla Shipbuilding & Engineering Works.

State Dockyard ceased building large vessels and has recently announced cessation of shipbuilding activity. These closures in addition to that of Adelaide Ship Construction during 1973 involved the loss of around 5,500 jobs. The closure of the Adelaide Ship Construction yard appears to have occurred for commercial reasons rather than as a result of revised thrust shipbuilding policy.

With regard to the positive effects of recent shipbuilding assistance policies, the Association considers it most significant that the industry in its present form is made up of companies that developed essentially under the umbrella of import controls. The Association also considers it most significant that these companies, which are essentially small, privately owned companies, are those that survived the problems of the 1970's and have continued to develop.

Moreover the Association considers that of all the factors that have been varied in recent years the one that has been of material assistance in the industry's development has been the abandonment of the need to call for tenders on a vessel by vessel basis. This revision of policy has contributed to faster and more meaningful communications between owners, naval architects and builders; a process which has led to improved marketing initiatives, which in turn have resulted in an expansion in the demand for new vessels.

Summary

- The Australian Government developed a systematic policy towards shipbuilding following World War II which was directed towards the development of an industry with a comprehensive range of skills.

- During the 1970's this policy was changed. The Government's present policy now encourages an industry capable of constructing vessels generally below 6,000 tons gross register.

- As a consequence of this policy change the Australian industry has developed a specialisation which addresses this market sector.

SECTION 2.

The Industry In Its Current Form

Introduction

As at 30th June 1982 there were around 40 yards registered under the Bounty (Ships) Act 1980 or the Ship Construction Bounty Act 1975. At that time each of these yards held orders for, or were currently constructing, or had recently completed, vessels which attracted bounty.

Of these yards 11 are members of the Australian Shipbuilders' Association. A list of the Association's membership is attached to this paper as Appendix No. 1. In addition to listing individual Association members, this Appendix identifies the types of vessels normally constructed in each yard.

The significance of the sector of the industry represented by the Association in relation to the total industry can be highlighted using the following criteria;

(a) Total employment.
(b) Employment engaged solely in ship construction.
(c) The Gross construction tonnage of vessels currently being built.

Total Employment

In Table No. 1 set out below, the total employment of both Association yards and yards outside the Association is tabulated. In arriving at total employment levels, allowance has been made for the numbers employed by individual yards in activities other than ship construction and ship repair. The employment levels for non Association member yards are based on the results of a survey conducted by the Association during October 1982.

TABLE NO. 1

Total Employment within the Australian Shipbuilding Industry.

Yards	Employment	%
Association Shipyards	4813	95%
Other Shipyards	275	5%
Total	5088	100%

From this table, it will be noted that those yards which are members of the Association account for around 95% of total industry employment, currently estimated at 5,088 persons.

Employment engaged solely in ship construction

In Table No. 2 (on page 7) employment engaged in ship construction within both sectors of the industry is tabulated. The results of the Association survey have once again been used to establish the level of employment in non Association member yards.

TABLE NO. 2

Employment within the Australian Shipbuilding Industry engaged solely in Ship Construction.

Yards	Employment	%
Association Shipyards	2735	93%
Other Shipyards	220	7%
Total	2955	100%

From this table, it will be noted that the yards which are members of the Association account for around 93% of total employment engaged in ship construction. At the present time this work force totals 2955 persons.

Gross construction tonnage of vessels currently being built.

In Table No. 3 set out below, the gross construction tonnage of vessels being built in both sectors of the industry is shown. The data set out in this table has been derived from the Association surveys of non member yards, and separate order analyses regularly prepared by the Association.

TABLE NO. 3

Gross Construction tonnage of vessels currently being built.

Yards	Gross Construction Tonnage	%
Association Shipyards	28,886	95%
Other Shipyards	1,650	5%
Total	30,536	100%

From this table it will be noted that Association yards account for 95% of the gross construction tonnage of vessels currently being built. In the preparation of these figures, the gross construction tonnage of the RAN fleet replenishment vessel has been included. As this vessel is not typical of the types of ships normally constructed by the industry, it could be argued that its inclusion in the data set out in Table No. 3 represents a distortion. If the gross construction tonnage of this vessel is excluded, the proportion of Association member's activity amounts to 91% of the total.

This analysis clearly indicates that those yards represented by the Association account for between 91% and 95% of total industry activity, depending on the criterion used.

The subdivision of the industry into Association and non Association yards is a reflection of the following:

Association member yards

(a) Are larger corporate entities than non Association members.
(b) Have developed within their corporate structures the skills to undertake the construction of larger vessels for specialised commercial end use, as well as the construction of certain types of naval vessels.
(c) Undertake shipbuilding as an ongoing commercial activity.

Other yards

(a) Are small commercial entities with limited resources.
(b) Generally undertake the construction of small, simple vessel types.
(c) In a number of instances only undertake ship construction on an intermittent basis.

In the following discussion on the industry attention will be focused on that segment of the industry represented by the Association. This approach is considered valid for the following reasons:

(a) That sector of the industry represented by the Association accounts for around 95% of total activity
(b) By reason of the size, skills and capabilities of the yards represented by the Association, it is this segment of the industry that is of prime significance from a strategic defence viewpoint.

Key Characteristics of the Industry

Location and Employment

This industry, unlike many other industries which are highly concentrated in the heavily industrialised States of New South Wales and Victoria, is widely spread in geographic terms.

Association members have yards established in Cairns, Bulimba, Newcastle, Sydney, Launceston, Adelaide and Fremantle.

In the following table, a further analysis of employment directly engaged in members' yards in the construction of vessels is presented. This table sets out the level of management/supervisory/technical staff as well as production employees. In some instances individual yards subcontract specialised activities on a permanent basis. The numbers of employees engaged on this basis and included in the work force of the industry are also shown in the table.

TABLE NO. 4

Location and type of employment engaged solely in ship construction.

Location	Yard	Management	Employment Production Employed	Contract	Total
Cairns	NQEA	67	232	50	349
Bulimba	Lloyds	12	126	18	156
Newcastle	Carrington	92	322	32	446
	State Dock	48	177	—	225
Sydney	Vickers Cockatoo	130	545	40	715
Launceston	Tamar	3	55	21	79
Adelaide	Colan	43	250	—	293
Fremantle	ASI	20	165	107	292
	McClarty	6	63	—	69
	Ocean	15	40	4	59
	"K"	8	44	—	52
Total		444	2019	272	2735

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From this table it will be noted that at the present time the level of management/supervisory/technical staff employed by the industry represents around 16% of total employment in shipbuilding. As well as embracing the normal management and commercial functions this category of employment covers naval architects, estimators and draftsmen.

At the present time, the level of permanent subcontractors used by the industry represents around 10% of total employment, or around 12% of total production employees.

The practice of employing permanent subcontractors has been developed as a means by which individual yards can stabilize to some degree fluctuations in the size of their permanent workforce. It should be noted however that the size of the subcontract workforce and the trades involved vary considerably from yard to yard.

The following table summarises the existing concentration of industry activity in relative terms. Also shown in the table is the expected concentration of industry activity following the cessation of shipbuilding at the State Dockyard.

TABLE NO. 5

Industry Concentration Based on Employment Levels.

Location	Relative Concentration	
	Current	Expected
Cairns	1.0	1.0
Bulimba	0.5	0.5
Newcastle	2.0	1.3
Sydney	2.0	2.0
Launceston	0.2	0.2
Adelaide	0.8	0.8
Fremantle	1.4	1.4

The implications of this widespread geographic spread of activity on the ability of the industry to recruit and train employees for its workforce are addressed in Section 9 of this paper.

Types of Vessels constructed by the Industry

The range of vessels constructed by the industry embraces the following:

- Tugs
- Workboats
- Offshore oil rig service vessels
- Ferries
- Dredges
- Cargo Vessels
- Defence Vessels.

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Given adequate demand conditions, there is a strong element of building preference amongst the yards.

Those yards located in Fremantle have developed a strong specialisation in the construction of standard fishing vessels and under normal demand conditions would prefer to undertake work for this segment of the market. However, Australian Shipbuilding Industries (WA) Pty. Ltd. has developed skills and facilities to undertake the construction of wide ranges of vessels, including tugs and oil rig service vessels.

North Queensland Engineers and Agents Pty. Ltd. (NQEA) in Cairns, has developed a strong specialisation in the construction of patrol boats, landing craft and barges, and under normal demand conditions would prefer to undertake the construction of these vessel types.

Lloyd's Ships has developed a strong specialisation in the construction of large pleasure/cruise vessels and would prefer to maintain this specialisation

Carrington Slipways and Tamar Steel Boats have developed considerable skills in the construction of tugs, oil rig service vessels and similar types of vessels and would concentrate their activities in these sectors if demand was consistently large enough to suit their operations. However because of the fluctuating nature of demand they generally undertake mixed construction programmes.

Colan Shipbuilders Pty. Ltd. is in the process of upgrading its operations with a view to constructing a similar range of vessels. This company recognises that fluctuations in demand will preclude it undertaking a restricted, specialised shipbuilding programme.

Because of the size of its shipbuilding facilities, State Dockyard has never pursued a deliberate strategy of product specialisation Rather this company tendered for contracts with a view to obtaining maximum utilization of installed capacity

The Vickers Cockatoo position within the industry is unique; a situation which flows from its special trading relationship with the Australian Government. Its principle role is the refit and modernisation of RAN submarines. However, the yard is also equipped to undertake ship construction and repair, with a very strong orientation towards naval vessels. The construction of H.M.A.S. *Success*, which is currently proceeding, is a reflection of this unique position.

The Rationale behind Specialisation

The preferred orientation of individual yards towards the construction of standard vessel types is not accidental, but is based on the fact that such a strategy results in lower construction costs and an enhanced competitive position.

The factors contributing to lower production costs from a construction programme of standard vessels flow from the following:

- Improved labour productivity which can be enhanced by matching capital investment programmes.

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- Improvements in production planning procedures, vessel modifications and a range of other ancillary factors which can be labelled as "job knowledge."
- The amortisation of certain overhead costs over a number of vessels, rather than full recovery on a single vessel.
- Savings arising from bulk ordering of materials and components.

The extent of cost savings that can be achieved through specialistion is significant, and lies in the range of 15% to 20% of the total cost of constructing the first vessel of a particular class. The rate at which these costs savings can be achieved is variable. Initially small gains are made, with the rate of savings recovery being established with the construction of the fourth or fifth vessel of the class. Efficiency losses can be experienced at the end of a production run of standard vessels due to worker "boredom." This problem is exacerbated if there are only limited prospects of follow on work.

In a situation where yards are unable to undertake the construction of standard vessels in an ongoing situation, and have to resort to the construction of vessels on a one off basis to maintain capacity, production costs are adversely affected.

Under such circumstances, it appears that construction costs will be between 10% to 15% higher than those that could be expected from a programme of standardised production.

Capital Investment.

The level of capital investment within the industry represented by the Association as at 30th June 1982 stood at $33.4 million

Of this amount $11.7 million has been invested by the industry over the past three years; the period immediately following the Government's decision in relation to the industry constructing vessels not exceeding 6,000 tons gross register. This additional level of investment within the industry is most significant and represents a 50% increase in the total level of investment as at 30th June, 1979.

The thrust of this new investment within the industry represented by the Association has been generally directed towards productivity improvement. In total $7.13 million or around 60% of the total new investment over the past three years, has been directed towards productivity improvement programmes. The specific investment targets are many and varied, but embrace improvements in materials handling and storage, revisions to production facilities, investments in new plant and equipment, including numerically controlled equipment as well as investments in data processing facilities

The balance of the investments made over the past three years, $4.57 million, or around 40% of the total, has been orientated towards the expansion of building capacity and improvements to yard facilities only indirectly connected with productivity improvement programmes

Labour Considerations.

The labour force employed by the industry can fluctuate markedly in size, depending on the volume of work in hand at any one time. In this regard the industry demonstrates similar characteristics to other industries involved in contracting for large volumes of work which occur on an intermittent basis. At the individual yard level variations of up to 35% in the size of the workforce can be experienced from time to time depending on market conditions.

In a number of instances, individual yards attempt to stabilise the size of their workforce by using sub-contractors to meet demand peaks which cannot be met by a planned workforce level.

In other instances, individual yards have developed general engineering capabilities or undertake ship repair in an attempt to stabilise the size of their workforces.

These separate strategies for workforce stabilisation have been implemented in an attempt to protect and conserve the industry specific skills required for ship construction. Such skills are difficult to preserve if the long term job prospects of individual workers cannot be stabilised.

Currently the industry has little or no difficulty in attracting workers with general trade skills. However because of the nature of the industry, general trade skills are not adequate for ship construction, major ship repair or conversions. Therefore individual yards maintain in house training programmes to upgrade general trade skills to the level required for ship construction.

The industry also relies heavily on the apprenticeship system to provide it with a continuing source of labour possessing industry specific skills. In total the industry represented by the Association has some 858 apprentices in training, representing around 18% of the total workforce of the industry.

It should be evident that the long term viability of this most significant training programme is contingent upon the ability of the industry to create and maintain stable workforce conditions.

In a number of instances, individual yards voiced their concern about the ability of the industry to retain skilled workers. In their view, the age profile of the workforce in the industry is abnormal in that it tends to be dominated by older employees in middle age ranges. They attributed this situation to the level of uncertainty that has existed since the early 1970's concerning the long term future of the industry.

A number of yards also voiced their concern about the ability of the industry to retain labour, particularly should the development of Australia's mineral sector be allowed to develop under boom conditions.

These two sets of concerns are most significant as they indicate a significant degree of vulnerability concerning the long term viability of the structure of the industry's workforce. These matters will require continuing attention by the industry, the unions, and other parties with a long term interest in the continuing viability of the industry. Without a workforce that is not only balanced in skills but also in respect of age distribution, the industry will face great pressure in maintaining its long term commercial viability as well as its long term defence strategic significance.

Summary

- Currently there are about 40 yards registered under the 1975 and 1980 Bounty Acts that are actively engaged in, or have recenly completed, bountiable vessels.

- Of these yards, 11 are represented by the Australian Shipbuilders Association. These 11 yards account for approximately 95% of total commercial ship-building activity which includes the construction of some naval vessels.

- Total employment in the industry stands at approximately 5,000 persons. Of these some 3,000 persons are directly engaged in ship construction. Industry employment is widely dispersed around the Australian coast from Cairns to Fremantle.

- The industry has directed its activities towards the following vessel types; tugs, workboats, oil rig service vessels, dredges, ferries, specialised cargo vessels and naval vessels.

- Recognising the competitive advantage that can be gained through the construction of standard vessels, many yards have developed a preferred orientation towards specific vessel types.

- Since the Government's latest decision on shipbuilding assistance policy, the industry has invested $11.7 million in new plant and facilities. This investment represents a 50% increase in the level of capital investment as at 30th June 1979.

- Approximately 60% of investment made over the past three years has been specifically directed to productivity improvement.

- At present the industry has little difficulty in attracting labour with general trade skills. However individual yards maintain internal training programmes to upgrade general trade skills to the level required for ship construction.

- The industry relies heavily on the apprenticeship system as a source of skilled labour. In total, Association yards have some 858 apprentices in training. This number of apprentices represents approximately 18% of total employment in these yards. The viability of this programme is contingent upon the maintenance of stable work force conditions.

- Association members are concerned about the predominance of older workers in their workforces and their ability to retain skilled workers in a more economic favourable climate.

SECTION 3.

State Of The Industry

Introduction

At the present time, the shipbuilding industry appears to be headed for a period of reduced demand and activity. This condition appears to apply equally to both the yards which are outside the Association and those that are Association members. The immediate work load and forward prospects for individual yards is quite mixed, reflecting a highly competitive situation within the industry. This is a position which is not unexpected in contracting market conditions.

Within the sector of the industry not represented by the Association, there has been a general and widespread contraction in demand for larger pleasure/cruise vessels. It will be recalled from the previous section of this paper, that this was the primary activity of this sector of the industry. The most significant factor affecting demand has been the application of sales tax at the rate of 17½% to these types of vessels. Not only has the incidence of this tax led to a significant increase in the cost of such vessels, it has also led to an increase in operating costs which have to be set to ensure the recovery of the capital cost of the vessel.

In the light of the depressed conditions within this sector of the market at least six yards have indicated that they have closed their yards or are seriously considering closing their yards.

Within that sector of the industry represented by the Association, a marked contraction in demand is also in evidence. The factors which are exerting a downward pressure on demand are as follows:

(a) The prawn fishing industry, based on the Western Australian coast line and in the Gulf of Carpentaria, is experiencing one of its worst seasons on record, due to a very severe reduction in catch sizes. The reduction in the profitability of this industry under these conditions has led to a sharp and significant curtailment of orders.

(b) The pace of development of the offshore oil industry has slackened as a result of the international oil/supply demand situation. This in turn has resulted in a lower level of demand for service vessels.

(c) The contraction in the world economy, which is resulting in reductions in the levels of exports of commodities such as iron ore and coal from Australia, is expected to result in a slower pace of port development and a reduced demand for tugs.

The reduction in demand arising from the interaction of these factors has created, and will further stimulate, intense competition between yards for available work.

The sharp and severe contraction in the demand for fishing vessels has created a situation in which those yards, which have a preferred orientation towards the construction of these vessels, are being forced to tender for vessels such as tugs and other service vessels to maintain their operations and workforces. Although such yards continue to actively seek export orders for fishing vessels to maintain their preferred orientation, in most instances they are unsuccessful with such tenders. The disability that these yards continue to face in export markets is their inability to provide attractive, low cost finance packages to support the sale. This aspect of international competition remains unchanged from that discussed during the 1979 report into the industry.

At the time of the 1979 report, the Commission noted that amongst the range of measures that had been used, and were still being used, by Governments to support their shipbuilding industries were finance facilities. In its 1976 report the Commission drew attention to the fact that during its 1971 inquiry into the industry, it estimated that the provision of low cost finance to shipowners was equivalent to a subsidy in the range of 5% to 10%. An independent study commissioned by the Association in 1976, confirmed that for vessels in the size range currently of interest to the Association, the disability arising from low interest finance packages was in the range of 7% to 10%.

Since that time however, the extreme volatility of, and upward pressure on, interest rates world wide would have resulted in an increase in this disability confronting the industry. In addition, the reported availability of 100% finance at interest rates of around 8% from European yards has also added to the industry's disability.

As a result of the interaction of these two factors, the Association estimates that its present level of disability arising from its inability to provide low cost finance facilities lies in the range of 15% to 20% of the cost a vessel.

The Association is conscious that the framework exists for the industry to provide finance packages for export sales through the facilities of EFIC. However it is also most conscious that speed of response is a vital component in the ability of a yard to assemble a competitive tender covering technical/operational details, price and finance in a highly competitive market. In relation to finance and dealings with EFIC, there appears to exist practical difficulties which have precluded full utilization of this facility.

In the light of this conclusion, it is apparent that a real opportunity exists for the industry and the management of EFIC to explore these difficulties with a view to improving the industry's ability to fully utilize this facility.

In addition, the national interest provisions relating to loans and loan guarantees incorporated in the Export Finance and Insurance Corporation Act present an opportunity for the Government to participate in such a review. Through the judicious use of these provisions, it should be possible to ensure that the industry can fully utilize the support of EFIC to complement export marketing programmes by the provision of low cost, long term loans to prospective customers.

Other developments which will result in an intensification of competition amongst Association member yards are as follows:

(a) With the progressive completion of the order for patrol boats, N.Q.E.A. will be forced to return to the commercial market to secure contracts to maintain its shipbuilding operation and its workforce. The impact of this development could be ameloriated if a follow on order for additional patrol boats was placed with N.Q.E.A.

(b) Over the past twelve months, the management of Colan Shipbuilders has invested considerable funds to re-position their yard so that it can compete in the market for tugs and other service vessels. This additional building capacity will also serve to intensify the competition between yards for the business that becomes available.

The only development within the industry that may serve to moderate the extent of the competition that is anticipated is the decision of the New South Wales Government to restrict the future operations of the State Dockyard to ship repair activities. The consequent loss of new building capacity that this decision entails could provide a small but useful step in balancing shipbuilding capacity and demand for future periods.

Key Indicators

Capacity Utilization.

As indicated in the previous section of this paper, the position of individual yards is quite variable.

In terms of capacity utilization four members of the Association currently have sufficient work on hand to ensure 100% utilization of installed plant and equipment. However two of these yards are now in a position where they require immediate orders to maintain this situation within their plate preparation and fabrication facilities. The other two yards however, have sufficient work on hand to maintain 100% utilization of their plate preparation and fabrication facilities for a further six to nine months.

The remaining members of the Association all report capacity utilization levels from 85% down to very low levels in terms of fitting out capacity. One of the yards reporting low capacity utilization is State Dockyard, and the reason for this situation was outlined in the previous sections of this paper. Each of the yards in this position reported that they were aggressively pursuing tenders for a wide range of vessels with a view to restoring the levels of capacity utilization.

In three instances, in addition to that of the State Dockyard, action has been taken to reduce employment levels. In two instances the extent of the retrenchments that have occurred are most significant in terms of the size of the yards involved. In total around 160 employees have been retrenched from the industry at this stage. The decision affecting the State Dockyard will involve up to another 200 employees by the end of the phase down of new construction. These retrenchments will represent a total reduction of around 13% in the size of this industry. Further reductions in the size of the industry can be expected as the impact of reduced demand conditions is felt within individual yards.

Current and Future Building Mix.

In every instance, each of the yards indicated that if they were successful with their current tenders the resultant building mix would represent a departure from their preferred building specialisation.

However, as indicated in the previous sections of this paper, the principal factors forcing individual yards away from their preferred building specialisation are beyond the control of the yards and were related to significant shifts in the market.

The ultimate effects on the industry of this shift in building mix could be most significant and should be highlighted in this paper. It will be recalled from Section 2 that there were significant cost/price benefits to be gained through the construction of a number of standard vessels. This discussion in this section of the paper also provided a broad indication of the cost price penalty involved in constructing varying vessel types on a one off basis.

In the light of this discussion, it will be readily appreciated that the changing circumstances of the industry in relation to building mix will probably lead to a deterioration in the international competitiveness of the industry. In turn, this could expose the industry to an increased threat of import competition.

The emergence of this situation, which will be exacerbated by significant increases in labour costs arising from increased wages, shorter working hours and increases in labour related costs such as workers compensation insurance and payroll taxes, will create acute problems for industry management. The magnitude of the task involved in stabilising and improving the industry's competitive position will therefore require very positive and imaginative solutions. Failure of management and unions to address this situation and to evolve appropriate solutions will only result in additional losses in production capacity.

In this regard industry management should also be fully aware that it is most unlikely that Government would be prepared to extend further direct assistance to the industry over and above that already in existence. The basis on which this observation is made is as follows:

(a) The levels of assistance provided by the current assistance arrangements are programmed to decrease with time.

(b) There is a general steady downward trend in assistance levels being extended to industry.

(c) The Australian Government is under strong international pressure to reduce industry assistance levels and improve trade opportunities for developing countries in particular.

(d) The Australian Government has taken international initiatives which call for the maintenance of existing assistance levels as a means of preventing further deterioration in the world economy.

In the light of these circumstances, therefore, it appears that industry management and unions will have to continue to draw heavily on their own resources in devising solutions to the problem of deteriorating international competitiveness.

Summary

- At the present time, a period of reduced activity and employment is confronting the industry.
- Within the sector of the industry outside the Association at least six yards have ceased shipbuilding or are actively considering this step.
- The most pronounced market developments are:

  A sharp and most severe contraction in the demand for fishing vessels.

  A lowering of demand for oil rig service vessels resulting from international developments in the world oil supply/demand situation.

  A lowering of demand for other vessel types resulting from the marked contraction in the world economy.

- The reduction in current order levels has already precipitated retrenchments of employees from Association yards.
- One undesirable feature resulting from the contraction in demand is that yards are now being forced to forego their construction preferences to obtain whatever work they can. Due to the interaction of a wide range of competitive forces evident in world markets, exports do not provide the opportunity for yards to maintain their preferred construction orientation.
- Loss of specialisation will add further to the decline in the industry's competitive position, which has already suffered from increased labour costs, shorter working hours and increases in other labour related costs.

SECTION 4.

The Markets

Set out below are the key market sectors serviced by the yards operated by members of the Association. In relation to that sector of the industry outside the Association, it will be recalled from previous discussions that these yards tend to service demand for larger pleasure/charter vessels.

In addition to identifying the key market sectors, a demand outlook which summarises the current views of individual yards is also presented.

Offshore oil rig service vessels, anchor handling vessels etc.

As a result of developments within the international arena regarding the balance between supply and demand for crude oil, the tempo of Australian offshore oil development has steadied. As a consequence, the demand for service vessels has subsided to a very low level at the present time. It is anticipated that these demand conditions could persist for the next four to five years.

Under these circumstances the industry anticipates that the demand from this sector of the market would be no more than one to two vessels per year over the next five years.

Fishing Vessels

In past periods, the demand for fishing vessels has been particularly strong, and provided a base for certain yards to develop a strong degree of construction specialisation.

However, the current fishing season off the Western Australian coast and within the Gulf of Carpentaria has been extremely poor. The combination of reduced catch sizes and hence lower gross income levels, together with sharply increased operating costs, has reduced the profitability of the fishing industry to a very significant degree.

Under these conditions, the level of demand from the fishing industry for new vessels has declined to an extremely low level. "Without an adequate level of profit, it is impractical to consider an investment in a new vessel" is a comment that is frequently made to describe the current conditions.

Operating conditions on the Eastern Australian coast appear to be relatively more buoyant than those in other fishing grounds.

A further factor which in the past was viewed as providing a broader demand base for the industry was the 200 mile fishing zone. However, progress towards exploitation of these fishing grounds has been very slow and is now not viewed as providing any short term relief for the industry in terms of new orders.

Because of the severity and depth of the decline in the fishing industry's profitability, particularly that based on the Western Australian coastline and the Gulf, individual yards anticipate that it could take up to three years before demand for new vessels returns to a more normal level.

Under these circumstances, the common view of the industry is that for the next three years demand will be around six vessels per annum. After that time, depending on the results of the intervening seasons, demand may be restored to around ten to twelve vessels per annum. This demand could also be influenced by the quality of maintenance provided during the next two to three years.

Work Boats other than those for the Offshore Oil Industry

The consensus view of the industry in respect of this sector of the market was that demand has subsided to a very low level and that there was little likelihood of any significant demand over the next four to five years.

The principal influence on this situation being the general deterioration in world trade which has resulted in reduced cargo movements through Australian ports

Tugs

The current level of demand for tugs is quote buoyant, with much of the demand being generated by new port development; particularly those ports being developed as a result of mineral projects initiated in the past two to three years.

Against this background, there is a measure of concern within the industry regarding the future demand for this type of vessel.

Because of the downturn in the world economy and the resultant downturn in the volume of cargo moving through existing Australian ports, some yards within the industry consider that tugs being built for these new ports may not be fully utilized. Such a development could result in lower levels of profitability within the tug operating industry and cause that industry to defer, to some extent, the replacement of existing tonnage.

Under these circumstances, the industry considers that the demand for tugs could stabilise at around three to four per annum over the next five years.

Dredges

The demand for this type of vessel is very spasmodic and again could be adversely affected by the lower volumes of cargoes moving through Australian ports

In the view of the industry, one new dredger may be required by the market over the next five years.

Survey/Research Vessels

Over the next five years, the industry anticipates that there could be a demand for up to three specialised research vessels. The first of these would be required by the CSIRO for oceanographic research activities. Currently this prospect is generating considerable interest within the industry.

The second two vessels would be orientated towards fisheries research and be constructed for State Governments. If the demand for these vessels eventuates, it would not occur before the second half of the next five year period.

Tourist Vessels

With the continuing development of the Queensland coastline as a major tourist centre, there is an emerging demand for larger, high speed tourist vessels capable of undertaking day trips. This market is being partially satisfied by those yards outside the Association.

It is the view of the industry that the demand for this type of vessel could amount to between one to two per annum over the next five years.

Ferries

Whilst the demand for smaller ferries is reasonably buoyant, the demand for larger ferries is spasmodic.

In the view of the industry there is a possibility that there could be a requirement for a further large ferry for Sydney Harbour within the next five years.

Cargo Vessels

The demand for cargo vessels within the size range of the industry's building capabilities is quite spasmodic. Based on current indications the industry anticipates that three new vessels of this type could be required over the next five years.

Defence Vessels

The demand for naval vessels constructed within yards operated by members of the Association is quite spasmodic and difficult to forecast.

This situation appears to be related to a continual review of naval defence strategies within the constraints of a finite and limited appropriation of funds. Because of the pace of technological development, the cost associated with that development and the experiences gained through limited naval engagements such as recently occurred in the South Atlantic, there is an obvious need for naval defence strategies to remain quite fluid.

Whilst the situation is sound from a strategic defence planning viewpoint, the extremely fluid demand situation that this creates causes significant planning problems for companies operating shipyards on a commercial basis. These embrace questions as to investment in plant, equipment and facilities, as well as the size and skill composition of the workforce that should be maintained within yards. Obviously the greater the degree of continuity that can be maintained in the construction of naval vessels the greater will be the confidence of individual yards in assessing the commercial risks associated with this type of work.

Notwithstanding the problems outlined in the preceding paragraphs, members of the industry have logical grounds on which to base anticipation of further orders for naval vessels over the next five years. These orders embrace up to a further five patrol vessels, a sister ship to the fleet replenishment vessel H.M.A.S. *Success* and a sister ship to the heavy lift ship H.M.A.S. *Tobruk*.

Forward Demand Levels

The following table presents a summary of the views of the industry in respect of forward demand levels for the various types of vessels discussed above.

TABLE NO. 6

Forward demand estimates for vessels of bountiable size.
1983 to 1987

Vessel Type	1983	1984	1985	1986	1987
Bountiable Commercial					
Oil Rig Service Vessels	2	1	2	1	2
Fishing Boats	6	6	6	10	12
Work Boats	—	—	—	—	—
Tugs	6	5	4	4	3
Dredges	—	1	—	—	—
Survey/Research Vessels	—	—	1	1	1
Tourist Vessels	1	2	1	2	1
Ferries	—	—	—	1	—
Cargo Vessels	—	—	1	1	1
Total Commercial	15	15	15	20	20
Naval Vessels	—	—	5	1	1
Total	15	15	20	21	21

The above table indicates the demand for new commercial vessels will significantly contract over the next five years. The extent of the contraction implied by this forecast is provided by the following table which sets out the number of bountiable vessels completed over the past five years.

TABLE NO. 7

Commercial Vessels completed under Bounty Assistance
1978/79 – 1982/83

Vessel Type	1978/79	1979/80	1980/81	1981/82	1982/83 (Estimated)
Oil Rig Service Vessels	2	—	4	3	4
Fishing Vessels	27	35	35	27	11
Work Boats	9	—	3	3	2
Tugs	3	—	1	2	9
Dredges	3	—	2	4	1
Survey/Research Vessels	—	—	1	2	—
Tourist Vessels	3	1	4	11	13
Ferries	2	1	3	5	—
Cargo Vessels	—	—	—	1	—
Total	49	37	53	58	40

The data set out in these two tables indicates that for 1983 and 1984, the output of the industry will decline by around 65% by comparison with output levels recorded over the past five years.

For the period 1985 to 1987, the decline in industry output by comparison with the five year period 1978/79 to 1982/83 will be around 55%.

Because of a wide variation in the mix of vessels forecast for delivery over the next five years, numbers of vessels may not necessarily be the most reliable guide to activity levels within the industry over this period.

An alternate indicator of industry activity is gross construction tonnage.

In the following table, estimates of the gross construction tonnage completed over the past five years, and that associated with forecast completions, is set out.

TABLE NO. 8

Gross Construction tonnage of Commercial Vessels completed between 1978/79 – 1982/83, and forecast completions 1983–1987

Year	Gross Construction Tonnage
1978/79	13,965
1979/80	7,725†
1980/81	14,425
1981/82	13,265
1982/83	12,400*
1983	5,770
1984	5,420
1985	9,770
1986	10,750
1987	10,740

Note: † HMAS *Tobruk* under construction 1978/80 not included in above figures.
*Estimated.

The data set out in this table confirms that for 1983 and 1984 the output of the industry will decline by around 60% by comparison with output recorded in the previous five years. In this regard, it will be noted that there is a high degree of correlation between both indicators of industry output levels for 1983 and 1984.

For the period 1985 to 1987, the data set out above indicates a recovery in industry activity to around 80% of the levels recorded during the period 1978/79 to 1982/83. It will be noted that the level of the recovery provided by this indicator is greater than that indicated by the previous analysis.

There is no doubt that 1983 and 1984 will be very difficult years for the industry. The decline in industry output forecast for these two years indicates that the workforce of the industry engaged in the construction of new commercial vessels could decline by up to 1500 over this period. A decline of this magnitude could well threaten the commercial viability of some yards operated by Association members.

During the remaining years of the forecast period a modest recovery in activity is possible with a consequent recovery in industry employment. The extent of this recovery could involve a gradual rebuilding of the industry's workforce from 1500 to 2100 persons — a process which will involve considerable cost.

Against this background, it will be readily appreciated that if the industry's expectations regarding naval vessel orders is correct, such orders would assist in stabilising the industry's workforce over the next five years.

Whilst the immediate impact of these orders would be felt within those yards where they were placed, a larger share of the commercial market would become available to other yards in the industry.

Over the past five years, local construction of naval vessels has provided a significant contribution to the development of the industry. With imaginative forward planning, the momentum of this programme can be sustained to the benefit of both the industry and the nation.

One tested approach to overcoming the present "stop-go" approach to ordering is legislation that provides for multiple year funding of a naval vessel construction programme. By providing continuity in construction, such legislation would assist in providing continuity and specialisation within the industry which in turn would improve the international competitiveness of individual yards.

To this background, it is appropriate to consider the outlook for the world shipbuilding industry.

Whereas in the late 1970's there was a general expectation that full recovery would be evident by 1984/85 it is now clear that this will not be the case, and a recovery is now not anticipated until the late 1980's at the earliest. A full discussion on this matter is set out in Section 7 of this paper.

Consequently the local industry will continue to experience strong competitive pressures from overseas yards. Any loss of orders arising from such competition will magnify the extent of the decline in industry activity forecast for the 1983-1987 period.

The Crawford Committee Recommendations

One initiative of Government which will assist in stimulating demand for new tonnage would be the application of the recommendations of the Crawford Committee to trading vessels operating on the Australian coast. The most significant of these being the provision for accelerated depreciation provisions.

The Association deplores the fact that the 2% revenue duty formerly applying to imported vessels was removed without consultation with the industry and without any apparent consideration as to its impact on the local shipbuilding industry.

To restore the loss of competitive advantage that this action has caused, the Association believes the revenue duty should be re-instated for imports of vessels under 6,000 tons gross register. However if the duty cannot be restored in this manner, then the Association would see as a minimum requirement the removal of the revenue duty applying to machinery and equipment for commercial vessels under construction.

Summary

- A careful review of market prospects for the next five years indicates a contraction of demand approximately 60% for both 1983 and 1984. For the 1985 to 1987 period a limited recovery in demand is in prospect.
- Inevitably the size of the industry must be reduced to match the size of the available market.
- The present "stop-go" approach to naval building programmes, particularly in the context of the difficult five years ahead, will prove to be disruptive to industry planning and rationalisation.
- Legislation providing for multiple year funding of naval vessel construction programmes would help to provide for continuity and specialisation; which in turn will improve the international competitiveness of yards.
- The Crawford Committee recommendations have some potential for stimulating the market, however, there is a need for Government action to redress the loss of competitive advantage occasioned by the removal of the 2% revenue duty which applied to imported vessels.

SECTION 5.

Competition And The Bounty (Ships) Act 1980.

Introduction

Before commencing discussion on this topic, the Association believed it to be important to record the views of individual members concerning the operation of the Bounty (Ships) Act 1980.

After some initial difficulties, which varied between yards, all members are in accord that the current administration of the Act is proceeding smoothly and effectively. In this regard the difficulties encountered with the administration of the previous Act, and fully discussed in the IAC's 1979 report have been overcome with the current Act.

One significant benefit that has resulted from the current Act is that more meaningful discussion between owners, naval architects and builders is now possible. Such was not the case with the 1975 legislation. This feature of the current Act has been of assistance to Association members in their marketing efforts and has led to market stimulation.

The Competitive Position of the Industry

During the period since the implementation of the Government's decision on the IAC's 1979 report, the industry has generally been able to maintain its competitive position against overseas yards with the assistance of current levels of bounty.

In recent months however, three oil rig supply vessels have been ordered on overseas yards in Hong Kong and Japan. The precise reasons as to why these orders were not placed locally are difficulty to determine. The two factors most commonly mentioned concerning the placement of these orders are price and delivery. Because operators of these vessels are concerned to exploit short term opportunities, it is considered that the short delivery times offered by the overseas yards would have been the most significant factor that influenced these decisions. In this regard, it is understood that perhaps up to two of the vessels are being completed on an ex stock basis, a factor which could have influenced price. Therefore any price advantage obtained from the overseas yards, including favourable payment terms, would be an added bonus for the operation.

If this analysis, that delivery times were the principal reason for the orders being placed overseas is correct, the same evidence also suggests that the local industry could have been competitive with overseas yards on a price basis. The fact that orders for three similar vessels have been placed with two local yards at approximately the same time tends to corroborate this view.

In assessing the extent of the industry's price disability after bounty, and hence its competitive position, due allowance has been made for the following factors which constitute a measure of local advantage for the industry. These include the following:

- The cost of delivery, which can be significant, particularly if the vessel is manned by an Australian crew.
- Owner supervision is closer and cheaper when construction is undertaken in Australian yards.
- Because overseas yards tend to offer standard vessels, the cost involved in modifications for local conditions can be substantial.
- Because of the close relationship between local owners and *builders and the detailed* knowledge of each others needs and capabilities, local owners tend to prefer to deal with local yards.

However, because of the difficulty in quantifying these factors, particularly at the level of each owner, it is not possible to derive a common factor to represent local advantage. Nevertheless in respect of any one order, it is quite conceivable that individual owners would make due allowance for each of these factors when deciding whether the order will be placed locally or overseas.

Summary

- The Association believes that the present level of bounty provided by the Bounty (Ships) Act 1980 is very finely pitched in relation to the industry's competitive position.
- All yards consider that the administration of the current legislation is proceeding smoothly and effectively, overcoming problems associated with the 1975 legislation.

SECTION 6.

Future Competitive Position.

Factors Affecting The Future

In Section 2 of this paper, attention was focused on the current position of the industry, and particular attention was drawn to the fact that market conditions were such that individual yards were being forced to depart from their preferred specialisation. In addition the implication of this development on the international competitive position of the industry was highlighted.

Further developments which will contribute to this loss of international competitiveness were also highlighted. These include significant wage cost increases, the introduction of the 38 hour week and significant increases in labour related costs such as workers compensation insurance and payroll tax.

In addition, the industry's loss of competitive advantage stemming from local material costs has not altered since the IAC reported on the industry in 1979.

All of these factors will interact in coming periods to worsen the international competitive position of the industry. *Most significantly it should be noted that all of* these developments are beyond the control of the industry.

Each of the yards of the Association is acutely aware of the adverse impact of these developments. Their awareness is stimulated by the fact that the existing level of bounty is to be progressively phased down over coming periods.

Under these conditions members have paid and are continuing to pay close attention to the introduction of new technology as a means of offsetting the steady loss of international competitiveness. However each of the members is also acutely aware that technological change in itself cannot offset the industry's deteriorating competitive position.

The reasons for this conclusion are as follows:

(a) Technological change is available on a world wide basis and is therefore equally available to yards in Australia and Eastern countries.

(b) The widely fluctuating nature of the industry's workload provides a positive disincentive to investment in new technology as there is insufficient certainty surrounding the profitable recovery of the costs involved. A broadening of the market serviced by the industry, including a more even timing of naval construction could provide the industry with more predictability and certainty in this regard.

(c) The work practices of some of the unions associated with ship construction have also militated against the successful implementation of new technology.

(d) All new technology is not equally adaptable to each yard. Because of the unique position of each yard and varying approaches to the construction of vessels, new technology, which can be successfully implemented in one yard, cannot necessarily be implemented in another. This situation appears to militate against a co-operative approach to the development and sharing of new technology such as occurs in the U.S. In this regard members of the Association consider that regular discussions between members and visits to other yards provide the most appropriate means of technology transfer. Additionally members also consider that the Association could serve as a useful forum for technology transfer.

Given that technological change in itself will not provide the industry with any significant relief from its deteriorating competitiveness, a very strong view emerged that the industry will have to seek other solutions to this problem.

These alternate views encompassed the following:

- **Management Training**
  A strong view emerged that there was a definite need for an upgrading of management skills within the industry. Because ship construction is essentially a materials handling and processing operation, it was considered that the focus of this training should be strongly orientated towards this aspect of its operations. The practical experience of overseas yards indicates that a concentrated effort in this aspect of training could result in useful productivity gains.

- **Overseas Marketing**
  Individual members of the Association recognise that the restricted size and uneven nature of the Australian market are factors that are limiting the successful development of the Australian industry. This recognition has led to the conclusion that action must be taken to broaden the markets which the industry services by entering into export activities.

However for individual yards to undertake this strategy successfully, high risk development of specialised vesels which can be produced in volume will have to be undertaken. By implementing such strategies, yards can obtain the lowest possible cost/price structure and penetrate selected segments of the world market to obtain increased volume. However the required approach needs to be highly selective so that yards can meet competition on a price/performance basis only, because at the present time they have no access to funds which would permit them to offer long term, low interest finance packages to supplement such marketing strategy.

Given the co-operation of the Australian Government in matters such as a review of EFIC financing arrangements and overseas aid programmes, it is possible that such a strategy could be implemented using selected naval craft, fishing vessels or tugs as vessel types.

In this regard, however, it must be clearly recognised that up to this time the type of imaginative and wholehearted support that would be required from the Australian Government has never been forthcoming.

Unless support of this nature is forthcoming, this marketing initiative will have little chance of success.

The adoption of this strategy would build on the greatest strengths of the industry which have been identified as innovative design and the ability to build vessels of high quality.

It should be recognised that management training and overseas marketing which could provide solutions to the long term decline in its international competitiveness are consistent with the need for positive and imaginative solutions already identified in Section 2 of this paper.

If members of the Association fail to explore these initiatives it is clear that the steady reduction in the bounty that will occur from 1984 will lead to increased import penetration of the Australian market and a steady reduction in the size and significance of the industry.

Summary

- The Association believes that the industry will suffer a deterioration in its competitive position over the next five years. The factors contributing to this situation are:

  Significant wage cost increases, the introduction of the 38 hour week as well as increases in labour related costs.

  A significant disadvantage stemming from local raw material costs.

  The deterioration in the industry's ability to maintain specialised construction programmes.

- Association members consider that strategies to deal with the difficult period ahead include:

  More extensive management training.

  Improved marketing strategies, both locally and overseas

  The introducton of new technology.

  The adoption of modern work practices.

- Unions will have an important role to play in the introduction of new technology and modern work practices.

- Government needs to play an active role in planning its requirements to maximise continuity and efficient production

SECTION 7

The International Shipbuilding Outlook

In its 1979 report on the industry, the IAC arrived at the following conclusions on this matter:

- That the situation outlined in its 1976 report had shown little, if any, improvement.

- That reports suggested that the nature and level of assistance by overseas governments had not been reduced and may have been increased.

- It appeared that the world wide slump in shipbuilding had caused overseas yards to look beyond their traditional markets for orders. Thus not only had such yards extended their geographic markets, reports also suggested that they were constructing smaller vessels.

- In addition it was also suggested that overseas governments were attempting to maintain shipbuilding capacity through substantial subsidies to allow overseas yards to quote prices below those they could otherwise offer.

Since 1979 there has been little significant change within the world shipbuilding industry. The figures set out in the following table set out in graphic terms the decline in the world industry that has occurred since it reached its peak activity in early 1974.

TABLE NO. 9

Order/Output Situation of World Shipbuilding Industry

Year	Total Orders on hand (million tons gross)	Completions (million tons gross)
1974	130.5	33.5
1975	102.1	34.2
1976	67.1	33.9
1977	45.8	27.5
1978	30.5	18.2
1979	25.4	14.3
1980	32.5	13.1
1981	37.5	13.7
1982	32.7	17.6

Source: Lloyd's Register of Shipping, Merchant Shipbuilding Return for Second Quarter, 1982.

The following comments extracted from Lloyd's Register of Shipping, Annual Report 1981 provide an equally graphic description of the industry on a world basis.

- The gradual recovery of the world order book, which had been noticeable since June 1979, was checked as the growth in new orders placed began to lose momentum in the latter half of 1981.

- The continuing world recession, with a low level of growth in OECD countries, high oil prices, reduced oil production and declining oil consumption, together with high interest rates has made an all round recovery for the shipping industry seem almost as far as ever away.

- Assistance from governments continues in the form of credits and subsidies.

- Despite improved shipbuilding prospects in the last two years, general market recovery will be slow, with setbacks such as we have witnessed during the latter part of 1981. Acceptable equilibrium from the shipbuilders point of view will not be established for some time to come.

At the time of the Draft Report hearings for the 1979 IAC report, it was the Association view that the recovery of the world industry could not be anticipated before 1984. Clearly that view, which was based on the views of world experts, has been overtaken by events such as slower rates of world economic growth and significant shifts in the oil supply/demand situation. On the basis of current data it is now the Association view that the recovery of the world industry will not be evident before the end of this decade.

Under these circumstances, the impact of the depression within the world industry on the Australian market described by the IAC in its 1979 report can be expected to continue well beyond 1984 and possibly up to the end of the 1980's.

As a further indication of the fiercely competitive situation of the world industry, one member of the Association reported that on a recent single call for tenders for fishing vessels, the Indian Government received 36 separate offers from yards in 24 countries. Whilst the Australian offer was reasonably competitive on price, the final outcome of the tender was decided on the basis of the finance packages that were offered. This experience underscores the comments made by Lloyd's Register set out earlier in this section of the paper.

Summary

- The international shipbuilding industry continues to experience very difficult trading conditions. In this environment, governments continue to support their particular shipbuilding industries with assistance in the form of credits and subsidies.

- It is quite clear that the recovery of the world industry that was expected in 1984 will now not occur. It seems likely that a recovery may not occur before the end of the 1980's.

SECTION 8.

Second Hand Vessels

Limitations on Imports

At the 1979 draft report hearings of the IAC on shipbuilding, the Association voiced great concern at the Commission's draft recommendation that the controls on second hand vessel imports be lifted.

The Association's view at that time was that it considered *this recommendation* to be the most important of the Commission's draft recommendations; and that implementation of this single recommendation would result in the destruction of the industry in the short term.

In support of this view, the Association presented to the Commission in evidence a wide range of prices for second hand vessels and new vessel prices ex local yards. The comparisons between these two sets of prices revealed that second hand vessels were available at around 40% to 50% of the prices for new vessels. It was also pointed out to the Commission that the prices shown for second hand vessels were "offer" prices and that these could be considerably in excess of final negotiated prices.

After a review of this evidence, the Commission amended its draft recommendations. On this matter, the Commission's final report stated:

> "Despite lack of conclusive evidence relating to overseas prices, the Commission considers that the potential exists for second-hand vessels to be imported at prices below their true value. This is particularly so in view of the present depressed state of the world shipbuilding industry and the incentives being offered by overseas governments for owners to replace existing vessels with new tonnage. Accordingly, the Commission suggests that controls on the importation of second hand vessels be retained until the world shipbuilding situation stabilises and that the *Government periodically review* the situation."

Against this background, the Association wishes to highlight the key conclusions of Lloyd's Register in relation to the world shipbuilding situation. These conclusions which were fully discussed in Section 7 are as follows:

- Stability has not been achieved.
- Stability will not be achieved in the short term.
- Government assistance in the form of subsidies *and credits remains widespread.*

Because these key features of the world industry, which caused the IAC to change its draft recommendation in 1979, are just as apparent today as they were in 1979, the Association maintains its strong view that the existing controls on imports of second hand vessels should continue.

In addition to restating this viewpoint, the Association also wishes to put forward two further points in relation to the importation of second hand vessels.

Firstly the existing controls relating to the permanent importation of second hand vessels are not unique. The Australian Government maintains similar controls on the importation of other large items of second hand capital equipment such as escavating, earthmoving and mining equipment. The reasons for these controls are similar to those that apply in the case of ships, in that the true value of such equipment is difficult to assess and its unrestricted importation has the potential to severely disrupt the operations of local industry.

Secondly, despite the fact that the importation of second hand vessels is rigidly controlled and permitted only on a temporary basis, the Association is aware that the total number of such imports on the Australian coast currently stands at around 50 vessels. In the view of the Association, any relaxation in the administration of the current policy would lead to a significant increase in the number of such imports.

In highlighting this issue, the Association wishes to focus attention on the fact that the existence of this fleet of vessels represents an outright loss of construction tonnage for the local industry. Therefore any increase in the size of the fleet of second hand vessels, imported even on a temporary basis, would lead to a further erosion of the market serviced by this industry.

Summary

- The Association maintains a strongly held view that the present controls on imports of second hand vessels must be continued to ensure the survival of the industry.

SECTION 9.

Training

As indicated in Section 2, the industry relies heavily on internal training programmes and the apprentice training system as its source of labour with industry specific skills.

Given its depleted size and significance as an employer of labour, as well as its very wide geographic spread, there is no single Technical College or other similar institution which can justify the provision of courses designed specifically for the shipbuilding industry.

Under these circumstances, the industry trains its apprentices via a dual system of general trade courses plus internal training programmes designed to upgrade general trade skills to the levels required by the industry.

As indicated in Section 2 of this paper, amongst the industry's workforce there are 858 apprentices. This represents around 18% of the total workforce of the industry. Individual practice as to the proportion of apprentices employed varies between yards. In each yard within the industry however, there is a deliberate and systematic approach to apprentice training.

The trade courses undertaken by apprentices in training tend to reflect the skill composition of the workforce with the greatest numbers of apprentices being concentrated in the trades of boilermaking, welding and fitting. The other trades involved in ship construction are reflected in the industry's apprenticeship training programme.

Because of the lack of industry specific skills within the general workforce from which the industry recruits labour, individual yards also require internal training programmes to upgrade the skills of such recruits to the levels required by the industry.

It must be recognised that considerable time is required to adequately train shipbuilding tradesmen. Whilst this time can be reduced in a national emergency when standards of workmanship and production costs may be less important, under normal circumstances the task of increasing a skilled shipyard workforce is a slow and expensive process. Hence a large reduction in the industry's workforce brought about by economic circumstances cannot be easily reversed when conditions improve.

One further aspect of training which is of great concern to the industry relates to that of naval architects.

As a direct result of the decline in Australia's shipbuilding industry, the only degree course in naval architecture remaining in Australia is at the University of N.S.W. in Sydney. This course graduates between six and eight naval architects per annum. It is understood that the bulk of graduates are employed by the Department of Defence or other Government departments.

Currently the existence of this course is threatened by increasing costs and the reduced funding of tertiary education. Should this course be lost, then Australia's future supply of naval architects will have to be either trained overseas or recruited from overseas. Already the opportunities for graduates to add a suitable breadth of experience to their tertiary training are becoming very limited. Any further deterioration in this situation will make it difficult for the industry to attract and retain the high quality people it will need in the future.

As regards management skills, some of the yards within the industry maintain direct or indirect sponsorship programmes for individuals undertaking tertiary studies. Whilst many of the management skills required by the industry are common to those used in other sectors of industry and commerce, there is a need for the development of specific shipbuilding management skills.

These can only be acquired through close association with the industry. In this regard, some yards within the industry have recognised some deficiencies in the management of the task of shipbuilding and are in the process of taking action to correct this situation.

This discussion clearly indicates that with the steady contraction of shipbuilding activity that has occurred since the mid 1970's, the industry has become progressively more reliant on self help programmes to ensure the creation of an adequate pool of industry specific skills. With a further general contraction in activity forecast for forthcoming periods, it is evident that these programmes may well have to be expanded as a result of further contractions in formal courses run in tertiary education/training institutions.

Summary

- The industry relies heavily on the apprenticeship system and internal training programmes to maintain a pool of labour with industry specific skills. The extent of these programmes has expanded through the 1970's, as the opportunities for external training have contracted.

- With a further contraction of the industry in coming periods, the Association is concerned that the Naval Architecture course at the University of New South Wales is threatened. The loss of this course would mean that the industry would either be forced to recruit such persons overseas, or alternatively train such persons overseas.

SECTION 10.

Governments As Customers

The experience of individual yards with governments as customers varies considerably depending on whether the government is a State Government or an Australian Government client.

State Government Contracts

The experience of individual yards in dealing with State Governments, or their separate instrumentalities, is generally most satisfactory.

The reasons for this situation appear to be as follows:

(a) State Governments have developed over a considerable period of time a wealth of experience in negotiating and bringing to a successful conclusion large engineering contracts.

(b) Based on this experience, State Governments, or their instrumentalities normally negotiate and control contracts using a key individual or a small group of individuals selected from the instrumentality directly concerned with the contract. This method of contracting ensures an appropriate balance of construction and/or operating skills at both the contractor and client level.

Australian Government Contracts

In marked contrast to the situation outlined above, those yards with current or recent experience of defence contracts in particular, have reported great difficulty in dealing with the Australian Government as a client.

The observations and comments made by individual yards based on their experience of Australian Government contracts are as follows:

- Negotiating teams representing the Government are large and unwieldy and more often than not lack shipbuilding and operating expertise.
- The prime orientation of teams representing the Government in negotiating contracts is from a legal viewpoint rather than from a commercial and/or operating viewpoint.
- The composition of negotiating teams can often comprise representatives from the following specific areas of Government:

Naval Design
Defence Support

Naval Production
Financial Services
Naval Materiel
Defence Security
Quality Assurance
Project Directorate
Australian Industry Participation (AIP)
Attorney General/Solicitor General.

Because of the multi-faceted composition of such a negotiating team, there is often lack of agreement between all parties. Until a harmonised view can be achieved between these varying interests, no progress can be achieved between the contractor and the Government in resolving contractual issues or problems. In short, negotiating teams representing the Government appear to lack a common purpose at all times. In addition they lack overall expertise in resolving and negotiating issues. Part of this lack of expertise can be attributed to a lack of shipbuilding/ship operating experience.

- The comments set out above provide background to the most common observation that in dealing with Government, lines of communication are very complex and as a result the achievement of a final decision in respect of an aspect of a contract is most difficult.

The above comment made in respect of both lines of communication and the decision making process is exacerbated in those contracts where separate technical support/advice facilities run concurrently with the prime contract. In these instances the lines of communication between the various parties to the contract are even more complex with the result that there is no direct route to a decision maker.

- When such contracts are finally negotiated, the commercial aspect proceeds smoothly provided no problems or contractual variations are encountered.

When contractual problems arise the experience of individual yards is that there appears to be no system for a satisfactory resolution of the matter in question. This situation is particularly noticeable when the problem arises from the Government side of the contract and it involves escalation in costs.

The practical experience of the yards is that resolution of such problems is very hard to achieve, short of legal action.

In the light of this experience, individual yards have separately reached the conclusion that there is a need for a major review of Australian Government contracting practices, particularly as they relate to naval defence contracts.

Because the monetary value of such contracts is so great in relation to the financial resources of any single yard, the management of these yards are now demonstrating some hesitancy about the commercial consequences of such contracts.

The above comments and discussion clearly demonstrate the need for the Australian Government to ensure that its contracts are fair and equitable and protect the commercial position of individual yards as well as the requirements of government.

In this regard, there appears to be a need for two separate contractual arrangements. The first arrangement should encompass the construction of a single vessel or the lead vessel of a class. The experience gained from the construction of a lead vessel, would provide valuable background against which a separate arrangement could be negotiated for follow on vessels. By implementing such arrangements the financial/commercial interest of both the Government and the contracting yard can be fully protected.

Summary

- From their experience of Governments as clients, Association members are in agreement that:

  State Government contracts are generally satisfactory from a commercial viewpoint.

  Australian Government contracts are generally unsatisfactory from a commercial viewpoint.

- The Association is firmly of the view that there is an urgent need for the Australian Government to modify its contractual arrangements to ensure that they are fair and equitable and adequately protect the commercial interests of individual yards.

SECTION 11.

Defence Significance

Over the past decade, the Department of Defence has consistently declared the need for the maintenance of an Australian shipbuilding industry. The Department's view is that the industry represented by its own yards and commercial yards is required to provide a capability to maintain, repair, refit and modernise naval vessels in peace and wartime, and to construct minor naval vessels in time of war. The Department has also been consistent in its view that the commercial yards of defence strategic significance would be those similar to the yards which are members of the Association.

In addition to this view, the Department has also indicated that it was concerned for the continued viability of the activities of firms which provide support for both naval and commercial yards and for the continued training of naval architects. Such an infrastructure is seen by the Department as underpinning Australia's capacity to construct naval vessels.

From the foregoing sections of this paper, it is clear that the decline in activity confronting the industry in coming periods must be of great concern to the Australian Government in respect of its strategic naval defence planning.

Whilst the demise of the industry that constructed large commercial vessels was of no immediate defence strategic significance, it must be recognised that the loss of this activity has seriously eroded the training base of the industry and has weakened the infrastructure supporting both naval and commercial shipbuilding.

In coming periods, the contracting demand for small commercial vessels will cause further contractions in the size and significance of the industry. This development will result in a further erosion of the training base and infrastructure support for the industry. In addition to a contracting local demand for small commercial vessels, the existing commercial industry will be exposed to an increasing level of international competition.

The degree and intensity of this competition is being sharpened by increasing hourly costs of employing labour and a shorter working week. Between 1984 and 1986 the current level of bounty will be reduced from its existing level to a level of 20%. Whilst this reduction in the level of bounty is based on sound economic theory, the consequence of this reduction in bounty could result in further capacity losses, particularly if individual yards meet with only limited or partial success in their efforts to maintain or improve their international competitiveness.

Because of the adverse impact of further reductions in Australia's shipbuilding capacity on strategic naval defence planning, there is an obvious need for the Government to focus increased attention on the current situation of the industry. This attention should reveal a need for a conscious effort on the part of Government to ensure a viable commercial shipbuilding sector. In this regard considerations relating to international competitiveness, and other economic theory, may have to be subservient to the requirements to sustain a viable naval defence strategy.

The Association believes that it was through a recognition of this situation that the Australian Government has actively pursued and encouraged Australian Industry Participation (AIP) programmes. Such programmes have benefitted industries in Australia, notably the aircraft industry. However, in relation to the shipbuilding industry AIP programmes, other than those involving the construction of ships in Australia, are of limited value.

Whilst it may be practicable to manufacture aircraft components in Australia under AIP programmes, the same cannot be said of ship's hulls or even parts of ship's hulls. Even if such a practice was economically feasible, no amount of such AIP work of this nature would provide the full range of experience for Australian industry in the construction, outfitting, testing and trials of ship's hulls and associated equipment. Because these are the skills that are central to the task of shipbuilding, major ship repair and conversions, their retention and renewal on a continuing basis in Australia can only be achieved by ship construction on an on going basis.

The following comments, arrived at separately by the Joint Parliamentary Committee on Foreign Affairs and Defence, set out in paragraphs 3.37, 3.38 and 3.39 of that Committee's report "An Aircraft Carrier for the Australian Defence Force" are particularly pertinent in this context.

These comments, which deal with the consequences for the Australian Shipbuilding Industry resulting from deferments of orders for naval vessels, are as follows:

3.37 Unless given continuity of new construction and/or major refit, modernisation and repair work, capital equipment replacement and pursuit of modern shipbuilding techniques and advanced technology cannot command the necessary return on investment in commercial yards in order to foster a viable and modern industry. As the industry declines, so do the various training capacities, within the yards themselves and at training institutions which are marine oriented. The pool of tradesmen and technologists skilled in shipbuilding and marine engineering in Australia is shrinking rapidly. The capacity of the industry to attract additional people for specific short-term, non-continuing projects is severely eroded. It is a matter of record that of 1700 works and staff employees of the State Dockyard at Newcastle who were retrenched in 1977, only some 10% sought re-employment when further shipbuilding opportunities became available in 1979.

3.38 The deferment of the second replenishment ship and five patrol boats, which were to be built in Australia, exacerbates an already severely depressed situation. Modernisation and maintenance programs provide some opportunity for continuing work, and to hold together work forces and maintain skills; the deferment of these further exacerbates the situation.

3.39 If and when the time comes to reinstate building and maintenance programs, there is a very real probability that the capacity to undertake or contribute to the work in Australia would have been lost. Even if they do exist, it is likely that construction and maintenance times will be lengthened considerably and costs increased accordingly, to preserve job continuity.

A study of these conclusions indicates that this Committee has independently identified the same range of problems confronting the industry as have been identified and presented in this paper.

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Summary

- The Association believes that the forecast contraction in the level of local shipbuilding activity will be a matter of concern to the Australian Government, particularly from a strategic naval defence viewpoint.

- The Association believes that whilst AIP programmes are of distinct benefit to industries such as the aircraft industry, their relevance to the local shipbuilding industry are only of limited value. The most effective form of AIP is the construction of ships in Australia.

- The maintenance of the defence capability of the industry would be greatly assisted by a continuity in defence orders.

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SECTION 12.

Future Direction Of The Industry

The common view of the yards which are members of the Association is that in the future the industry should concentrate on those markets that it currently services. These markets include the market for less specialised and general purpose naval vessels.

The reasons supporting this view are related to a recognition of the competitive position of the industry. It will be recalled from previous discussion that the industry suffers from disabilities in respect of both material costs and the costs of employing labour by comparison with overseas yards. However, by using innovative design, maintaining high quality standards and maintaining close relationships with local clients individual yards can bridge, in part at least, the competitive disabilities confronting them in terms of labour and raw material costs.

To undertake the construction of large vessels, such as was undertaken by larger Australian yards in the past, existing yards would expose themselves to competitive pressures which could not be offset in the manner described above. Large overseas yards have developed standard product ranges and have invested in high production technology. When these two factors are combined with volume production for world markets, even in the current depressed climate, very competitive building costs are achieved. In most instances, these costs can be made more attractive to potential owners through the effects of government assistance in the form of subsidies and credits. Under these circumstances, individual yards recognise that whilst these conditions prevail the construction of large vessels cannot be undertaken in Australia.

It is a recognition of this situation that has led the members of the Association to the view that in the foreseeable future, shipbuilding in Australia will remain confined principally to servicing the needs of the local markets for small specialised vessels.

The resultant future size and structure of the industry will therefore be shaped primarily by the demand generated by these markets. Other factors which will exert a bearing on the size and structure of the industry will be the demand for locally built naval vessels and the degree of success the industry can achieve in penetrating export markets in future periods.

Summary

- Members of the Association believe that in the foreseeable future, shipbuilding in Australia will remain essentially confined to supplying the needs of the local commercial market for small specialised vessels.
- Carefully planned and managed the local construction of naval vessels has the potential to shape the size and structure of the industry in the future.

SECTION 13.

Synopsis

Each of the preceding Sections concluded with a summary of the major points made. The following is a condensation of those summaries and therefore represents a condensation of the paper.

- During the 1970's the present policy of the Australian Government towards shipbuilding was evolved.
- As a consequence of this policy, the Australian industry has developed a specialisation towards the construction of vessels generally below 6000 tons gross register.
- Aided by relatively buoyant market conditions and naval vessel construction, a strategy of specialised construction has been in evidence.
- Since implementation of the present assistance policy the industry has invested $11.7 million in new plant and facilities. Approximately 60% of this investment has been directed specifically to improving productivity.
- The total workforce of the industry is approximately 5000 persons. Of these some 3000 persons are directly engaged in ship construction.
- Association member yards account for approximately 95% of total industry activity.
- The industry is confronted by very weak market conditions over the next five years, a situation which has already precipitated retrenchments and closures of smaller yards.
- During 1983 and 1984 a downturn of approximately 60% in demand is forecast. Between 1985 and 1986 a modest recovery in demand is forecast
- The size of the industry, and its workforce will decline to match the size of the available market.
- A more consistent Government ship construction programme would assist *the industry in coping with the problems of the next five years.*
- The operations of the Ships (Bounty) Act 1980 is proceeding smoothly and effectively.
- The present level of bounty provided by the Act is finely pitched in relation to the competitive position of the industry.

- Over the next five years the competitive position of the industry will deteriorate due principally to wage cost increases and other labour related costs.

- The loss of specialised construction programmes will also contribute to a decrease in international competitiveness.

- The inability of yards to compete in highly competitive international markets is also severely restricting the maintenance of specialised construction.

- Strategies to deal with the problems of the next five years include management training, marketing initiatives and the introduction of new technology and modern work practices.

- Conditions within the world shipbuilding industry are expected to remain depressed until the late 1980's.

- Overseas Governments continue to support yards with assistance in the form of subsidies and credit.

- In the light of the very depressed world industry, the Association maintains that existing controls on imports of second hand vessels must be retained to ensure the survival of the industry.

- The industry continues to depend heavily on apprentice training and other internal training programmes to maintain its skilled labour force.

- The Association is concerned about the long term future of the only formal Australian course for Naval Architects.

- The Association is concerned about the contractual arrangements of the Australian Government for naval ship construction. Association members believe that there is an urgent need for these arrangements to be changed.

- The impending contraction in the local industry will be a matter of great concern to the Australian Government in respect of naval defence planning.

- The consequences of this contraction have been separately identified by the Joint Parliamentary Committee on Foreign Affairs and Defence in their report "An Aircraft Carrier for the Australian Defence Force."

- AIP programmes, other than those involving the construction of ships in Australia, are of only limited significance to the industry.

- In the foreseeable future shipbuilding in Australia will remain essentially confined to servicing existing markets

- Carefully planned local naval/government vessel construction programmes have the potential to shape the future size and structure of the industry

SECTION 14.

Recommendations

In the light of the analysis set out in this paper, the Association recommends the following courses of action:

1. That the present support arrangements inherent in the Government's shipbuilding policy remain unaltered.

2. That Government examines the prospects of planning and managing its ship construction requirements to provide greater predictability and continuity of work for the industry. In this regard, the Association draws attention to the multi-year funding legislation used by overseas governments.

3. That the Unions associated with the industry join with the Association in investigating approaches that will maximise the benefits of the introduction of new technology and modern work practices.

4. That the management of EFIC join with the Association in investigating approaches that will result in the full utilization of its finance facilities for export orders. In this regard, there is also an opportunity for the Government to participate in this review to ensure that the national interest provisions of the Export Finance and Insurance Corporation Act are fully utilized.

5. That the Government join with the Association in an urgent review of its contractual arrangements for naval ship construction.

6. That the Government take action to redress the industry's loss of competitive advantage occasioned by the removal of the 2% revenue duty which applied to imported vessels.

Appendix No. 1

Member Companies of the Australian Shipbuilders' Association

Company	Fishing Vessels	Tugs	Oil/Rig Service Vessels	Dredges	Survey/ Research Vessels	Tourist Vessels	Ferries	Cargo Vessels	Naval Vessels
	Vessel types normally constructed by Association members								
Australian Shipbuilding Industries (WA) Pty Ltd	x	x	x	x	x	x	x	x(2)	
Carrington Slipways Pty Ltd	x	x	x	x	x	x	x	x	x
Colan Shipbuilders Pty Ltd	x	x	x	x	x			x	
'K Shipyard Construction Company	x				x(3)				
Lloyd's Ships Pty Ltd						x			
James McLarty and Son	x							x(2)	
North Queensland Engineers & Agents Pty Ltd	x	x	x	x	x	x	x		x
Ocean Shipyards	x	x						x(2)	
State Dockyard(1)			x	x	x		x	x	
Tamar Steel Boats Pty Ltd	x	x				x		x(2)	
Vickers Cockatoo Dockyard Pty Ltd									x

Notes (1) The N.S.W Government has announced that new ship construction will be terminated when current construction contracts have been finalised.
(2) Simple vessel types such as barges.
(3) Patrol Vessels non Naval

APPENDIX H

Department of Defence 'Review of HMAS Tobruk Board of Inquiry Into the Death of Naval Reserve Cadet Kenneth Dax' and associated internal departmental correspondence

Note: The Committee and the Australian Government Publishing Service are not responsible for the quality of reproduction of the documents contained in this appendix. The documents have been reproduced in the form supplied to the Committee. For clarity some material has been re-typed and marked as a copy.

N137/3/262
DCNS 381/83

REVIEW OF HMAS TOBRUK BOARD OF INQUIRY INTO THE DEATH OF NRC DAX

DGFM

For Information: CNTS

References: A. DGFM minute 0553/82 of 3 June 82

B. DGND minute 507/82 of 4 Jun 82

C. CNTS minute 467/82 of 15 Jun 82

1. I have noted the content of the review undertaken by DGFM into the Board of Inquiry report and I agree with the recommendations contained in sub-paras 168 c., to 168 g. and 169 a. to 169 v. You are requested to consult with DGNM, DNLS and DNRC as appropriate to draft suitable correspondence to give effect to those recommendations.

2. With regard to sub-paras 168 a. and 168 b. CNTS is being asked to take the action proposed by him in para 4 of reference C.

3. DGFM is to be commended for the depth and breadth of this review and the attention to detail which he has demonstrated.

(SGD.) P. H. DOYLE

21 Jun 82

(P. H. DOYLE)
Rear Admiral RAN
Deputy Chief of Naval Staff

NAVY OFFICE

N137/3/262
DCNS 352/82

REVIEW OF HMAS TOBRUK BOARD OF INQUIRY INTO THE DEATH OF NRC DAX

CNTS

For Information: DGFM

References: A. DGFM Minute 0553/82 of 3 Jun 82

B. DGND Minute 507/82 of 4 Jun 82

C. CNTS Minute 467/82 of 15 Jun 82

1. You are requested to undertake the examination proposed in para 4 of Reference C and advise me of the outcome.

(SGD.) P. H. DOYLE

(P.H. DOYLE)
Rear Admiral RAN
Deputy Chief of Naval Staff

21 June 1982

Department of Defence

MINUTE PAPER

Reference: CNTS 467/82

Subject: REVIEW OF HMAS TOBRUK BOARD OF INQUIRY INTO THE DEATH OF NRC DAX

DCNS

For Information: DGFM

DGND

References: A. Review of Board of Inquiry

B. DGFM Minute 0553/82 dated 3 June 1982

C. DGND Minute 507/82 dated 4 June 1982

Reference A is forwarded. It is a most comprehensive and thorough review, and DGFM is to be congratulated on it. It has clearly involved great effort on his part to produce such a document concurrently with undertaking his demanding day-to-day responsibilities.

2. I agree generally with his recommendations in Reference A paragraph 169.

3. Reference C, in my view however, properly challenges the action proposed in paragraph 168(a) and (b). I accept that there is an apparent contradiction in this proposal with the recommendation at 168(t).

4. You may conclude that it may be more appropriate for CNS to task CNTS to establish the validity of DGFM's conclusions that Navy Office drawing amendments created a leakage path for the gas and increased back pressure on this leakage path to a degree which significantly contributed to the accident.

5. With the exception of the above, I agree broadly with paragraphs 6 and 7 of Reference B, but I would like to draw attention also to the involvement and complicating aspects of the project management responsibilities and also the unfortunate effects of the partial exclusion of RANTAU in trials.

15 June 1982

(D.F. LYNAM)
Rear Admiral, RAN
Chief of Naval Technical Services

Department of Defence

MINUTE PAPER

N137/3/262
Reference: DGND 507/82

Subject: HMAS TOBRUK - REPORT ON BOARD OF ENQUIRY

[illegible]

DGFM (CP1-2-12)

CNTS (CP2-6-13)

[illegible]

References: A. DGFM Minute 0553/82 dated 3 Jun 82.

B. Telecon DGFM (CDRE Holthouse)/A/DGND, (L.S. Knight) am, 3 Jun 82.

1. As requested vide Reference B I have in the time available (about 3 hours) read Reference A and pages 1 to 54 of the review document attached to Reference A in order to be aware of the contents. As DGFM suggested, such a short period is insufficient to pursue in any but a cursory fashion the validity of new material introduced since the matter was last discussed in February 1982 nor the validity of conclusions drawn therefrom.

2. Due to DGFM's immediate personal programme and desire to forward the report before proceeding overseas, he has requested that after a brief perusal I return the file for similar perusal by DGNP. I understand the reasons for request and in the circumstances will comply. The file and attachments is therefore returned herewith.

3. In my short perusal of the report I have been generally impressed by the format of the report, the wide scope of the investigations and the apparent logic of the conclusions and recommendations deduced therefrom. Paragraph 2 of the report correctly indicates that such a wide scope is necessary to decide with CONFIDENCE the factors which led to the tradgedy but also introduces the fact that the cover has sometimes been superficial due to capacity limitation. Nevertheless the report does state its conclusions and recommendations with confidence.

4. The report identifies design difficiencies and at paragraphs 169 r and t recommends CNTS (DGND) action to conduct a design deficiency review and a review of design validation procedures. I concur wholeheartedly with these recommendations.

5. Paragraph 168 however is cause for a great deal of concern. After summarising apparent individual errors of judgement it recommends that individuals and organisations be advised by personal letter from DCNS of their shortcomings or lack of appreciation of the dangers of their actions. The paragraph is not specific in this regard and apparently leaves the drafting of the letter to DNLS and DGFM. I can only assume that such letters are to be regarded as letters of censure. To me justice demands that guilt be established before censure occurs.

.../6.

6. In this regard I find that paragraphs 168 a and b, and 169 r and t are inconsistent. The report concludes that cross connection of the vent pipes and extension of the vents to atmosphere were major contributing factors to the tragedy. The recommendation of paragraph 169 r must be expected to confirm the truth or otherwise of this. Paragraph 169 t must be expected to establish the contribution of all parties to the design change which authorised the modification. Surely then, and then only can the degree of censure warranted by any person be established in this matter.

7. I wish it to be recorded that I strongly disagree that any immediate action in respect of paragraph 168 a and b to taken and recommend that any such action only be taken where found warranted by the results of recommendations 169 r and t.

4 Jun 82

(L.S. KNIGHT)
A/Director General Naval Design

Department of Defence

FOLIO 46

MINUTE PAPER

Reference: N137/3/262
DGFM 0553/82

Subject: REVIEW OF HMAS TOBRUK BOARD OF INQUIRY INTO THE DEATH OF NRC DAX

~~CNTS~~ Remarks noted

DCNS

Reference: DCNS 32/82 (N137/3/262) of 13 Jan 82

1. The attached review of the report of the Board of Inquiry into the death of Naval Reserve Cadet Kenneth Dax is forwarded in accordance with the reference. The delay, which is regretted, resulted from the need to explore a broad field in order to decide with reasonable confidence exactly what were the factors which contributed to this tragic accident.

2. Some new ground has been broken in the course of this review: particularly regarding the nature of the product gases, which are believed to have poisoned Dax, rather than asphyxiated him. A number of outside organisations have asked for information about the accident and one of the recommendations of this review is that they be provided with it.

3. The outcome of the review is a lengthy report, not all of which goes directly to the circumstances of Dax's accident: the object of the Board of Inquiry. This aspect is covered in sufficient detail in the earlier part of the review and busy readers may wish to confine their attention to paras 1-69 before moving to the general conclusions at para 161 and recommendations at paras 165-169. More detailed conclusions are at para 162.

4. Comments on the BOI conclusions and recommendations and the Fleet Commander's covering remarks thereon, are at paras 163,164, and 170 of this review.

5. For easy reference, copies of all conclusions and recommendations are attached at Annex A to this minute.

6. This review has concluded, at para 161j that there was no single act or omission but for which this tragic accident would not have occurred. The ship's failure to aerate the holding tank continuously, created a new and dangerous gas source. The Navy Office design amendment which combined the Macerator/Collector tank and holding tank vent pipes, created a potential leakage path for the gas: and the further Navy Office decision to cross-connect the port and starboard vent pipe systems and extend them up the starboard derrick kingpost created the back pressure necessary to turn the potential leakage path into a reality.

.../2

6. In this regard I find that paragraphs 168 a and b, and 169 r and t are inconsistent. The report concludes that cross connection of the vent pipes and extension of the vents to atmosphere were major contributing factors to the tragedy. The recommendation of paragraph 169 r must be expected to confirm the truth or otherwise of this. Paragraph 169 t must be expected to establish the contribution of all parties to the design change which authorised the modification. Surely then, and then only can the degree of censure warranted by any person be established in this matter.

7. I wish it to be recorded that I strongly disagree that any immediate action in respect of paragraph 168 a and b to taken and recommend that any such action only be taken where found warranted by the results of recommendations 169 r and t.

4 Jun 82

L. S. Knight
(L.S. KNIGHT)
A/Director General Naval Design

Department of Defence

FOLIO 46

MINUTE PAPER

Reference: N137/3/262
DGFM 0553/82

Subject: REVIEW OF HMAS TOBRUK BOARD OF INQUIRY INTO THE DEATH OF NRC DAX

~~CNTS~~

DCNS

Reference: DCNS 32/82 (N137/3/262) of 13 Jan 82

1. The attached review of the report of the Board of Inquiry into the death of Naval Reserve Cadet Kenneth Dax is forwarded in accordance with the reference. The delay, which is regretted, resulted from the need to explore a broad field in order to decide with reasonable confidence exactly what were the factors which contributed to this tragic accident.

2. Some new ground has been broken in the course of this review: particularly regarding the nature of the product gases, which are believed to have poisoned Dax, rather than asphyxiated him. A number of outside organisations have asked for information about the accident and one of the recommendations of this review is that they be provided with it.

3. The outcome of the review is a lengthy report, not all of which goes directly to the circumstances of Dax's accident: the object of the Board of Inquiry. This aspect is covered in sufficient detail in the earlier part of the review and busy readers may wish to confine their attention to paras 1-69 before moving to the general conclusions at para 161 and recommendations at paras 165-169. More detailed conclusions are at para 162.

4. Comments on the BOI conclusions and recommendations and the Fleet Commander's covering remarks thereon, are at paras 163,164, and 170 of this review.

5. For easy reference, copies of all conclusions and recommendations are attached at Annex A to this minute.

6. This review has concluded, at para 161j that there was no single act or omission but for which this tragic accident would not have occurred. The ship's failure to aerate the holding tank continuously, created a new and dangerous gas source. The Navy Office design amendment which combined the Macerator/Collector tank and holding tank vent pipes, created a potential leakage path for the gas: and the further Navy Office decision to cross-connect the port and starboard vent pipe systems and extend them up the starboard derrick kingpost created the back pressure necessary to turn the potential leakage path into a reality.

.../2

7. Had the system been set to work properly at the outset and had the ship's staff been taught the theory and trained in the operation of the sewerage system, the new and dangerous gas source would not have developed and the circumstances which generated the final disastrous vent pipe system cross-connection and extension, would not have arisen. And finally, had the early warnings been properly investigated at the time, the effects of the ship's maloperation of the plant and the risk inherent in the combined Macerator/Collector tank and holding tank vent pipes could have been recognised for what they were, and steps taken to correct the circumstances.

8. It is, in DGFM's view, a measure of the overstretch on all sides within Navy that all of these circumstances arose. Having come together as they did, a very serious accident became inevitable.

DGFM

03 Jun 82

Annex A: Copy of Conclusions and Recommendations

Enclosure: Review of the Board of Inquiry into the Death of NRC Kenneth Dax

N137/3/262
[redacted]

REVIEW OF
HMAS TOBRUK BOARD OF INQUIRY INTO
THE DEATH OF NAVAL RESERVE
CADET (NRC) KENNETH DAX

Reference: DCNS 32/82 (N137/3/262) of 13 Jan 82

BACKGROUND

1. The following review of the Report of the Board of Inquiry into the circumstances surrounding the death of NRC Dax of TS ONSLOW, following an accident on board HMAS TOBRUK on 14 Dec 81, is submitted in accordance with the reference. (In this review the term 'death' has been used instead of 'asphyxiation' as used by the Board of Inquiry because it is by no means certain that the victim died simply from a lack of oxygen.) The delay in submission has been caused by the complicated nature of the background and the need for considerable research.

2. Upon receipt of the reference, DGFM circulated copies of the Board of Inquiry report (TAB A) together with its enclosures and later, the Fleet Commander's covering remarks (folio 22), to the Navy Office authorities listed below. This review takes account of the written opinions expressed by those authorities, which are attached at folios 26-33 and 38. Representatives of DNSD and DFM visited HMAS TOBRUK during the course of their investigations, as did [redacted].

3. Navy Office authorities consulted were:

DGNHS - Health Services Branch

DGND - Design Branch

DGNP - Production Branch

DFM

DNUR

DONS

4. Fleet Staff Officers have been consulted verbally, as have representatives of the General Overseer and Superintendent of Inspection, East Australia Area (GOSIEAA) on matters relating to HMAS TOBRUK's building and inspection schedule, by arrangement with DGNP. Other external authorities consulted include the Department of Housing and Construction (verbally), the United States Navy (Sewerage and Waste Pollution Control Branch and Environmental Pollution Control Section folios 39 and 40), and the Yarrow-Admiralty Research Department (Y-ARD) UK, (folios 41-44).

5. The contributing factors which led to NRC Dax's death are complex, largely because they stem from a shipboard system - Sewage Collection, Holding and Transfer (CHT) - which is new to the RAN, designed by outside agencies (the Shipbuilder in consultation with Mono Pumps), and installed in a contract built ship (Carrington Slipways P/L - CSPL) to commercial standards. Comprehensive 'as fitted' information was not available to the ship, nor to Navy Office, at the time of the accident.

6. The complexity of the issues involved in the TOBRUK accident and their interrelationships have caused this review to pursue its work over a very wide field and this has been necessary in order to decide with confidence the factors which led directly to Dax's death. Capacity limitations as much as the need to keep the final report within a reasonable size has meant that its cover has sometimes been superficial and this is particularly so in its review of the management of the LSH project. Nevertheless the broad scope has the merit of gleaning the maximum lessons to be learnt from this tragic accident and follow-up should be simplified by reference to the long list of conclusions and recommendations at paras 161-162 and 165-169 respectively.

7. In order that the causes of the accident may more readily be explained it has been decided to include in this review a brief outline of the CHT principle and a description of the plant as fitted, as well as the sequence of events involving NRC Dax himself. An additional benefit of this approach is that readers should not need to study background and supporting papers except to pursue a particular issue which has been highlighted in this review.

8. It is evident that HMAS TOBRUK's CHT system has been the source of continuing problems since some 3 months before the ship commissioned. A chronology of incidents is at Annex A. Without seeking to pre-empt the conclusions reached in this review it might be said that a proper appreciation at the time, of all the factors surrounding these earlier incidents, ought to have precluded this final tragic accident. That such an appreciation did not take place, and that the accident did occur are attributable in no small measure to the complicated system of management within which the ship was built, commissioned and set to work.

Board of Inquiry

9. The Fleet Commander convened a Board of Inquiry (BOI) on board HMAS TOBRUK, on 17 December 1981. The report of the BOI contains a copy of the post mortem certificate (TAB B) and a transcript of evidence (TAB C) together with a photograph (TAB D) and sketches of the relevant sections of the ship (TAB E).

10. The report is brief and is in the nature of a resume of events. Whilst it could be criticised for 'situating the appreciation' (its exclusion of poisoning as a cause of death led inevitably from the line of questioning pursued; as did its conclusion that the CHT system in TOBRUK is inherently dangerous); BOIs do suffer time and information restrictions from which Navy Office is relatively free.

11. Suffice to say, the factors contributing to NRC Dax's death are manifold and the BOI has not explored them adequately. Had it been more inquisitive it might have provoked a different response from the Coroner (who has accepted the BOI findings without formal inquiry) and perhaps from the Fleet Commander, but it is unlikely that it would have materially reduced Navy Office work in the conduct of this review.

12. The conclusions and recommendations of the BOI and of the Fleet Commander subsequently, are discussed at paras 163, 164 and 170.

Post Mortem Findings

13. The examining doctor has stated that NRC Dax died from cerebral oedema arising from an inadequacy of oxygen (hypoxia) which he has attributed to inhalation of vomit. DGNHS has pointed out at folio 27 that whilst this conclusion is reasonable in the circumstances, (lacking knowledge of what had happened on board), it is possible that the hypoxia might have been directly attributable to breathing an oxygen-starved atmosphere, or even one charged with toxic levels of other gases as well. In response to further, specific questions DGNHS has stated in part (folio 38), that:

a. Concentrations of hydrogen sulphide (H_2S) of the order of 50-200 ppm will cause loss of sense of smell.

b. Long exposure to relatively low concentrations of H_2S will cause death.

c. Death occurs rapidly at high concentrations, say above 600 ppm.

d. There are identifiable physiological effects resulting from H_2S exposure but they would not normally be noticed in a post mortem examination.

14. It is certain that other gases were present (see folio 30A for gas models). It is not feasible to establish concentration levels after the event but experimental evidence has come to hand which tends to establish the range of possible concentrations in the ullages of the tanks concerned in the accident, (para 139 et seq). On balance it appears that the most dangerous of these gases, hydrogen sulphide (H_2S), could have been present in concentrations sufficient to cause death, contrary to a conclusion of the BOI.

15. Whilst NRC Dax was certainly breathing an oxygen-starved atmosphere containing toxic gases, when he collapsed, it cannot be established whether the vomit found in his lungs was inhaled before he stopped breathing, or was drawn in afterwards. All that can be determined is that NRC Dax died, either from hypoxia attributable to him breathing an oxygen starved atmosphere, and/or the inhalation of vomit; or from the effects of breathing H_2S contained in an oxygen starved atmosphere.

16. Despite the post mortem finding, there is a very strong inference that NRC Dax was poisoned by H_2S.

Advice Given to NRC Dax's Parents

17. NRC Dax's father is a long serving Naval Reserve Cadet Petty Officer. He was not on board HMAS TOBRUK at the time of the accident.

18. Mr and Mrs Dax have made several enquiries of naval authorities about the circumstances of their son's death and copies of correspondence are contained on Navy Office file N2/4/64. These are signs that they may be considering legal action. The latest advice given them was to the effect that:

a. Their son died from hypoxia (lack of oxygen) which the post mortem attributed to inhalation of vomit.

b. He had felt seasick and appears to have gone to the heads to be sick. Therein he unwittingly breathed an oxygen starved atmosphere and lost consciousness.

c. He would have suffered no symptoms other than seasickness.

d. Oxygen had been displaced from the heads compartment by sewage gases leaking from the collection tank via deficient water seals in the heads bowls.

e. The loss of water seals might have been due to evaporation or to syphoning resulting from a design deficiency.

f. Investigations continue.

g. The Coroner had accepted that death was due to hypoxia and no inquest was expected.

SEQUENCE OF EVENTS IMMEDIATELY SURROUNDING THE INCIDENT

19. NRC Dax and 29 fellow sea cadets joined TOBRUK in Brisbane at 0800 on 14 Dec 81, for three days' sea training. They were accommodated in No 6 Troops Mess, 4C4, and were to use 3CY4 Troops heads. Their direct route to the cafeteria led past 3DZ4 Troops heads, which they were able to use, also. they were under the supervision of two NRC officers and their presence on board was covered by the usual sort of XOTM (TAB F).

20. The ship sailed at 0957 and at about 1530 aeration and pumping overboard of the sewage holding tanks began, as was the usual but erroneous practice on proceeding to sea (see para 45 regarding need for continuous aeration). Pumping continued for about half an hour, causing the usual (Q/A 226, Q/A 294 and Q/A 328) foul smell in the ship. Pumping was suspended at about 1600, on the orders of the MEO(Q/A 483), following representations

to the Chief Shipwright by the POMED who had received a report from the CPOCOX on behalf of some NRCs, about the smell and its effect on them (Q/A 111), in the vicinity of 3DZ4 heads.

21. Earlier, at about 1600, NRC Dax was in his messdeck in the company of witnesses (Q/A 143). Like other cadets, he appears to have lain on his bunk and had been heard to remark lightly that he could hardly breath because of the smell (Q/A 153). It appears that he may in fact have become seasick (Q/A 24) soon afterwards and gone to 3DZ4 heads where he entered a cubicle, closed the door and crouched or sat on the deck, apparently in order to vomit into the bowl. He lost consciousness whilst in this position and collapsed against the inwards opening door (see photograph at TAB D), which made his subsequent rescue difficult. It is possible that he was there when the NRCs at para 20 first complained of the smell but they were unaware of his presence.

22. Dax was discovered by NRC Pullen and another cadet not long before 1615, when Pullen entered 3DZ4 heads to see if someone had forgotten to flush them after use, thereby accounting in his mind for the smell. When Dax did not answer a call, Pullen realised something was seriously wrong and went for help. Unlike the NRCs at para 20 Pullen does not appear to have been affected at this stage, other than by the smell (Q/A 55).

23. NRC Pullen ran to his messdeck for help but found everyone asleep. Back in the passageway he encountered LSETC3 D.I. Hughes S113014 and ABETW G.J. McLeod S124711 who followed him to the heads, which they all entered. They called to Dax and tried to open the door against his weight but without success. At this stage Pullen began to behave oddly, as if drugged (Q/A 280) and Hughes realised that there was danger. He ran to HQ1, and telephoned the OOW to raise the alarm. Back in the passageway he encountered LSMTP S.R. Wilson S116012 and together they returned to the heads flat, where they found McLeod 'very drugged and getting nowhere' (Q/A 286), attempting to telephone HQ1.

24. Hughes realised Pullen must still have been inside the heads compartment. He entered and found the cadet sitting on the deck, semi-conscious (Q/A 286) and dragged him out. Wilson and Hughes moved both casualties into the next compartment.

25. There is no evidence of a general alarm being raised or of an Emergency Party muster. However LSMTP G.R. Bosworth R107478 now arrived in response to Hughes' HQ1 report, carrying a Normalair SCBA. Hughes and Wilson began to help him into it but Hughes realised that Bosworth was too big and the SCBA too bulky for Bosworth to get to Dax. Hughes, with the experience of his two previous entries to the heads compartment, rationalised the danger (Q/A 287 and 313), took a deep breath and went inside. He entered the cubicle two removed from Dax (the intermediate cubicle showed 'engaged' but was empty) and then scaled across the top of both partitions and got down to Dax. He dragged the cadet clear of the door, opened it and began to haul him out of the cubicle. Bosworth took over and the rescue was completed. It was now close to 1615 (para 17 of BOI report and see also Q/A 505 which suggests that the rescue was completed a little earlier than 1615).

26. A sketch of the heads layout is at TAB E. It appears from Q/A 342 that the 'engaged' indicator on the adjacent cubicle probably vibrated into position and that the door could have been opened from the outside.

27. Meanwhile LSMTP Wilson had also telephoned HQ1 and asked for the Chief Shipwright to be called. After an interval and not having heard a pipe for the Chief Shipwright, Wilson went to HQ1 himself, to supervise a further pipe (Q/A 324). He encountered POMED ACC S.T. Dean R106535 on the way and directed him to the scene of the accident.

28. PO Dean was apparently returning from his visit to the Chief Shipwright's cabin (para 20). He reached the area at about the time Hughes re-entered the heads to rescue Dax. Pullen was on the deck and Dean took him to the weather deck and left him with several other cadets before returning to the heads area on the further advice of Wilson, to find Dax outside in a cyanosed state, with no pulse (Q/A 493).

29. Dean appears to have attempted mouth to mouth resuscitation but encountered vomit (Q/A 301) although Dean's own testimony was that he first checked that Dax's mouth was clear (Q/A 497). In any case, Dean sent for an oxy-viva, sucked out the patient's throat and applied oxygen. There may have been a slight pulse now (Q/A 301) but it was immediately lost and Dean and Hughes then applied cardiac massage which tended to expel the contents of Dax's stomach. This added to Dean's difficulties in the confined space and he ordered the cadet to be taken up to the weather deck. Hughes carried him up and then Hughes, Dean, ABMED Foley and LEUT A.T. May RAN (the incoming Supply Officer) continued cardiac massage there.

30. On arrival on deck Dean directed one of those present to keep notes, and the first entry shows 1615 (Q/A 505). About 10 minutes later Dax's colour began to improve and at 1655 a pulse was established. However Dax's eyes remained dilated and glazed throughout and he showed no sign of breathing spontaneously. Dean became worried about Dax's accelerating pulse rate and administered Xylocard at 1730 to slow it down. At 1737 the patient appeared to dry reach, or suffer a cough spasm (Q/A 520/1).

31. Dean had sent word for the Commanding Officer (CAPT K.A. Doolan RAN) when he first saw Dax's condition. The CO visited the scene (Q/A 515) before returning to the Bridge to arrange for a medevac. A civilian doctor arrived in the Wales helicopter at 1750 and took over management of the patient at 1752.

32. The doctor conducted an intubation, and administered a drip and further drugs (Q/A 525). He recognised that Dax's conditions was grave and the medevac was effected immediately, departing at 1843 for the Royal Brisbane Hospital.

33. NRC Dax remained in a coma until 16 December 1981 when he died. The post mortem certificate is at TAB B.

34. Other affected personnel suffered variously from drowsiness, loss of co-ordination and headaches. All recovered quickly and had no after-effects. They were not examined by the doctor at the time.

HMAS TOBRUK'S CHT SYSTEM

35. The following paragraphs describe briefly how the CHT sewage system in TOBRUK was intended to work. For further details see folio 30 where DNSD's Environmental Control Officer has investigated the system's shortcomings and proposed solutions. His analysis contains some errors of fact which are identified in margin notes, in red. They do not invalidate its conclusions.

36. Unlike the sewerage plant in HMAS STALWART for example, TOBRUK's CHT system relies on aerobic digestion for any decomposition which occurs, and this is intended to avoid the generation of dangerous gases, and foul odours. The chemistry appropriate to both aerobic and anaerobic systems is at folio 30A.

37. The purpose of a CHT system is to permit a ship to transit the 4 mile zone and to enter and berth in a harbour without discharging either sewage (blackwater) or bathroom, laundry, galley, sick bay etc drains (greywater), into the sea. (The greywater restrictions are not necessarily as stringent as the rules governing raw sewage). Between the 4 mile and 12 mile limits, the discharge overboard of sewage after it has been processed through the CHT system is permissable. Beyond the 12 mile limit, heads and all drains should be directed overboard, as in any other ship, and the CHT system washed through and shut down. In harbour, the contents of the holding tanks are to be pumped out as required, either directly into the metropolitan sewerage system (which is the case in Brisbane town), or into sewage lighters.

38. HMAS TOBRUK's system comprises two Holding tanks (P&S) and six Macerator/Collector (M/C) tanks; three associated with each holding tank. Heads and urinals (blackwater) drain to the M/C tanks which are pumped automatically from time to time, to the holding tanks. Laundry, bathroom and galley (greywater) and sickbay drains go directly to the holding tanks, or overboard.

39. Exceptionally, the forward M/C tanks receive both blackwater and greywater drains, thereby simplifying the pipe system runs to the holding tanks much further aft. Design guidance specified otherwise but this departure from guidance is not a factor in NRC Dax's death.

40. Navy Office design guidance was that all permanent ship's company heads should drain to the aft M/C tanks, leaving the midships and forward tanks for embarked troops only, thereby enabling them to be shut down for long periods, see para 10 of folio 30. Following the accident, it has been established that a small number of ship's company heads actually discharge to the midships M/C tanks (para 12 of folio 30). The relevance of this departure from guidance will be discussed later (para 71h).

41. The M/C tank transfer pumps are operated by high and low level switches with a time clock override. Alarm switches are also fitted; as are remote reading contents gauges. Thus M/C tanks are pumped down to the low level, as required, and never less frequently than every 12 hours. The low levels are presently set at 6-10 inches in order to protect the transfer pumps from losing suction and burning out their rubber stators. In the case of the port midships M/C tank, some 1.04 tonnes of material remains in the tank below the low level cut-out.

42. The M/C tank transfer pumps suck through electrically driven macerators (chopping blades) so that only liquid carrying a fine slurry is transferred to the holding tanks.

43. Each M/C tank has only one transfer pump and macerator unit. A breakdown or blockage would necessitate either shutting down the associated heads during the repair, or directing their drains overboard. (This lack of redundancy would have debilitating consequences should the breakdown or blockage necessitate tank access when partly filled. A ship-check will be necessary to establish the likelihood of such a circumstance.)

44. The contents of the holding tanks are treated at pre-set levels with calcium hypochlorite ($CaOCl_2$), in order to chlorinate and disinfect them before discharging to the environment. This may not be necessary in harbour when discharging to municipal mains. The chemical is a strong oxidising agent and needs care in handling and storage (para 40 of folio 30). Mixing is controlled by hand; dosing is automatic.

45. Air must be bubbled through the contents of the holding tanks whenever the tanks are in use. The air is supplied by two small blowers backed up by an emergency cross connection from the ship's compressed air system. Constant aeration is necessary to prevent the onset of anaerobiosis and the generation of dangerous and foul smelling gases (cf intermittent use of air blowers at para 20), including hydrogen sulphide (H_2S).

46. The characteristics of product gases associated with sewage treatment generally are listed at page A-3 of folio 30A. Ammonia, which is a product of aerobic digestion, is readily soluble in water and should have little significance as an explosion hazard, unlike H_2S and CH_4.

47. CH_4 was assumed by the BOI and subsequently by Fleet Headquarters and within Navy Office to have been present and there was a strong inference that it had played a big part in Dax's asphyxiation; (BOI report paras 13 and 22 and folio 30 at page 6). As discussed later (para 139 et seq), it is now almost certain that there was little or no CH_4 present, at all.

48. The air and generated gases are released to atmosphere from both holding tanks through a single combined vent pipe which runs to the top of the starboard derrick kingpost. The outlet is fitted with a gooseneck and flash gauze.

49. The marrying of the two vents and their extension from the upper deck to the top of the kingpost was a post-commissioning modification designed to carry offensive smells away from the ship and its ventilation air intakes. The extension of the port and starboard vents separately, had Navy Office approval (see para one of folio 32C and Navy Office Sketch No A200204 (Issue 1) at Annex B) as did the later decision to marry them, see Navy Office Drg No A200206 (Issue 3) (Annex B), due to welding problems represented by the kingpost material. The single extended vent pipe was bolted to an existing ladder on the starboard kingpost.

50. The holding tanks are fitted with remote reading contents indicators (fitted after early difficulties with the system) and alarm switches (improved type following earlier problems). These tanks have their own transfer/discharge pumps which are cross-connected and thus back-up one another. The pumps are started by hand but stop automatically before the suctions run dry.

51. The M/C tanks are also vented to the upper deck, via goosenecks fitted with flash gauzes and dead-weighted flap valves designed to keep water from flooding down the vents. The flap valves, which may be pinned open, are a Lloyds' requirement (para 17 of folio 30) and it is assumed that in normal circumstances they should be pinned. Care is necessary to keep them free of paint and corrosion, see para 47 of folio 30 where a flap was found to have been sealed with fresh paint. The valves are not pinned open in TOBRUK.

52. Each of the forward and aft M/C tanks has its own separate vent but the midships tanks do not: instead they join into the vent lines from their associated holding tanks. These midships M/C tanks are sited within but separate from their associated holding tanks and this close proximity undoubtedly accounts for the decision to marry the vent lines, which was done in accordance with a design guidance amendment provided in Navy Office drawing No A000077 (Issue 2), see Annex C. It is certain that the marrying of the vent lines was a major factor in NRC Dax's death.

53. The net effect of paras 49 and 52 was to vent all four midships tanks up a single vent pipe, to the top of the starboard kingpost. As discussed later, at para 89 there was some evidence that the vent system may have been inadequate and the matter was further explored. Calculations which have been made (Annex D) tend to prove that the first modification, to combine the holding and midships M/C tank vents in pairs port and starboard, although inherently dangerous for other reasons, did not overload the vent pipe capacity but the second modification, to combine the port and starboard pairs into a single pipe, increased the back pressure beyond the capacity of the water seals in the heads bowls (para 56 below), thereby leading directly to Dax's gassing and death.

54. All blackwater drains to the M/C tanks rely on water seals ('P' traps, 'U' bends etc) to isolate the compartments from which they drain (ie heads), from the atmospheres within the relevant tank ullages. (Similar arrangements are used in the most recent RN designs, see para 2 of folio 43.) Greywater drains also use 'P' traps and 'U' bends but they are backed up by non-return

valves, see para 64. Exceptionally amongst the blackwater drains, non-return valves were fitted between the forward M/C tanks and related WC bowls only, in June 1981. The work was done by CSPL, presumably following their experience of an earlier sewage spill from the forward M/C tanks (Q/A 450). There is no knowledge on board of why a similar modification was not made to the midships and aft systems, see para 23 of CO's Investigation report at TAB G, but had its significance been appreciated at the time and the modification, or something like it, been extended throughout the ship, the accident involving NRC Dax could well have been avoided.

55. The water seals must be protected from being sucked out (by venturi action, or by syphoning); or blown out (eg by a sufficient positive pressure developing in the relevant tank beneath), or from simply drying out, due to disuse in a hot environment (para 22d of BOI report).

56. The heads bowls in HMAS TOBRUK and other RAN ships with sewage holding systems are of the 'minimum flush' design, a feature of which is the smallness of their water seals (17mm, see paras 19-21 of folio 30). Note that the pressure at the M/C tank and holding tank vent pipe cross connection, assuming the heads bowls water seals to be intact, would be of the order of 36 mm, see Annex D.

57. The M/C tanks are not aerated even though they cannot be emptied completely (para 41). It is probable that anaerobic conditions develop in the tanks whilst they are in use, notwithstanding that they are pumped out frequently (para 41) and that their contents are more or less constantly being diluted with flushing water and fresh sewage.

58. The extra importance of good ventilation of compartments connected by water seals to potentially dangerous tank ullages is evident. The air change capacities of installed ventilation systems throughout HMAS TOBRUK's heads compartments have not been explored but it has been established that the capacity of the forced exhaust system in 3DZ4 heads is less than specified by the Naval Construction Manual (247 cfm actual, 300 cfm specified) see Annex E. It is significant that the exhaust fan in 3DZ4 heads was defective and had been removed for repair some days before the accident (BOI report para 12c). Thus the only ventilation available would have been the natural draught through the exhaust fan trunking itself, plus any leakage that may have occurred through the passageway door. The importance of this defect is discussed further, at para 67.

59. Finally, both holding tanks are fitted with seawater connections for flushing out before being shut down. It had been thought that the M/C tanks, which do not have direct sea water connections, must be opened up for hosing if they are to be cleaned before shutting down the system (para 34 of folio 30). However enquiries of GOSIEAA reveal that salt water connections are provided for flushing out soil pipes, and these could be used equally well for flushing out tanks. GOSIEAA representatives have advised that these valves were considered by CPSL to have been a possible source of a sewage overflow in May 1981 (para 87).

60. Nevertheless the arrangements as fitted are less than ideal as tank cleaning aids, bearing in mind the periodic requirement to enter the tanks for inspections and maintenance. An improved design arrangement involving Butterworthing is being considered by DGND.

CHAIN OF CAUSATION

61. NRC Dax's death occurred at least partly (para 15) because he breathed an oxygen-starved atmosphere which contained toxic gases: he was being sick at the time and would not have been aware of the onset of other symptoms. It is possible that he also inhaled vomit, and choked.

62. As already discussed, there is persuasive evidence that significant quantities of H_2S would have been present, possibly above 1700 ppm within the tank ullages, see para 141. H_2S is an insidious poison which has the effect at concentrations of 50-200 ppm, of deadening the sense of smell. Above this level unconsciousness occurs rapidly and death would follow after continued exposure. It also appears from para 4 of folio 44, that respiratory paralysis follows on from unconsciousness. Concentration levels above 600-800 ppm are lethal in a short span.

63. At the time of his gassing, Dax was sitting on the deck of a compartment which was connected via blackwater drains (five heads and one urinal) to the port midships M/C tank in which sewage gases were almost certainly generating (see Annex F for quantities); and via greywater drains (wash basin and deck waste) to the port holding tank where sewage gases had undoubtedly been generating strongly and into which air was now being forced, in quantity. Moreover, there was a direct connection between the two tanks via the common vent system, along which sewage gases would assuredly flow from the holding tank to the M/C tank, if there were a leakage path from the latter, to atmosphere. See Annex G for gas path models.

64. Although the greywater path at para 63 is possible, it cannot be positively established as it is now too late to confirm whether the water seals were present at the time of the accident. However it is known that the depth of the water seals in the greywater drains in TOBRUK is of the order of 75 mm, and thus should be proof against the system overpressure. Moreover most if not all greywater drains to the holding tanks are fitted with NRVs, thereby protecting the water seals against any eventuality.

65. The blackwater drain path is positively established by the testimony of several witnesses that at least three of the heads bowls were dry; ie they had no water seals at all (Q/A 359). It is possible (Q/A 353 et seq) that the bowl over which NRC Dax must have been leaning, was also dry; therefore that he was breathing directly in the gas stream issuing from the probably anaerobic port M/C tank but emanating mainly, under slight pressure, from the strongly anaerobic contents of the port holding tank.

66. It is important to note at this stage that the complete absence of water seals in the heads bowls would allow the M/C tank to vent its own gases into the heads compartment, whether or not the M/C tank had been connected via the common vent pipe to the holding tank; and whether or not the holding tank pressure had been increased by starting up the aerators. With aeration in progress and in the absence of seals, there would have been a significant gas flow, as described.

67. There would have been only a slight natural exhaust flow from the compartment. If any fresh air replacement occurred at all (through the jalousie in the passage-way door to the heads compartment, see sketch at TAB E) it would have been at a lower rate even than the exhaust, due to the ingress of sewage gases via the defective water seals. Of course it is possible that the flow at the jalousie had reversed: that gas flowed outwards to the passage way, rather than that fresh air flowed inwards from the passage way to the heads compartment. This possibility tends to be confirmed by the strong smell outside the heads, experienced by NRC Pullen (para 22) and described by the senior Sea Cadet Officer, at Q/A 27.

68. Although times between about 1600 (Q/A 143) when he was last seen and 1615 (Q/A 510) when resuscitation began on the weather deck, have not been firmly established, it is clear that NRC Dax spent very little time in the heads before lapsing into unconsciousness. It is also clear from his position when he was found (TAB D) and the neat condition of his uniform (Q/A 307) that he suffered no distress other than the seasickness which took him to the heads in the first place.

69. The very rapid and irreversible deterioration in NRC Dax's condition tends also to support gassing rather than hypoxia as the principle factor in his death.

FACTORS

System Deficiencies

70. Included below is a list of as fitted deficiencies which have been identified in this review as contributing in one way or another to the accident involving NRC Dax. The list is not necessarily comprehensive; a thorough examination of the as-fitted arrangement in HMAS TOBRUK will be necessary before a final retrofit package for the ship's sewerage system could be defined.

71. The identified shortcomings in the sequence mentioned in the review are:

a. Some ships company heads discharge to the midships M/C tanks, preventing their isolation when troops are not embarked. This lost any significance it might otherwise have had for Dax because of the holding tank cross connection and because the ship could not readily flush out M/C tanks after use. (para 40)

b. Too much material is left in the M/C tanks below the low level cutouts. This lost its significance in Dax's death because of the holding tank cross connection. (para 41)

c. No redundancy in M/C transfer pumping arrangements. This had no significance in Dax's death. (para 43)

d. The marrying of holding tank vent lines introduces an excessive system backpressure. This was a major factor in the accident. (paras 48 and 49)

e. The dead-weighted flap valves on system vents are potentially dangerous. It is unlikely that this had any significance in Dax's death. (para 51)

f. The commonality of the P&S midships M/C tank vents with their associated holding tank vents. This was a major factor in the accident. (paras 52 & 53)

g. Unsatisfactory features of the sealing and venting arrangements of the systems draining to the M/C and holding tanks. The extent of the deficiencies will not be known until a full ship check has been completed but it is evident from folio 30 and from personal observation that there are widespread shortcomings, including departures from normal practice. This was a major factor in the accident. (paras 54 - 56)

h. The probably anaerobic state of the M/C tanks, due to the residual volume of material below the low level cutout. This was a significant factor in the accident particularly in view of the very low (but not nil, as designed) usage of the relevant M/C tank during the long period immediately prior to the accident. (para 57)

i. Unsatisfactory features of the heads compartment ventilation arrangements, bearing in mind the potential hazards from CHT system malfunction or maloperation. The unserviceability of the exhaust fan may have been a factor in Dax's death although it seems clear that he would have been breathing directly in the gas stream, whether or not the exhaust fan had been running. (para 58)

j. The inadequacy of flush-out arrangements, for M/C tanks in particular, bearing in mind the intermittent nature of CHT system usage. (para 59)

72. Little more than lip service appears to have been paid to the potential explosion hazard represented by the sewage gases generated and there are significant discrepancies in the provision of flame proofing devices. However the explosion hazard is less than has been thought in some areas, eg para 2b at folio 30 and para 12 of folio 27, due to the absence of CH_4.

73. Access to some parts of the system, eg the midships M/C tank pumps and macerators is poor, (para 23 of folio 30) inviting either poor maintenance standards or poor damage control. It is understood that at least one major sewage spill early in the ship's life was via poorly secured access plates (manholes), to the port midships M/C pump compartment and the port M/C tank beneath.

Design

74. The detailed design was carried out by the shipbuilder (CSPL) and his subcontractor (Mono Pumps) with drawing office assistance from Y-ARD (UK). The design guidance provided to the shipbuilder by Navy was minimal, consisting of a schematic and general instructions included in specifications attached to the contract. It did little more than indicate:

a. That a CHT type of system was required.

b. That only the aft M/C tanks were for ship's company use; the remaining four tanks being for embarked troops use only.

c. That both blackwater and greywater drains should be capable of being directed either overboard or to M/C and holding tanks.

d. Air agitation of holding tanks was to be provided, at a stated air flow.

e. Flame proofing of holding tank air vents was required.

f. Tank cleaning arrangements were to be provided (hose connections for M/C tanks; fixed flooding arrangements for holding tanks).

g. Chlorination of holding tanks was to be provided.

75. Nevertheless, leaving aside for the moment the important matter of the vent pipe cross connection, the design guidance should have been sufficient were the shipbuilder's working drawings to have been referred back to the Design branch for vetting, noting that the branch possesses an Environmental Control Officer whose tasks within Navy Office include sewage handling. As is evident from his report on TOBRUK's installation, at folio 30, there is an awareness within the Design branch of the need for adequate venting and sealing of sewerage systems and of the inherent risk of dangerous gas generation.

76. In any case, it appears that even the conventional sections of TOBRUK's sewerage system have departures from normal practice, particularly with regard to venting to avoid syphoning and back pressure (paras 19 and 45 of folio 30 and para 55 above).

77. DGFM's own necessarily brief examination of TOBRUK's CHT system indicated the possibility of further shortcomings. For example, the slops sink in the washdeck locker outside 3DZ4 heads compartment had originally been connected to the holding tank itself; and no doubt there are other potential gas paths throughout the ship. They have a particular significance in troops' accommodation where, during prolonged periods of disuse, water seals could be lost dynamically or through evaporation.

78. One departure from design guidance which did occur and which was potentially dangerous though not significant in TOBRUK's accident, was the routing of several blackwater drains from ships company heads to M/C tanks intended for embarked troops use only (paras 39 and 56 of folio 30).

79. As already discussed, a feature of the design guidance which was potentially hazardous and which did contribute to the accident was the marrying of the midships M/C tank and holding tank vents (para 52).

80. Generally, the Design branch had no responsibility for positive vetting of the shipbuilder's implementation of guidance. Having contributed to the Shipbuilder's Estimating Package (SEP), Design branch involvement was confined to making responses to Project Office demands. The shipbuilder set about his task of detailed design and subsequent build, subject only to Quality Auditing by the General Overseer (GOSIEAA) and to the requirement to demonstrate at the acceptance stage that he had successfully fulfilled his contract. Matters arising from QA or from trials which required Design branch attention would need to have been referred to that branch, by the Project Office.

81. It is evident that a specification forming part of the SEP must contain any particular requirements Navy may have, if it is to be assured that those requirements are met by the shipbuilder. With the benefit of hindsight it appears that Design guidance for TOBRUK's CHT system should have dwelt more heavily on the need for safety from both suffocation/gassing and fire/explosion and the greater than usual attention to be paid to gas seals and venting. Nevertheless CHT systems are not newcomers to the marine environment and it seems reasonable for a reputable shipbuilder to be considered competent to design and build a viable plant.

82. There is nothing particularly wrong with the nature of the Design branch's involvement, at para 80, but its dependence upon a satisfactory Inspection Tests and Trials (ITT) procedure is evident. Again, leaving aside for the moment the important matter of the specified vent pipe cross connection it is in ITT that the installation of TOBRUK's CHT system seems to have failed.

Inspections, Tests and Trials

83. The arrangements under which the ship was built by CSPL excluded direct oversight by Navy. CSPL were required to establish a Quality Control (QC) plan and they did eventually do so. Navy was represented on site during the build, by GOSIEAA, whose officers audited CSPL's QC procedures. GOSIEAA

representatives have advised DGFM that CSPL's performance in this field was unsatisfactory and that towards the end of the build GOSIEAA officers had virtually to revert to overseeing, see Annex H. The dissatisfaction felt by the standby crew, with the situation, is strongly expressed at Annex I.

84. An agreed ITT plan was developed and included in the contract specification. It included both a Final Installation Inspection (FII) and a Contractor's Sea Trial (CST) of the sewerage system (Annex J).

85. Although the ship was apparently not to be built formally under the terms of ABR 1921, Instructions for HMA Ships Building, Undergoing Modernisation, Conversion or Extended Refit (Aug 1973), GOSIEAA had been identified by Navy Office as the authority responsible for ITTs, as in ABR 1921 Art 2107 (Annex K). RANTAU assistance was used by GOSIEAA to the extent felt to be possible in a ship not built to normal naval standards - a source of some difficulty and confusion for RANTAU, see Annex L. It is understood that disagreements arose between GOSIEAA, RANTAU and the ship's staff to the extent that working relationships were strained, see para 83.

86. The FII of the CHT system appears to have been conducted on 19 Jan 81 and setting to work was attempted over the next several days at sea. The system overflowed several times and the attempt was abandoned. Records (folios 30D at second page) indicate only that the system had not been set to work and that the trial was unsuccessful. However a witness, (a Fleet Staff officer representing DGNHS at GOSIEAA's request) has informed DGFM that the M/C tank transfer pump starting switches did not operate and that alarm systems were unsatisfactory. The spill involved the forward and midships M/C tanks. A further trial was attempted during CSTs on 17-19 Mar 81 under GOSIEAA supervision but it was unsatisfactory also, judging from the recorded deficiencies, see folios 30D at fifth page.

87. The ship commissioned on 23 Apr 81 by which time it is understood that the deficiencies identified at CSTs had been corrected. However a major sewage spill occurred on the day of the commissioning, attributable to system deficiencies (unsatisfactory pump switches). This spill involved the forward M/C tanks only.

88. A further major spill occurred on 18 May 81, in Sydney, this time involving both midships M/C Tanks and the holding tanks. The spill is believed to have occurred when the holding tanks overflowed to the M/C tanks via the common vent pipes and thence via the WC pans in both 3DZ4 heads and 3DZ3 heads, to port and starboard messdecks. However, although the spill was damaging and led to expensive repairs (TSM 200 DH 16/85 at folio 32B and see Annex M) there does not appear to have been a formal investigation of its cause.

89. The same witness as before (para 86) has reported seeing huge gas bubbles in the contents of the overflowing heads pans. It appears that he had been called on board by the ship, to consider health aspects of the sewage spill and he states that he submitted a report on his return to Fleet Headquarters expressing

concern over the potential dangers of the plant. A search by the Fleet Staff has not unearthed a copy of that report and it is not known whether any action was taken on it.

90. The 'huge gas bubbles' were at first seen to imply a complete or partial blockage of the common vent pipe, perhaps arising from unsatisfactory work during construction and a test was conducted by the ship at DGFM's request but it proved negative, see Annex N. As discussed at para 53, further consideration led to the realisation that the obstruction to flow may simply have been due to under designing of the pipe, worsened later by the modification at para 49.

91. Further deficiencies were identified by the Project Design Manager on 11/12 Jun 81, during a ship visit to explore the sewerage installation, see folio 32C. His report discusses the existence of foul odours emanating from the midships combined vents and forecast the extension of the vents up the derrick kingposts in accordance with the Navy Office drawings at Annex B. The existence of anaerobic conditions in the M/C tanks seems to have been recognised and the solution was seen to lie in the provision of six hour time switches. Twelve hour switches were subsequently fitted (para 41) but the difference is not considered significant in the context of the accident.

92. Some rectification work was undertaken by CSPL during the period 10-16 Jun 81, including switch improvements and setting to work of the chlorination units (Annex M). It was observed that the ship was using the wrong chemical, see BOI report para 21a, the second page of folio 32D and Q/A 481. Apparently liquid sodium hypochlorite was being used because of difficulties experienced in dissolving calcium hypochlorite tablets and various patent chemicals had been added in the hope of controlling the smells.

93. Form TI 338, 'Report of Inspection of Ships prior to Acceptance into Service in HMA Fleet' - which was prepared by GOSIEAA staff with the concurrence of Navy Office was read for the first time on 11 Apr 81 upon the ship's delivery, and for the second time on 31 Jul 81. On neither occasion was the sewage system listed as deficient, although the Project Office had been advised of the possible need to include the outcome of the Design Manager's visit, at para 91. (It appears instead that forms TSM200 were used to report the deficiencies, because there was no contractor liability).

94. Further rectification work was undertaken as arranged by CSPL during the Post Shakedown Availability (PSA) in Brisbane 14 Aug - 11 Sep 1981, this work taking the form of modifications etc, not regarded as a contractor liability. It included the marrying and extension of the holding tank vents up the starboard kingpost (para 49), the supply and installation of contents gauges (para 50) and the restoration of spaces contaminated by the May 81 spill. The PSA work was carried out by local contractors under the supervision of GOSIEAA.

95. In summary, there does not appear to have been a formal trial with a satisfactory outcome. At least two Contractor's trials were conducted and both were unsuccessful, with identified shortcomings to be made good. Nevertheless the system appears to have been in use in one way or another, from some time before the ship commissioned until the fatal accident and as a result there were several spills, not all of which appear to have been satisfactorily explained. Modifications were made at intervals throughout the period, mostly aimed at improving the reliability of pump switching and at removing the smell away from ventilation intakes. There is clear evidence that the system was not and has never been set to work and operated as intended. There is also some evidence that sewage gases were entering the ship with the smells, following the same route they took when Dax was killed.

Documentation

96. The provision of documentation by the shipbuilder to Navy has lagged badly and even at the present time there is a shortfall in as-fitted drawings. A steady trickle of documentation has continued since commissioning which indicates that the cover and extent of general technical information available to the ship at the time of the accident was poor.

97. Concerning the sewerage system, the availability to the ship of supporting documentation is as follows:

Item (a)	Whether on Board 14 Dec 81 (b)	Remarks (c)
(1) As-fitted drgs	No	Only line diagrams were available.
(2) ABR 5431 - Equipment Handbook	Yes	Aimed mainly at component maintenance and repair but contained some useful guidance, see para 100.
(3) ABR 5407 - Piping Systems Handbook	Yes	Recorded as received by ship on 4 Nov 81 but may not have been distributed. Apparently found (unissued) in stores on board, after the accident. Contains essential guidance on valve operation but little to say about system theory see para 101.
(4) Miscellaneous Issues of Operating Instructions	Yes	Provided by manufacturers and ship-builder (see Q/A 474) as they became available from sub-contractors.

(5) Ship's Standing Orders	Yes	Chapter 0855 of the MEO's Section of the orders were earmarked to cover the sewerage system but had not been written at the time of the accident.

98. Ships Drawings. The lack of as-fitted information is a serious problem for any ship. In the absence of comprehensive ITTs, as in this case, it would not have been possible to identify the mis-direction of certain of the ship's company heads drains (para 71a) without as-fitted drawings. However, given that the ship had a very poor understanding of the CHT system (para 104) which had never been set to work properly (para 95), it cannot be said that the absence of drawings was a factor in NRC Dax's death.

99. Supply Support Documentation. Had not been supplied to the ship but cannot be said to have contributed to the accident.

100. ABR 5431 - Sewage System Equipment Handbook, HMAS TOBRUK. This book was available to the ship. It provides detailed descriptions of the mechanical and electrical components of the CHT plant necessary for their maintenance and it illustrates the system in block diagram form and schematics. It does little to describe the theory and operation of the system but it does contain the following relevant passages, from which important deductions should have been possible. They relate particularly to the vital importance of continuous aeration and chlorination, and indicate the different modes of operation, at sea and inside the 12 mile limit:

a. Ch 1. Introduction - Scope.

'2. The functions in the system include:

(c) The aeration of wastes in the holding tanks to prevent coagulation and onset of anaerobic conditions'.

b. Ch 1. Introduction - Purpose.

'4. ..... while steaming in unrestricted waters raw sewage and other liquid wastes can be discharged directly overboard without entering the system'.

c. Ch 4. Holding Tank Aeration Blower - General Description.

'3. An emergency air supply source is described in para 19 to 22'.

d. Ch 4 - Blower Operating Instructions.

(1) '16. The blower should be operated at all times when sewage is present in the holding tank'.

(2) '17. When the tank is emptied and no sewage is being transferred from the collector tanks, the blower may be shut down by pressing ....'

e. Ch 4. Emergency Air Supply.

'19. In the event of a breakdown or disconnection of a blower for service, aeration of the holding tanks can be maintained from the ship's main compressed air supply'.

f. Ch 5. Chlorination Unit - General Description.

(1) '4. The mixture of calcium hypochlorite tablets and water ....'

(2) '6. The effluent to be discharged should be tested regularly and the bacteria count should measure 10 000 coliform per litre or less ....'

g. Maintenance.

'19. The proper chlorination of the sewage in the holding tanks is vital to the safe storage of human waste on board .....'

101. ABR 5407 - Piping Systems Handbook - HMAS TOBRUK. This book was on board at the time of the accident but its presence was not recognised by the ship. The book describes the various piping systems throughout the ship, and the associated equipment and operating instructions for each system. Chapter 14 describes the sanitary and sewerage system valve operation in detail and it would be very difficult for the ship to recognise which valves to set correctly, according to whether the system was in operation or shutdown, without the book or similar instructions. However it provides no guidance on the theory behind the system and in this regard ABR 5431, described above, is much more valuable. Moreover it contains no relevant schematics which are not incorporated in ABR 5431, also.

102. Miscellaneous Items. Manufacturers' instructions, handbooks etc, were issued to the ship as they became available to the shipbuilder. It would be normal for some of them to be identified formally as Temporary Equipment Manuals. There was none of relevance to the accident but the ship does appear to have received relevant line diagrams and the like.

103. Ship's Standing Orders. They do not yet include a section to cover the sewerage system, see BOI report, Annex G, page 3.

Material Failure

104. The defective exhaust fan serving 3DZ4 heads, which had been removed for repairs, has been discussed, at para 58. Further discussion is at paras 156-158.

Ignorance and Maloperation

105. It appears from the MEO's evidence at the BOI (Q/A 431-485) that the ship had a satisfactory knowledge of the general layout of the system but little knowledge of its purpose or methods of operation including the difference between the 'restricted waters' and 'open sea' modes, (Q/A 437, concerning discharge to sewerage main or overboard, when the holding tank reaches the 60% level). There was a complete misunderstanding of the purpose and effect of aeration; with the result that aeration was employed only when discharging the contents of the holding tanks 'because during this process the smell throughout the ship is unbearable' (Q/A 437). Having misunderstood the reason for aeration and the effects of not doing so, it is not clear why the ship started up the aerators at all, unless it was to mix the injected chemical, calcium hypochlorite with the sewage, see para 16 of CO's Investigation, TAB H. Sometimes aeration was not used when pumping out, in order the avoid the smell. It appears from Q/A 485 that aeration was considered by the ship to be part of some sort of purifying process.

106. There is an impression given by the the MEO's evidence (see Q/A 467, 477, 483 and 484 in particular) of a continuing series of experiments with only part of the CHT system in use at a time, in a desperate attempt to combat the foul smells generated by it. No thought seems to have been given to whether the existence of the smell indicated some sort of malfunction or maloperation.

107. The ship was aware of the commonality of the midships M/C tank vents and the related holding tanks (Q/A 468) and that the modification which extended the common vent (para 52 and 53) to the top of the starboard kingpost resulted in all 4 tank vents being cross connected (Q/A 439). Moreover, they had the experience of the flood in May 1981 and appreciated that it followed the route of the common vent (Q/A 476). therefore on the basis of the BOI interview with the MEO, the ship appears to have been aware that there was a potential gas path from the holding tanks to the midships M/C tanks (Q/A 442) thence to the heads compartments via deficient water seals in the heads bowls (Q/A 445-446). There is an inference however that this questioning took place after some sort of reconstruction ex poste facto (para 22d(4) of BOI report); accordingly it is of limited value in establishing delinquency.

Personnel Factors

108. The CO, CAPT GLEX K.A. Doolan RAN stood by the ship from 18 Feb 80 and was still in command at the time of the accident.

109. The MEO who stood by the ship throughout the build, LCDR GLEN MESM N.J. Hornsby RAN, resigned and was relieved on 6 Apr 81, only seventeen days before the ship commissioned. LCDR Hornsby's reasons for resignation included dissatisfaction with the management of the build (Annex I). The incoming MEO, LCDR GLEN ME L.F. Shimbel RAN had received no PCT related to TOBRUK, there being no courses available. His seniority in rank is 31 Dec 81 but he had been granted acting rank from 6 Jul 81. His limited

experience had been a matter of concern at the time of his posting but shortages precluded any alternative.

110. The Chief Shipwright at the time of the accident, CPOMTH4 D.R. Green R42926 had relieved his predecessor on 23 Nov 81, only three weeks before the accident occurred. He had received no PCT.

111. The total management system under which the ship was built, commissioned and set to work is discussed in a later section of this review. It was complex and tended to isolate the standby crew from their *ship before commissioning,* thereby inhibiting self-teaching and on-the-job training. This was a source of particular difficulties for the ship, see Annex I. After commissioning, the ship's company found themselves beset by difficulties. In addition to the normal problems of getting to know their new ship and of working up an inexperienced crew (without benefit of formal technical training, at least) they were distracted by major engineering problems, affecting main propulsion performance and reliability, particularly.

112. Compounding the engineering problems were difficulties imposed by warranty considerations, *necessitating the multilateral* involvement of the Project Staff, GOSIEAA, the Shipbuilder, his Main Machinery Contractor, Sub Contractors, the Administrative Authority (and in some aspects his delegate, COMAUSPHIBRON), and finally the ship itself. It is small wonder that in this complicated situation, the Administrative Authority's normally close involvement with a fleet unit's materiel problems, particularly during safety inspections and the workup period, may have been reduced.

113. Undoubtedly the ship was further distracted by her programme and forthcoming involvement in K81. The *very small* complement appears to have been determined to get the ship going one way or another and prudence may sometimes have given way to 'can-do' and often commendable initiative.

114. [redacted] is acutely aware that his examination of the background to the personnel and overall management factors has been unavoidably cursory but feels that little would be gained by further dissection at this stage. It is sufficient to observe that the ship's staff had a very difficult time of it, from when they first stood by until the accident, and that there were many factors which helped distract their attention *from the latent* dangers of the, by now thoroughly offensive sewerage system.

115. With the benefit of hindsight an obvious option available to the ship was to shut down the CHT system until the other more pressing problems had been overcome or until assistance could be obtained. However, this would have been a major administrative step for such a junior MEO to have initiated, particularly in the light of his SD List background. It is not quite so clear why a similar course was not initiated by the command or by the Administrative Authority.

MANAGEMENT ASPECTS

116. Management of the ship's build, trials, transition into service and subsequent operation played its part as a factor in the circumstances surrounding the accident but because of its complexity it is appropriate to consider management under a separate heading.

117. Put at its simplest, Navy specified in very broad terms a sewerage system for installation in TOBRUK, but does not appear to have provided itself with the means of ensuring that it got what it paid for. The system, which now contained severe design deficiencies (vents, seals, accessibility etc), was not set to work nor proved functional, regardless of whether it was to design specification. It suffered a number of component deficiencies (pump switches, alarms) whilst still under warranty. It was put in the hands of a ship's staff which had received no training or instruction in its use. Supporting documentation was insufficient for self teaching. The ship was commissioned and employed whilst it still suffered a number of seriously distracting problems with main machinery and auxiliary systems. Being commercially built these and other problems were dealt with under an unusual and difficult set of rules governed by warranty considerations.

118. The ship's staff never did hoist in the underlying theory of the sewage treatment system and in their futile attempts to put it into operation, the system was allowed to become anaerobic, very smelly and highly dangerous. The material deficiencies (no contents gauges, inadequate alarms, defective switches) led to a series of debilitating and expensive spills, before and after commissioning. Those before were dealt with by the shipbuilder, with the knowledge of Navy's representatives; those after were dealt with at first hand by the ship's staff, keeping all concerned naval authorities informed, including the Fleet Commander, the Type Commander and Navy Office.

119. The follow-up, which does not appear to have involved FHQ in an executive role, nor functional areas in Navy Office in an advisory role, concentrated on clean up, improved component reliability and diversion of the smell away from crew spaces. There was no formal investigation, inquiry or design review, on board, by the administrative authority or Type Commander, or in Navy Office. Nor does the ship appear to have called for help in setting the system to work; or, as discussed at para 115, to have refused to operate it until it could be shown to be functionable.

120. Against this background, it is not possible to identify a single act of mismanagement but for which this fatal accident would not have occurred. Unquestionably however, management in the total sense, failed and in order that lessons are learnt it is necessary to explore any shortcomings in the various functional areas which together make up the total management picture.

121. One aspect, that of Project Management, is too big a subject for this review to explore thoroughly without delaying this report unacceptably. The following comments concerning Project Management should therefore be considered as indicative only.

Construction Phase

122. Navy Office - Functional Areas. It would be futile for functional areas within Navy Office to become directly involved in the management of a new construction project. Responsibility must be left in the hands of the Project Director, to consult with and enlist the aid of functional areas as the need arises. In this he has the authority and guidance of Materiel Division to support him. In the case of TOBRUK's CHT difficulties, any consultation would have been with the Design Division but it appears from para 55 of folio 30 that there was none, during the setting-to-work phase. Earlier Design Branch involvement appears to have been within the Project organisation and resulted in the highly significant amendment to the guidance drawing at Annex C, which resulted in the marrying of the midships M/C tanks' and holding tanks' vent lines.

123. Project Office. The complement of the project office was minimal. Nevertheless, in general terms when faced with setting-to-work difficulties it must surely rest with the project organisation to go to the Design Branch and say: 'This is the problem; are you satisfied your design requirements have been met?'; and this was not done. However in the particular circumstances of TOBRUK's CHT system, the setting-to-work problems centred on component failures and although they were not overcome until well after commissioning, the process of correction appears to have continued purposefully, under GOSIEAA supervision. The necessity of confirming that design guidance has been met, with satisfactory results, was discussed earlier, at para 82. The trials schedule must be adequate and enforced, which does not appear to have been achieved in TOBRUK's case, so far as the CHT system is concerned.

124. Supervision. The difficulties confronting GOSIEAA, RANTAU and the standby crew were briefly mentioned, at para 85.

a. The notion that GOSIEAA should not provide an overseeing service is practicable only where it can be assured that the contractor has an adequate QC organisation, and this does not appear to have been so in TOBRUK's case.

b. RANTAU needs clear guidelines in the way of trials schedules and standards to be met. The schedule for the sewerage system at Annex J was inadequate, given the brevity of the design guidance provided for the contractor. What seems to have been necessary was a schedule of tests to ensure a working system, not merely to ensure that the specified design guidance criteria had been incorporated.

c. It is probably right that the standby party should not become directly involved in contract supervision but they represent a scarce resource, technical expertise, which should not be wasted. Their incorporation into the project as some sort of an extension of the Project Office, or of GOSIEAA appears desirable for the project and essential for their own morale. This latter aspect has already been addressed at para 83.

d. Upon commissioning, the Fleet Commander assumed Operational Control and still retains it. As far as can be established he was then, and still remains the ship's Administrative Authority but DGFM has had varying advice from elements within Fleet Headquarters as to the way in which that responsibility was to be exercised. It appears from a review of signal correspondence during the period concerned that defect reports were being directed to COMAUSPHIBRON but subsequent actions were taken by a variety of authorities including HMAS MORETON and GOSIEAA, as well as COMAUSPHIBRON, with reports being variously directed: to COMAUSFLT, or COMAUSPHIBRON or MORETON.

e. The warranty element further confused the situation. For example recovery from the spill in May 1981 appears to have dwelt heavily on warranty considerations even though it was never positively established how the spill occurred. Such uncertainties, at least in the administration of technical matters undoubtedly played their part in the circumstances which ultimately led to the accident involving NRC Dax.

Commissioning

125. With the benefit of hindsight, particularly in view of the main machinery problems being experienced, it is arguable that the ship should not have commissioned when she did, despite the pressing administrative problems inherent in a further deferral of the ceremony itself. Commissioning per se should alter nothing but in practice it does. A ship's company with morale to be considered, is introduced; the command assumes a direct responsibility hitherto denied it and the Fleet Commander acquires an asset to be programmed.

126. Just what is to be done with a commissioned ship which has not yet been completed has to be decided and the ground rules published. This is a task of great complexity, involving inputs from functional areas not previously involved, like the Fleet Maintenance Branch and the Fleet Commander. Once again it is the Project Office which must take the lead in providing the guidelines for what amounts to the transition of a ship from procurement to maintenance. There is an apparent need for this task to be tackled on a broader front, with the object of providing a standard operating procedure for the guidance of all new construction project offices.

Form TI338 - Report of Inspection of Ships Prior to Acceptance for Service in HMA Fleet.

127. In the absence of any other transition package, form TI338 in its initial form (first reading) should define the condition of the ship at handover, identifying those discrepancies which the contractor has responsibility to make good. (Probably it should also acknowledge other shortcomings, for attention in

due course by Navy). As discussed at para 93, TOBRUK's TI338 at the first reading did not include the sewerage system (Annex O). Discussions with GOSIEAA staff have established that it had been incorporated at the draft stage but was removed at the last moment, on completion by the contractor of some component repairs.

128. The decision to exclude the sewerage system altogether from the TI338 appears in retrospect to have been unwise but in the absence of a more demanding ITT requirement, was not entirely wrong. On the one hand, the contractor might have claimed that he had met the terms of design guidance and thus had no unfinished work; and Navy might have had some difficulty in sustaining an argument that trials of the type specified (Annex J) had not been completed. On the other hand, the plant had not been set-to-work as a system and there had been (and still has been) no trial of the system's ability to treat sewage as intended.

129. On balance it is considered that the TI338 at the first reading should have included notice of an outstanding trials requirement for the sewerage system. Whether the notice should have been included amongst the 4 pages of List 1 items (contractor rectification) or as a List 2 item, (of which there appear to have been none), should have been for the Project Office to agree with the shipbuilder.

130. It is relevant that an additional 76 pages of outstanding work identified during FIIs had been prepared for the first reading of the TI338 but not annexed thereto. They are the source of continuing contractual discussions between Navy and CSPL but have no direct relevance to the sewage plant, which does not appear in them.

Post Commissioning

131. Navy Office Functional Areas. The Project Office retained some responsibility for TOBRUK at least until the end of the warranty period but delineation of the project/functional interface has not been clear. In the absence of a published transition policy (para 126) the interface has been marked by uncertainty and some reluctance on the part of functional areas to become involved. Although DEFNAV CANBERRA received information copies of most relevant traffic there appears to have been a generally held view that, because of continuing problems with equipments under warranty, the ship remained under procurement and therefore with the Project Office. The Fleet Maintenance Branch which could by now have become usefully involved, does not appear to have been consulted on the sewage problems, nor taken any initiatives. The Design Branch involvement appears to have been limited to a ship visit by the Project Design Manager following the serious spill on 18 May 1981, see para 91.

132. Project Office. Given that para 131 reflects the Navy Office attitudes at the time then it rested with the Project Office to seek functional area involvement. That this did not happen tends to suggest an unawareness on the part of the Project Office, of the serious nature of the sewerage plant problems being experienced by the ship. This is taken in turn to imply that the

Project had reasonably supposed an assumption of some related responsibilities by the ship and by the Fleet Commander.

133. Supervision. The Administrative Authority's involvement is discussed later, at para 136. Supervision by GOSIEAA appears by now to have been limited to TI338 and warranty matters, on behalf of the Project Office, which seems satisfactory.

134. Form TI338, Second Reading.

a. An attempt was made to read and sign HMAS TOBRUK's TI338 for the second time, on 14 May 1982. By now the additional 76 pages of deficiencies (para 130) were being addressed by the Commanding Officer, who sought also to include the 'unsatisfactory sewerage system' (Annex P). The Commanding Officer HMAS TOBRUK refused to sign form TI338-3 for the reasons outlined in Annex P and sought an extension of time. Shortly afterwards, on 18 May 81, the major sewage spill discussed at para 88, occurred.

b. Following the system modifications and equipment repairs during the AMP in Brisbane in June 1981 (Annex M) form TI338 was signed on 31 July 1981 in its original form (ie 4 pages only), by the ship. Again there was no mention made of the sewerage system although it is clear that it was still not understood nor being run properly. It appears from the Commanding Officer's decision to exclude it from his earlier list of deficiencies that there were by now no defective components in the CHT system and that the ship believed it to be operable.

c. It was during the June 81 AMP that the Design Manager inspected the sewerage plant on board and wrote the report at folio 32C, out of which came the vent pipe modification discussed at para 49.

135. Further Contractor Involvement. The ship underwent her post shakedown availability (PSA) in Brisbane in August 1981, during which period the effects of the May spill were made good, at an approximate cost of $24 000. Other work included the Navy Office inspired modifications identified by the Design Manager at Folio 32C. They included the vent pipe extensions, the addition of time overrides on the M/C tank transfer pump controls (para 91) and the addition of remote reading contents gauges.

136. Command, and Administrative and Operational Authorities. The involvement of the Fleet Medical Administration Officer in the FII and aborted trials in January 1981, is discussed at para 86. The same officer was also involved in the aftermath of the 18 May 1981 spill, (para 89), as was the Fleet Marine Engineer Officer (FMEO), and both viewed the spill at its worst. Like Navy Office, FHQ was an addressee on all signals to and from the ship dealing with the spill and its aftermath and defect reports and work requests (TSM200) were routinely addressed to FHQ for approval and allocation. After discussion with ship's and Fleet staff officers, [redacted] is left with the impression that both groups were more concerned with overcoming the symptoms than with the disease

itself. Perhaps, as discussed at para 115, they were distracted by the evidently defective components (principally the switches and alarms) and of course with combatting the smell, and they appear to have given little thought to the reason for and significance of the latter. The Fleet Medical Administration Officer's apparent concern for safety aspects (para 89) was not pursued. A formal enquiry into the 18 May 81 spill appears to have been warranted and the lack of one is considered very significant in what followed.

FURTHER CONSIDERATIONS ARISING FROM REVIEW

Magnitude and Rapidity of Gas Build Up

137. It appears that the BOI view, at para 22d(4) of their report, that preferential leakage from the holding tank to an M/C tank would be rapid is purely supposition, since no trials were conducted. However, it was because a similar inference could be drawn from the witness' report of 'huge gas bubbles' (para 89) in the over-flow during the May 1981 spill, that the possibility of a complete or partial blockage in the holding tank vent lines was explored with negative results (Annex N). However, positive checking of all vents should be carried out as part of an eventual set-to-work of TOBRUK's CHT system.

138. Nevertheless there is little doubt that on starting up the aeration plant, a flow of sewage gases from the holding tanks to the heads compartment via the M/C tanks did occur, and as discussed at paras 63 and 64, such a flow is possible under dynamic conditions, see Annex G. That this flow pattern developed is demonstrated by the rapid increase in the foul smell at the aft end of the ship after aeration began, notwithstanding the remote location of the holding tank vent outlet (at the top of the king-post) and the high recirculation rate of ventilating air. The evidence of a witness at the BOI (Q/A 26-27) suggests that sewage gases may have been leaking along this path, from time to time over a long period, and indeed there is no reason to think otherwise.

Nature of Gases Present

139. The gas models used by DGND's Environmental Control Officer at folio 30 were abstracted from a research paper developed at the USN's David Taylor Naval Ship Research and Development Centre (DTNSRDC) at Bethesda. A copy of the whole paper has since been examined in the course of this review and it was as a result that it is no longer believed that methane played a part in NRC Dax's death. The paper is at Annex Q.

140. The DTNSRDC research included tests on a series of sewage mixtures aimed at establishing the gas content of tank ullages in naval CHT systems, and in no case was methane found to be present. Test samples were monitored for periods of up to 359 hours which is well in excess of the dwell time in TOBRUK's holding tanks, though less than the time spent in the M/C tanks by some of the approximate 1.04 tonnes of sewage waste below the low

level suction of the macerator/transfer pump. Noting, however, that a rapid increase in smell was associated with aeration of the holding tank, and that all the reported incidents of gassing effects, including NRC Dax, followed the commencement of aeration (notwithstanding that there had probably been earlier use of the heads compartment by other cadets, Q/A 37-39 and 44-45), it appears that the primary sources of the toxic gas were the holding tanks.

141. The DTNSRDC research indicates that tank ullages would have contained significant quantities of toxic gases (the foul smelling mercaptans as well as hydrogen sulphide and ammonia) of which it is considered hydrogen sulphide was both plentiful (above 1700 ppm) and the most dangerous.

142. The absence of methane has been briefly discussed with USN authorities, see folios 39 and 40. The USN response confirms the DTNSRDC experimental results and attributes the lack of methane to the high acidity of the waste caused by salt flush water. The addition of calcium hypochlorite as a sterilizing agent would tend further to inhibit the production of methane.

143. Significantly, the USN attributes the condition of a very seriously ill sailor following a CHT system accident on board USS INDEPENDENCE (folio 40) to his inhalation of H_2S boiling off from pressurized sewage waste, released to the atmosphere in the course of mal-operation of a system component.

144. Correspondence with Y-ARD (folios 41-44) has elicited the assertion that both CH_4 and H_2S would have been present, the latter still in lethal concentrations. The data appear to have been collected experimentally but it is not known whether the test samples used salt flushwater, as in the DTNSRDC experiments. The Y-ARD paper also introduces the remote possibility that Chlorine was the cause of death, and it is noted in this context that the ship had experimented with various chemicals to overcome both the smell and some difficulty experienced with dissolving the approved calcium hypochlorite tablets (para 92). These matters should be pursued separately.

145. Whilst H_2S is unquestionably very dangerous (para 62), it must be borne in mind that there should have been none in a properly operated holding tank and even in a mal-functioning or mal-operated but properly built tank there should be no leakage across the tank boundary. TOBRUK's M/C tanks are a different matter of course, because a degree of anaerobiosis appears inevitable (para 57), despite time switching, and frequent partial changes of their contents. The extra importance of gas boundary seals for the M/C tanks has already been identified.

146. The BOI conclusion that methane may have contributed to Dax's death followed from its assessment that the sailors and cadets affected by the sewage gases on 14 Dec 1981, generally reported no symptoms of H_2S poisoning, namely, prickling or stinging of eyes, nose and throat. (The BOI appears to have discounted some minority evidence to the contrary at QA 269/270, perhaps on the balance of probability). [redacted] is unaware of the clinical effects of H_2S inhalation at a level below that at which death occurs (for which, see DGNHS' remarks at folio 38),

apart from dulling of the sense of smell (para 13) but the rapidity with which NRC Pullen and ABETW McLeod were affected (para 23) appears significant. Moreover, NRC Dax's own irreversible collapse appears to have resulted from the briefest of exposures to the contaminated atmosphere: possibly a matter of only a few minutes. The Y-ARD advice (para 62) that respiratory paralysis occurs in H_2S poisoning is obviously relevant.

147. As discussed by DGNHS at *folio 38*, H_2S poisoning can be established by careful post-mortem examination but is unlikely to be recognised where, as in Dax's case, the examining surgeon is not first acquainted with the possibility.

148. On balance, [redacted] formed the opinion that suffocation by the inhalation of an atmosphere in which oxygen had been displaced by methane was not the most likely cause of Dax's death: rather that poisoning had occurred. The subsequent find of the DTNSRDC research paper accorded with this opinion and led to the conclusion that it was as a result of breathing an oxygen-starved atmosphere containing H_2S amongst other by-products of anaerobic decomposition of highly acidic sewage, that NRC Dax died.

Tank Cleaning Arrangements

149. As discussed at para 59, the CHT system tanks should be cleared of sewage before securing the system after use and to this end Design guidance called for permanent salt water connections to be installed in the holding tanks and hose connections supplied for the M/C tanks. The former appear to have been used by the ship's staff and though inefficient as tank cleaning aids, were probably adequate for the purpose. There is no evidence that the latter were used routinely, if at all, and they are clearly inadequate, since their use requires that the tanks be opened for access first. There is an obvious inference that they were intended for use only for periodic tank cleaning, prior to access by maintenance personnel, for hull inspection or preservation, or for maintenance of such internal fittings as the macerator units.

150. The M/C tanks, and for that matter the holding tanks, are confined spaces as defined in ABR 5225 and thus, before entry is permissable, they would have to be opened and force-ventilated for a minimum period of 24 hours: an untenable situation in view of the tanks' use and the unavoidable residue below pump suctions. The fortuitous provision of an alternative flushing arrangement in the form of soil pipe clearing connections (para 59) was not known to the ship's staff and in any case provides only a partial solution.

151. Design guidance was minimal and the as-fitted arrangement was inadequate, and it is concluded that insufficient consideration had been paid by both Navy Office and the shipbuilder, to the requirements for tank cleaning and access for maintenance. At the minimum, installed sprays are required in both holding and M/C tanks, as in the FFG's CHT tanks and in RN Type 22 ships for example, and some form of bottom agitation seems desirable in the M/C tanks, particularly in view of the residue below the transfer pump low level cut-outs. Redesign of tank bottoms to minimise this residue could prove to be a better solution.

Macerator/Transfer and Discharge Pumps

152. The use of hull tanks, rather than free-standing units as in the FFGs and DEs, probably led to the selection of positive displacement pumps for the transfer and discharge of sewage wastes. As discussed at para 41, the Mono pumps fitted must not be allowed to run dry lest their stators be permanently damaged. The unacceptable result, in the absence of a suitable 'stripping' arrangement is that the tanks cannot be pumped dry. In addition to the danger of gas generation already discussed, a consequence is that tank ventilating and cleaning is difficult and very unpleasant, if not actually dangerous.

153. Several solutions to the pumping problem present themselves, viz:

a. minimize residual waste by the provision of pump suction sumps or sloped tank bottoms, like the FFGs for example; or

b. retain existing Mono pumps but add positive displacement stripping pumps eg, diaphragm operated units; or

c. as for b. but use air, steam or water operated venturi pumps as in SUPPLY's cargo tanks; or

d. replace Mono pumps with other positive displacement pumps such as in b. which may be hand-controlled when desired to pump the tanks dry (similar overrides are fitted to the centrifugal pumps installed in the FFGs); or

e. re-engineer the CHT system to provide free-standing tanks (permitting the use of centrifugal or axial flow pumps), or the installation of one of the many packaged Marine Sewage Devices (MSDs) presently on the market.

Machinery Space Access, Ventilation and Anti-flash Devices

154. Both the BOI and DGND's Environmental Control Officer (folio 30) have highlighted an explosion risk based, in both their assessments, upon the presence of methane. Design guidance included the requirement for flash gauzes to be fitted to holding tank vents only (para 74e). As discussed at para 139, the likelihood of flammable gases being present in significant quantities is probably slight; however, sensible precautions appear prudent and their provision in TOBRUK should be validated.

155. Except in the case of the aft pair of M/C tanks, macerator motors and transfer and discharge pumps and associated valves are located in unventilated compartments below mess decks and passageways, accessible only through bolted-on manhole covers. This quite unsatisfactory arrangement invites either the disregard of rules governing entry to confined spaces, (para 149) or poor standards of inspection and maintenance of machinery.

Improved access arrangements will be hard to achieve and this will be a factor in deciding whether a major pump re-design is necessary.

Heads Compartments - Ventilation, Access and Security

156. The significance of a defective fan and its removal from the exhaust trunking serving 3DZ4 heads has already been discussed. Other heads compartments, including 3CY4 which was also used by the sea cadets, drain to the midship M/C tanks and it is scarcely likely that none was entered and used during the period 1530-1600 on the day of the accident.

157. There was no inspection of water seals in any of these other heads following the accident and therefore it is not possible to assess whether one or more of them were also in a leakage path from either the port or starboard holding tank. In the absence of such evidence the part that the missing fan played in NRC Dax's death cannot be established though there is no doubt that had it been there, it would have reduced the gas concentration in the compartment generally. However, as pointed out at para 71i, Dax's face was directly in the gas stream and he was at serious risk regardless of the fan.

158. The BOI, at para 25b, considered that the ventilation supply arrangements were inadequate; a matter for consideration on a number of grounds:

a. Balance. The flow area through the jalousie in the passageway door must be sufficient for the exhaust fan capacity. This needs checking.

b. Capacity. As indicated at para 52, Naval standards require that the air change rate in 3DZ4 heads should have been 300 cfm. The measured capacity of the fan is only 247 cfm, suggesting underdesign. This needs checking.

c. Redundancy. In the absence of a gas hazard there is no requirement to provide redundancy in heads ventilation. Should it prove impossible to design against anaerobiosis in the M/C tanks then it would be more appropriate to provide a secure gas boundary and gas monitors/alarms, than to rely on ventilation system redundancy.

d. Location. The BOI considered that the fresh air inlet should be relocated from the bottom of the passageway door to a higher position in the compartment. This is not agreed because to do so would be to provide a short circuit between the fresh air inlet and the stale air exhaust which is at deckhead level. In any case, it is relevant that H_2S is lighter than air and should therefore be replaced from the bottom of the compartment, not the top.

159. With regard to access, the BOI was concerned that heads cubicle doors should be rehinged to swing both ways (ie batwings). This should not be necessary, see the Fleet Commander's comments at para 6g of folio 22 and DNUR at folio 26.

160. Concern was also expressed by the BOI that heads cubicle door latches should be operable from the outside. this seems a quite unnecessary reaction to an isolated incident. More to the point perhaps, the BOI explored whether the troops' heads and bathrooms were locked when no troops were embarked (Q/A 417), with negative results. It would be sensible to do so but is presently impracticable because of the poor quality of door locks and catches on the solid core, timber-laminate doors fitted. Improvements are necessary in this area, noting that had the heads compartment (and all other unoccupied troops' spaces) been locked then neither Dax nor any other cadet could have entered 3DZ4 heads compartment in the first place.

CONCLUSIONS

General

161. The following conclusions relate to the immediate circumstances of NRC Dax's death:

a. He had felt seasick at about 1600 on 14 Dec 81 and had gone to 3DZ4 troops heads where he vomited into a dry heads bowl. The atmosphere in the heads compartment was deficient in oxygen due to the presence of sewage gases, including hydrogen sulphide which was almost certainly in lethal concentration. He was discovered by NRC Pullen who raised the alarm. He was rescued after only a few minutes exposure but although resuscitation eventually restored his pulse, his brain did not recover and he subsequently died, on 16 Dec 81.

b. The rescue was performed expeditiously, with initiative and great courage on the part of Leading Seaman ETC Hughes.

c. Resuscitation was prompt and correct except in one particular - failure to intubate - but it is probable that Dax's condition was already irreversible due to respiratory paralysis resulting from his inhalation of hydrogen sulphide.

d. Hydrogen sulphide was present in the sewage gases, firstly because the ship's sewerage plant suffered both design and construction deficiencies; and secondly, because it had been operated incorrectly for a long period, due to ignorance.

e. The sewage gases escaped to 3DZ4 heads compartment because some water seals forming the sewage tank gas boundary had been lost, probably dynamically due to system deficiency, but possibly through disuse over a long period.

f. The pressure of the sewage gases in the tanks when they were generated, was higher than it should have been, because of a vent pipe modification.

g. The gas concentration in 3DZ4 heads compartment had built up because the exhaust fan was defective and had been removed for repair. However this may not have been a factor in Dax's death because he was directly in the path of the gas stream when he was overcome.

h. The Board of Inquiry erred in attributing oxygen starvation (hypoxia) to the displacement of air by methane, of which there was probably none present.

i. The pathologist may have erred during his post-mortem examination, in attributing death to hypoxia resulting from inhalation of vomit. The vomit found in Dax's lungs could have found its way there during the resuscitation attempt.

j. Whilst this review of the circumstances surrounding NRC Dax's death has identified many shortcomings in the design, construction, setting-to-work and operation of the sewerage plant, it has found no single act or omission but for which this tragic accident would not have occurred.

k. Subject to the integrity of water seals in heads bowls under dynamic conditions being confirmed and to the Holding tank and midships Macerator/Collector tank vent pipes being separated and enlarged, it is believed that TOBRUK's CHT system could safely be returned to operation. However, there are so many other features to be validated or modified, that little would be gained by its reactivation in the meantime.

162. The following detailed conclusions are drawn from the text of this review as indicated by the paragraph numbers quoted:

a. The BOI did not reach the right conclusion concerning the cause of death. Their assessment that methane was generated in the sewerage system and that it may have contributed to NRC Dax's death was incorrect. It is not known what effect this had upon the Coroner's decision to dispense with a separate inquiry.

(Paras 9-11, 47, 139 and 142)

b. NRC Dax's parents may be considering legal action against the Navy.

(Para 19)

c. The post mortem examination seems almost certain to have been wrong in attributing death to suffocation alone but did so in ignorance of the presence of sewage gases, including hydrogen sulphide, at the scene of the accident.

(Paras 13-16, 69, 139-141, 146 and 147)

d. Dax had probably become seasick and in order to vomit had gone to the heads where he became unconscious.

(Para 21)

e. In the heads he breathed an oxygen starved atmosphere deficient in oxygen and containing toxic gases which included hydrogen sulphide in apparently lethal concentrations. He lost consciousness very quickly and would have suffered very little distress apart from his seasickness.

(Paras 15, 16, 61 and 68)

f. NRC A.D. Pullen's alertness and unselfish action led to Dax's discovery and rescue.

(Paras 22 and 23)

g. Leading Seaman ETC3 D.I. Hughes' quick intelligence, commonsense, courage and perseverance were directly responsible for Dax's rescue.

(Paras 23-25 and 29)

h. TOBRUK's damage control organization had shortcomings at the time of the accident but they did not prejudice Dax's survival.

(Paras 23, 25, 27 and 28)

i. [redacted] attempted resuscitation did not include intubation as it should have done, but there is no reason to believe that this contributed to Dax's death.

(Para 29)

j. When rescued, NRC Dax's condition was probably irreversible and his death inevitable. Other personnel were temporarily affected by the gas but there were no casualties amongst them.

(Paras 30-33)

k. TOBRUK has a Collection Holding and Transfer (CHT) sewerage system which is intended to be aerobic in operation. Aerobic systems depend upon constant aeration of sewage to prevent onset of anaerobiosis and the generation of dangerous and foul smelling gases. The ship did not aerate holding tanks correctly.

(Paras 20, 36 and 46)

l. A shipbuilder's departure from design guidance in the arrangement of greywater (laundry, bathroom, galley etc) drains to the forward (ie., troops') Macerator/Collector (M/C) tanks was not significant to the accident.

(Para 39)

m. A shipbuilder's departure from design guidance in the arrangement of some ship's company blackwater (ie., heads and urinals) drains to the port and starboard midships (ie., troops') M/C tanks is potentially dangerous but in the context of this accident it lost its significance in the face of other considerations.

(Paras 40 and 78)

n. The effects of some inadequacies in system redundancy require closer examination.

(Para 43)

o. Calcium hypochlorite, which is used as a disinfectant, requires careful handling and instructions are inadequate.

(Para 44)

p. The sewage aeration system is provided with ample redundancy.

(Paras 45 and 100)

q. Post-commissioning modifications which married and extended the holding tank vent pipes were intended to carry foul smells away from occupied spaces. This modification effectively increased system back pressure and was a major factor in the accident.

(Para 49)

r. M/C tank (and other) vent pipe weather deck fittings should be pinned open in normal circumstances and kept free of paint and corrosion but they have been given insufficient attention onboard.

(Para 51)

s. The port and starboard midships M/C tank and holding tank vent lines were married by the shipbuilder in accordance with a design guidance amendment from Navy Office. This, coupled with the modification at 162q, became a major factor in the fatal accident.

(Paras 52, 53, 79 and 122)

t. Except for some shipbuilder's modifications forward, all blackwater drains rely on domestic water seals between the compartment from which they drain and the relevant sewage tank. This is common practice and should suffice if the seals' inherent limitations are appreciated and they are adequately constructed and protected. Greywater drains have the additional protection of NRVs between their water seals and the holding tanks.

(Paras 54, 55 and 145)

u. Extra care in the protection of water seals is necessary where minimum flush heads bowls are specified, particularly when the associated M/C tanks are anaerobic, as in TOBRUK.

(Paras 55-57)

v. However, the effect of the vent pipe modifications at para 162q and 162s was to generate maximum system gas pressure in excess of the obstructions provided by heads bowl water seals, thereby breaching the gas boundry, even if the seals had been in place.

w. The shipbuilder's modification at para 162t was to fit non-return valves (NRVs) in blackwater drains between heads and M/C tanks. Depending on the efficiency of the NRVs, similar modifications elsewhere could have avoided the accident.

(Para 54)

x. The 3DZ4 heads exhaust fan capacity is less than specified in the Naval Construction Manual but this was of no significance in Dax's death because the fan was defective and had been removed at the time of the accident.

(Paras 58 and 156-158)

y. The sewage tank cleaning arrangements are inadequate, and invite hazardous practices by maintenance personnel.

(Paras 59, 60, 149-153)

z. Dax was directly in the way of a leakage path for toxic sewage gases, from both the port holding tank and the port midships M/C tank, to compartment 3DZ4, when he vomited into a heads bowl which had lost its water seal. The same or similar gas leakage paths had probably existed over a long period.

(Paras 63-65 and 138)

aa. The generally dangerous situation was aggravated by the unserviceability and removal of the compartment exhaust fan. However, because Dax was directly in the gas path, the absence of the fan is unlikely to have been a factor in his death.

(Para 67 and 71i)

bb. The deficiencies already identified in the as-fitted sewerage arrangements may not be comprehensive and a ship check by Navy Office will be necessary to define the full retrofit package.

(Paras 70, 71 and 76)

cc. Flash proofing is incomplete and appears inadequate.

(Paras 72 and 154)

dd. Access to some parts of the sewerage plant is bad and invites hazardous practices and poor maintenance standards.

(Paras 73 and 155)

ee. The danger from the large number of potential gas paths was increased by the intermittent use made of troops' accommodation.

(Para 77)

ff. The design guidance given to the shipbuilder by Navy Office was minimal but except for the design error at para 160s, it should have been sufficient had there been a requirement for the detailed design to be sent back to Navy Office for vetting. There was no such requirement.

(Paras 74, 75, 80 and 123)

gg. The lack of detailed design vetting by Navy Office could have been compensated by comprehensive Inspection, Tests and Trials (ITT) procedures but these were not satisfactory.

(Para 82)

hh. The shipbuilder's Quality Control and Overseeing arrangements appear to have been unsatisfactory and were the source of dissatisfaction and criticism by the standby crew and GOSIEAA. The standard was not good enough for GOSIEAA's involvement to have been restricted to QA.

(Paras 83, 84 and 124a)

ii. An ITT Programme existed but RANTAU felt compromised by the requirement that the ship was not to be built to normal naval standards. RANTAU's involvement in ITT was too limited.

(Paras 85 and 124b)

jj. The specified trials of the sewerage system were unsuccessful, but hardware shortcomings were corrected to GOSIEAA's satisfaction by the time the ship commissioned. However the system continued to malfunction.

(Paras 87 and 88)

kk. A full-scale inquiry into the circumstances of a major sewage spill in the month following commissioning was warranted and could have focussed long overdue attention on the whole problem. There was no inquiry, despite concern about possible implications of the spill, expressed in some quarters.

(Para 89)

ll. Activity was confined to correcting hardware failure and removal of foul odours instead of exploring the cause of the smell and method of operation of the system. The system has never been operated correctly.

(Paras 91-95 and 134b)

mm. Documentation for the ship has generally been late and much 'as-fitted' information is still unavailable.

(Paras 96 and 99)

nn. The ship's staff possessed sufficient basic sewerage system information for them to have developed procedures for correct plant operation but were either unaware of it or incorrectly interpreted it. In these circumstances it was of no consequence that they had insufficient documentation to reveal the incorrect routing of the blackwater drains at para 160m.

(Paras 98-103)

oo. Whilst there are no sequenced operating instructions for the plant as a whole, the available documentation was clear and positive about the requirement for continuous aeration and the reason for chlorination.

(Para 100)

pp. Ship's Standing Orders dealing with the sewerage system had not been written at the time of the accident.

(Para 103)

qq. The ship's staff appear to have been completely ignorant of the principle of operation of the plant and became understandably distracted by the need to limit the smell, and pursued its effect rather than its cause.

(Paras 105-107)

rr. The ship's MEO and Chief Ship-wright were inadequately prepared for their jobs, particularly in view of the first-of-class nature of the CHT system installed.

(Paras 109-110)

ss. The MEO was really too junior and under-experienced to be posted as commissioning MEO of a new and unique ship like TOBRUK but Engineer officer shortages left no alternative.

(Para 109)

tt. The arrangements made for the standby crew did not adequately prepare them for commissioning the ship and were a source of acrimony and dissatisfaction.

(Paras 109-111)

uu. Warranty considerations obscured normal lines of responsibility.

(Paras 112 and 116e)

vv. There were many factors which distracted the small ship's company's attention from the latent dangers of the malfunctioning sewage system. The competing commitments ought to have prompted higher authority to cause the plant to be shut down until circumstances improved but there are understandable reasons why this was not done.

(Para 115)

ww. The ship's staff were not helped by a failure of Navy's total management system to recognize the evident shortcomings of the ship's operation of the plant and the inherent risks involved. This was an important factor in the accident.

(Paras 116-118)

xx. In the confused and confusing circumstances surrounding the ships entry into service there is no single act or omission but for which the accident would not have happened. However the ship should have called for help and refused to operate the plant until provided with 'expert' assistance; and the administrative authority should have inquired formally into the situation at the time of the 18 May 81 spill. Either action might have averted the accident.

(Paras 119 and 136)

yy. Design Branch involvement during the setting-to-work would have to be called in by the Project Director. There appears to have been little involvement, although the causative vent line modification (Para 160s) clearly came from Design Branch at an earlier stage.

(Para 122)

zz. The Project Director's role in enlisting NTS assistance during setting to work was not sufficiently exploited.

(Para 123)

aaa. The standby crew was a largely wasted resource during the ship's build and trials.

(Para 124c)

bbb. The identity and role of the Administrative Authority was cloudy.

(Para 124d)

ccc. With the benefit of hindsight and in the knowledge of the overall management problems, the ship commissioned too soon.

(Para 125)

ddd. Uncertainty could best have been avoided by the publication of a transition document detailing the arrangements for the transfer of responsibilities. This should be a standard procedure for ships commissioning and recommissioning.

(Para 126)

eee. The exclusion of the sewage system from the list of uncompleted work in TOBRUK's Form TI338 at the first reading might have been justifiable at the time in the light of the inadequate trials schedule, but was unwise.

(Paras 127-130)

fff. The Navy Office functional areas' involvement in the ship's sewerage system difficulties after commissioning was inadequate, apparently because of uncertainty over the transfer of responsibilities. The uncertainty should have been resolved by the Project Director.

(Paras 131-132)

ggg. The ship's refusal to sign Form TI338 at the second reading and its desire to include in it the 'unsatisfactory sewerage system' was valid but the opportunity for a fullscale investigation was not pursued. A subsequent assessment that the problems had been overcome sprang from ignorance.

(Para 134)

hhh. The Navy Office decision to modify tank venting arrangements and fit time overrides on M/C transfer pump switches was taken in the knowledge that anaerobiosis had occurred but the danger does not seem to have been appreciated. This was an important factor in the accident.

(Paras 49, 50, 131, 134, 135)

iii. The tank vent pipes are probably not obstructed but this should be further explored.

(Para 137)

jjj. USN experimental evidence of H_2S in lethal concentrations rather than CH_4, appears conclusive and is supported by the circumstances of a USN accident, as well as by factors in TOBRUK's accident.

(Paras 139-143 and 146-148)

kkk. Recent comment from Y-ARD (UK) that both H_2S and CH_4 would have been present, the former in lethal concentrations anyway, may be invalid and requires further inquiry.

(Para 144)

lll. Were TOBRUK's system to have been operated correctly, some H_2S would still have been present in the M/C tanks, thereby underlining the fundamental importance of gas boundary seals.

(Paras 54 and 145)

mmm. The use of hull tanks for sewage collection and treatment in TOBRUK introduced tank stripping and pumping problems not experienced with the free standing tanks in other ships. Redesign is desirable.

(Paras 152-153)

nnn. Troops' quarters, particularly heads and bathrooms should be secured when troops disembark but doors and fittings are inadequate.

(Para 160)

ooo. Heads cubicle doors cannot be opened from outside and it would be beneficial were their hinge pins to be made removeable.

(Paras 159, 160)

Conclusions Drawn by the Board of Inquiry

163. The following comments relate to the BOI's conclusions, seriatim, noting the Fleet Commander's (FC) remarks in each case.

a. Para 22a. NRC K. Dax:

(1) entered 3DZ4 heads because he was seasick.

FC: Agreed.

Comment: Agree.

(2) he (Dax)......suffered from oxygen starvation.

FC: Agreed.

Comment: Agree, noting that this is unlikely to have been the cause of death.

(3) his (Dax's) vomiting made him unaware that he was being affected by lack of oxygen.

FC: Agreed.

Comment: Agree, noting that the same would have been true for other gases too.

(4) he (Dax) then collapsed into a sitting position where he inhaled vomit.

FC: Agreed.

Comment: It cannot be established whether he inhaled vomit at this stage or during resuscitation, see para 29 supra and para 5 of DGNHS remarks at folio 27.

(5) his (Dax's)......position......made rescue difficult.

FC: Agreed.

Comment: Agree.

(6) when rescued his (Dax's) brain was irreversibly damaged.

FC: Agreed.

Comment: This is no more than a reasonable assumption in the circumstances, see DGNHS remarks concerning irreversible brain damage, at para 6 of folio 27.

b. Para 22b. Methane displaced oxygen through the kick panel of the passageway door.

FC: Agreed.

Comment: Agree that air would have been displaced from the heads compartment by sewage gases, through the door jalousie and through the exhaust fan trunking by chimney effect.

c. Para 22c. Methane was generated in both the M/C tank and holding tank. Further, the BOI noted that when emptied the M/C tank contains a residue of 1.04 tonnes of effluent and that only two sets of heads, disused for approx one month, were connected to the M/C tank.

FC: Agreed.

Comment: Disagree. It is unlikely that the generated gases included methane. Agree that there is a residue of 1.04 tonnes but disagree about heads use, noting that a set of ship's company heads are also connected, see para 12b of folio 30.

d. Para 22d. Methane built up in 3DZ4 heads as a result of:

(1) Lost water seals in heads bowls due to disuse.

FC: Agreed that the seals had been lost but subsequent tests showed that seals could be lost dynamically.

Comment: Agree Fleet Commander.

(2) The only natural exhaust being low down in the passageway door.

FC: No Comment.

Comment: Agree but note chimney effect of exhaust trunking, at para 163b.

(3) The removal of the defective exhaust fan.

FC: No comment.

Comment: Agree BOI.

(4) Gas leakage to the M/C tank from the holding tank.

FC: The 1.04 tonnes residue would act as a water seal and prevent gas leakage to the heads bowls.

Comment: Agree BOI. The Fleet commander's remark is not understood.

e. Para 22e. The unserviceable state of a non-return valve which had been fitted between the M/C transfer pump discharge and the holding tank was not a contributory factor.

FC: Agreed.

Comment: Agree. The Fleet Commander's additional remarks are not understood.

f. Para 22f. The rescue was expeditious and LSETC Hughes was courageous.

FC: Agreed.

Comment: Agree, with some reservations about TOBRUK's Damage Control organisation, see para 162h supra.

g. Para 22g. The rescue was hampered by the inwards swinging arrangement of the heads cubicle doors.

FC: Agreed. However best arrangement is traditional outwards swinging doors with removable hinge pins.

Comment: Agree FC. DONS agrees with FC but DNUR considers outward swinging doors to be dangerous and recommends double acting doors.

h. Para 22h. Resuscitation was prompt, thorough and correct.

FC: Agreed.

Comment: At para 8 of folio 27 DGNHS notes that [redacted] should have attempted an intubation before beginning resuscitation, to optimise the airway and to prevent aspiration of stomach contents into lungs (see para 163a.(4) supra). Agree DGNHS, noting that Dean's failure to do so is unlikely to have contributed to Dax's death, particularly in view of the presence of H_2S.

i. Para 22i. The minor deficiencies in (sewerage plant) operating procedures were not contributory to the incident.

FC: (1) Agree with regard to use of liquid in lieu of tablet sodium hypochlorite.

(2) The failure to aerate continuously did contribute to methane concentration and by starting aeration when pumping out, the methane was displaced into the sewerage system and hence to 3DZ4 heads compartment. Continuous use of the aerator made the ship almost uninhabitable.

Comment: Disagree with BOI. The discrepancies in the ship's use of the sewerage system were major and contributed largely to the incident. The following remarks concern the Fleet Commander's comments, seriatim:

(1) The ship appears to have used liquid sodium hypochlorite in lieu of tablet calcium hypochlorite. Agree that this was unlikely to have been contributory although the dosages used are not known. The ship also used a variety of anti-oderants directly into M/C tanks. Their effect is unknown but is unlikely to have been contributory.

(2) Agree Fleet Commander that the failure to aerate continuously is likely to have been a major factor in the accident but factors beyond the ship's control combined with the non-aeration to create the fatal circumstances, in particular the cross-connection between M/C and holding tank vent pipes and the dynamic loss of water seals in heads bowls.

j. Para 22j. There is poor system redundancy, in particular:

(1) The fan exhaust system provides the only overhead ventilation.

(2) Water seals provide the only gas barrier around the M/C tanks.

(3) The loss of the water seals provides a gas leakage path from holding tank to M/C tank to heads compartment, causing a gas buildup if the fan should be defective.

FC: The system is both lacking in redundancy and inadequate as installed.

Comment: As indicated at para 162w supra, the ventilation arrangement should be adequate though it is acknowledged that fan capacity is below the NCM standard. Also, as discussed at 162t supra, water seals should be adequate if properly protected from dynamic loss or from drying out. The as-fitted arrangement is deficient in this regard.

Additional Conclusion by Fleet Commander

164. The Fleet Commander considered, at para 7 of folio 22, that the supervision of Naval Reserve Cadets should be reviewed and that cadets should be required to operate a 'buddy' ie., a 'paired' system when on board HMA ships for sea training. DONS agrees, at para 4 of folio 33.

Comment: The recommendation has merit but may be difficult to enforce, for example during visits to the heads, particularly at night. It is considered more appropriate to concentrate on briefings, tours and comprehensive written orders. DNRC should explore the buddy system as part of an overall review of NRC sea training.

RECOMMENDATIONS

Relating to Blame

165. Much thought has been given to the matter of delinquency and blame but the circumstances are considered to have been far too complex for individual contributions to the accident to be delineated. Even the [redacted] decision not to aerate the holding tanks constantly, (contrary to the instructions available to him and of which he was aware), could not be said to have caused the accident in isolation from other factors because, for example the M/C tanks would have been generating hydrogen sulphide anyway.

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166. Identifiable design deficiencies and as-fitted departures from design played their part but so too did the total management system which placed an unproven system in the hands of an untrained and inexperienced ship's staff and left it there long after it should have been recognised as being maloperated and malfunctioning.

167. The [redacted] failure to institute a formal investigation into the 18 May 81 spill was a factor but he did seek FHQ advice on habitability aspects and the opportunity was there for the Fleet Commander to convene a BOI and he did not do so.

168. In summary, whilst the following individual errors of judgement have been identified and are to be criticised, it is not considered appropriate to apportion blame for NRC Dax's tragic death, between the persons concerned. Too little was known about marine sewage treatment, on all sides, for the latent dangers to be appreciated, and it is recommended that the following personnel and organisations be informed accordingly, by personal letter from DCNS, to be drafted by DNLS and DGFM.

a. The [redacted] who approved guidance drawing A000077 (Issue 2) which cross-connected the holding tank and midships M/C tank vent pipes.

b. The [redacted] who approved sewage tank vent pipe extensions, to remove the smell from occupied areas, knowing that anaerobiosis had developed.

c. CSPL who had incorrectly re-routed some ship's company heads drains, apparently without drawing Navy's attention to the change.

d. [redacted], who authorised a departure from the published requirement for continuous aeration of the contents of holding tanks.

e. [redacted], neither of whom sought outside help specifically to determine why the plant was foul smelling. Nor did they unilaterally decide to shut down the plant pending further assistance.

f. [redacted] who did not instigate a formal investigation into the circumstances of the 18 May 81 spill, iaw MNL 2521.

g. The [redacted] who did not convene a Board of Inquiry iaw MNL 2501 to investigate the circumstances of the same spill.

General

169. It is also recommended that:

a. DCNS advise the Coroner of the principle conclusions relating directly to the NRC Dax's death, at para 161 supra. If approved, DGFM and DNLS to be tasked to draft a suitable letter.

b. DCNS advise Mr and Mrs Dax, similarly. DGFM and DNLS to draft a suitable letter.

c. DGFM be authorised to provide the Department of Transport (see folio 36), CSPL, Y-ARD (UK) and USN authorities with an outline of the causes of the accident, in response to individual requests from them. CNTS to approve drafts.

d. Copies of this review be furnished to the Fleet Commander, CNTS, CNM, CNORP, CNP and DGNHS as background for any follow-up action to be required of them.

e. TOBRUK's CHT sewerage system remain out of service until all approved modifications have been installed and the system proved by a proper authority. The Fleet Commander, Type Commander and CO TOBRUK to be informed by signal. DGFM to draft for CNTS approval.

f. NRC Pullen receive a Flag Officer's commendation for his part in Dax's discovery and rescue. DNRC to draft for Fleet Commander's signature.

g. Leading Seaman ETC D.I. Hughes S113014 be nominated for a bravery award. DGNM and DGFM to draft nomination and citation for CNP approval.

h. In a letter covering his copy of this review, the Fleet Commander's attention be drawn particularly to the conclusions at para 162a, f, g, h, i, k, o, r, t, u, y, cc, dd, ee, kk, ll, nn, oo, pp, qq, vv, ww, xx, bbb, jjj, lll, and nnn.

i. The CO HMAS TOBRUK be informed of the content of para 161 and of the conclusions at para 162a, e, f, g, h, i, j, k, m, o, q, r, s, t, u, y, z, bb, cc, dd, ee, kk, ll, mm, oo, pp, qq, ww, xx, ggg, iii, jjj, lll, and nnn.

j. The Fleet Commander be requested to inform DCNS when he is satisfied that action has been taken by TOBRUK to correct the deficiencies or circumvent the risks identified at para 162h, o, r, u, y, dd, mm, oo, pp, qq, bbb, iii and nnn.

k. DGNHS be tasked to ensure all appropriate and qualified MED sailors receive periodic refresher instruction on intubation technique.

l. [redacted] be informed of the conclusion at paras 162i and 162j. DGNHS to draft letter for DCNS' approval.

m. DGNHS be tasked to draft a DI(N) on the dangers of hydrogen sulphide and the risk of its presence in sewerage systems in HMA Ships.

n. DGNHS and CNTS (DGND) explore the availability of practical hydrogen sulphide monitor/alarms.

o. CNM (DGSUP) and CNTS (DGFM) be tasked to develop instructions for the storage and handling of calcium hypochlorite.

p. CNTS and CNM (lead) be jointly tasked with the development of a general policy document for the transition of ships and craft from procurement to maintenance; the policy to take account of the conclusions at para 162l, m, q, w, x, y, dd, ff, gg, hh, ii, jj, mm, pp, qq, rr, uu, vv, ww, xx, yy, zz, aaa, ccc, ddd, eee, fff and ggg. The document should provide the basic format for 'transition reports' to be produced in future by relevant project directors.

q. CNTS and CNM (lead) be jointly tasked with the revision of ABR 1921, Instructions for HMA Ships Building, Undergoing Modernisation, Conversion or Extended Refit, to take account of the conclusions at para 162l, m, q, w, ff, gg, hh, ii, jj, mm, oo, pp, qq, rr, tt, uu, vv, ww, xx, yy, zz, aaa, bbb, ccc, ddd, eee, fff and ggg.

(Note: It is understood that DGNP has ABR 1921 under revision at present.)

r. CNTS (DGND (lead) and DGFM) be tasked with the conduct of a design deficiency review aimed at validating TOBRUK's CHT system, in toto; the review to take account of the conclusions at para 160k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z, aa, bb, cc, dd, ee, ll, hhh, iii, jjj, kkk, lll, mmm, nnn, ooo.

s. In step with para 169r, CNTS (DGND (lead) and DGFM) conduct a design deficiency review of sewerage plants in all other IMCO-fitted fleet units.

t. CNTS (DGND) be tasked to explore and identify any shortcomings in the design validation procedures under which the following occurred:

(1) The marriage of the holding tank and midships M/C tank vent lines, vide Issue 2 of Navy Office Drawing No A000077. Paras 162s, ll, ww, yy and hhh are relevant.

(2) The extension of selected vent lines to the starboard kingpost, when it was known that anaerobiosis had developed. Para 162q and 162y are relevant.

u. CNTS (DGNP) be tasked with listing all remaining TOBRUK documentation shortfalls and prosecuting delivery. Status reports to DCNS at 3 monthly intervals.

v. CNTS (DGFM) identify TOBRUK CHT system PJT requirements for CNP (DGNTE) action. Similar action to be taken in respect of all other IMCO-fitted fleet units.

__Recommendations made by the Board of Inquiry__

170. The following comments relate to the recommendations of the BOI, seriatim, noting the Fleet Commander's (FC) remarks in each case:

a. __Para 23a and b.__ Medically examine other affected personnel and shut down the system.

__FC:__ Action complete.

__Comment:__ Noted.

b. __Para 24.__ Install NRVs in all blackwater lines before M/C tank.

__FC:__ Agree but further protection to be provided by extending all blackwater drains within M/C tanks to below the 1.04 tonne level.

__Comment:__

(1) Agree NRVs or some other form of positive seal. In view of the deteriorated condition of the NRV at TAB G, it may be better to rely on additional deep water-seals in blackwater drains, coupled with improved syphon breakers.

(2) Disagree FC regarding extension of drains, noting proposal at para 153, to redesign tank bottoms for minimum residue.

c. __Para 25.__ Modify heads cubicle doors and elevate fresh air inlet.

__FC:__

(1) Disagree. Recommend outward swinging doors and removable hinge pins.

(2) Agree.

Comment:

(1) Agree FC.

(2) Disagree, because of short circuiting, see para 158d.

Para 26.

(1) Flush M/C tanks when not in use and fill with water to avoide methane generation.

(2) Flush unused heads and check water seals weekly.

(3) Lock unused heads and treat as confined spaces iaw ABR 5225 when exhaust fans become unserviceable.

FC:

(1) Unnecessary when blackwater drain pipe modification has been completed.

(2) Disagree. Better to rely on improved syphon breakers which do not have dead weighted flap valves fitted.

(3) Agree.

Comment:

(1) Hydrogen sulphide is more likely than methane. The CHT system instructions require that sewage tanks should be flushed out and emptied after use. To this end it will be necessary to improve pumping and tank cleaning arrangements; see para 153.

(2) Agree FC.

(3) Agree FC.

e. Para 27. Though not a major contributory factor in the accident, the holding and M/C tank vents should be separated.

FC: Agree. Navy Office redesign; TOBRUK to aerate continuously thereafter.

Comment: Agree FC noting however that the marrying of the M/C and holding tank vent lines was a major factor in the accident, contrary to BOI view.

f. Para 28. Orders to be included in Ship's Standing Orders.

FC: Agree but ship needs help from Navy Office due to the inadequacy of delivered documentation.

Comment: Agree generally with FC although ABR 5231 and ABR 5407 probably do contain sufficient information for suitable orders to be written. However a ship check is necessary first, as recommended at para 169r.

g. Para 29. Those who participated in the rescue be recognized as a group and LSETC Hughes be commended.

FC: Agreed. TOBRUK to raise.

Comment: Agree; however Navy Office to raise in view of passage of time. Further to para 169i, and agree TOBRUK should be informed that all those involved did well, in the best traditions of the RAN.

h. Para 30. Press release.

FC: No need.

Comment: Agreed FC.

i. Other Considerations.

(1) FC Para 10. The removal of the exhaust fan from 3D24 heads was normal and correct, because the fan had burnt out and there was no spare available.

Comment: Agree FC.

(2) FC Para 11. All Fleet fitted sewage treatment systems should be validated by Navy Office.

Comment: Agree FC, see para 169s.

19 May 82 Fleet Maintenance Branch

ANNEXES:

A. *Chronology of Sewerage System Incidents in HMAS TOBRUK.*

B. Navy Office Sketch No A200204 (Issue 1) and Drawing No A200206 (Issue 3).

C. Navy Office Guidance Drawing A000077 (Issue 2) - 'Sewage Arrangement (Diagrammatic)'.

D. Vent Pipe Calculations.

E. Calculated Ventilation Requirement, 3DZ4 Heads.

F. Sewage Gas Generation Rates.

G. Gas Path Model.

H. Copy of GOSIEAA letter N16-1-600 of 15 Sep 81.

I. Copy of HMAS TOBRUK letter 42.1.1 of 06 Oct 81.

J. HMAS TOBRUK Test and Trials Procedure Applicable to Sewage Treatment and Disposal Arrangements.

K. Extract from ABR 1921 - ITT Responsibilities.

L. RANTAU Representation about ITT Difficulties.

M. *Documentation Concerning JUN 81 AMP in Brisbane.*

N. Signal Correspondence Between Navy Office and TOBRUK Concerning Possible Vent Pipe Blockage.

O. HMAS TOBRUK's Form TI338 of 10 Apr 81.

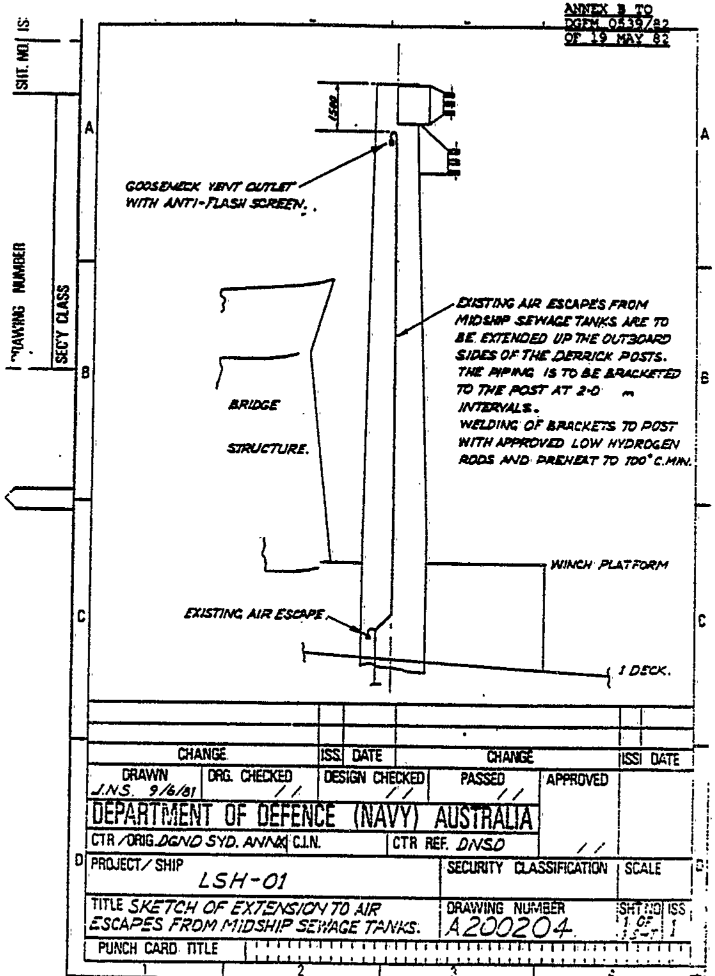
P. *HMAS TOBRUK's Signal Traffic Concerning Second Reading of Form TI338.*

Q. DTNSRDC - 78/041 of January 1978. A Paper Entitled 'Biodegradation of Shipboard Wastewater in Collection, Holding and Transfer Tanks'.

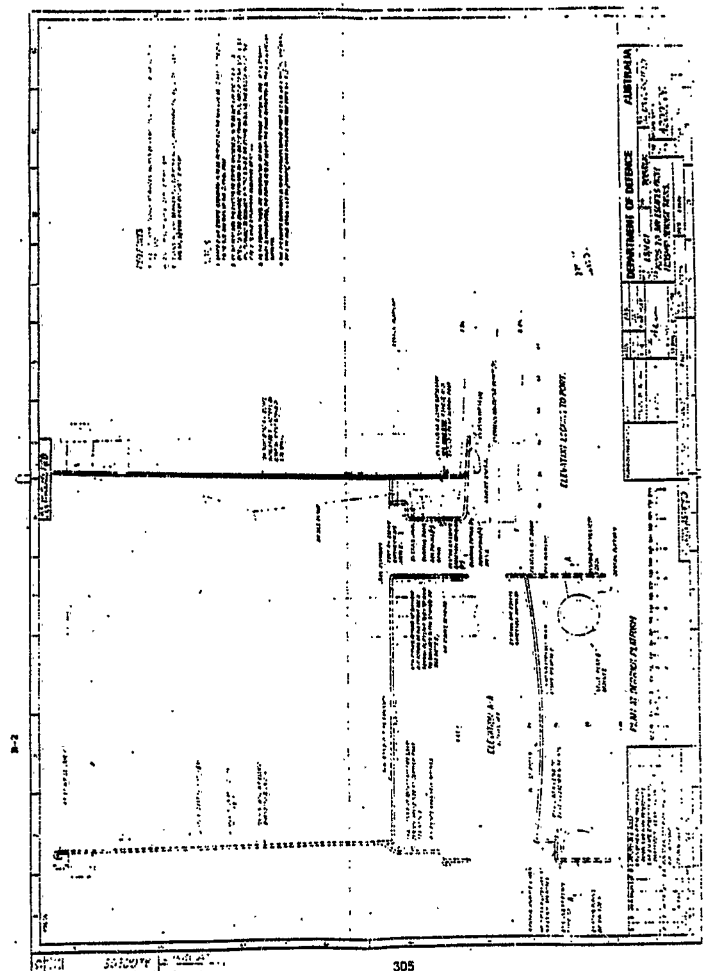
CHRONOLOGY OF SEWAGE SYSTEM INCIDENTS IN HMAS TOBRUK

19-22 JAN 81	Final Installation Inspection. Setting to work aborted due to successive spills involving forward and midships M/C tanks.
17-19 MAR 81	Contractors sea trials. System flooded with saltwater four times within 48 hours. Trials aborted.
APR 81	TI338 first reading. No mention of sewerage system.
23 APR 81	Day of Commissioning. Major spill involving forward M/C tanks.
15 MAY 81	Ship refused to participate in Form TI338 second reading. Reasons included 'Unsatisfactory Sewerage System'.
18 MAY 81	URDEF 17/85. Sewage flood. URDEF listed as priority 2 Warranty Defect. TM200 raised in accordance with ABR 5230. INDEF 7/85 re Mess Deck Flood. TOBRUK signal 230202Z MAY 81 to COMAUSPHIBRON requesting assistance to investigate and repair.
11-12 JUN 81	AMP in progress. Shipboard Inspection of sewerage installation by DNSD (Project Design Manager). Minute suggesting various modifications. Various equipment repairs and mods.
31 JUL 81	Form TI338-1 read and signed by HMAS TOBRUK. Sewage treatment system not recorded. -
19 AUG 81	PSA in progress. TSM 200 DH 54/85 Air Escape Modification. Consequent to sewage flood, air escape pipes modification proposed and subsequently completed at PSA. Mess decks rehabilitated.
14 DEC 81	Sewage gassing of NRC DAX.

ANNEX B TO
DGFM 0539/82
OF 19 MAY 82



FORM NO. TD 113



NCA520 UNCLASSIFIED
PRIORITY/ROUTINE 190432Z AUG 81
FROM NAVDES SYDNEY
TO NOCQLD
INFO DEFNAV CANBERRA
BT
UNCLAS
SIG UNF/UNH
HMAS TOBRUK - SEWAGE TSM200 DH54/85
A. TELECOM WO BLUHDORN/SMITH NAVDES
B. DWG NO A200206 ISSUE 2
C. TELECON LT KERRISON DNSP/OWEN NAVDES
1. ARRANGEMENT SHOWN ON REF B TO BE MODIFIED AS FOLLOWS
2. STBD AIR ESCAPE TO BE AS SHOWN EXCEPT THAT NEW PIPE 100MM NB TO RUN DIRECT FROM EXISTING AIR ESCAPE TO AFT SIDE OF VELLE MAST AND UP LADDER SUPPORTS
3. PORT AIR ESCAPE TO BE 75 MM N.B. RUN BELOW DERRICK PLATFORM TO CONNECT WITH STBD AIR ESCAPE
4. REVISED DRAWING WILL BE ISSUED THROUGH NORMAL CHANNELS
5. IF REVISED ARRANGEMENT INCURS ADDITIONAL COST TO THAT PREVIOUSLY ADVISED NEW COST ESTIMATE TO BE SIGNALLED TO DEFNAV CANBERRA BEFORE START OF WORK
BT
END UNCLASSIFIED

18.95 70 04 56 19 61

SIG UNF
ACTION DNSP
R, CNM, DJWP-N
C, DNSP(2), DGND(2), CNTS, DGNP, SEONP, DNSD, DNED, DNCD(2)
C, DMED, DNEP
(3R 16C)
SIG UNH
ACTION DJWP-N
R, ~~CNM, DJWP~~-N
C, CNTS, DGFM(3), DNSP(2)
(3R 7C)

8

W NCA116 UU
RR
DE RAYBAN 663 2320532
ZNR UUUUU
R 202530 AUG 81
FM NOCQLD
TO RAYWKE/NAVDES SYDNEY
INFO RAYWNN/DEFNAV CANBERRA
BT
BAS
SIG UNF/UNH
HMAS TOBRUK AMP - TSM220 DH 54/85.
A. TELECON J SMITH (NAVDES)/WO BLUHDORN 11.30 20 AUG 81
B. NAVDES SYDNEY P190432Z AUG 81 PARA 3.
1. DUE TO INHERENT PROBLEMS INVOLVED IN RUNNING PORT AIR ESCAPE BELOW DERRICK PLATFORM IE, EXCESSIVE BENDING, UNAVOIDABLE CONDENSATION TRAPS, ADDITIONAL TIME AND EXPENCE INVOLVED, PROPOSE (AS DISCUSSED REF A) RUNNING PIPE ABOVE PLATFORM WITH A CLEARANCE OF 40 MM FROM DECK AND BRIDGE FRONT
BT
END UNCLASSIFIED

SIG UNF
ACTION DNSP
R, CNM, DJWP-N
C, DNSP(2), DGND(2), CNTS, DGNP, SEONP, DNSD, DNED, DNCD(2)
C, DMED, DNEP
(3R 16C)
SIG UNH
ACTION DJWP-N
R, ~~CNM, DJWP-N~~
C, ~~CNTS,~~ DGFM(5), DNSP(2)
(3R 7C)

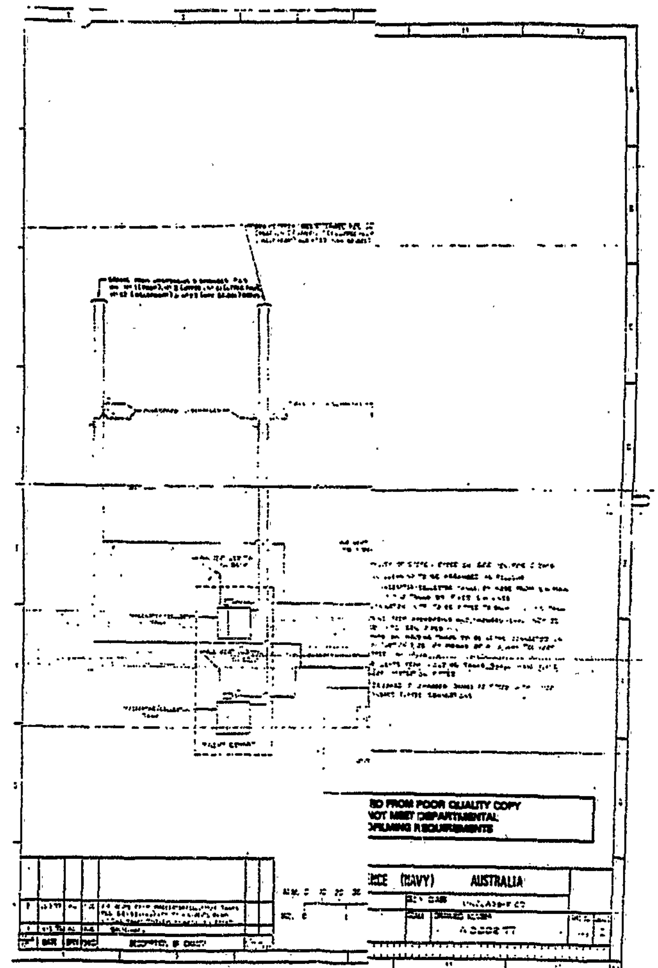
3 + 18

Aug 21 08 43 '81

NCB537 UNCLASSIFIED
PRIORITY/ROUTINE 210515Z AUG 81
FROM NAVDES SYDNEY
TO NOCQLD
INFO DEFNAV CANBERRA
BT
UNCLAS
SIG UNF/UNH
PRIORITY - FOR ACTION OFFICERS DESK 8800
HMAS TOBRUK - SEWAGE TSM202 DH 54/85
A. NOCQLD UNF/UNH 202530Z AUG 81
B. NAVDES SYDNEY UNF/UNH 190432Z AUG 81
C. TELECON LT KERRISON (DNSP)/GRUMLEY (NAVDES) 211330Z AUG 81
1. CONCUR REF A PARA 1
BT
END UNCLASSIFIED

SIG UNF
ACTION DNSP
R, CNM, DJWP-N
C, DNSP (2), DGND (2), CNTS, DGNP, SEONP, DNSD, DNED, DNCD (2)
C, DMED, DNEP
(3R 16C)
SIG UNH
~~ACT: N DJWP-N~~
~~R, CNM, DJWP-N~~
C, CNTS, DGFM (3), DNSP (2)
(3R /C)

25



ANNEX D TO
DGFM 0539/82
OF 19 MAY 82

HMAS TOBRUK SEWAGE SYSTEM
VENT PIPE CALCULATIONS

1. **Aim**

To estimate the pressure generated within the port midship's collector-macerator tank due to gas flow through the vent system before and after the vent system was modified in accordance with Department of Defence Drawing A200206.

2. **References:**

A. ABR 5407 - Piping Systems Handbook - HMAS TOBRUK

B. ABR 5431 - Sewage System Equipment Handbook HMAS TOBRUK

C. HMAS TOBRUK Drawing 138-1H General Arrangement

D. HMAS TOBRUK Drawing 138-605-H (4 sheets) Sewage Arrangement

E. Kempes Engineers Yearbook 1980 Sections K1/24 and K4/24

F. HMAS TOBRUK RFH Ø9Ø755Z MAR 82

G. HMAS TOBRUK letter 6/2/1 of 22 MAR 82 and enclosure

H. NCM VOL 3

3. **Introduction**

The investigation takes the form of a calculation, based on ventilation flow principles, of gas flow in the vent pipes driven by ingress of sewage and air to the holding/collector/macerator tanks. A sketch model is given (at Annex C of the main report) showing basic vent pipe runs and sizes in the relevant section of the ship. Note that the calculations are exclusive of gasses generated by the sewage, of which there would have been a considerable volume, see Annex F.

4. **Calculation of the amounts of air and sewage displacing air from the holding tank**

It is assumed that the drains from the decontamination area, sickbay and galley and the salt water supply for tank cleaning are all shut off.

Inflow to the holding tank will then come from:

a. The aeration blower. (No information is given in ABR 5431 on the quantity of air provided by the blower. Enquiries are being made with the manufacturer. The ship specification para 4.10.3.8. gives the required quantity as 50 c.f.m. @ 4psi. This figure is used in this calculation).

b. Drains from washbasins and showers portside (see calculation para 5).

c. Discharge of sewage from the collector/macerator tanks. (ABR 5431 gives the capacity of the MONO discharge pumps fitted to the collector/macerator tanks as $10m^3/hr$ @ 1.49 bar).

d. Chlorine mixture from the system chlorination unit. (ABR 5431 states: the unit delivers at 136.5 l/hr max).

Hence maximum inflow to each holding tank consists of:

	SOURCE ITEM	FLOW m^3/min
1.	Aeration Blower (50 cfm) This figure is assumed from the ship specification	1.42
2.	Drains from washbasins and showers	0.26
3.	Collector/Macerator Tanks $10m^3/hr$*	0.167
4.	Chlorination unit 136.5l/hr	0.002
	Total assumed flow =	$1.85m^3/min$

* NOTE only 1 collector/macerator tank is included as discharge from the midship's collector/macerator tank to the holding tank is made up with gas vented from the holding tank. It is assumed also that the forward collector/macerator tank was empty.

5. **Calculation of Flow from drains and washbasins**

The number of drains and washbasins is approximately equal each side of the ship. Only the port side has been calculated References D and E.

Number of Washbasins (WBN) and Showers (SHR)

3 dk

FWD Bathroom	3 SHR
	6 WBN
Aft Bathroom	6 SHR
	13 WBN

2 dk

Frs 18-24 Bathroom	2 SHR
	4 WBN
Frs 4-17 Bathroom	2 SHR
	5 WBN

1 dk

Frs 11-16 Bathroom	1 SHR
	2 WBN

01 dk

Frs 10-19 Bathroom	5 SHR
	6 WBN

02 & 03 dks

Nil to Port side

Totals SHR = 19
WBN = 36

From reference E K4/24.

The demand of a Washbasin with ½" tap is $0.0113m^3/min$

The demand of a shower with a 100mm rose is $0.017m^3/hr$

∴ Total demand of washbasins is 36 X .0113 = $.407m^3/min$

∴ Simultaneous demand of washbasins is $0.18m^3/min$
(refer table 21 Reference E.K4/24)

Add to this the total demand of showers
[= 19 X .017 = $.323m^3/min$]

This is considered to be too conservative an estimate as all showers would not be in use onboard at this time. It is considered that a reasonable demand for showers is more likely to be $0.09m^3/min$ ie 25% in use. (the 0.16 simultaneous

Total demand is therefore: 0.34 m³/min

$0.08 + 0.18 = 0.26m^3/min$

6. **Calculation of Flow & Pressure in the Holding Tank Vent Pipe**

Assumptions

a. All flow is through the holding tank vent to atmosphere. No flow occurs in the vent branch from the collector macerator tank.

b. All pipes from the collector macerator tank are effectively closed, except the vent pipe. ie, no flow can occurout of the collector macerator tank except through the vent pipe.

c. There is no flow from the 1 dk senior sailor's heads into the system.

d. The density of gas in the system is equal to that of air.

The total gas flow from each holding tank is:

$1.85m^3/min$ or $0.031m^3/sec$

Therefore from Reference E Section K1/24

a. For an 80mm bore pipe with a flow of $0.031m^3/sec$

(1) Pressure drop per meter run = 71 Pa/m

(2) Velocity in the pipe = 5.9m/s

(3) Velocity head = ½ X 1.2 X 5.4^2 = 17.5Pa

b. For a 125mm bore pipe with a flow of $0.031m^3/sec$

(1) Pressure Drop per meter run = 0.9Pa/m

(2) Velocity in pipe = 2.5m/sec

(3) Velocity head = 3.7Pa

c. For a 100mm bore pipe with a flow of $0.062m^3/sec$

(1) Pressure drop per meter = 10Pa/m

(2) Velocity in pipe = 7.9m/sec

(3) Velocity Head = 37.4Pa

7. **Summary of Calculation of Pressure at the Connection of the Vents from the Port Collector Macerator and Holding Tanks before and after Modification in accordance with Dept of Defence Drawing A200206**

A. **Before Modification**

COMPONENT OF VENT SYSTEM		LOSS (Pa)	CUMULATIVE PRESSURE (Pa)
Vent outlet with Anti Flash Gause and Flap		10	10
0.3m Pipe	125mm bore	-	10
180° Bend		2	12
1m Pipe		1	13
90° Bend		1	14
3m Pipe		3	17
Junction of Vents			17Pa

B. **After Modification**

COMPONENT OF VENT SYSTEM		LOSS (Pa)	CUMULATIVE PRESSURE (Pa)
Combined vent pipe up derrick post			
Vent outlet with Anti Flash Gause		56	56
0.3m Pipe	100mm bore	3	59
180° Bend		15	74
14.5m Pipe		145	219
45° Bend		4	223
0.4m Pipe		4	227
45° Bend		4	231
1.15m Pipe		11	242
Junction of Port & Starboard Vent Pipes			
90° Bend	80mm bore	4	246
1.1m Pipe		8	254
60° Bend		2	256
10.4m Pipe		74	330

B. **After Modification (cont)**

COMPONENT OF VENT SYSTEM		LOSS (Pa)	CUMULATIVE PRESSURE (Pa)
Junction of Port & Starboard Vent Pipes		4	334
90° Bend	80mm bore	3	337
0.45m Pipe		2	339
45° Bend		2	341
0.3m Pipe		2	343
45° Bend		9	352
1.3m Pipe		2	354
45° Bend		2	356
0.36m Pipe		2	358
45° Bend		3	361
0.48m Pipe		1	362
Reduction 125Ø-80Ø		-	362
0.25m Pipe	125mm bore	-	362
90° Bend		1	363
0.95m Pipe		-	363
90° Bend		2	365
2.4m Pipe			365Pa
Junction of Vents			

8. **Conclusions**

a. It is found that, making the assumptions previously outlined, the pressure in the holding tank vent pipe at the collector macerator tank vent junction is increased from approximately 17Pa (0.1" WG) to 365Pa (1.47" WG) by modifying the vent system in accordance with Dept of Defence Drawing A200206. It is deduced that the pressure in the collector macerator tank is equivalent to the above pressure assuming that there is no flow through the collector macerator tank and that tank is a blind branch of the holding tank vent.

b. It is considered probable that pressure generated in the holding tank vent system is sufficient to cause gas flow through the 17mm water seals in the heads connected to the midship's collector macerator tank. There would certainly be sufficient pressure to blow gas through depleted or non existent water seals; those in the water closets being the only seal between the collector macerator tank and the heads and noting that some seals were measured at less than 17mm.

c. Although the arithmetic in these calculations has been checked, the method is the opinion of myself and is unchecked by an independent person.

(D. MAGILL)
DFM-SH

31 May 82

ANNEX E TO
DOFM 0539/82
OF 19 MAY 82

HMAS TOBRUK 3DZ4 HEADS -
CALCULATED VENTILATION REQUIREMENTS

References: A. NCM VOL 3

B. Carrington Slipways DRG 138-605-H

C. HMAS TOBRUK Ventilation Trial Results held by Mr J. MAIN (DNSD Staff)

1. The following calculated air exhaust rates are required.

a. Reference A section J.3. specifies the following exhaust quantities for heads:

(1) 50 cfm per WC,
(2) 25 cfm per urinal,
(3) 50 cfm per shower, and
(4) 25 cfm per washbasin.

b. Reference B indicates that 3DZ4 heads contain the following:

(1) 5 WC's,
(2) 1 urinal,
(3) 1 washbasin.

c. Therefore the NCM requirement for exhaust air is given by:-

5 X 50 + 1 X 25 + 1 X 25 = 300 cfm.

2. The results given at reference C show that the exhaust quantity at trial was 247 cfm.

3. <u>Conclusion</u>. The foregoing indicates a shortfall in the ventilation exhaust from 3DZ4 heads compartment of 53 cfm, or approximately 18%.

(SGD) D. MAGILL
DFM (SH)

6 May 82

<u>ANNEX F TO</u>
<u>DGFM 0539/82</u>
<u>OF 19 MAY 82</u>

<u>SEWERAGE SYSTEMS - GAS GENERATION RATES</u>

1. The following information was obtained from Mr Wayne Harris, the principal Engineer (Sewage Planning) of the Department of Housing and Construction. It relates to 'normal' sewage treatment, ie where the flushwater is fresh. It appears from the reference that the product gases in the shipboard environment are quite different; therefore the following may be considered as no more than indicative of the volumes of gas likely to be generated by the residue in M/C tanks, below the pump low level cut out.

2. A normal quantity of Digestor Gas ie product gases from an anaerobic condition, would be approximately:

a. 65% Methane CH_4;

b. 35% Carbon Dioxide.

3. There would be other gases present, but in very small quantities. One is Hydrogen Sulphide which produces the 'bad eggs' smell and is highly toxic.

4. The digestor gas would take time to develop, from several days to weeks, depending upon the temperature, nature

of the vessel, agitation etc. The gas is lighter than air and could be expected to vent off naturally.

5. Typically, one lb of Biological Oxygen Demand (BOD) will produce 4¼ cuft of Digestor Gas at standard conditions. Therefore, assuming that an 'undiluted' effluent could contain 50% BOD, 1.04 tonnes could produce about 10,000 cuft gas at STP.

HMAS TOBRUK SEWAGE SYSTEM
VENT PIPE CALCULATIONS

1. Aim. To estimate gas flow to the port midship's collector macerator tank through the vent pipe system assuming depleted or non existent water seals in 3DZ4 heads.

2. References: As for Annex D.

3. Introduction.

The same principles are used as for Annex B. The flow is considered to split at the junction of the holding tank vent and macerator tank vent, a proportion flowing up the combined vent pipe and a proportion flowing down the macerator tank vent pipe to the macerator tank then to the heads. The flow rate in each vent is assumed and the resistance is calculated. Flow rate is then adjusted depending on the difference in total pressure resulting at the junction. The process is continued by iteration until a balance of pressure is achieved at the junction. The total gas flow from each holding tank is assumed to be the same as that calculated at Annex D ie $0.031m^3/sec$.

4. Summary of Calculations

It is found by iteration that with $0.01m^3/sec$ flowing up the combined vent and $0.02m^3/sec$ flowing back through the macerator tank the pressures approximately balance ie 116Pa for the combined vent and 92Pa for the macerator tank path to the heads. Within the limitations of the assumptions this is taken to be the approximate proportion of gas flow in the respective vent branches.

5. Conclusion

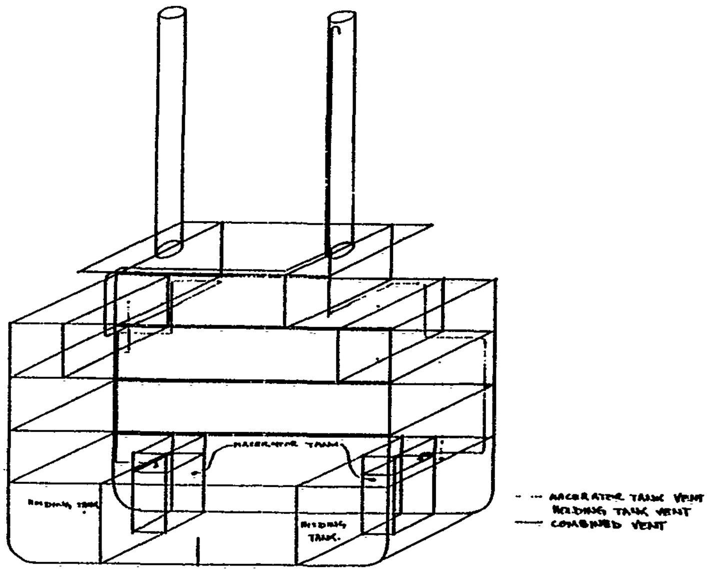
a. This calculation shows that a large proportion of gas from the holding tank will flow back through the macerator tank to the heads during aeration if the water seals in the WCs are severely depleted or non-existent following the modification to the vent system in accordance with Dept of Defence Drawing A200206.

b. Although the arithmetic in these calculations has been checked, the method is my own opinion and is unchecked by an independent person.

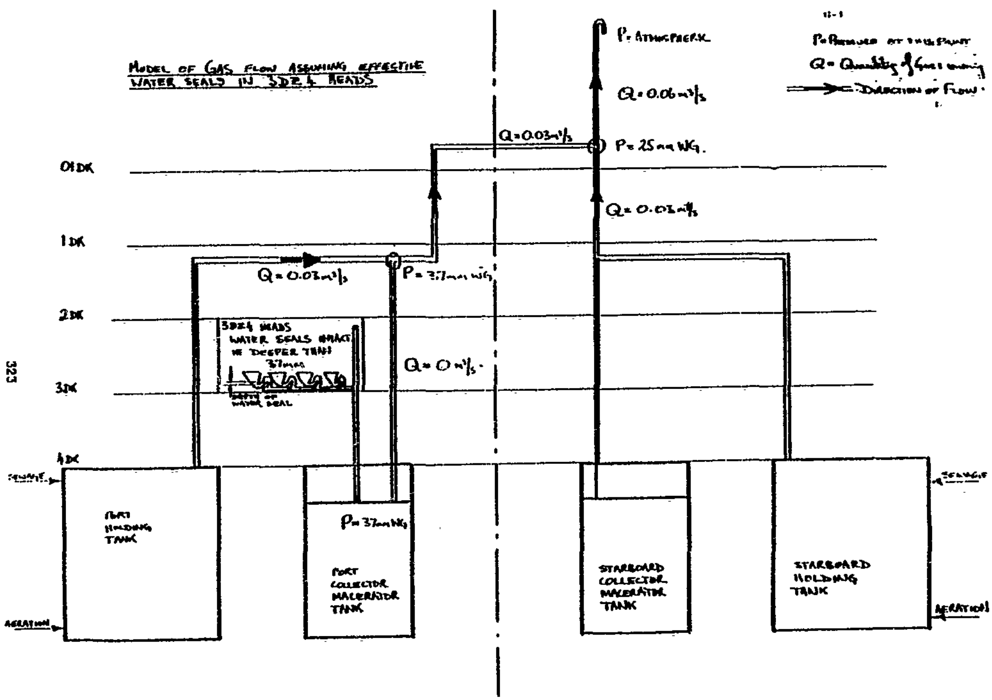
(D. MAGILL)
DFM/SH

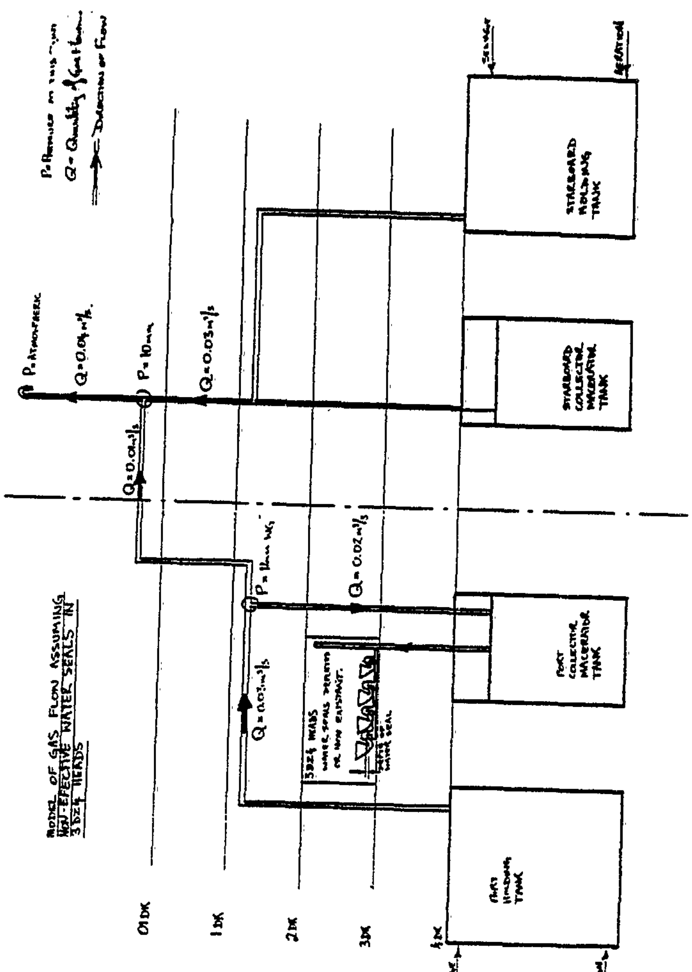
31 May 82

GAS PATH MODEL.



ISOMETRIC SECTION OF HMAS TOBRUK FROM FRAME 54 TO FRAME 64 LOOKING FWD.
SHOWING THE HOLDING TANK | COLLECTOR-MACERATOR TANK VENT SYSTEM.





(2228)

ANNEX H TO
DGFM 0539/82
OF 19 MAY 82

N16-1-600
HMAS TOBRUK Seq No: 252/81G

Office of the General Overseer and
Superintendent of Inspection
East Australia Area
Defence Regional Office
P.O. Box 706
DARLINGHURST NSW 2001

15 SEP 1981

Department of Defence (Navy Office)

For Attention: Director General Naval Production.

HMAS TOBRUK - FINAL REPORT

Reference: Department of Defence (Navy Office) letter N1500/90/54 DGNP 708/81 dated 25 Aug 81.

The following comments are forwarded.

2. HMAS TOBRUK was the first major warship constructed in recent times to a fixed price contract in a commercial yard, and generally constructed to commercial standards. These factors were and are not fully appreciated by all personnel who have had some input into the project or who have been associated with operation of the ship.

3. Where special Naval requirements were included in the specification they were not always adequately defined, and this resulted in difficulties in interpretation by the contractor and/or GOSIEAA staff. In addition, there were errors and omissions in the detailed schedules for the supply of Government Furnished Equipment, which, together with delays in supply, resulted in some disruption to the contractor's programme.

4. Although it was a contractual requirement for the contractor to operate a quality control system to the level of AS 1822, and it was assessed that he had established such a system, in practice it was difficult to get the contractor to give more than lip service to this requirement. In particular, during the final few weeks of the construction period the contractor abandoned formal quality control practices and in effect, GOSIEAA staff, in nominating defects for correction, were carrying out the QC function. However if this had not been done the ship would not have been completed to the standard it was in the given time. In the event, of course, it is considered that a very satisfactory ship was handed over by the contractor.

/ 5. The

5. The matters in para 4 were not satisfactory, and experience with this, and other, contracts highlights the fact that if a satisfactory level of quality assurance is to be achieved it is essential that stage payments be aligned to definite stages of physical progress which incorporate definable quality audit parameters.

6. With further regard to para 3 of the enclosure to the reference, matters of detail have been fully reported, with comments as necessary, during the contract period, and it is considered that it would be appropriate for the report on these aspects to be prepared within DNMS.

(SGD) K. H. KRUMMEL

(K.H. KRUMMEL)
Captain, RAN
General Overseer and
Superintendent of Inspection
EAST AUSTRALIA AREA

COPY

ANNEX I TO
DGFM 0539/82
OF 19 MAY 82

DEPARTMENT OF DEFENCE

42.1.1

HMAS TOBRUK
at Sea

06 October 1981

Department of Defence (Navy Office)
Russell Offices
CANBERRA ACT 2600

Attention: The Director of Fleet Maintenance

For Information:

The Flag Officer Commanding
H.M. AUSTRALIAN FLEET

The Flag Officer
Naval Support Command

The General Overseer and Superintendent of Inspection
East Australian Area

The Director Joint Warfare Policy - Navy

DUTIES OF PERSONNEL STANDING BY SHIPS BUILDING

References:
A. ABR 1921
B. Navy Office letter N7610/3/237 DFM 329/81 of 21 August 1981 (NOTAL)
C. HMAS TOBRUK UNF/RDI/RDC 220428Z SEP 81 (NOTAL)
D. Navy Office letter N108/1/12 of 13 March 1981 (NOTAL)

1. Comment sought by reference B is attached at Annexes A to D. In preparing this information it has not proved possible and was not considered realistic to confine comment simply to Chapter 2 of reference A. The Annexes have been presented in such a way that the recommendations made therein can either be extracted for comparison to those of the other annexures of reference B, or applied by way of amendment to the appropriate articles in ABR 1921 itself.

2. In general reference A had little relevance to the situation experienced by Navy and Army personnel who stood by HMAS TOBRUK during building.

3. It is recommended that for any future building programme at Carrington Slipways Pty Ltd (CSPL), a special directive be prepared for the standby crew and that if possible, this directive be included as an appendix to the contract with CSPL.

(K.A. DOOLAN)
CAPTAIN RAN
COMMANDING OFFICER

Annexes: A. Duties of Personnel Standing by Ships Building at CSPL - Command and Control

B. Duties of Personnel Standing by Ships Building - Administration

C. Duties of Personnel Standing by Ships Building - Technical

D. Duties of Personnel Standing by Ships Building - Naval Stores

ANNEX I TO
DGFM 0539/82
OF 19 MAY 82

DEPARTMENT OF DEFENCE

42.1.1

HMAS TOBRUK
at Sea

26 October 1981

Department of Defence (Navy Office)
Russell Offices
CANBERRA ACT 2600

Attention: The Director of Fleet Maintenance

9/10/81

For Information:

The Flag Officer Commanding
H.M. Australian Fleet

[illegible]

[illegible] Superintendent of Inspection [illegible]

[illegible] Policy - Navy

[illegible] STANDING BY SHIPS BUILDING

References:
A. [illegible] 1981
B. Navy Office letter [illegible]10/3/237 DFM 329/81 of [illegible] August 1981 (NOTAL)
C. [illegible] 220428Z SEP 81 (NOTAL)
D. Navy Office letter [illegible]/1/12 of [illegible] March 1981 (NOTAL)

1. Comment sought by reference B is attached at Annexes A to D. In [illegible] information it has not proved possible and was not [illegible] to confine comment simply to Chapter 2 of reference [illegible] been presented in such a way that the [illegible] for comparison to those of the [illegible] applied by way of amendment to the appropriate [illegible].

2. [illegible] reference A had little relevance to the situation [illegible] personnel who stood by HMAS TOBRUK during [illegible]

.../2

3. It is recommended that for any future building programme at Carrington Slipways Pty Ltd (CSPL), a special directive be prepared for the standby crew and that if possible, this directive be included as an appendix to the contract with CSPL.

(K.A. DOOLAN)
CAPTAIN RAN
COMMANDING OFFICER

Annexes: A. Duties of Personnel Standing by Ships Building at CSPL - Command and Control

B. Duties of Personnel Standing by Ships Building - Administration

C. Duties of Personnel Standing by Ships Building - Technical

D. Duties of Personnel Standing by Ships Building - Naval Stores

Annex A to the Commanding Officer
HMAS TOBRUK letter 42.1.1 of
6 October 1981

DUTIES OF PERSONNEL STANDING BY SHIPS BUILDING AT CSPL

COMMAND AND CONTROL

Status of Senior Officer of Standby Ship

1. In the circumstances which prevailed during the building, launching, fitting out, sea trials, handover and up to the commissioning of HMAS TOBRUK, the Senior Officer was, of necessity, required to interface with a wide variety of authorities. These included the following:

a. Resident Naval Overseer;

b. The Shipbuilder and their staff;

c. The General Overseer and his staff;

d. The Project Director;

e. The Captain Trials and his staff;

f. The Commanding Officer, HMAS PENGUIN;

g. The Naval Support Commander;

h. The Fleet Commander;

i. The Officer Commanding, RAAF Williamtown;

j. The Commanding Officer, Base Squadron, Williamtown;

k. Various sub-contractors to the Shipbuilder;

l. Representatives of numerous trade unions; and

m. Navy Office Directorates

2. The degree of interface varied but there was no clear guidance for the Senior Officer on joining. As a result, all non naval personnel listed above were initially confused as to the role and functions of the Senior Officer and it was only through persistent personal diplomacy that the position was clarified. This took time and largely denied the Senior Officer the opportunity to influence events prior to sea trials. It is asserted that had the position of the Senior Officer been identified more clearly within the project and had he been thereby given some formal authority, at least a month of the delay in building would have been avoided.

Command and Control: Award of Contract to Commissioning

3. For ease of examination this has been divided into the following phases:

a. Award of Contract to date of posting of standby ships Engineering Officer (EO);

b. Arrival of EO to date of posting of standby ships Commanding Officer (CO);

c. Period prior to sea trials;

d. Sea trials; and

e. Period between handover and commissioning

...../2

The period up to the arrival of the EO is not germane to this examination and therefore it is not further discussed. Consideration of the other areas is as follows:

(1) Period when EO was the Senior Officer. The experience with HMAS TOBRUK was that the EO was unable to perform functions other than to:

(a) observe and report on progress;

(b) arrange training for standby crew; and

(c) administer standby crew

He was specifically excluded from meetings about the ship which other Navy representatives attended at the shipbuilders yard, he was denied access to documentation and his advice went unheeded. In short, the officer concerned was placed in an invidious position and his treatment by more senior naval authorities certainly contributed to his subsequent resignation from the RAN.

(2) In any future build at CSPL it is vital that:

(a) the EOs position be properly established and fully documented prior to his arrival;

(b) he be given access to all documentation relevant to his responsibilities;

(c) he be required to attend all meetings at the shipyard relevant to the build at which building or contractural matters are to be discussed; and

(d) he be granted right of direct access to the Project Director, the Director General Ship Production, the Chief of Naval Technical Services and the Chief of Naval Materiel on matters related to the build.

(3) Period prior to Sea Trials when CO was Senior Officer. This period was much longer than originally planned due to the nine month delay in delivery of the ship. In retrospect, it is just as well that some of this delay occurred so that numerous fundamental problems could be resolved. On arrival, the Commanding Officer (designate) found himself to be in a position somewhat akin to that previously described for the EO. Nonetheless, with launching taking place within two weeks of joining, the CO was, by dint of circumstance, thrust into involvement.

(4) The command and control problem was not one with the shipbuilder. Indeed it was an embarrassment for the shipbuilder not to be able to take action on the advice of the CO and his staff. On several occasions such advice was finally acted upon only after inordinate delays which occurred after the information was fed into the naval system. In this context it is fair to state that the Resident Naval Overseer (RNO) was also placed in an invidious position. The fact that he was directed by the General Overseer not to inform the CO of certain matters (which the RNO in all conscience knew had to be passed on to the CO) placed him in an impossible position.

...../5

(5) In any future build at CSPL it will be necessary to:

(a) clearly define the position, status and responsibilities of the CO; and

(b) ensure that the CO has right of direct access to all authorities including the right to provide written guidance to the shipbuilder within certain limits e.g. in fitting out, the placement of built in furniture in compartments or the resiting of equipment when time is of the essence.

(6) Sea Trials. The arrangements for sea trials in HMAS TOBRUK worked very well. Certain fundamental points are, however, worthy of note. These are:

(a) the appointment of a Master for sea trials should be left flexible in the contract. CSPL eventually agreed to the appointment of the CO as Master only after knowing him for some time (and it is expected gauging union reaction). There is no doubt that the firm would not have agreed to his appointment as Master if the CO had been foist upon CSPL at short notice;

(b) it is prudent for the CO to hold a Certificate of Service as a Foreign Going Master; and

(c) it is essential that the legal status of the CO be resolved before he moves the ship. The circumstances in HMAS TOBRUK were that after the Chief of Naval Staff had given his approval for the CO to act as Master during sea trials, verbal advice from the Fleet Legal Officer was at variance with verbal advice from other private legal sources. Accordingly the CO took the initiative of requesting the company to appoint him as a temporary employee whilst he was acting as Master so as to avoid being able to be sued had any mishap occurred. CSPL agreed to this but found that in doing so they were required to pay a nominal sum to the worker's compensation authority.

(7) Period between Handover and Commissioning. There was no command and control problems during this period and it is recommended that in future similar circumstances, the procedure of passing full command of the ship to the Fleet Commander on handover be repeated

Date of Posting of Officers

4. Had HMAS TOBRUK commissioned as originally scheduled, the posting dates for most officers would have been far too late. The reasons for this assertion are that the ship was not only the first of class but also the first warship built by CSPL and the first warship of its type to enter service in the Australian Defence Force. As such there was a considerable amount of effort required by key officers and senior sailors and soldiers which would not necessarily apply in other circumstances. A good example of this is technical training. Considerable forethought had been given to the training required for LSH personnel both within the project and by other authorities and every reasonable assistance was provided. Despite this, much essential training could only be provided after experienced senior staff had first learned the ship and its systems, and then documented this information into a training format.

...../4

Similarly, documentation such as Ships Standing Orders had to start from zero. The LSH is so markedly different in so many respects from other ships that this was the only viable approach to this time consuming task.

5. It is recommended that for future "one off" building projects, like that for HMAS TOBRUK, posting dates for key personnel should be as early as possible. There seems little point in providing generalised guidance in ABR 1921 as each case is likely to vary markedly.

Annex B to the Commanding Officer HMAS TOBRUK letter 42.1.1 of 6 October 1981

DUTIES OF PERSONNEL STANDING BY SHIPS BUILDING

ADMINISTRATION

1. The experience of the TOBRUK standby crew at RAAF Williamtown was that until handover, the administration was organised along the lines of a tender to HMAS PENGUIN. Although on handover the Fleet Commander assumed full command, current regulations are couched in such terms that until a ship actually commissions, many administrative functions cannot commence. This is a most unsatisfactory situtaion which requires amendment.

2. Until a ship commissions it is not recognized as HMAS and, as such, cannot operate as an autonomous unit financially, or to a large extent administratively. For the standby crew, the reality of the matter is that administration is worked up from zero to 100% at commissioning day.

3. Administrative arrangements for future builds must make allowance for this gradual progression. The situation whereby certain vital functions cannot, by regulation, be commenced until commissioning day (e.g. the operation of a cash account) requires amendment. In this context the following is a list of activities which cannot be commenced until commissioning:

a. operation of a cash account (with all aspects that this covers);

b. claiming of victualling allowance;

c. ordering of provisions;

d. use of local purchase for stores/services;

e. operation of canteen;

f. operation of CSB agency;

g. operation of Non Public funds;

h. operation of Relief Trust Fund Account;

i. delegation of write off of stores (CO and SO);

j. use of sales tax exemption/other customs entitlements;

k. authority to punish (prior to handover date the CO HMAS PENGUIN was able to delegate);

l. payment of allowances (e.g. seagoing - none of which was payable during sea trials under current regulations despite the fact that Defence Force personnel were at sea);

m. operation of repayment messing;

n. payment of ship's accounts; and

o. use of AUSHIMPS

4. The provisions of Navy Office letter N108/1/12 of 13 March 1981 did not cover all these requirements and the issue of the letter was much too late to allow for the gradual build up of administration considered necessary. It was a matter of considerable frustration to the standby crew and a total misuse of trained manpower that the aspects covered in paragraph 3 above were not authorised well before sea trials commenced. Once all the key administration billets were filled there was no logical reason why the standby crew could not have become an autonomous accounting unit.

.../2

5. It is recommended that for any further build the regulations be amended to allow for the most efficient management of the administration of a standby crew to be implemented.

Annex C to the Commanding Officer
HMAS TOBRUK letter 42.1.1 of
6 October 1981

DUTIES OF PERSONNEL STANDING BY SHIPS BUILDING

TECHNICAL

1. Documentation. It follows from the comment in Annex A that technical staff must have access to all documentation. The repeated refusal to provide the standby crew with the LSH specifications was not understood during the standby period and has still not been satisfactorily explained. Even at this point in time, 6 months after commissioning, there are instances where the task of running and maintaining this ship during its initial period of service would be made easier if the ship held the builders specifications. Instances have occurred where higher authority has asked the ship to comment on whether or not equipment/fittings are in accordance with the specifications.

2. Quality Assurance/Control. There are countless examples in HMAS TOBRUK of items/finish/equipment siting and the like which are wholly unsatisfactory and which could and would have been remedied had the expertise of the standby crew been used. Fortunately, common sense prevailed in some instances when problems arose e.g. the siting of the TV monitor on the bridge, (when the advice of the ultimate user, the standby crew, was accepted). In the vast majority of instances however, a dogmatic approach to a perception of the contractural arrangements by the General Overseer resulted in unnecessary problems. Many of these still exist e.g. the poor drainage in some shower stalls and the continued existence of insulating material on the sides of shower stalls which is causing an unnecessary corrosion problem.

3. It is recommended that in any future build in similar circumstances:

a. all technical documentation be made available to the standby crew; and

b. the standby crew be required to be fully involved in the QA/QC aspects of the build.

Annex D to the Commanding Officer
HMAS TOBRUK letter 42.1.1 of
6 October 1981

DUTIES OF PERSONNEL STANDING BY SHIPS BUILDING

NAVAL STORES

1. The storing operation for HMAS TOBRUK was carried out at the RAAF Base, Williamstown. It is not known where the responsibility for this decision was taken as it seems to have been made purely on the information that the RAAF were able to make the appropriate space available in an adjacent building to the one occupied by the standby crew. The specifications omitted that stores space had to be made available shipside to undertake the ship's SOAP storing operation in CSPL. In the final stages of storing RAAF Williamstown was unable to provide the total amount of storage space required. Recommendations on this aspect are as follows:

- a. mock-ups and storing operations to be carried out at SOAP Sydney;
- b. SOAP storing operation and requirements be detailed in specifications; and
- c. shipyard be required to provide working accommodation for SOAP team working in conjunction with the Inspector Stores.

2. Despite instructions laid down in ABR 5153, ABR 4 and ABR 1921, information regarding the receipt and return, distribution and variation in the provision of stores both AGFE and CFE, was not passed to the Supply Officer (designate) by the RNO. Copies of the issue vouchers were not passed on. The reason given by the General Overseer was that due to the contractural arrangements of a private shipbuilder, this action in accordance with RAN regulations was not required. As a consequence many items of AGFE stores remained in the custody of CSPL until the ship was actually due to sail from Newcastle after commissioning. It is essential for RNO to be supported by and accept advice from a person with Naval Stores expertise. It is recommended that an LSSN/ABSN be attached to work alongside him for this purpose.

3. A further frustration in the storing of HMAS TOBRUK was that advantage was not taken by RNO or CSPL of the experience available for establishing the arrangements and layouts for the various storerooms. By way of example:

- a. Supply Officer (designate) indicated the necessity for COMPACTUS racking to be installed, and although successful in having this equipment acquired, it was installed without further reference and in such an unprofessional manner that efficient use of the bulkhead racking as well as the COMPACTUS itself was precluded;
- b. the aluminium type shelving in the Cleaning Gear Store could not carry the weight of items to be stowed thereon. Several shelves actually sagged and had to be braced. This shortcoming was identified by Naval Stores staff before handover;
- c. the superfluous installation of light stainless steel racking in the Cold Room and Potato Refrigerator was identified by Supply Officer (designate) before handover; and
- d. the racking built in the rear of the Canteen was done with mild steel angle iron whereas light stainless steel racking would have sufficed.

...../2

It is recommended that more flexible arrangements be instituted so that the expertise of the officers standing by can be fully exploited in this regard.

4. A further shortfall identified during the standby period was the lack of documentation made available to the Naval Stores staff. A copy of Detailed Schedules had to be photocopied in Canberra for use at RAAF Williamstown. EBASALS are still not held and the S.A.I.D. has suffered multitudinous amendments and deletions of necessity, leaving it in a very dilapidated condition and appearance. It is recommended that the following documentation be made available to the standby stores staff and Stores Inspector:

- a. copies of supply vouchers for AGFE items supplied to CSPL or Dockyard;
- b. Detailed Schedules and all amendments;
- c. drawings of compartment arrangements;
- d. copies of CAPOs; and
- e. details of equipment recited.

5. A great deal of work has been generated in trying to get the allowances for stores correct for HMAS TOBRUK. Presently the allowances are assessed by DNSUS, who is distant from the actuality of equipment and is not in a position to quickly and accurately assess the necessary allowances for the ship. It is recommended that:

- a. the Naval Stores staff have a recognized input channel to amend or propose new/adjustments to ships allowances; and
- b. an alternative system be devised for new construction ships to increase or amend allowances for permanent items in lieu of the current SA242 procedure.

6. Experience in standing by the construction of HMAS TOBRUK highlighted several aspects with regard to stores personnel that should be addressed. It is recommended that:

- a. the Stores Inspector should join in advance of the Naval Stores staff so that the validation of equipment and raising of the account can be completed before the complications of assessing general stores allowances and OAL and APL problems are undertaken;
- b. the Naval Stores staff should join the standby crew not earlier than 6 months before commissioning. After joining, the Naval Stores staff should work independently of the SOAP team until such time as the T-force is raised; and
- c. the stores personnel manning sections at Navy Supply Centre, Sydney be fully briefed about the new construction ship, its roles and its production time scale so that they are aware of the ship's requirements, its location and any supply/demand limitations that may obtain at the construction site.

ANNEX J TO
DNTM 0539/82
OF 19 MAY 82

(184)

TTP No 8 Date 30/5/80

HMAS TOBRUK

TEST & TRIALS PROCEDURE APPLICABLE TO SEWAGE TREATMENT & DISPOSAL ARRANGEMENTS

Shipbuilder

Carrington Slipways Pty Ltd
Old Punt Road
TOMAGO NSW 2322

Prepared by

Needham-Clark Associates
Defence Industry Consultants
PO Box 221
CIVIC SQUARE ACT 2608

CONTENTS

1. **PURPOSE**

To define the requirements for achieving a satisfactory CST for the treatment, maceration and disposal of sewage.

2. **SCOPE**

This procedure covers the test and trials required to demonstrate the satisfactory installation and performance of the installed sewage treatment and disposal arrangements viz:-

a) The discharge of raw sewage directly overboard.

b) The maceration and chlorination of sewage before discharge.

c) The discharge of sewage to a shore facility using IMCO standard connections when in harbour.

d) The storage of all body and domestic waste from 500 men for 2 days at the rate of 20 galls/man/day

3. **APPLICABLE DOCUMENTS**

3.1 **Specifications**

Technical Spec, Vol 2 - 4.10.3

Vol 3 - 11.1.15, 11.1.16

3.2 **Drawings**

138/605 - Sewage Arrangements

3.3 **Forms** - Nil

4. **DEFINITIONS**

T.O - Shipbuilders Test & Trials Officer

G.O.S.I - General Overseer & Superintendent of Inspection - East Australia Area

R.A.N.T.A.U - RAN Trials and Assessing Unit

5. **REQUIREMENTS AND PERFORMANCE TO BE ATTAINED**

5.1 **General Requirements**

5.1.1 All test/trials shall be programmed and phased to suit the shipbuilders organisation and availability of manpower

5.1.2 The inspection team shall consist at least of:-

(i) T.O Plus assistance as required

(ii) G.O.S.I and/or R.A.N.T.A.U representatives as applicable.

5.2 **Pre-requisites**

CST's

(a) That the Final Installation Inspection has been satisfactorily completed and confirms that the installation is in accordance with the drawings and specifications including e.g

(i) That SW lines have been fitted for tank cleaning purposes.

(ii) That the chlorination units have been correctly fitted

(iii) That the LP Air Agitation System has been installed.

(iv) That all pumps/motors, alarms and warning devices are appropriately fitted

(b) That the system has been primed, and mechanically/electrically "set to work" including the setting of alarms and cut "in/out" switches.

5.3 **Performance**

5.3.1 The capacity of the system has been designed to store in the Holding tanks all body and domestic waste from 500 men for 2 days at the rate of 20 galls/man/day and consists of drains led to 6 in No. Macerator/Collecting Tanks discharging into 2 in No. Holding Tanks ($50m^3$ capacity each) located as follows:

Holding tanks - Frms 56-64 (P&S) D.B. Wing

Macerator/Collecting Tanks - Frms 22-25 (P&S) AMR

Frms 61-64 (P&S) DB Wing

Frms 121-124 (P&S) No 2 Army Store

5.3.2 Each Holding Tank is fitted with air vents, a chlorination unit and an air agitation system 4 psi (34.5kpa) 50cu ft/min to prevent the settlement of sludge.

5.3.3 Technical Data of Pumps and motors are as follows:-

a) **Holding tank discharge pumps** - 2 in No.

Pump - D60 Mono Type CD62R5

Motor - ASEA 4kw, 1155 RPM Type 132M4

[illegible]

c) Collecting tank transfer pumps - 6 in No
Pumps - D60 Mono Type GD62R5
Motors - ASEA 4kw, 1155 RPM Type 132MA

d) Chlorinators - 2 in No
Pump - Mono Type D45P/72SPM
Motor - GMF Cadet 0.5HP 1750 RPM
Type NFT BU5C2/4

6. TEST/TRIAL PROCEDURE & CHECK LISTS

6.1 Precautions Prior to Commencement of Test/Trials

The pre-requisites enumerated in para 5.2 are to be fully complied with.

6.2 CST - Sewage Treatment and Disposal System

6.2.1 General

The trial shall be constrained by the following agreed International Anti-pollution Rules:

a) Discharge of sewage whether treated or untreated is not permitted in Port or Harbour and within 4 miles of the nearest land.

b) Sewage discharge at sea is permitted between 4-12 miles from the nearest land providing such discharge is comminuted and disinfected.

6.2.2 Test/Trial

At a time and date to be nominated by the shipbuilder during Contractor's Sea Trials and with all W.C, urinal and galley drains discharging into the Collector and Holding Tanks examine/test the following when outside the 4 mile limit:

a) That all the macerator revolving cutterheads operate correctly and that the pump float switches - "high & low" level cut in/out as appropriate

b) That the chlorinator units suitable discharge hypochlorite into the Holding tanks.

c) That the LP Air Agitation System functions correctly.

d) That tank cleaning facilities in the form of S.W washing is adequately arranged i,e:

i) Flexible hose from an IHC for the Macerator/Collecting Tanks.

ii) Fixed installation to the Holding Tanks.

e) That air vent terminals from the holding tanks have flame proof protection fitted, and any odours readily disperse to atmosphere.

f) That the contents of Holding Tanks can be readily pumped overboard or to the shore discharge outlets at -

Port - No 1 Deck Frms 50-51
Std - No 1 Deck Frms 48-49

7. RECORD SHEETS/FORMS

Record sheets attached.

SHIP No/NAME	TEST & TRIAL PROCEDURE No 8	RECORD SHEET
	CST-SEWAGE TREATMENT & DISPOSAL ARRANGEMENTS	

TEST/TRIALS DATA -

PUMP/MOTOR LOCATION	TYPE	SERIAL No	RPM	VOLTS	AMPS	REMARKS
A.M.R						
Transfer Pump (Frm 19½P)						
Transfer Pump (Frm 22½S)						
Mascerator Unit (Frm 24½P)						
Mascerator Unit (Frm 24½S)						
M.M.R						
Chlorination Unit (Frm 45P)						
Chlorination Unit (Frm 45S)						
Discharge Pump (Frm 49½P)						
Discharge Pump (Frm 49½S)						
Blower Unit (Frm 50½P)						
Blower Unit (Frm 50½S)						

SHIP No/NAME	TEST AND TRIAL PROCEDURE No 8	RECORD SHEET
	CST - SEWAGE TREATMENT & DISPOSAL ARRANGEMENTS	

TEST/TRIALS DATA - continuation sheet

PUMP/MOTOR LOCATION	TYPE	SERIAL NO	RPM	VOLTS	AMPS	REMARKS
DB WINGS						
Macerator Unit (Frm 61-64P)						
Macerator Unit (Frm 61-64S)						
Transfer Pump (Frm 61-64P)						
Transfer Pump (Frm 61-64S)						
No 2 Army Store						
Macerator Unit (Frm 121-124P)						
Macerator Unit (Frm 121-124S)						
Transfer Pump (Frm121-124P)						
Transfer Pump (Frm 121-124S)						

General Comment: ______________________

____

Signed (Shipbuilder) ______________ Date ________

Signed (Inspecting Authority) ______________ Date ________

EXTRACTS FROM ABR 1921 - ITT RESPONSIBLITIES

The following extracts from ABR 1921 list the responsibilities of the GENERAL OVERSEER AND SUPERINTENDENT OF INSPECTION (GOSI) and RANTAU with respect to Inspection Tests and Trials (ITT):

"2107. GENERAL OVERSEER AND SUPERINTENDENT OF INSPECTION (GOSI). The GOSI:

a. co-ordinates inspections, tests and trials at outside contractors.

b. carries out or participates in inspections, tests and trials shown at Annex A; and

c. drafts in conjunction with builders, Captain Trials and any other parties concerned, the trials programme for ships in commercial yards.

2108. All inspections, tests or trials are to be made or witnessed by the appropriate GOSI representative, and a record is to be made, whether or not the regulations call for a report.

2109. The GOSI is to ensure that all necessary test equipment, dummy loads or other external services detailed as necessary by the Inspection or Trials Authority, are available on the scheduled date for trial.

2110. All services, systems and items of Naval equipment, except where otherwise mentioned, are to be subject to tests and trials under the supervision of the GOSI after installation onboard, to ensure that specific requirements are met. The results of all such tests and trials are to be recorded.

2111. The GOSI is responsible for ensuring that the work specified has been carried out prior to any trial or inspection. If the work is obviously not on schedule and cannot be ready in time for the inspection, he is to alert the shipbuilder to this fact and is to advise all concerned if he considers the lack of preparedness warrants cancellation of the trial or inspection.

RANTAU

2119. RANTAU is to inspect ships under construction, modernisation, conversion or extended refits by Naval or Civil organisations as shown at Annex A to confirm that the ship meets the established requirements for Naval Service.

2120. RANTAU is to conduct trials on ship equipment installed or modified by Naval or Civil organisations as at Annex A to ensure that its performance and installation is satisfactory for acceptance into Naval Service.

2121. RANTAU is to liaise with GMs/GOSI and Commanding Officers in the preparation of programmes of inspections, tests and trials.

2122. RANTAU is to advise on amendments to Acceptance Trials Schedules.

2123. RANTAU is to produce schedules for inspections, tests and trials for which he is responsible. Part time trials officers are to produce such schedules as requested by RANTAU subject to the requirements of the parent establishment. These schedules are to be submitted to Navy Office for approval.

2124. RANTAU is to advise the GOSI or General Manager if the satisfactory acceptance of equipments cannot be achieved within the allowed time scale.

DGFM 0539/82
OF 19 MAY 82

C O P Y

UNCLASSIFIED

In reply quote: 18-13-74

RAN Trials and Assessing Unit,
54-56 Miller Street,
NORTH SYDNEY, NSW 2060
TELEPHONE (02) 9297722
TELEX AA27145

16 FEB 1979

Department of Defence (Navy Office)

Attention: Director General Naval Production

For Information:

Controller, Service Laboratories and Trials
Director General, Naval Operational Requirements
General Overseer and Superintendent of Inspection,
East Australia Area
AOR and Patrol Craft Project Director
Amphibious Heavy Lift Ship Project Director

L.S.H., P.C.F. AND 12 M.W.B. - TESTS AND TRIALS

Reference: A. DNSP letter ..?../6/163 dated 30 October 1978

B. ABR 1921, Instructions for HMA Ships Building, Undergoing Modernisation, Conversion or Extended Refit.

1. The intention, stated at Reference A, to keep tests and Trials of L.S.H., P.C.F. and 12m Work Boats building to a minimum and, further, to keep RANTAU attendance at trials to a minimum, appears to conflict with the requirements at Reference B, Chapter 21 and Annex A.

UNCLASSIFIED

UNCLASSIFIED

2. It is considered that Reference B makes sufficient distinction between the functions and responsibilities of GOSI and those of RANTAU to preclude the duplication of effort suggested at reference A, paragraph 5. Reference B Article 0107 begins:

> "The main function of GOSI is to ensure that orders placed on contractors are completed to specified standards...."

whereas Articles 0124, 2119 and 2120 charge RANTAU with determining that ships and their equipment meet the requirements for Naval Service. The inference of Reference A Paragraph 1, that RANTAU provides an extension of the GOSI's capacity or capability, appears to be at variance with those distinctions.

3. The transfer of RANTAU to the Defence Science and Technology Organisation has ...?...?...?...the substance of the functions and responsibilities mentioned.

4. Clarification of the intended implementation of instructions at Reference B is requested.

(J.G. McDERMOTT)
Captain RAN
Officer-in-Charge
RANTAU

Enclosure: *Copy of Reference A (to DSLT AND DGNOR only)*

DGFM 0539/82
OF 19 MAY 82

Inspection ... Trials Docs

UNCLASSIFIED

In reply quote: 18-13-74

RAN Trials and Assessing Unit,
54-56 Miller Street,
NORTH SYDNEY, NSW 2060
TELEPHONE (02) 9297722
TELEX AA27145

16 FEB 1979

Department of Defence (Navy Office)

Attention: Director General Naval Production

For Information:

Controller, Service Laboratories and Trials
Director General, Naval Operational Requirements
General Overseer and Superintendent of Inspection,
East Australia Area
AOR and Patrol Craft Project Director
→ * Amphibious Heavy Lift Ship Project Director — COPY TO LSH-PD / AOR/PCPD NOT AOR/PCPD

L.S.H., P.C.F. AND 12 M.W.B. - TESTS AND TRIALS

References: A. DNSP Letter ... dated 30 October 1978

B. ABR 1921, Instructions for RAN Ships Building, Undergoing Modernisation, Conversion or Extended Refit.

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> "The main function of GOSI is to ensure that orders placed on contractors are completed to specified standards.... "

whereas Articles 0124, 2110 and 2120 charge RANTAU with determining that ships and their equipment meet the requirements for Naval service.

UNCLASSIFIED

UNCLASSIFIED

The inference of Reference A paragraph 4, that RANTAU provides an extension of the GOSI's capacity or capability, appears to be at variance with those distinctions.

3. The transfer of RANTAU to the Defence Science and Technology Organisation has not altered the substance of the functions and responsibilities mentioned.

4. Clarification of the DNSP and implementation of instructions at Reference B is requested.

(J.G. McDERMOTT)
Captain RAN
Officer-in-Charge
RANTAU

Enclosure: Copy of Reference A (to CSLT and DGNOR only)

UNCLASSIFIED

(47)

RESTRICTED

NNNNVV BQA102 .HH
RR RAYWKE
DE RAYWBZD 005 1430228
ZNY RRRRR
R 230202Z MAY 81
FM HMAS TOBRUK
TO RAYBNA/COMAUSPHIBRON
INFO RAYBNA/HMAS MORETON
RAYWNN/DEFNAV CANBERRA
RAYRMT/GMGID
RAYWKE/GOSIEAA
RAYRMT/COMAUSFLT
BT
R E S T R I C T E D
SIG UNA/RDF
INDEF 07/85 PRIORITY THREE
A. ABR 5230 ART 0535
B. HMAS TOBRUK UNA/RDF/IAH 150903Z MAY 81
1. A. TROOP MESSDECKS. 4EA2 4EA1
B. MESS DECK FLOODED WITH RAW SEWERAGE REF B SATURATING LOCKERS, LININGS AND INSULATION.
C. REQUEST ASSISTANCE TO INVESTIGATE AND REPAIR AS NECESSARY
D. TROOP MESS UNINHABITABLE, HEALTH HAZARD
E. N/A

PAGE 2 RAYWBZD 005 R E S T R I C T E D
F. BRISBANE 15 JUNE - 22 JUNE 81
G. TM000 DH 15/85
BT

DIST FILE GOSI, PH04
MINT11

TOR0341Z/23 BQA102

NNNN

RESTRICTED

RESTRICTED

47A

PRIORITY

V EYA495 HH
PP RAYWKE
DE RAYBNA 557 1630634
ZNY RRRRR
P R 120630Z JUN 81
FM HMAS MORETON
TO RAYRMT/COMAUSFLT
RAYWKE/GOSIEAA
INFO ZEN/NOCQLD
RAYWKE/COMAUSNAVSUP
RAYRMT/GMGID
ZEN/HMAS TOBRUK
RAYWNN/DEFNAV CANBERRA
BT
R E S T R I C T E D
SIG RDH/UNF
HMAS TOBRUK - TROOP MESS DECKS NOS 10 AND 11
A. HMAS TOBRUK UNA/RDF 230202Z MAY 81 (INDEF 7/75)
B. DEFNAV CANBERRA UNF/UNL 030033Z JUN 81
1. TWO BRISBANE CONTRACTORS WERE INVITED TO TENDER FOR CLEANING UP CONTAMINATED MESSES. ONE CONTRACTOR REFUSED TO TENDER AND ..TERS SHIP REPAIR PTY LTD QUOTED DOLLARS TWO FIVE ZERO ZERO ZERO ..NTS NIL PER MESS
2. QUOTE INCLUDES:

RESTRICTED

PAGE 2 RAYBNA 557 R E S T R I C T E D
(A) REMOVE ALL ELECTRICAL FITTINGS AND LATER REPLACE
(B) REMOVE AND REPLACE BUNKS, SETTEES CUPBOARDS, LOCKERS ETC
(C) REMOVE AND REPLACE DECKHEAD PERIMETER PANELLING WHERE NECESSARY
(D) REMOVE AND REPLACE ALL BULKHEAD PANELS AND STEAM CLEAN WHERE REQUIRED
(E) SCRUB AND DISINFECT DECK AREA
(F) STEAM CLEAN WITH DEODORIZER BEHIND BULKHEADS
(G) REMOVE AND REPLACE VINYL SKIRTING
3. CONTRACTOR WOULD REQUIRE TEN DAYS, INCLUDING WEEKEND, TO COMPLETE JOB
4. CSPL MANAGEMENT TEAM INSPECTED THE MESSES PM 11JUN81 AND CONFIRMED THEY WOULD ACCEPT NO RESPONSIBILITY FOR CLEANING MESS DECKS
5. REMOVAL OF PANELS AT MOST CONTAMINATED END OF MESSES REVEAL THAT LIQUID HAS CONTAMINATED BOTTOM OF INSULATION MATERIAL. SWABS OF AREAS BEHIND BULKHEADS HAVE BEEN DESPATCHED TO ONE MILITARY HOSPITAL (BRISBANE) FOR BACTERIAL ANALYSIS. RESULT EXPECTED 15[illegible] JUN
6. TOTAL REMOVAL OF ALL FURNITURE, BULKHEADS AND FITTINGS FOR DECONTAMINATION IS AN AWESOME TASK AND WILL PROBABLY RESULT IN SOME DAMAGE TO FITTINGS AS A CONSEQUENCE. TASK CONSIDERED ABOVE INTERMEDIATE LEVEL MAINTENANCE

PAGE 3 RAYBNA 557 R E S T R I C T E D
7. WAY AHEAD. IN ABSENCE OF PROVEN RECTIFICATION OF SEWAGE SYSTEM DEFECT (INDEF 17/75), WOULD SEEM PREMATURE AND IMPRUDENT TO COMMIT WORK AT PARA 2 DURING THIS AMP. IN ANY CASE TASK COULD NOT BE COMPLETED WITHOUT DELAYING SHIPS TRIALS PROGRAMME
8. SUBJECT TO [illegible]
[illegible]
[illegible]
9. [illegible]

M-4

Department of Defence

TSM 200
Formerly TM 200
Revised Nov 78

SHIPS WORK REQUISITION – NAVY

	Date Raised	Serial No	Defect Priority	SIC
1112	20 MAY 81	DH16/65	2	H N D C K U C B

DEF/HRDEF/REDEF No: 7/85 | System/Equipment: TROOP MESS | Unit/Sub Assembly: TROOP MESS 4EA2, 4EA1

Component Identification | Relevant Handbook, Drawing etc

Defect/Failure (A full description and history will assist estimating and planning, to include sketch if applicable)

MESS DECK FLOODED WITH RAW SEWERAGE SATURATING LOCKERS, LININGS AND INSULATION.
TROOP MESS UNINHABITABLE, HEALTH HAZARD.

Symptoms/Cause

Repair (Completely describe repairs required and indicate amounts, sizes, types and lengths of material, eg cable/pipes together with appropriate stock numbers, finalised on completion of investigation).

- [x] Investigation needed to determine full nature of repairs.
- [ ] Repair action definite - no investigation needed.
- [ ] Documentation action only.
- [ ] Ships staff remove and replace.
- [ ] DYD supply finished material.

REMOVE LININGS AND FITTINGS, STEAM CLEAN AND REPLACE.

Access (Briefly indicate action required to gain access or items to be removed/cut away, plus any dependency)

LOCKERS, LINING REMOVED.

Support (Detail support services required during repairs, eg fresh water, compressed air)

N/A

PM: Relevant PM routines to be completed concurrently with repair. DYD — Schedule Numbers: N/A — Date Due
SS — Schedule Numbers: N/A

DOCKYARD USE ONLY: Trade in Sec | TOTAL | Mode of Repair | Manhours | Quality Assurance Acceptance

Department of Defence

PURCHASE ORDER – NAVY

THE MANAGER
TOWERS SHIP REPAIR
36 BAILLON STREET
KANGAROO POINT QLD 4169

Amendments Code	No	Consignee Code	First Delivery Date	Final Delivery Date
5169	82	E	51	-

FROM: Ordering Authority: NAVAL HEADQUARTERS, GPO BOX 1416, BRISBANE QLD 4001

Enquiries to: MR K.J. ARNOLD; Telephone: 226 2600 Ext 2647; Telex:

DELIVER TO: Deliveries should be made between ......am and ......am or ......pm and ......pm Monday to Friday to the following address: HMAS TOBRUK AT BRISBANE

Where condition No 7 (See overleaf) is applicable the mode of transport to be used is.

Class	Catalogue No	Description, Item or Service	UI	Quantity to be Supplied	Rate $	Amount $
		FSA HMAS TOBRUK – TSH 200 – DH16				
		TROOPS MESS – PORT AND STARBOARD		FIRM	COST	$16,000.00
		a. PORT MESS – RELEASE BERTHS ETC FROM BULKHEADS, STEAM CLEAN MESS AND DEODORISE, REPLACE BERTHS ETC ON COMPLETION.				
		b. STARBOARD MESS – CROP OR CUT LOWER SECTION OF BULKHEAD PANELS, REMOVE INSULATION IN WAY OF PANELS REMOVED, STEAM CLEAN AREA AND DEODORISE. REPLACE 9" OF LOWER SECTION REMOVED FOR STEAM CLEAN.				
		DAS MINUTE NO 7170 REFERS.				
		Note: All work/repairs to be carried out in accordance with the Terms/Conditions of Period Contract P.O. 2712 and as per the requirements of Naval Inspection Form T.1.364.				

Vocation Code	Working/Cost Code	Project Number	Amount	Expenditure Authority No
			$16,000-00	FA 40512

Requiring Supply (Signature): [signature] 28.8.81. Approved (Signature) ... Date ... Funds are available – Authorising Officer (Signature) ... Date

TREASURY FORM 11
REQUISITION
CERTIFYING OFFICER'S COPY

Department of Defence

TSM 200
Formerly TM 200
Revised Nov 79

SHIPS WORK REQUISITION – NAVY

[illegible]	Date Raised	Serial No	Defect Priority	EIC
1112	5 JULY 81	DH 54/85	4	

INDENT/ORDER/REDEF No	System/Equipment	Unit/Sub Assembly
N/A	SEWAGE	MA[illegible] TANKS

Component Identification

Relevant Handbook, Drawing etc

Defect/Failure (A full description and history will assist estimating and planning, to include sketch if applicable)

VENTS TO BE FITTED I.A.W. N.O. DWG. A200206. (SEWAGE HOLDING TANK AIR ESCAPE EXTENDS (N))

Symptoms/Cause

SYSTEM GENERATES EXCESSIVE SMELL & GAS.

Repair (Completely describe repairs required and indicate amounts, sizes, types and lengths of material, eg cables/pipes together with appropriate stock numbers, finalised on completion of investigation).

- ☐ Investigation needed to determine full nature of repairs.
- ☐ Repair action definite – no investigation needed.
- ☐ Documentation action only.
- ☐ Ships staff remove and replace.
- ☐ DYD supply finishing material.

Access (Briefly indicate action required to gain access or items to be removed/cut away, plus any dependency).

Support (Detail support services required during repairs, eg fresh water, compressed air).

PM — Relevant PM routines to be completed concurrently with repair. DYD — Schedule Numbers — Date Due; SS — Schedule Numbers

DOCKYARD USE ONLY: Trade in Sec. / Manhours / Material Cost / TOTAL / Mode of Repair / Quality Assurance Acceptance

PURCHASE ORDER – NAVY

THE MANAGER
CARDIFFE ENGINEERING PTY LTD
PO BOX 49
ALDERLEY QLD 4051

5169 02 E 41

FROM — Ordering Authority: NAVAL HEADQUARTERS, GPO BOX 1416, BRISBANE QLD 4001

Enquiries to: MR K.J. ARNOLD Telephone: 226 2600 Ext 2647

DELIVER TO: HMAS TOBRUK AT BRISBANE

Class	Catalogue No	Description, Item or Service	UI	Quantity to be Supplied	Rate $	Amount $
		FSA HMAS TOBRUK – TSM 200 – DH 54/85				
		EXTEND SEWAGE VENTS AS DETAILED ON DWG 200206		FIRM COST		$6,166.00
		Note: All work/repairs to be carried out in accordance with the Terms/Conditions of Period Contract P.O.2712 and as per the requirements of Naval Inspection Form T.I.364				

Expenditure Authority No FA 40512

Amount $6,166-00

TREASURY FORM 11
REQUISITION
CERTIFYING OFFICER'S COPY

Department of Defence

TSM 200
Formerly TM 200
Revised Nov 79

SHIPS WORK REQUISITION — NAVY

Source	Date Raised	Serial No.	Defect Priority	EIC
[illegible]	[illegible] AUG 83	[illegible]		

INDEF/URDEF/REDEF No	System/Equipment	Unit/Sub Assembly
[illegible]	[illegible] AG	[illegible]

Component Identification	Relevant Handbook, Drawing etc

Defect/Failure (A full description and history will assist estimating and planning, to include sketch if applicable)

[illegible] SYSTEM FAILED ON PREVIOUS OCCASION [illegible] SEWAGE FLOODING.

Symptoms/Cause

Repair (Completely describe repairs required and indicate amounts, sizes, types and lengths of material, eg cables/pipes together with appropriate stock numbers, finalised on completion of investigation).

- ☐ Investigation needed to determine full nature of repairs.
- ☐ Repair action definite - no investigation needed.
- ☐ Documentation action only.
- ☐ Ships staff remove and replace.
- ☐ DYD supply finished material.

[illegible] MACERATOR TANKS CONTENTS GAUGES

EACH OF THE [illegible] MACERATOR TANKS SHALL BE FITTED WITH A CONTENTS GAUGE COMPLETE WITH A LOCAL CONTENTS LEVEL READOUT. THE CONTENTS GAUGE EQUIPMENT WITHIN THE MACERATOR TANK MUST BE SUITABLE FOR USE WHEN IMMERSED IN RAW SEWAGE [illegible], MATERIALS USED SHALL NOT BE ADVERSELY AFFECTED AND THE DESIGN SHALL ENSURE AGAINST BUILD UP OF FAECES, TOILET PAPER ETC WHICH COULD LEAD TO A FALSE READOUT.

MACERATOR TANKS TIME SWITCHES

EACH OF THE [illegible] MACERATOR TANK PUMPS SHALL BE FITTED WITH A TIME SWITCH (SET TO APPROX 12 HOUR INTERVALS) IN ORDER TO PREVENT BUILD UP OF FOUL ODOURS WHEN TANKS ARE USED INFREQUENTLY.

Access (Briefly indicate action required to gain access or items to be removed/cut away, plus any dependency).

Support (Detail support services required during repairs, eg fresh water, compressed air).

PM				
Relevant PM routines to be completed concurrently with repair.	DYD	Schedule Numbers		Date Due
	SS	Schedule Numbers		

DOCKYARD USE ONLY														
Trade in Seq.												TOTAL	Mode of Repair	
Manhours													Quality Assurance Acceptance	
Material Cost													(Signature)	

TSM 200
Formerly TM 200
Revised Nov 79

SHIPS WORK REQUISITION — NAVY

Source	Date Raised	Serial No	Defect Priority	EIC

INDEF/URDEF/REDEF No	System/Equipment	Unit/Sub Assembly

Component Identification	Relevant Handbook, Drawing etc.

Defect/Failure (A full description and history will assist estimating and planning, to include sketch if applicable)

Symptoms/Cause

Repair (Completely describe repairs required and indicate amounts, sizes, types and lengths of material, eg cables/pipes together with appropriate stock numbers, finalised on completion of investigation).

- ☐ Investigation needed to determine full nature of repairs.
- ☐ Repair action definite - no investigation needed.
- ☐ Documentation action only.
- ☐ Ships staff remove and replace.
- ☐ DYD supply finished material.

MAIN SEWAGE HOLDING TANK PRESSURE SWITCHES

EACH HOLDING TANK (IP & IS) SHALL BE FITTED WITH A PRESSURE SWITCH AT UNDERSIDE OF AIR ESCAPE TO SOUND BOTH LOCALLY AND WITHIN MCR WHEN TANK IS FULL.

Access (Briefly indicate action required to gain access or items to be removed/cut away, plus any dependency).

Support (Detail support services required during repairs, eg fresh water, compressed air).

PM				
Relevant PM routines to be completed concurrently with repair.	DYD	Schedule Numbers		Date Due
	SS	Schedule Numbers		

DOCKYARD USE ONLY														
Trade in Seq.												TOTAL	Mode of Repair	
Manhours													Quality Assurance Acceptance	
Material Cost													(Signature)	

TREASURY FORM 11
REQUISITION
CERTIFYING OFFICER'S COPY

Department of Defence
PURCHASE ORDER - NAVY

THE MANAGER
CARRINGTON ENGINEERING PTY LTD
PO BOX 49
[illegible] QLD 4051

FROM — Ordering Authority: NAVAL HEAD QUARTERS, GPO BOX 1416, BRISBANE QLD 4001

Telephone: 226 2600 Ext 2647

DELIVER TO — HMAS TOBRUK AT BRISBANE

Class	Catalogue No.	Description, Item or Service	UI	Quantity to be Supplied	Rate $	Amount $
		FOR HMAS TOBRUK - TSH 200 - H19		FIRM COST		$17,401.82
		SUPPLY AND FIT TO 6 NO MACERATOR TANKS, CONTENTS GAUGES, LOCAL READOUTS, TIME SWITCHES AND 4 PRESSURE SWITCH.				
		DES NUMBER NO 7170 [illegible]				
		Note: All work/repairs to be carried out in accordance with the Terms Conditions of Period Contract P.O.2712 and as per the requirements of Naval Inspection Form T.I.364				

Amount: $17,401-82
Expenditure Authority No: FA 40571

Carrington Slipways Pty. Ltd.

Shipbuilders.

Old Punt Road, Tomago, N.S.W., Australia, 2322.
Cables: "Carrslips", Newcastle.
Telephone: Newcastle 64 8071.
Telex: AA 28185.

OUR REF: JWMcP:KMcP
YOUR REF:

23rd June, 1981.

[redacted]Superintendent [redacted]
East Australian Area,
Regional Defence Office,
P.O. Box 706,
DARLINGHURST. N.S.W. 2010

Photocopy to: Department of Defence (Navy),
Russell Offices,
CANBERRA. N.S.W. 2600

Attention: Director of Naval Ship Production

Our Ref: N138-LT-234/81C

Subject: N138 LSH Tobruk - Warranty Defects

Ref :
A. GOSIEAA Letter 203/81G 20th May, 1981.
B. GOSIEAA Letter 207/81G 27th May, 1981.
C. GOSIEAA Letter 220/81G 17th June, 1981.
D. T1338 Defects List.

Dear Sir,

The following items were attended to by C.S.P.L. Personnel and Sub-Contractors in Brisbane during period 10th to 16th June inclusive.

A. Port Midship Macerator Ref. A

Pump and macerator motors found faulty, both were rewound, replaced and tested.

B. Sewage Discharge Pump Ref. A

Port pump, damaged rotor renewed and tested.

C. Holding Tank Alarms Ref. A

All level switches in both P. & S. holding tanks replaced with new type.

An additional high level switch fitted in each tank.

The system was tested and witnessed by Ships' Staff.

D. **Chlorination Units Ref. A**

System checked and set to work.

Ship is currently using a liquid chemical from Gibson Chemicals (type X1588). This chemical appears to have effected the solenoid disc which will require to be changed if use of this chemical is to continue.

E. **Fwd. Macerator**

Gate valves replaced with non return valves where necessary.

F. **Incinerator Sludge Burner (T1338)**

Permanent electrical connections completed.

C.S.P.L. to provide an in line "Y" type strainer to sludge pump suction line.

G. **Main Air Compressor Intakes Ref. B**

Air intakes to remain as modified by Ships' Staff.

H. **Bow Door Leaks Ref. A**

Pin and cleating repaired both P. & S. to give additional compression.

I. **Bow Ramp Leaks Ref. A**

Rubber chalk tested and packed where necessary. Rubbish in way of seal had caused indentation in rubber.

J. **Main Engine Exhaust Manifold Leaks Ref. B**

Ships' Staff replaced gasket. No action taken by C.S.P.L. or H.S.E.

K. **Diesel Generators Ref. B & C**

1. A.P.E. Service Engineer attended ship and repaired M.M.R. stbd. D.G. Spares for other 3 D.G.'s ordered from U.K. by A.P.E.

K. **Diesel Generators Ref. B & C (Cont.)**

2. C.S.P.L. had new exciter motor shaft together with a spare made locally. Exciter replaced and tested. A.P.E. advise that a spare shaft is being obtained from U.K.

3. D.G. F2, faulty transducer was replaced, however due to maintenance being carried out on prime mover a test could not be made.

L. **Capstans Ref. D**

New current transformers were fitted to all 5 Capstans on 3 Deck. All were tested satisfactorily.

M. **Boiler Safety Valves Ref. C**

C.S.P.L. agreed to supply 4 new safety valves for the Auxilliary Boilers.

Ships' Staff to fit and float to set pressure.

N. **Bow Thruster Oil Leak Ref. C**

H.S.E. Engineers have investigated and found oil reservoir vent blocked.

Following further use, if leak persists seals will be replaced first available opportunity.

O. **Funnel Emblem**

Modifications are being carried out by the Brisbane manufacturer to prevent recurrence of mounting bracket failure.

P. **C.C.T.V. Camera (Flight Deck)**

Cabling to this camera has been re-run external to funnel, in conduit, to prevent apparent overheating problem.

Q. **Sick Bay Sterilizer Ref. C**

It will be necessary to run a 2" vent pipe from the exhaust outlet at the top of the sterilizer to the outboard side of the external passageway to conduct exhausting steam to atmosphere.

To : GOSIEAA,
Our Ref: M138-LT-234/81C

Page 4.
23rd June, 1981.

Q. **Sick Bay Sterilizer Ref. C (Cont.)**

This job was not able to be attempted during this period. C.S.P.L. estimate a total of 40 hours labour necessary.

R. **Galley Potato Peeler**

C.S.P.L. placed order with "Hobart" office to carry out modifications to the unit to prevent excessive foaming.

Ships' Staff to install a S.W. flushing valve to prevent blockage of "S" trap in scupper.

S. **Aft Hatch Ramp Leaks**

Seals were chalk tested and packed where necessary.

T. **Gear Case Locks**

These were found to have been provided by C.S.P.L. in accordance with the Design Change Package, Item 9, TOBR-009-E.

U. **Police Lights (T1338)**

All blue lens have now been replaced with red lens.

This report covers all warranty work notified in writing or verbally up to and including 18th June, 1981.

Yours faithfully,
CARRINGTON SLIPWAYS PTY. LTD.,

John W. McPhee

J. W. McPHEE,
PROJECT CO-ORDINATOR.

ANNEX N TO
DGFM 0539/82
OF 19 MAY 82

VV NCA393 UU
RR
DE RAYWNN 148 0710818
ZNR JUUUU
R 120817Z MAR 82
FM DEFNAV CANBERRA
TO HMAS TOBRUK
BT
UNCLAS
SIG ADA
PERSONAL FOR CO FROM DGFM
SEWERAGE SYSTEM ACCIDENT
1. AN INFERENCE TO BE DRAWN FROM MY REVIEW THUS FAR IS THAT THERE IS A RESTRICTION OR EVEN A BLOCKAGE IN THE VENT PIPE SOMEWHERE BETWEEN THE PORT HOLDING TANK AND THE TOP OF THE STARBOARD KING POST
2. IF POSSIBLE, WOULD APPRECIATE EARLY INVESTIGATION AND ADVICE
3. ONE POSSIBLE METHOD, AFTER BLANKING MASCERATOR/COLLECTER TANK VENT CROSS-CONNECTION AND PLUGGING DRAINS TO HOLDING TANK, WOULD BE:
A. PLACE SMOKE OR SMELL SOURCE IN HOLDING TANK
B. START UP AERATION
C. SNIFF OUTLET:
D. TAKING CARE NOT TO OVER-PRESSURISE HOLDING TANK
4. GOOD LUCK
BT
END UNCLASSIFIED

Mar 12, 08 34 '82

SIG ADA
ACTION MSO
R, MSO
C, MSO
(1R 1C)

DGFM/S) (0)

NCA394 DE RAYWNO 580 3710444

N-2

NCA933 DE RBQPOZD 010 2821213

NCA933 UNCLASSIFIED
ROUTINE 231150Z MAR 82
FROM HMAS TOBRUK
TO DEFNAV CANBERRA
BT
UNCLAS
SIG ADA
PERSONAL FOR DGFM FROM CO
SEWERAGE SYSTEM TRIAL
A. DEFNAV CANBERRA ADA 120317Z MAR 82
1. TRIAL HAS BEEN CARRIED OUT WHILE SHIP WAS UNDERWAY AND AT ANCHOR IAW PARA 3 OF THE REF.
2. WITH AERATOR RUNNING MINIMAL BUILD UP OF PRESSURE IN HOLDING TANK WAS EXPERIENCED AND THIS WAS NOT SUFFICIENT TO MEASURE WITH ONBOARD EQUIPMENT. CONSTANT AIR DISCHARGE FROM KING POST VENT WAS OBVIOUS WHILE AERATOR WAS RUNNING. ALTHOUGH NO SMOKE OR ARTIFICIAL SMELL WERE USED TANK/SEWERAGE SMELL WAS OBVIOUS IN CLOSE PROXIMITY TO VENT DURING TRIAL.
3. RESULTS WERE THE SAM ON BOTH OCCASIONS.
4. DELAY IN RESPONSE REGRETTED BUT UNAVOIDABLE
BT
END UNCLASSIFIED

Mar 23 13 46 '82

SIG ADA
ACTION MSO
R, MSO
C, MSO
(IR (C)

DGFM (5)

1+6

Department of Defence

ORIGINAL

(7)

T1338 (1973)

ANNEX D TO DGFM 0539/82 OF 19 MAY 82

REPORT OF INSPECTION

HMAS TOBRUK

Tick appropriate box

- [x] Built
- [ ] Modernised
- [ ] Converted
- [ ] Extended Refit

By Commodore R.R. Calder RAN

PRIOR TO ACCEPTANCE FOR SERVICE IN HMA FLEET

Date and place of inspection 10 April 1981

at Newcastle NSW

This Report Comprises:-

List 1 - 4 pages

List 2 - Nil pages

INSTRUCTIONS:

Copies of this form are to be prepared for distribution as follows:-

1. New Construction - Contract Built Ship (ABR 1921 Refers)
   a. 2 copies to Navy Office (1 for Navy Office Copy of Ships Book)
   b. 1 copy to NOC of the Area
   c. 1 copy to the GM of the Dockyard at which the ship will be refitted
   d. 1 copy to be retained by GOSI
   e. 1 copy to ship for insertion in Captains Ship's Book
   f. 1 copy to RANTAU
   - HMA NAVAL DOCKYARD BUILT SHIP
   As for above, less copy to GOSI.

2. Modernisations, Conversions, Extended Refits. (ABR 1921 Refers)
   The requirement for Form TI338 to be raised will depend on the nature and extent of the work involved in the project. The Project Directive for each modernisation, conversion or extended refit will state whether or not Form TI338 is to be rendered. If required distribution will be as in 1 above.

If space is insufficient for inclusion of all items in Lists 1 and 2, additional serially numbered pages are to be inserted. The number of pages is to be shown in this form.

REPORT OF INSPECTION – LIST 1

Items outstanding at the date of inspection which it has been agreed will be completed by the shipbuilder at no additional charge to the Australian Government.

Page

Documentation to be completed: Captains Ships Book;
Drawings;
EBASALS;
Trials Reports.

Air conditioning system to be completed.

Incinerator sludge burner to be completed.

Damage control markings to be completed.

Radhaz markings to be done.

Tank deck lighting insufficient (subject to SG2 action).

~~Guardrail pins to be fitted~~.

Main engine flywheel guards to be extended.

~~Anchor cable guillotine – turnbuckle acceptable (sheet 2)~~.

Army store bulkhead to be watertight up to door opening.

Fuel oil filling stations door 462 P. & S. – bottom dogs to function correctly.

Anode securing to be to drawing requirements.

Stores hoist motor to be correct voltage and frequency.

~~Engine room service hoists to be [illegible]~~.

Helo starting and servicing arrangements.

Storm rails to be fitted 01 deck passageways.

3 Deck 1-4	Tank Deck Lighting does not meet the requirements of Vol IV of spec (appendix to Chapter 3 P4a) refer SG271 L1168.
3 Deck 1-4	Tank level indicators cables Frame 65 do not comply with ABR 862 or CSPL Drwg 720 H as marked "DANGEROUS AREAS".
3 Deck 1-4	Fluorescent Fitting end smashed broken diffuser clip Frame 27 Pt.
03 Deck 1	URA-38 Aerial does not have a copper strap fitted between the aerial and the coupler.
03 Deck 1	PVC covering to within 1 metre of aerial is not installed – incomplete.

.../2

It is agreed that List 1 items comprising ... pages will be completed by the Shipbuilder at no additional charge to the Australian Government | Shipbuilder (Signature)

REPORT OF INSPECTION – LIST 1

Items outstanding at the date of inspection which it has been agreed will be completed by the shipbuilder at no additional charge to the Australian Government.

Page 2.

04 Deck 1	Pt and Stbd Receiver Aerials not connected to coupler.
04 Deck 1	Receiver Aerial Couplers are not connected to Cable.
04 Deck 1	Copper Strap from coupler to URA-38 Aerial is not fitted.
04 Deck 1	Marconi Marine Receiver Aerial Wire and Cable are not connected.
03 Deck 3	Lifeguard auto alarm bell is not fitted.
03 Deck 3	Sonalert alarm bell is not fitted. Cable hanging loose.
~~03 Deck 3~~	~~[illegible]~~.
03 Deck 5	AEL not fitted.
03 Deck 7	3 in No. AEL's not fitted.
03 Deck 8	Cable for Intermediate Signal Light Box is not connected – stbd bridge wing.
02 Deck 1	Pt and stbd helicopter socket boxes have rusted earth studs and various positions on top are rusty. Internal and external voltages supply tallies not i.a.w. supplies available.
~~02 Deck 3~~	~~Unconnected wire is coiled [illegible] bulkhead [illegible]~~.
02 Deck 12	AEL's are not fitted.
~~02 Deck 17~~	~~Amenity Socket is not fitted~~.
02 Deck 18	J-Box Lid located behind head of bunk is missing – C.O. sleeping cabin.
02 Deck 29	J.B. Cover missing – helo clothing store.
01 Deck 4	AEL's are not fitted to location Pt and Stbd.
01 Deck 7	AEL not fitted.
01 Deck 8	AEL missing.

.../3

It is agreed that List 1 items comprising ... pages will be completed by the Shipbuilder at no additional charge to the Australian Government | Shipbuilder (Signature)

REPORT OF INSPECTION – LIST 1

Items outstanding at the date of inspection which it has been agreed will be completed by the shipbuilder at no additional charge to the Australian Government.

01 Deck 15	Blue painted lens on police light is to be replaced by red lens.
01 Deck 17	AEL not fitted to position.
01 Deck 20	Zone 4 Fire Alarm pushbutton stn has black pushbutton missing.
01 Deck 31	AEL is not fitted.
01 Deck 42	AEL is not fitted.
01 Deck 52	AEL not fitted.
1 Deck 7	AEL's not fitted to galley canopies i.a.w. Vol 4.3.9.1.
1 Deck 20	AEL not fitted.
1 Deck 15	Red lenses for police lights not fitted.
1 Deck 15	Red lens on police light missing.
~~1 Deck 22~~	~~Anti-condensation heater light is inoperative~~.
1 Deck 26	AEL's are not fitted to locations in the lobby and stairwell to 2 Deck.
1 Deck 47	Middle and inbd Hydraulic Pump controllers have incorrect tallies.
04 Deck 2	Vorta Aerial disconnected for S.T.W. by GMGID.
3 Deck 16	The blue lens on the police light is to be replaced by a red lens.
2 Deck 11	Capstan Control Panel C.T. to be replaced by correct type.
~~2 Deck 11~~	~~Mounting screws used as bonding medium in Capstan Controller~~.
2 Deck 15	Police lights not fitted with red lenses.
2 Deck 15	Police lights not fitted with red lenses.
~~2 Deck 37~~	~~[illegible] Repair Phone tally to be replaced~~. ~~Tally says connection to aft instead of fwd~~.
2 Deck 39	Transformer terminals not protected or covered.
2 Deck 39	Nicad Charger Instruction Plate cannot be seen.

../4

It is agreed that List 1 items (comprising .... pages) will be completed by the Sh[illegible] at no additional [illegible]	Shipbuilder (Signature)

REPORT OF INSPECTION – LIST 1

Items outstanding at the date of inspection which it has been agreed will be completed by the shipbuilder at no additional charge to the Australian Government.

2 Deck 39	Transformer is not protected.
2 Deck 40	Fwd Zone 18 Fire Alarm pushbutton stn is hidden by damage control lockers cannot be seen except from immediately to the side of position.
3 Deck 13	Police light fitting does not have a lens fitted to it.
3 Deck 16	The blue lens on the police light is to be replaced by a red one.
3 Deck 81	There is a full earth on the ring main strd switchboard.
3 Deck 81	M.C.R. air cond control panel door will not close.
3 Deck 90	Red lenses not fitted to police lights.
4 Deck 21	"GEM" indicator cable to ballast tank not enclosed i.a.w. dangerous areas BR1754 and Dwg Ref 720H - subject to SG2 action.
~~Stores Hatch 03 Dk [illegible]~~	~~Hoist and Supporting Structure not tested & trialled~~ - ~~test certificates to be supplied~~.
Fuel Pump Room Compt 45-2 Deck	Indicator board is inaccurate - fittings shown on 2 Deck are sited on 1 Deck - valves shown on 2 Deck and sited on 4 Deck.
Main Engine Room No. 5 Compt.	1. Ventine provisions required for ME Lub Oil Cooler - S.W. and Lub Oil Sides - Jkt Water Cooler - S.W. and F.W. Sides. 2. All Serk coolers to be fitted with sacrificial anodes. 3. Oily water separator to be trialled.
Avcat System	Not tested - test certificates to be supplied.

It is agreed that List 1 items (comp[illegible] .... pages) [illegible]	Shipbuilder (Signature)

ANNEX P TO
DGPM 0539/82
OF 19 MAY 82

[illegible]242Z MAY 81
[illegible]TOBRUK
[illegible]/COMAUSFLT
[illegible]/DEFNAV CANBERRA
RAYWKE/GOSIEAA
RAYBNA/COMAUSPHIBRON
RAYWKE/COMAUSNAVSUP
BT
R E S T R I C T E D
SIG UNH/UNF
HMAS TOBRUK SECOND READING FORM TI338
A. ABR 1921 ARTICLES 2716 TO 2721
B. NAVY OFFICE LTR N108/1/12 OF 13 MAR 81 PARA C
C. GOSIEAA LTR N18-4-14 OF 28 APR 81 NOTAL
D. DEFNAV.CANBERRA UND/UNF 260004Z MAR 81 NOTAL
E. HMAS TOBRUK UNH/RAZ 301310Z APR 81 [illegible] (141321Z MAY 81)
1. AT A MEETING ONBOARD HMAS TOBRUK AT 14[illegible] MAY 81 ATTENDED BY REPRESENTATIVES OF CARRINGTON SLIPWAYS PTY LTD, GOSIEAA, DNSD, DGNP, COMAUSFLT, DGND AND SHIP FORM TI338-1 OF FOUR PAGES AND A LIST OF UNCOMPLETED WORK OF 72 PAGES WERE READ.

RESTRICTED

PAGE 2 RAYWLZD 008 R E S T R I C T E D
2. MAJOR ADDITIONS TO THE LIST BY THE [illegible] WERE:
A. UNSATISFACTORY BOW DOOR SECURING ARRA[illegible]ENTS AND UNSATISFACTORY BOW DOOR AND BOW RAMP WATER-TIGHTNESS
B. UNSATISFACTORY SEWERAGE SYSTEM ←
C. UNSATISFACTORY METAL PREPARATION AND [illegible]INTING THROUGHOUT THE SHIP RESULTING IN WIDESPREAD CORROSION
3. DETAILS OF THESE ITEMS WERE BRIEFED [illegible] MEETING AND THE SEWERAGE PROBLEM IS THE SUBJECT OF A SE[illegible] MESSAGE.
4. AT THE CONCLUSION OF THE MEETING I [illegible]INED GOSIEAA [illegible] FORWARDED AT REF C EITHER TO SIGN FORM TI[illegible] OR TO REQUIRE SHIPS OFFICERS TO SIGN THIS DOCUMENT AT THIS [illegible]. THERE ARE SEVERAL REASONS FOR THIS DECISION PRIME AMONGST [illegible] IS THE UNACCEPTABLY SHORT PERIOD THE SHIP HAS BEEN PERMITTED [illegible] CONSIDER THESE DETAILED SHORTCOMINGS. IT IS CONSIDERED THAT THE [illegible] REQUIRES AT LEAST ANOTHER EIGHT WEEKS BEFORE A PROPER ASSESSMENT CAN BE MADE
5. OTHER REASONS FOR DECLINING TO SIGN [illegible]:
A. RESERVATIONS ARE HELD ABOUT THE BOW [illegible]R/BOW RAMP ARRANGEMENTS. AT THE SHIP COMPLETION MEETING CONVENED BY REF D THE SHIP REPRESENTED THAT IT WAS HIGHLY DESIRABLE A BEACHING BE UNDERTAKEN BEFORE FORMAL ACCEPTANCE. ALTHOUGH TENTATIVELY PROGRAMMED FOR THE PERIOD PRIOR TO 14 MAY AN LSH BEACHING HAS NOT BEEN POSSIBLE BECAUSE

KQL ESSENTIAL TRAINING OF PERSONNEL IN T[illegible]ING SHIP FOR BEACHING CANNOT BE PROGRESSED AS SHIP LACKS AS FITTED DRAWINGS OF PUMPING /FLOODING ARRANGEMENTS. REF E IS RELEVANT
(2) NO SHIP STABILITY STATEMENT IS HELD. THE CURRENT PROBLEM WITH THE BOW DOORS/BOW RAMP OUTLINED IN PARA 2A ABOVE LENDS ADDITIONAL SUPPORT TO THE RESERVATIONS.
B. THE CERTIFICATES OF OFFICERS RESPONSIBLE FOR SUPERVISION OF WORK [illegible]

RESTRICTED
P-2

VV BOA195 HH
RR RAYWKE
DE RAYWLZD 002 2040035
ZNY RRRRR
R 230030MLYUL 81
FM HMAS TOBRUK
TO RAYRMT/COMAUSFLT
INFO RAYWNN/DEFNAV CANBERRA
RAYWKE/GOSIEAA
RAYBNA/COMAUSPHIBRON
RAYWKE/COMAUSNAVSUP
RAYRMT/GMGID
RAYBAN/NOCQLD
BT
R E S T R I C T E D
SIG IAG/RDG
[illegible]S TOBRUK - ACCEPTANCE/SIGNING FORM TI338
A. ABR 1921 ARTICLE 2718
B. HMAS TOBRUK UNH/UNF 141320Z MAY 81 NOTAL
HMAS TOBRUK IAG/UNG 182819Z JUL 81 NOTAL
D. HMAS TOBRUK EDG 220512Z JUL 81 NOTAL
1. AS A RESULT OF SUCCESSFUL BEACHING (REF C) AND SUCCESS WITH MOST ASPECTS OF INSTREAM LOADING (REF D) HMAS TOBRUK IS ACCEPTED FOR OPERATIONAL SERVICE IAW REF A

PAGE 2 RAYWLZD 002 R E S T R I C T E D
2. PROPOSE FURTHER READING AND SIGNING OF FORM TI338 ONBOARD HMAS TOBRUK AT NO.3 WALSH BAY AT 311000K5 JUL 81
BT
DIST..FILE COS ADSFC CSOCF MA3 CST SIS RPM MINST
TOR..01207/23 BOA195

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.NNN

ANNEX Q TO
DGFM 0534/82
OF 19 MAY 82

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AD-A053 642

REPORT DOCUMENTATION PAGE

DTNSRDC-78/042	
BIODEGRADATION OF SHIPBOARD WASTEWATER IN COLLECTION, HOLDING, AND TRANSFER TANKS	Research & Development
Alexander E. Lardis and Andrew T. Geyer	
David W. Taylor Naval Ship Research and Development Center, Bethesda, Maryland 20084	Work Unit 1-2863-512
David W. Taylor Naval Ship Research and Development Center, Bethesda, Maryland 20084	January 1978
	83
	UNCLASSIFIED

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

Anaerobiosis
Hydrogen sulfide
Wastewater degradation
Shipboard sewage treatment
Wastewater gas generation
Hazardous gases
Sanitary microbiology

A study was conducted to determine the extent to which anaerobic biological activity occurs in U. S. Navy ship collection, holding, and transfer system holding tanks and to identify potential hazards. Eight different waste mixtures representing shipboard holding-tank contents were incubated in test tanks under controlled conditions to determine gas-generation rates

(Continued on reverse side)

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(Block 20 continued)

and the quantitative effects of varying specific environmental parameters. Indicators of biological activity monitored in the waste mixtures included oxidation/reduction potential, pH, dissolved oxygen, and the concentrations of sulfate, nitrate, and volatile acids. In addition, concentrations of various gases in the tank ullage were monitored, including oxygen, hydrogen sulfide, carbon dioxide, ethyl mercaptan, methyl mercaptan, carbon monoxide, methane, ammonia, and hydrogen cyanide. Gas-generation rate constants and other relevant data were applied to the development of a gas-generation model capable of predicting the concentrations of potentially hazardous gases in shipboard holding tanks. Recommendations concerning tank cleaning, tank gas-freeing, and general collection, holding, and transfer system operational safety are offered:

- Anaerobic conditions in collection, holding, and transfer tanks should be avoided.
- Tank ullage must be analyzed for hazardous gases and oxygen content before it is opened; it must be considered dangerous to personnel entering it without proper breathing apparatus. The tanks must be ventilated positively prior to entry. Tank vents should be located to avoid exposure of shipboard personnel.
- Tanks should be cleaned at regular intervals to avoid high concentrations of sludge.

A

UNCLASSIFIED

ADMINISTRATIVE INFORMATION

This task was accomplished at the request of NAVSEC (SEC 6159B), references (a) through (h).

ADMINISTRATIVE REFERENCES

(a) NAVSEC Work Request N65197-75-WR-55776 of Jan 1976
(b) NAVSEC Project Order N65197-75-PO-50176 of May 1975
(c) NAVSEC Project Order N65197-75-55794 of May 1975
(d) NAVSEC Work Request N65197-75-WR-55564 of May 1975
(e) NAVSEC Project Order N65197-76-PO-60020 of Aug 1975
(f) NAVSEC Project Order N65197-76-PO-60020 of Nov 1975
(g) NAVSEC Project Order N65197-76-PO-60020 of Jan 1976
(h) NAVSEC Project Order N65197-76-PO-60371 of July 1976

ACKNOWLEDGMENT

The authors acknowledge the efforts of Mr. J. W. Mooney, DTNSRDC Code 286, for his assistance in the development of the GASGEN computer program; Mr. H. Feingold, DTNSRDC Code 184 for statistical assistance; and Dr. S. Finger, DTNSRDC Code 286, for his thoughtful comments.

LIST OF ABBREVIATIONS

atm - atmosphere
°C - degrees Celsius
cc - centimeter
CHT - collection, holding, and transfer
cm - centimeter
COD - chemical oxygen demand
DCA - damage control assistant
DO - dissolved oxygen
g - gram
GC - gas chromatograph
g/hr - grams per hour
g/L - grams per liter
ID - inside diameter
°K - degrees Kelvin
L - liter
m - meter
m^3 - cubic meter
MEF - mass emission factor
mg - milligram
mg/L - milligrams per liter
min - minute
mm - millimeter
mole - molecular weight in grams
MW - molecular weight
NEPSS - Naval Environmental Protection Support Service
ORP - oxidation/reduction potential
OSHA - Occupation Safety and Health Administration
P-.90 - probability at 90th percentile
pH - negative logarithm of the hydrogen ion concentration
ppm - parts per million
TLV - threshold limit value
TOC - total organic carbon
TS - total solids
TSTEL - tentative short-term exposure limit
TVA - total volatile acids
TVS - total volatile solids
vol - volume

TABLE OF CONTENTS (cont)

ABSTRACT

A study was conducted to determine the extent to which anaerobic biological activity occurs in U. S. Navy ship collection, holding, and transfer system holding tanks and to identify potential hazards.

Eight different waste mixtures representing shipboard holding-tank contents were incubated in test tanks under controlled conditions to determine gas-generation rates and the quantitative effects of varying specific environmental parameters. Indicators of biological activity monitored in the waste mixtures included oxidation/reduction potential, pH, dissolved oxygen, and the concentrations of sulfate, nitrate, and volatile acids. In addition, concentrations of various gases in the tank ullage were monitored, including oxygen, hydrogen sulfide, carbon dioxide, ethyl mercaptan, methyl mercaptan, carbon monoxide, methane, ammonia, and hydrogen cyanide. Gas-generation rate constants and other relevant data were applied to the development of a gas-generation model capable of predicting the concentrations of potentially hazardous gases in shipboard holding tanks.

Recommendations concerning tank cleaning, tank gas-freeing, and general collection, holding, and transfer system operational safety are offered:

- Anaerobic conditions in collection, holding, and transfer tanks should be avoided.

- Tank ullage must be analyzed for hazardous gases and oxygen content before it is opened; it must be considered dangerous to personnel entering it without proper breathing apparatus. The tanks must be ventilated positively prior to entry. Tank vents should be located to avoid exposure of shipboard personnel.

- Tanks should be cleaned at regular intervals to avoid high concentrations of sludge.

Aerobic digestion is the biological decomposition of wastes in the presence of free O_2. Aerobic organisms use O_2 as the hydrogen acceptor following metabolic energy transformations. Common biochemical reactions mediated by aerobic microorganisms are illustrated in equations (1) and (2).[2,3]

$$\text{Carbonaceous Compound} + O_2 \longrightarrow CO_2 + H_2O, \qquad (1)$$

$$\text{Nitrogenous Compound} + O_2 \longrightarrow CO_2 + H_2O + NH_3 \quad . \qquad (2)$$

Anaerobic digestion is the biological decomposition of waste material in the absence of free O_2. It is generally thought to occur in two main stages. In the first stage, complex organic carbon compounds are degraded to short-chain volatile organic acids (acetic, propionic, butyric, etc) by saprophytic bacteria. Consequently, this stage is referred to as the acid-forming or acid-fermentation stage. The volatile acids are converted into CH_4 and CO_2 by methane-forming bacteria in the second stage. The methane formers are strict anaerobes which grow very slowly, and are sensitive to changes in the environment. They are the rate-limiting organisms in anaerobic digestion.[4] These methane bacteria may also use CO_2 as a hydrogen acceptor as indicated in equation (3).

$$CO_2 + 8H \xrightarrow{\text{Bacteria}} CH_4 + 2H_2O \; . \qquad (3)$$

CO_2 reduction, however, is a minor route for CH_4 formation in comparison to acetic acid breakdown.[5]

In addition to acid- and methane-forming bacteria, other heterotrophic anaerobes are involved in anaerobic waste degradation. Sulfate-reducing bacteria mediate biochemical reactions which produce H_2S, as indicated in equation (4).

$$SO_4 + 10H \xrightarrow{\text{Bacteria}} H_2S + 4H_2O \; . \qquad (4)$$

Facultative nitrate-reducing bacteria are involved in biochemical reactions which produce N_2, as illustrated in equation (5).

$$2NO_3 + 12H \xrightarrow{\text{Bacteria}} N_2 + 6H_2O \; . \qquad (5)$$

(Equations (3), (4), and (5) are simplified representations. Energy transfers and the states of the reacting particles are not shown.) Additional by-products produced during the second stage include the extremely malodorous compounds indole, skatol, and mercaptans. Figure 1 summarizes the metabolic pathways of anaerobic digestion of organic wastes by microbial action.

A number o. the gases generated during waste decomposition are considered to represent potential hazards. Table 1 summarizes the characteristics, TLV, TSTEL, and hazardous properties of various gases associated with anaerobic waste degradation.

TABLE 1
CHARACTERISTICS, THRESHOLD LIMIT VALUES, TENTATIVE SHORT-TERM EXPOSURE LIMIT, AND HAZARDOUS PROPERTIES OF VARIOUS GASES ASSOCIATED WITH ANAEROBIC WASTE DEGRADATION

Gas	Formula	Threshold Odor, ppm	TLV* (TSTEL) ppm	Remarks
Methane	CH_4	Odorless	None adopted	Flammable; explosive in air; lower limit - 5.5%; upper limit - 14%; human toxicity; asphyxiant, narcotic, 9% causes nausea
Hydrogen sulfide	H_2S	0.0011, rotten-egg odor	10 (15)	Explosive in air; lower limit - 4.3%; upper limit - 46%; human toxicity: 0.07% for 2 minutes
Ammonia	NH_3	0.037, sharp pungent odor	25 (35)	Explosive in air at 15%; human toxicity: 0.01%
Hydrogen cyanide	HCN	Not known, characteristic pungent odor	10 (15)	Flammable in air; human toxicity: 150 ppm - danger; 300 ppm - death
Methyl mercaptan	CH_3SH	0.001, decayed cabbage odor	0.5 (0.5)	Flammable in air; lethal concentration for rats: 1%; human toxicity: nausea, narcotic in high concentrations
Ethyl mercaptan	C_2H_5SH	0.0002, decayed cabbage odor	0.5 (0.5)	May be narcotic in high concentrations; causes nausea
Carbon dioxide	CO_2	Odorless	5,000 (15,000)	Nonflammable; human toxicity: high concentration may cause death by suffocation
Carbon monoxide	CO	Odorless	50 (400)	Explosive in high concentrations; human toxicity: absorbed into body via respiratory system; prolonged exposure causes coma and death

*TLV - refers to time-weighted concentrations for an 8-hour workday and 40-hour work week, and represents conditions under which it is believed that nearly all workers may be repeatedly exposed daily without adverse effect (as established by the American Conference of Governmental Industrial Hygienists, 1976). (TSTEL) is considered an absolute ceiling not to be exceeded any time during a 15-minute excursion.

4

AUTOTROPH — AN ORGANISM CAPABLE OF SYNTHESIZING ORGANIC NUTRIENTS DIRECTLY FROM SIMPLE INORGANIC SUBSTANCES SUCH AS CO_2 AND INORGANIC NITROGEN.

HETEROTROPH — AN ORGANISM THAT OBTAINS NOURISHMENT FROM THE INGESTION AND BREAK

SAPHROPHYTE — A PLANT THAT LIVES ON DECAYING ORGANIC MATTER

PSYCHROPHILE — AN ORGANISM WHICH FLOURISHES AT LOW TEMPERATURES

MESOPHILE — AN ORGANISM WHICH GROWS AT A MODERATE TEMPERATURE.

THERMOPHILE — AN ORGANISM THAT THRIVES AT HIGH TEMPERATURES

PH VALUE IS THE LOGARITHM OF THE RECIPROCAL OF THE HYDROGEN ION CONCENTRATION

$\therefore pH = \log_{10} \frac{1}{[H^+]}$

THE CONCENTRATION OF HYDROGEN IONS IN A SOLUTION IS A MEASURE OF ITS ACIDITY OR ALKALINITY AND IS USUALLY EXPRESSED IN TERMS OF ITS PH VALUE. PURE WATER HAS A PH VALUE OF ALMOST EXACTLY 7 : A PH LESS THAN 7 INDICATES ACIDITY AND A PH ABOVE 7 INDICATES ALKALINITY.

FACULTATIVE BACTERIA — THERE IS NO SHARP DIVISION BETWEEN ANAEROBIC AND AEROBIC BACTERIA; THERE IS AN IN BETWEEN CLASS 'FACULTATIVE' WHICH CAN LIVE UNDER PART AEROBIC AND PART ANAEROBIC CONDITIONS.

The biochemical status of the substrate on which waste degradation proceeds is important not only because of the bacterial population's sensitivity, but also because the products formed are dependent on it. The presence or absence of free O_2 will determine whether aerobic or anaerobic digestion will occur.

During oxidation of organic matter, the bacteria remove hydrogen atoms from the organic molecule and transfer them to a hydrogen acceptor which may be an inorganic substance (i.e., O_2, NO_3^-, $SO_4^=$, CO_2, etc) or another organic molecule. The microorganisms gain the energy required to sustain life during these biochemical reactions. A measure of the relative concentrations of hydrogen acceptors (oxidants) and hydrogen donors (reductants) is the ORP which is expressed as positive or negative (millivolts). A positive ORP indicates high concentrations of oxidants compared to reductants, and consequently, an aerobic environment.

Biological degradation processes are sensitive to temperature. Bacterial activity is generally classified into three groups based on the temperature ranges they can grow in: psychrophilic bacteria (0 to 30° C), mesophilic (25° to 40° C), and thermophilic (40° to 60° C). Anaerobic digestion and consequent gas generation is retarded at temperatures above 60° C.*

Another environmental factor that influences the growth of bacteria and hence gaseous by-product formation is the pH. The pH has an effect on both NH_3 and CO_2 generation under aerobic conditions. For example, urea is a very unstable molecule in wastewater and rapidly breaks down to the NH_4^+ ion. If the pH is below 9, it remains mainly in this form; if the pH is 9 or above, most of the NH_4^+ changes to NH_3 gas. CO_2 that is formed in wastewater combines with the water to form H_2CO_3, which in turn dissociates into H^+, HCO_3^-, and $CO_3^=$. The concentration of each species is a function of the pH of the substrate. Under anaerobic conditions the pH will have an effect on CH_4 formation and on the amounts of H_2S that will be liberated. The growth of methane-forming bacteria is inhibited at pH values lower than 4 and higher than 10. H_2S dissolves in water and dissociates into HS^-, $S^=$, and H^+ ions:

$$H_2S \rightleftharpoons HS^- + H^+ \rightleftharpoons 2H^+ + S^= \quad (6)$$

If the pH decreases, this equilibrium is driven to the left, forming more H_2S. This gas will then be partially released to the atmosphere.

THEORETICAL ANALYSIS OF CHT TANK GAS GENERATION

During the course of this study, it was considered desirable to be able to predict the concentration of a specific gas in the ullage of a CHT tank at any time. Accordingly, a predictive mathematical model of gas generation by unaerated shipboard wastewaters held in CHT tanks was developed. Figure 2 is a diagrammatic

representation of the hypothetical gas-generation scheme upon which this model is based. The derivation is as follows.

The amount of a gas (e.g., H_2S, CO_2, NH_3, etc) in a tank partially filled with sewage can be calculated from equation (7).

$$Y_t = Y_s + Y_f \quad (7)$$

where:

Y_t = weight of the gas present in the tank, mg.

Y_s = weight of the gas dissolved in the sewage, mg.

Y_f = weight of the gas in the ullage, mg.

Y_s can be evaluated with equation (8).

$$Y_s = C_s V_s \quad (8)$$

where:

C_s = concentration of the gas in the sewage, mg/L.

V_s = volume of sewage in the tank, L.

The concentration of a gas dissolved in the sewage is computable when the partial pressure of the gas above the sewage is known and if diffusion equilibrium exists. As indicated in figure 2, if the gaseous anaerobic metabolic end products are generated mostly by the sludge layer formed on the bottom of the tank, the gases must migrate through the two wastewater zones and the gas/wastewater boundary layer before it is liberated to the tank ullage. The gas/liquid boundary layer is considered to be made up of two distinct regions. Proceeding upward from the liquid phase they are the liquid and gas film regions, respectively.[10] Therefore, a gas liberated by the sludge zone must pass through two zones and two boundary layer regions before it is liberated to the tank ullage. The flux of a gas in any zone as a function of position and time can be expressed as:

$$F_{(x,\,y,\,z,\,t)} = -(D + \epsilon_d)\,\nabla C_{(x,\,y,\,z,\,t)} + V_{(x,\,y,\,z,\,t)}\,C_{(x,\,y,\,z,\,t)}, \quad (9)$$

X = the mole fraction of the gas in the sewage

H = Henry's constant, atm/mole fraction.

Simultaneous solution of equations (10) and (11) is required to compute accurately the concentration of dissolved gas in the sewage; however, with the present state of knowledge, this is not feasible.

MODEL FOR PREDICTING HAZARDOUS CHT CONDITIONS

The purpose of this model is to provide a tool for predicting hazardous situations in CHT tank operation. Assumptions, which must be made to construct a workable model, will result in establishment of a "worst-case" for gas accumulation in the tank ullage. Consequently, predicted ullage gas concentrations will tend to be greater than the actual expected value.

The assumptions made are that the liquid phase of the system is well mixed, and that the partial pressure of the gas in the vapor phase is related to the concentration of the gas in the bulk solution directly by Henry's Law (equation (11). (The applicability of Henry's Law to wastewater mixtures is not precisely defined, but it is believed that errors resulting from this discrepancy are not large.) The variable, X, in equation (12) can be computed by converting C_s to moles of dissolved gas per liter, and by dividing the number thus obtained by the total number of moles in 1 liter of solution* as follows:

$$X = \frac{C_s/\omega_m}{1000/18} = \frac{C_s}{\omega_m} \cdot 18 \times 10^{-3}, \qquad (12)$$

where ω_m = gram molecular weight of the gas, mg. The gas concentration in the ullage was measured in ppm by volume. PPM is converted to partial pressure (atm) and equation (12) is rewritten as follows:

$$P = C_f \times 10^{-6} = \frac{C_s H}{\omega_m} \cdot 18 \times 10^{-3}, \qquad (13)$$

which, rearranged, yields equation (14) for calculating Y_s.

$$Y_s = V_s \left(C_f \frac{(55.6 \times 10^{-6})}{H} \omega_m \right) \qquad (14)$$

---

*The moles of gas and wastes per liter are very small compared to the moles of water in a liter and therefore can be omitted from the denominator.

where C_f = measured concentration of the gas in the tank ullage, ppm by volume.

Y_f can be calculated from equation (15).

$$Y_f = V_f \times \frac{C_f}{10^6} \times \rho_{T_r} \times 1000 \times \frac{T_r}{273 + T_c}, \qquad (15)$$

where:

ρ_{T_r} = the density of the gas when measured at reference temperature, g/L

T_c = temperature at which ρ is measured, °C

V_f = volume of ullage, L

T_r = reference temperature, K.

Using equations (8), (14), and (15) yields equation (16).

$$Y_t = V_s \left(\frac{C_f (55.6 \times 10^{-6}) \omega_m}{H} \right) + \frac{V_f (C_f) \rho_{T_r} (T_r)}{(273 + T_c) 10^3}. \qquad (16)$$

Gas-generation rates during early waste degradation (less than 12 days) may be expressed by equation (17).[11]

$$Y_t = e^{Kt} + C, \qquad (17)$$

where:

t = elapsed time, days

K = experimentally determined gas-generation rate constant, $days^{-1}$

C = the initial concentration of gas (assumed equal to zero).

This study will determine values of K for each CHT tank waste mixture at each condition (temperature, salinity, seeding, etc). Equations (16) and (17) can be combined:

$$Y_t = e^{Kt}\left(\frac{V_{s1}}{V_{sm}}\right)$$

$$= \frac{(V_{s1})\ P_1\ (55.6 \times 10^{-6})\ (w_m)}{R} + \frac{V_{f1}\ (P_1)\ \rho_{Tr}\ (T_r)}{(273 + T)\ 10^3} \quad (18)$$

where:

V_{s1} = volume of sewage in the CHT tank

V_{sm} = volume of sewage in the laboratory test tank

V_{f1} = volume of ullage in the CHT tank

P_1 = concentration of gas in the CHT tank ullage, vol/vol.

Transposing equation (18) yields:

$$P_1 = \frac{e^{Kt}\ V_{s1}}{(V_{sm})\left[\frac{(V_{s1})\ 55.6 \times 10^{-6}\ (w_m)}{R} + \frac{(V_{f1})\ \rho_{Tr}\ (T_r)}{(273 + T_c)\ 10^3}\right]} \quad (19)$$

A computer program has been written to facilitate the use of the gas-generation prediction model developed in the foregoing for Navy CHT tanks. Appendix A is a manual which explains the use of the "GASGEN" program. Knowledge of an applicable gas-generation rate constant, as developed in this study, permits the prediction of the concentration of a hazardous gas after a given incubation period. Appendix B is an example of the use of "GASGEN" with results applicable to USS DIXON (AS 37).

INVESTIGATION

APPROACH

The approach to accomplishment of this task was as follows:

- Develop a plan to evaluate the anaerobic waste degradation process as it occurs in CHT system holding tanks.
- Implement the plan with results of preliminary studies in the laboratory and aboard selected ships of the Fleet.
- During the laboratory experimentation phase, investigate the anaerobic decomposition of CHT system influent wastes to determine the effect of temperature, pH, loading, seeding, flushing medium, and other factors on the decomposition of the waste and the associated gas buildup.

- From the laboratory results, extrapolate representative 12-, 24-, and 48-hour hazardous gas generation, and identify potential hazardous situations.
- Investigate the nature and types of odors stemming from anaerobic decomposition that may be sensed by shipboard personnel. Obtain and analyse gas samples to determine concentrations and compositions.
- Prepare a report containing a summary of test results, conclusions, and recommendations concerning potential hazards due to CHT system anaerobic degradation of waste.

PRELIMINARY STUDIES

Preliminary laboratory experiments were conducted to determine the following:

- The daily variability that could be expected in the waste stock (head, food, and laundry wastes).
- The variability in degradation characteristics to be expected from similar wastes collected at the same time and at different times and incubated under identical environmental conditions.
- The reproducibility of the various waste mixtures.
- The reliability of sampling procedures.

Food and laundry wastes were obtained from the U. S. Naval Academy dining halls and laundry, respectively. Head wastes were obtained from the DTNSRDC sewage treatment test site. Samples were taken from stock solutions and analyzed for COD, TOC, TS, and TVS. These data were analyzed statistically to determine variance in the stocks. The results are indicated in table 2. To determine the variability in degradation, identical waste mixtures were incubated in test chambers under the same controlled environmental conditions. The ORP, pH, and DO concentrations were monitored and recorded as plotted in figures 3 through 5. The reproducibility of the results gives an indication that a high degree of confidence could be placed on the large-scale experiments. In addition, identical waste mixtures were incubated at two different temperatures to assess degradation trends and instrumentation requirements for the large-scale laboratory tests.

TABLE 2
CHARACTERISTICS OF STOCK WASTES
(ALL VALUES IN MG/L)

	Head (n = 15)		Food (n = 13)		Laundry (n = 13)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
COD	3,700	210	19,000	1,100	1,500	140
TOC	890	50	2 [illegible]00	110	490	40
TS	16,000	1,100	24,000	1,200	2,900	240
TVS	9,800	1,000	21,000	1,300	2,000	190

n = number of samples
$\bar{x}$ = mean
SD = standard deviation

WASTE MIXTURES

Eight significantly different mixtures were selected for testing. The selection was based on an investigation of the waste mixtures predicted to be received by 28 different CHT holding tanks on 13 different ship types as indicated in table 3. The composition is also indicated in table 3. The mixtures were targeted to the P-.90 NEPSS data base mass-emission factor values for in-port, head, galley, and laundry wastes.* These waste sources constitute at least 95% of the total waste load in any given CHT system holding tank. A range of values for the waste stock was selected from the MEF values and is presented in table 4. The selection of the waste concentration values for use in the experiments (target values) is based on the 90th percentile of the concentration values, measured, and corrected for the type of data distribution and sampling error.

APPARATUS

Six tanks, measuring 61 cm wide by 61 cm long by 76 cm high were constructed with 13-mm-thick Plexiglas. These tanks were placed in a 1.5- by 3.5-m water bath. Each tank was secured by a drain which penetrated the bottom of the bath tank. Four sampling ports, spaced vertically, penetrated the side walls of the water bath and each tank as depicted in figures 6 and 7. Each port was sealed with soft rubber septum. A removable lid was bolted to the top of each tank, as indicated in figure 8. Each lid was fitted with a bulkhead fitting connected to a 38-mm ID pipe. The water bath tank was insulated and provided with a pump for circulating water to a heating/cooling device as shown in figure 9. A 3.8-m^3 plastic mix tank, fitted with drain line and stirrer, was elevated on scaffolding and placed on a stand adjacent to the water bath, also illustrated in figure 9.

*This data available from Naval Environmental Protection Support Service, NCBC, Port Hueneme, California 93403.

- Oxygen
- Ammonia
- Hydrogen cya[illegible]ide
- Dissolved oxygen
- pH
- Oxidation/reduction potential.

TABLE 6
ENVIRONMENTAL TEST CONDITIONS FOR LARGE-SCALE
LABORATORY STUDIES

Run	Incubation Temperature °C	Salinity %	Total Time	
			Days	Hours
1A-1C	45	1	3.8	91
1D	45	1	4.9	117
1E	45	3	15	359
2	45	3	4	95
2A	45	3	3.8	91
3	35	3	4	97
3A	35	3	5.9	142
4	25	3	3.9	94
4A	25	3	3.8	90
5	15	3	4	95
5A	15	3	3.8	92
6	25	3	8	193
6A	25	3	5.9	143

Note: All fluids were comminuted and seeded except in cases 1A-1E which had not been seeded.

ANALYSES

CH_4 and O_2 concentrations were measured in the ullage of each tank with an Antek model 500 GC. An Antek model 650 programmer was incorporated into the GC system to allow for the automatic and sequential sampling of each tank every hour. The programmer also controlled a series of six air pumps that circulated the ullage atmosphere of each tank for 10 minutes prior to the drawing of a sample. A schematic of the automated GC system is shown in figure 10. CH_4 and O_2 concentrations were automatically recorded on a strip-chart recorder. The pH and ORP were monitored by probes placed within each test tank and read on an Orion model 701 ion meter. The DO and temperature were measured with a Yellow Spring DO meter. H_2S, C_2H_5SH, CH_3SH, NH_3, CO, HCN, and CO_2 concentrations were measured with a Matheson Gas Products model 8014K toxic gas detector. CO_2 concentration was also measured with a Firerite* CO_2 detector. COD, TOC, TS, TVS, NO_3^-, $SO_4^=$, and TVA analyses were performed in accordance with "Standard Methods."[13] Liquid samples from inside each test tank were drawn periodically during each run for the determination of NO_3^-, $SO_4^=$, and TVA. A 50-cc syringe with a 12-inch needle was inserted in one of the sampling ports on the side of each tank and a sample extracted. During runs 1A through 1C, a sample was extracted, in the manner mentioned above, from different depth levels in each tank. The pH and ORP were measured to determine whether there was any appreciable difference from top to bottom. There was none found. Samples for TVS analysis were obtained from the seed material left in each tank by means of a length of Tygon* tubing and a hand-held vacuum pump.

RESULTS AND DISCUSSION

OXYGEN DEPLETION IN THE HOLDING-TANK ATMOSPHERE

The O_2 depletion rates in the ullage of the tanks, expressed as grams of O_2 removed per hour, are shown in items (a) through (h) of figure 11 for each mixture, during each run.* The rate of O_2 depletion was found to be related to the temperature of incubation and whether or not the mixture was provided with seed material. There was no significant difference in rates between 1% and 3% salinity of the flushing water. The effect of temperature is indicated by the declining O_2 depletion rates during runs 2 (45° C), 3 (35° C), 4 (25° C), and 5 (15° C), respectively. This concurs with a study on the influence of temperature on anaerobic biological digestion: it was found that increased temperatures (up to an optimum) induce increased rates of bacteriological decomposition of organic matter.[13]

A comparison of O_2 depletion rates during runs 1E (unseeded) and 2 (seeded) suggests the influence of seeding. Results of runs 1 (1% salinity) and 1E (3% salinity) indicate that this salinity difference produced no significant effect. Analysis of data acquired during runs 1E (unseeded, 45° C) and 3 (seeded, 35° C) signifies the seeding is a more important factor in O_2 depletion than temperature, since faster rates were generally found during run 3 even though the temperature was lower.

Oxygen depletion has practical significance in that health standards, as prescribed by OSHA, call for a minimum O_2 concentration of 19.5% in spaces where personnel may work without a

*Firerite - Registered trade name of Bacharach, Incorporated.
Tygon - Registered trade name of Norton Company.
*Information concerning mixtures and test conditions for each run can be obtained by cross-referencing tables 3 and 6.

respiratory device.[14] The O_2 concentration in the tank atmospheres dropped below 19.5% in a majority of cases within 18 hours, and in all cases within 24 hours.* Therefore, the absence of O_2 in a CHT tank, as well as the presence of toxic and/or explosive gases, must be considered a potential hazard to personnel entering the tank.

DISSOLVED OXYGEN DEPLETION

The DO depletion for each set of conditions is indicated in items (a) through (h) of figure 12. The depletion rates were found to increase in the following order: run 5 (15° C, seeded), run 4 (25° C, seeded), run 3 (35° C, seeded), run 1 (45° C, unseeded), run 2 (45° C, seeded). The effects of seeding and temperature during these runs are evident. The lower temperature during run 5 substantially hindered microbial activity as evidenced by the O_2 utilization. DO concentrations were below 1 mg/L within 24 hours during a majority of the runs. Small concentrations of DO detected during runs 1 through 4 were measured 10 cm below the liquid surface and were derived from the tank atmosphere via simple diffusion.

OXIDATION/REDUCTION POTENTIAL

The development of anaerobic conditions within 24 hours is further illustrated by ORP data acquired during various runs. Items (a) through (d) of figure 13 show representative cases. As indicated, the substrates were well within the negative millivolt range within 24 hours.

pH

The variations of pH as a function of time for each mixture, during each run, are illustrated in items (a) through (h) of figure 14. In most cases, the pH decreased continuously for approximately 48 hours, at which time it leveled off at values between 2 and 4. During the extended runs (1E and 3), the pH did not rise above a value of 4 following the initial decline. The two exceptions were: mixture 7 during run 3 (item (g) of figure 14) and mixture 8 during run 6 (item (h)). In the former instance, it is suspected that the laundry waste stock used had an unusually high alkalinity which helped to buffer this particular batch during the incubation period. In the latter case, the slight variation of pH agrees well with observations made aboard USS SURIBACHI (AE 21) during shipboard monitoring of black water in CHT tanks.[15]

*O_2 depletion, DO, ORP, and pH data should be used on a qualitative basis. While general trends in tank data should be analagous to that of the CHT tank, extrapolation is not sufficiently reliable.

The initial decrease in pH is believed to have been produced by an increase in the concentration of dissolved CO_2 resulting from aerobic metabolism. Upon depletion of the substrate DO, anaerobic conditions develop, and consequently, the production of volatile organic acids continues the pH depression. The production of organic acids continues until the pH inhibits further microbial growth, at which point the system stabilizes. This marks the beginning of development (growth) of methane-producing bacteria.[3]

HYDROGEN SULFIDE GENERATION

H_2S generation rate constants for each mixture, during each run, are given in items (a) through (h) of figure 15. Seeding, temperature, relative concentration of $SO_4^=$ and pH were the most important factors influencing the rate of H_2S generation. The effect of seeding is indicated in figure 15, items (a) through (e). All mixtures exhibited faster rates during run 2 (45° C, seeded) than run 1E (45° C, unseeded). As indicated, the unseeded runs exhibited the longest initial lag period for all mixtures. The initial lag in gas generation is brought about by the absence of sulfate-reducing organisms. During the seeded runs, however, a population was already established, and consequently, H_2S generation began in a relatively shorter period of time.

Rate constants were proportional generally to the incubation temperature. The difference between rates at 35° C (run 3) and those incubated at 25° C (run 4) were moderate. A similar observation was made by Baumgartner[4] who, in his studies of the effect of temperature and seeding on H_2S formation in sewage, noted that samples incubated at 37.5° C did not demonstrate a great rate increase over those incubated at 30° C. During experiments at the Center (run 5, 15° C), low temperatures suppressed H_2S generation in all mixtures as expected.

The generation of H_2S is markedly affected by the pH. The pH of the substrate decreased with time (figure 14, items (a) through (g), resulting in a shift of equation (6) to the left (figure 2) and the liberation of additional H_2S to the tank atmosphere. The pH of run 6 (25° C, head waste, seeded) remained fairly constant in the neutral range (item (h) of figure 14). Consequently, the H_2S generation rate is substantially lower (see figure 15, item (h)) than would be expected from the effects of temperature and seeding alone.

The effect of salinity on H_2S generation is indicated by data from runs 1 (1% salinity) and 1E (3% salinity). The increased rate of H_2S generation during run 1E could be due to the higher initial $SO_4^=$ concentrations which accompany higher salinity.

H_2S was detected in all mixtures during runs 1, 1E, 2, and 6 within 24 hours. H_2S was detected in all mixtures during runs 3 and 4 within 92 hours, and only once after 92 hours during run 5, and only in mixture [illegible]. During run 2 (45° C, 3% salinity, seeded

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all mixtures generated H_2S in excess of the detector's upper limit (1700 ppm). Therefore, it is evident that all the mixtures have the potential for generating large amounts of H_2S under the proper environmental conditions. The amount of H_2S produced was proportional to the amount of head waste incorporated in the mixture (see table 3).

Items (a) through (h) of figure 16 indicate the variation of $SO_4^=$ concentrations for each mixture with time. The mean concentration of $SO_4^=$ in the mixtures at the beginning of each run was approximately 500 mg/L. As expected, a close correlation between H_2S generation and $SO_4^=$ reduction was exhibited. Furthermore, the rate of $SO_4^=$ reduction was enhanced by increased incubation temperatures and seeding.

CARBON DIOXIDE GENERATION

CO_2 was generated in copious amounts in all mixtures during all runs. It is apparent that the upper stratum of the tank contents underwent aerobic degradation (utilizing O_2 diffused from the tank ullage), while the lower stratum underwent anaerobic degradation. Thus, a stratified system was maintained in the tanks. Items (a) through (g) of figure 17 indicate CO_2 generation rate constants for the various waste mixtures. With the exception of mixtures 3 and 6, increased incubation temperatures resulted in increased CO_2 generation rates. The effect of seeding was inconclusive.

ETHYL MERCAPTAN GENERATION

Concentrations of C_2H_5SH after 92 and 142 hours of incubation are shown for each mixture in items (a) through (h) of figure 18. The effects of temperature and seeding were not readily apparent. There appeared to be an inhibition of C_2H_5SH in runs 2 (45° C, 3% salinity, seeded) and 5 (15° C, 3% salinity, seeded). The highest concentration (100 ppm) of C_2H_5SH was encountered in mixture 5 during run 3 following 142 hours of incubation.

METHYL MERCAPTAN GENERATION

CH_3SH was not detected during runs 1, 1E, or 2. A maximum concentration of 70 ppm was measured in mixture 5 during run 3 after 142 hours of incubation. CH_3SH was also detected during runs 4 and 6. The gas was liberally generated in mixture 8 during run 6, with a minimum of 2 ppm after 24 hours of incubation to a maximum of 45 ppm after 143 hours. CH_3SH generation was inhibited at temperatures above 35° C and below 25° C.

TOTAL VOLATILE ACID PRODUCTION

Items (a) through (h) of figure 19 indicate TVA variation with time for each wastewater mixture. In all cases, a gradual increase in TVA concentration continued throughout the incubation period. Increased temperature and the presence of seed material

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resulted in greater production of TVA. Increase in TVA concentration was instrumental in depressing pH and indicative of the aforementioned acid-forming phase of anaerobic decomposition.

DENITRIFICATION

Initial NO_3^- concentrations in the mixtures were generally between 4 and 7 mg/L. In all cases, a gradual decrease in NO_3^- continued throughout the incubation period. Increased incubation temperatures, as well as the presence of seed material, resulted in a larger decrease in NO_3^- concentration. NO_3^- concentration versus time plots for all runs are given in items (a) through (h) of figure 20.

CARBON MONOXIDE GENERATION

CO was detected only during run 1E in mixtures 1, 2, 4, and 5. Run 1E was an extended run (359 hours), and CO was found only after 120 hours of incubation. Following 191 hours of incubation, the CO concentration reached a maximum of 70 ppm with no additional increase. It was never detected in mixture 3. CO is generated primarily as an oxidation product from petrochemical and industrial wastes and is not usually found in domestic sewage. Its presence during these runs was unusual because industrial wastes were excluded from the mixtures. However, past experience at the Center indicates that petroleum products can occasionally be encountered in the black water distribution system, although its occurrence is rare. It is possible, therefore, that an oil may have been discharged into the system from a toilet facility. Inference of this possibility may be found in the fact that the mixture which contained no head waste (from distribution system) did not produce CO under otherwise similar conditions.

METHANE AND AMMONIA GENERATION

CH_4 and NH_3 were not detected in any mixture during any of the runs. It is believed that CH_4 was not detected primarily because of the low pH of the mixtures and the extended incubation period required for establishment of a stable methane-forming bacteria population. Methane-forming bacteria can survive within a pH range of 5-9.[4] The pH dropped below 5 in all the mixtures during all runs except mixture 7 in run 3 and mixture 8 in run 6. However, these bacteria are also sensitive to concentrations of volatile acids greater than 2000 mg/L.[4] Figure 19, items (g) and (h), indicate that the TVA concentrations increased to 3000 mg/L in mixture 7 and 3300 mg/L in mixture 8. This indicates that even though the pH was conducive to CH_4 generation, the process may have been inhibited by the TVA concentrations. Run 1E was extended to 359 hours to ascertain whether the decreasing trend in pH would reverse and thus produce an environment more conducive to CH_4 generation. The pH continued to decrease for 119 hours; then it stabilized between 1.6 and 2.2 fluctuating slightly until the run was terminated. This situation is analagous to "digester souring" in conventional anaerobic wastewater treatment facilities.

The pH is also considered instrumental in its inhibition of NH_3 production. For NH_3 to exist to any degree, the pH must be greater than 9. At no time, during any of the runs, was this value attained. HCN was detected only once during the experiments (in concentrations of less than 1 ppm). This is not considered significant.

SUMMARY OF FINDINGS

A brief background of aerobic and anaerobic waste degradation principles with emphasis on anaerobic processes was presented, followed by a report of the work done. The results and findings can be summarized as follows:

- The rate of O_2 depletion in the tank atmosphere and the DO of the wastes were found to be related to the temperature of incubation and whether or not the mixture was provided with seed material. The faster rates were related to higher temperatures of incubation and the presence of seed material. There was no significant difference in depletion rates between 1% and 3% salinity of the flushing water. The lack of sufficient concentrations of O_2 may present a hazard to personnel entering a CHT tank, even though other hazardous gases are not detected.

- The ORP values decreased from positive to negative potentials in all mixtures during all runs.

- The pH values decreased continuously until approximately 48 hours then level off and fluctuate slightly between 2 and 4.

- The rate of H_2S production was influenced by seeding, temperature, and relative concentration and availability of sulfates. Greater amounts of H_2S were generated and at a faster rate during seeded runs than unseeded runs, and during higher incubation temperatures than lower ones. The TLV (10 ppm) was surpassed whenever H_2S was detected, and concentrations greater than 1700 ppm were often detected. The flushing medium with a salinity of 3% appeared to give faster rates than when 1% was used. This occurred presumably because of the higher concentrations of available $SO_4^=$ in the 3% medium. The effect of low pH values on H_2S generation is discussed. Additionally, H_2S production was related to the amount of head wastes incorporated into each mixture. The mixtures with greater proportions of head waste to other wastes produced greater amounts of H_2S.

- $SO_4^=$ and NO_3^- concentrations decreased with time. A relation between temperature of incubation and presence of seed material was evident in that greater reductions were observed during the seeded and higher temperature runs.

- CO_2 above ambient levels was detected during all runs. The unusually large amounts of CO_2 during anaerobic degradation is indicative of a stratified system wherein the upper levels of the tank contents were undergoing aerobic digestion (utilizing available O_2 from the ullage atmosphere) and the lower strata were undergoing anaerobic digestion. The effect of temperature, salinity, and seeding on CO_2 generation was inconclusive.

• C_2H_5SH was detected in concentrations ranging up to 100 ppm (after 142 hours of incubation). The effect of temperature and seeding was not readily apparent.

• TVA in all the mixtures increased with incubation and was indicative of acid-forming microbial activity. Increased temperatures and the presence of seed was related to faster production rates of volatile acids. The increased TVA concentration was instrumental in depressing the pH.

• CO was detected only during run 1E at a maximum concentration of 70 ppm (TLV = 50 ppm) and only after 120 hours of incubation. The potential threat from CO to personnel is considered insignificant.

• CH_3SH was not detected during runs incubated at 45° and 15° C. It was detected only once in runs incubated at 35° C and only after 142 hours. The maximum concentration at that time was 70 ppm. CH_3SH was generated during runs incubated at 25° C (runs 4 and 6) with a minimum concentration of 2 ppm after 24 hours and a maximum of 45 ppm after 143 hours. Temperatures greater than 35° C and lower than 25° C appeared to inhibit CH_3SH formation.

• CH_4 and NH_3 were not detected in any of the mixtures during any of the runs. This was attributed to the low pH of the waste mixtures.

• HCN was detected once in concentrations less than 1 ppm.

• A predictive mathematical model of gas generation by unaerated shipboard wastewaters has been developed and programmed. Data from the real-time studies can be used with this model to identify potentially hazardous conditions in CHT tanks.

RECOMMENDATIONS

• Positive ventilation of CHT tanks prior to personnel entry should be emphasized, and all current safety practices as concerns CHT tanks must be followed.

• Anaerobic conditions in CHT tanks should be avoided.

• A sampling port should be installed in each CHT holding tank in the ullage above the high level mark (see figure 21).

• Each shipboard DCA/gas free engineer should be provided with a detector for H_2S and mercaptans.

• Gas analysis for hazardous gases and oxygen content should always be conducted prior to opening CHT tanks. CHT tanks should always be considered dangerous to personnel entering them without proper breathing apparatus because of the possible presence of toxic gases.

• CHT tanks should be relocated when necessary to avoid exposure of shipboard personnel to potentially dangerous concentrations of hazardous gases.

• CHT tanks should be cleaned at regular intervals utilizing an effective tank cleaning system to avoid seeded conditions.

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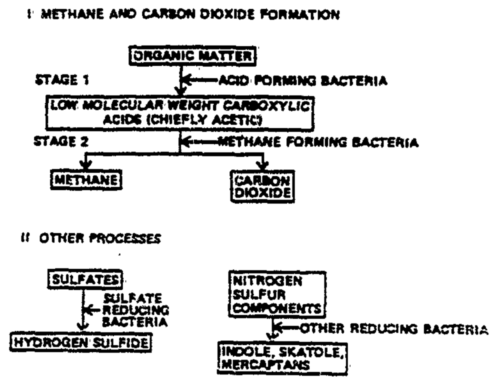


Figure 1
Anaerobic Digestion of Organic Wastes Mediated by Microbial Action

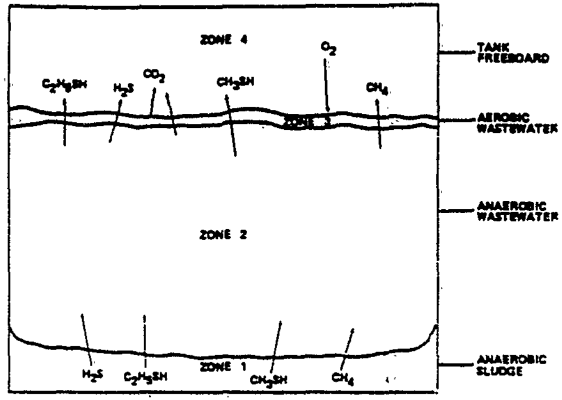


Figure 2
Hypothetical Gas-Generation Model

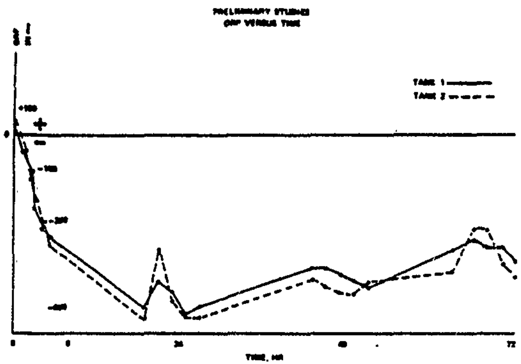


Figure 3 - Comparison of Preliminary Test Oxidation Reduction Potential Data

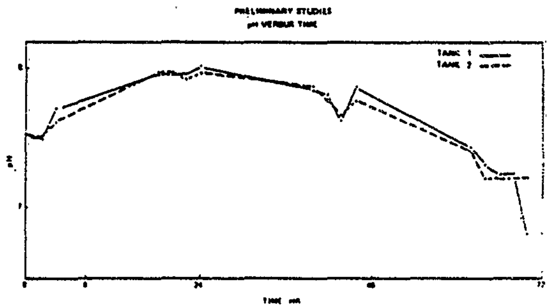


Figure 4 - Comparison of Preliminary Test pH Data

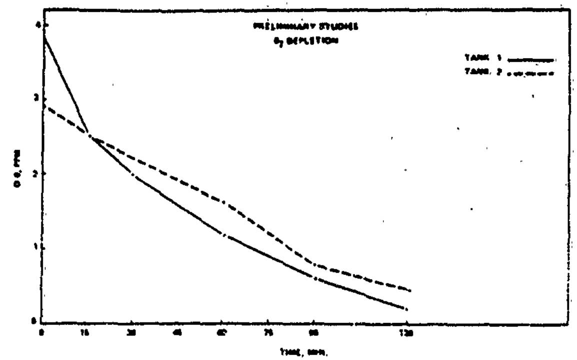


Figure 5
Comparison of Preliminary Test Dissolved Oxygen Data

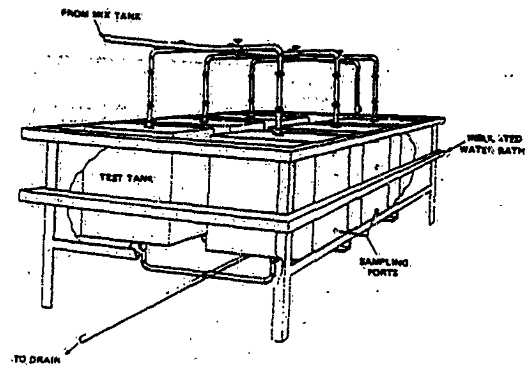


Figure 6
Waste Degradation Studies Experimental Tank Setup

1 - Water Bath
2 - Test Tank
3 - Sampling Ports
4 - Automated Gas Chromatograph
5 - Mix Tank

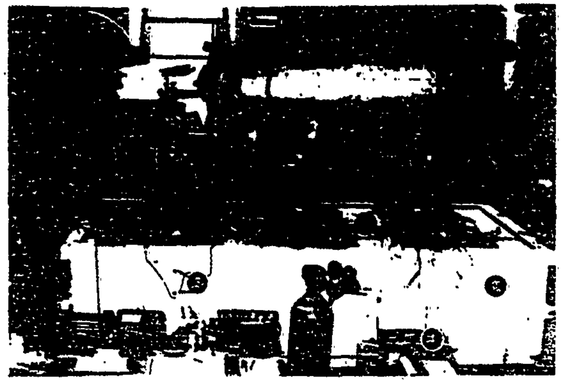


Figure 7
Waste Degradation Studies, Test Tank Assembly

- pH, ORP, DO Electrode Leads
- Gas Sampling Port
- Sampling Lines to Gas Chromatograph

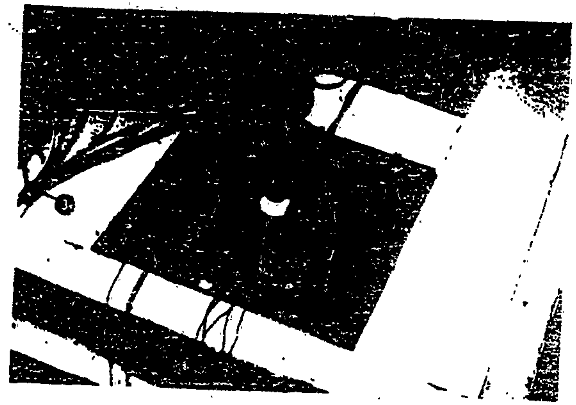


Figure [illegible]
Waste Degradation Studies, Test Tank

- Mix Tank
- Water Heater/Cooler

[illegible]

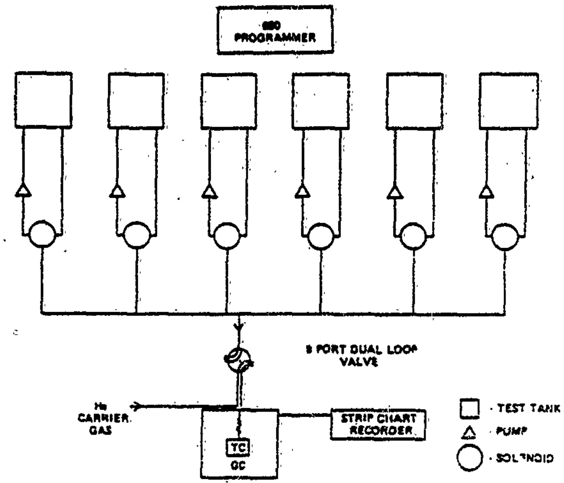
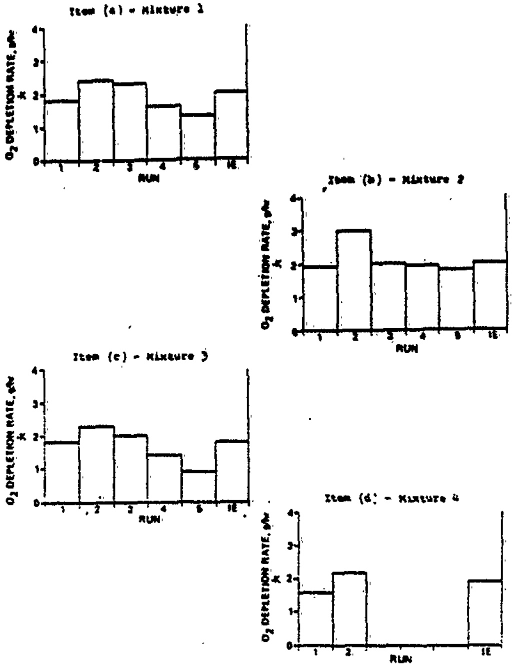


Figure 10
Automated Gas Chromatograph



NOTE: -K = O_2 DEPLETION IN g/hr DERIVED BY LINEAR EXPRESSION y = kx + b.

Figure 11
Freeboard Oxygen Depletion Rates of the Mixtures Under Various Conditions of Temperature, Salinity, and Seeding

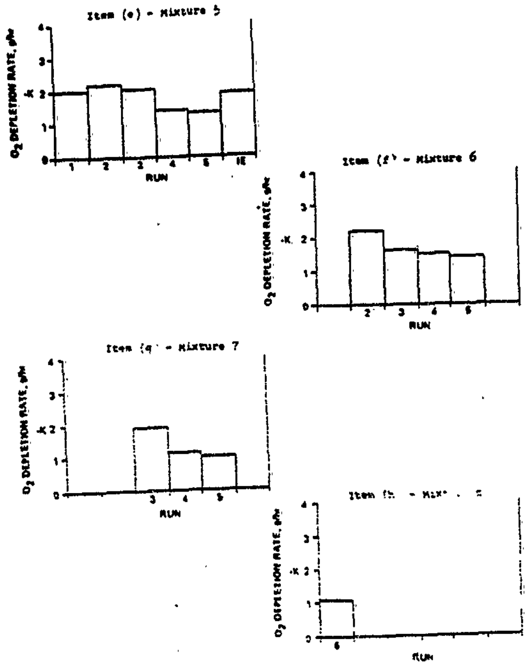


Figure 11 (Cont)

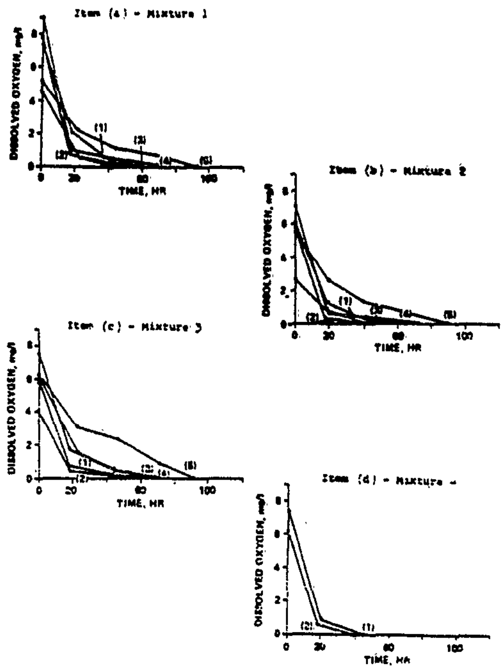


Figure 12
Dissolved Oxygen Depletion with Time for Each Mixture
Under Various Environmental Conditions
(Numbers in Parentheses Indicate Runs)

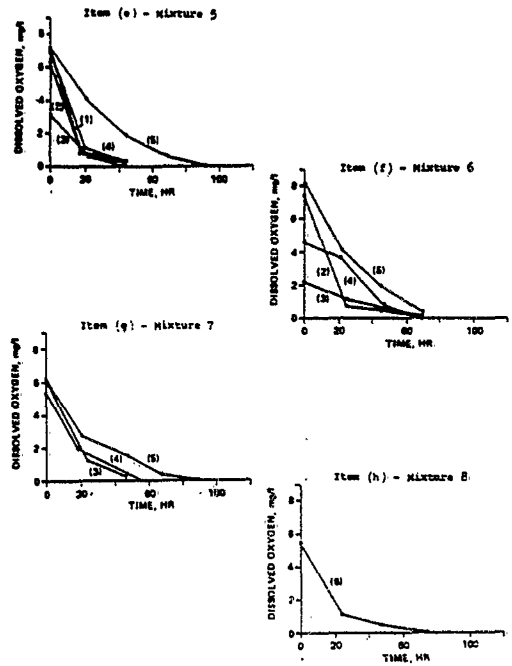
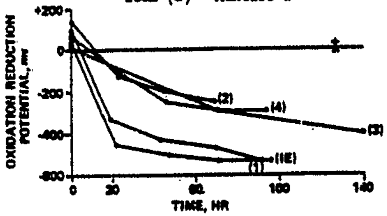


Figure 12 (Cont)

Item (a) - Mixture 1



Item (b) - Mixture 3

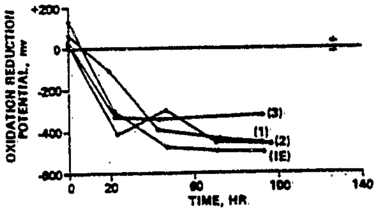
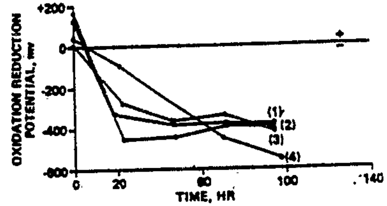


Figure 13
Variation of Oxidation Reduction Potential with Time for Mixtures 1, 3, 5, and 6 Under Various Environmental Conditions
(Numbers in Parentheses Indicate Runs)

Item (c) - Mixture 5



Item (d) - Mixture 6

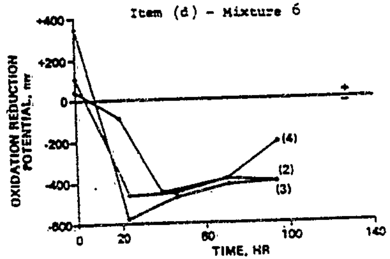


Figure 13 (Cont)

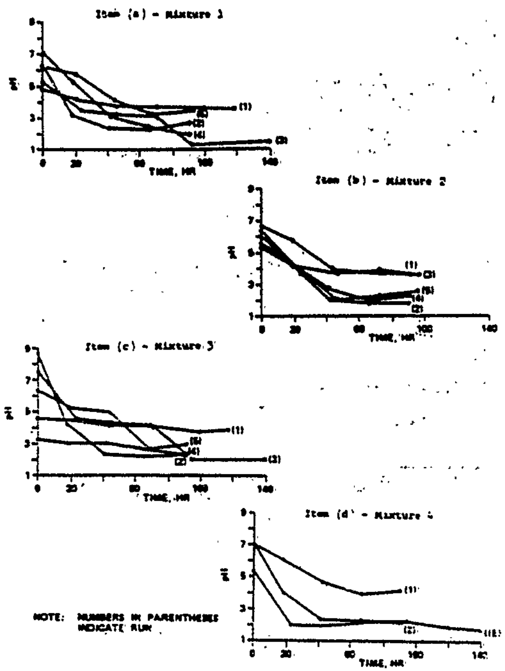


Figure 14.
Variation of pH with Time for Each Mixture Under Various Environmental Conditions
(Numbers in Parentheses Indicate Runs)

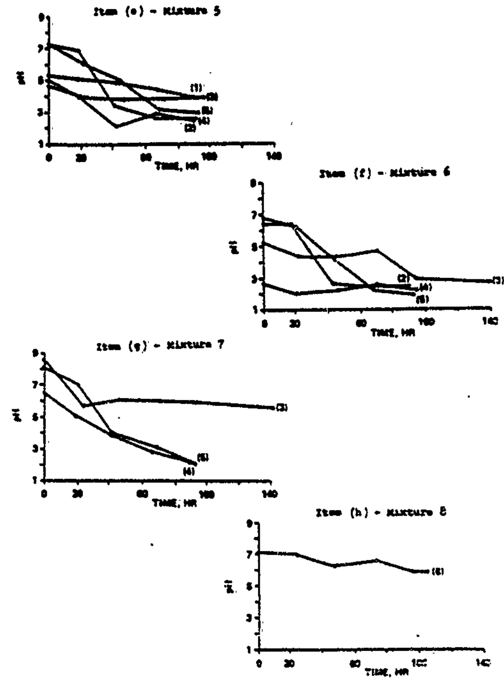
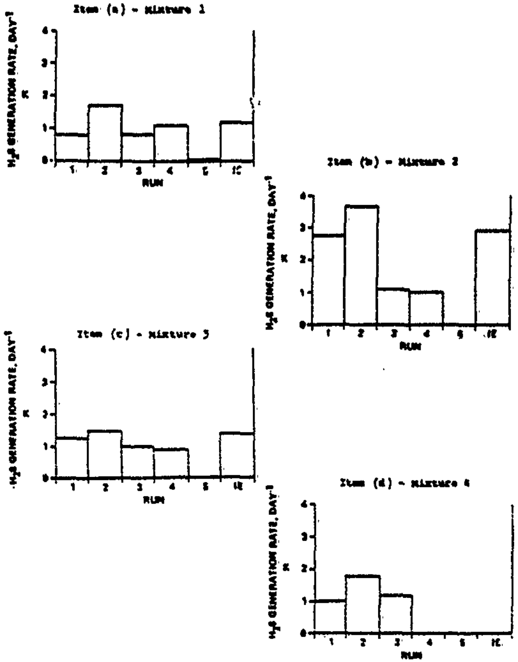


Figure 14 (Cont)



NOTE: K = H_2S RATE CONSTANT (DAY^{-1}) DERIVED BY LINEAR REGRESSION
[illegible] (REFERENCE 11)

Figure 15
Comparison of H_2S Rate Constants for Each Mixture
Under Various Environmental Conditions

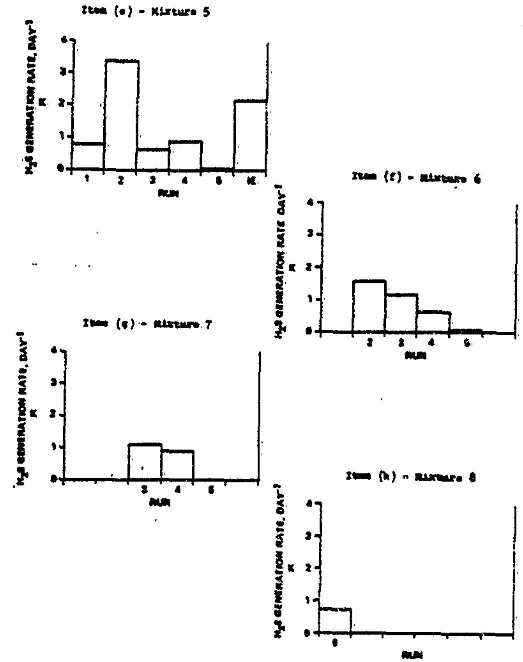


Figure 15 (Cont)

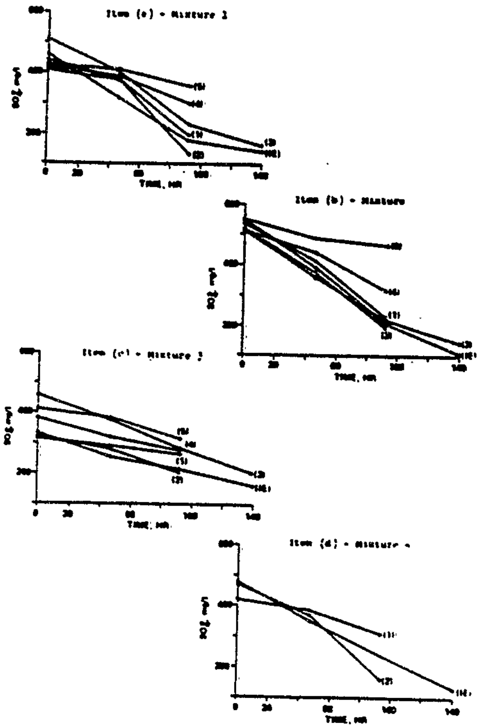


Figure 16
Variation of $SO_4^=$ with Time for Each Mixture
(Numbers in Parentheses Indicate Runs)

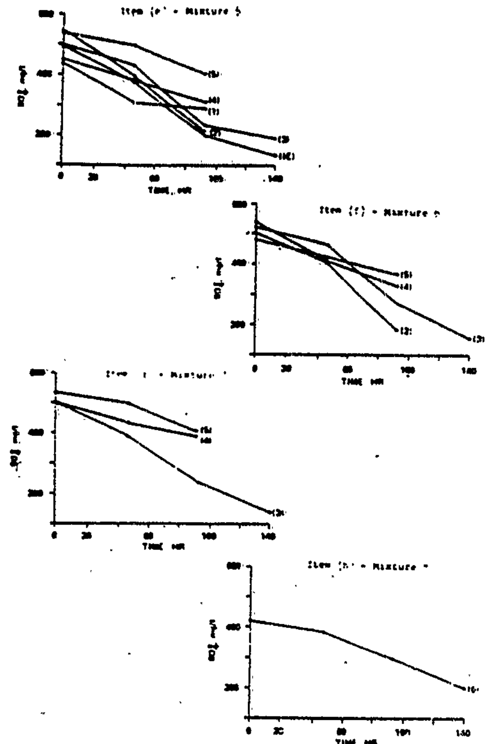


Figure 16 (Cont

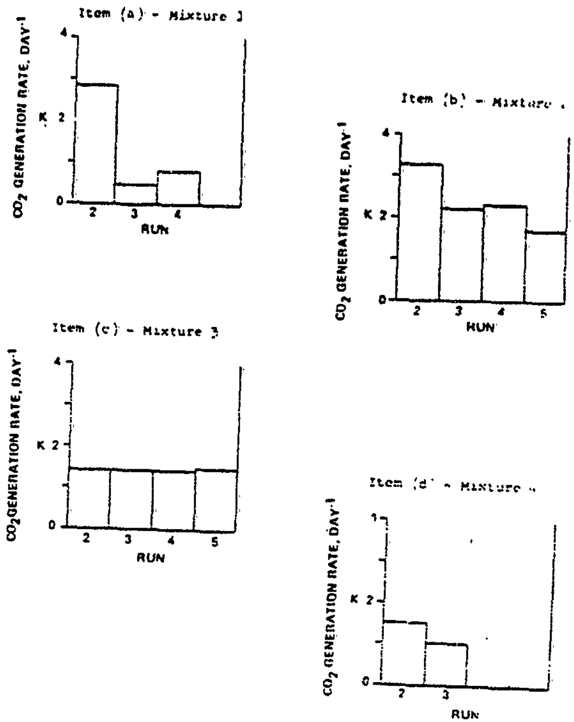


Figure 17
Comparison of CO_2 Rate Constants for Each Mixture
Under Various Environmental Conditions

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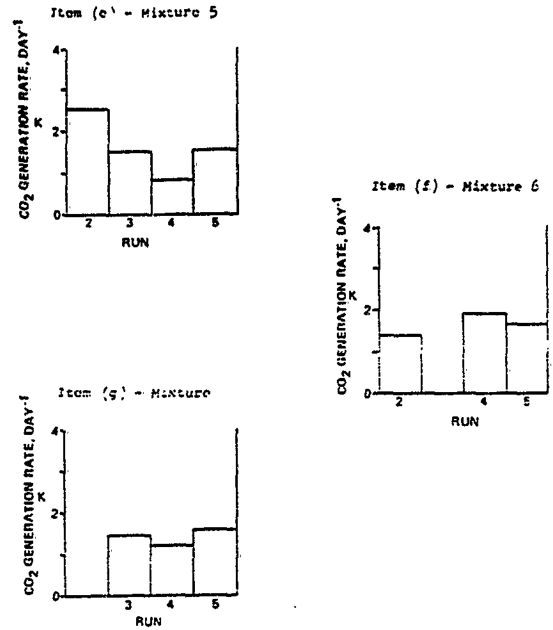

NOTE: K = CO_2 RATE CONSTANT (DAY^{-1}) DERIVED BY LINEAR EXPRESSION
$\ln y = k_t + \ln c$ (REFERENCE 11).

Figure 17 (Cont.)

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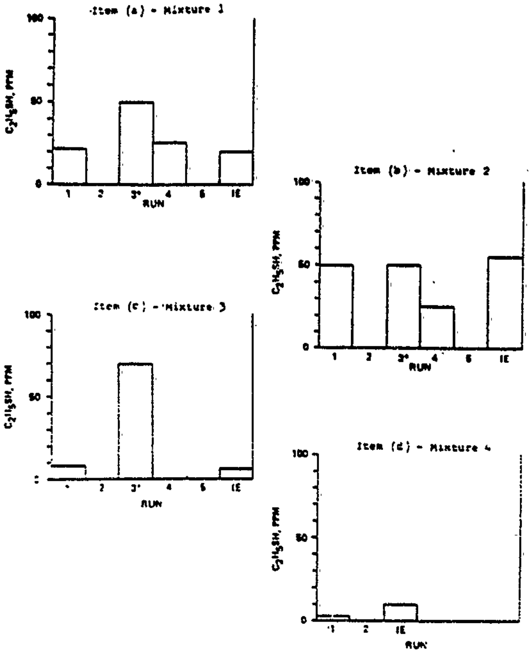


*RUN 3 SHOWS CONCENTRATION AFTER 142 HOURS OF INCUBATION. AFTER 92 HOURS, CONCENTRATION WAS 0.

Figure 18
Comparison of Ethyl Mercaptan Concentrations After
92 Hours of Incubation

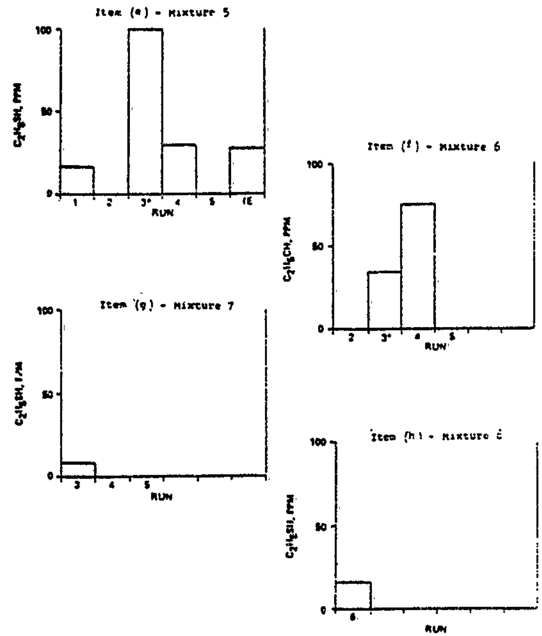
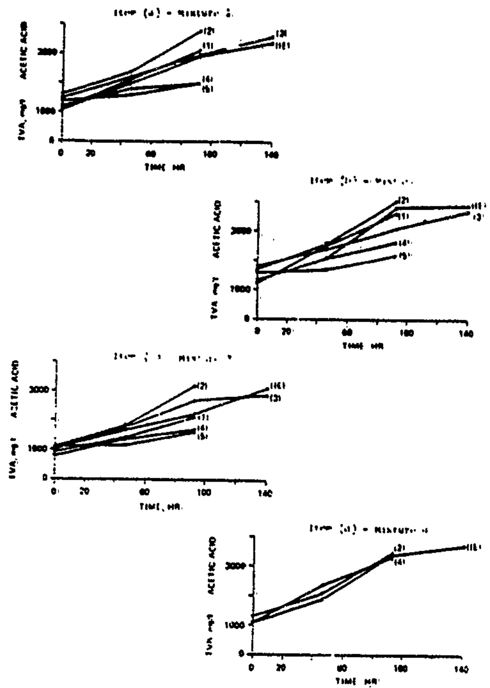


Figure 18 (cont)



NOTE RUN 1 MEAN OF FOUR REPLICATES
RUN 2-6 MEAN OF TWO REPLICATES

Figure 19
Variation of TVA Concentration with Time for Each Mixture
Numbers in Parentheses Indicate Runs

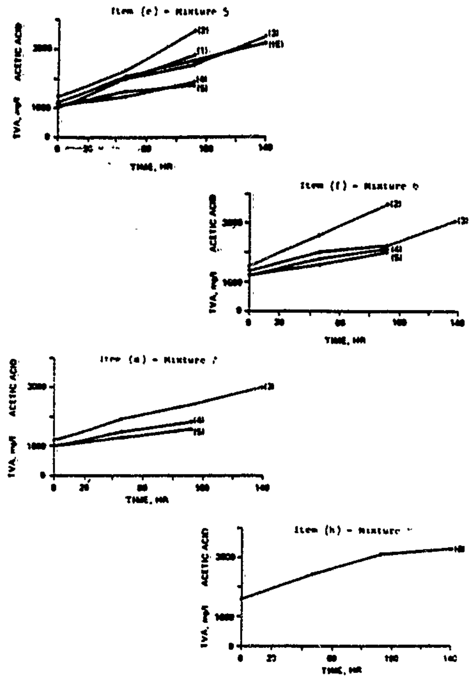
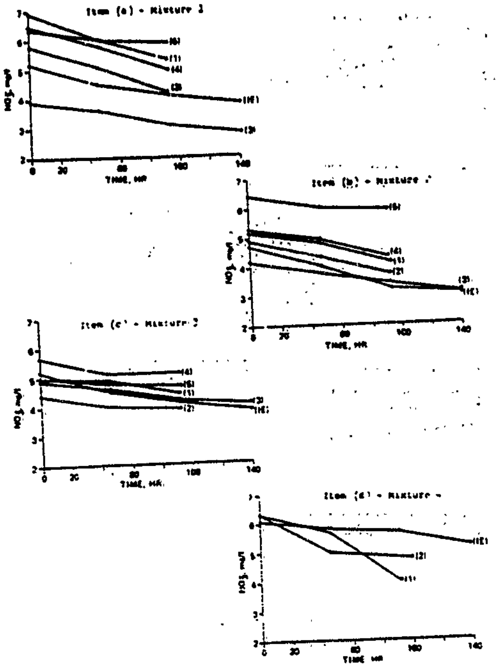


Figure 19 (Cont.)



NOTES: RUN 1 - MEAN OF FOUR REPLICATES
RUN 2-6 - MEAN OF TWO REPLICATES

Figure 20
Variation of NO_3^- Concentration with Time for Each Mixture
(Numbers in Parentheses Indicate Runs)

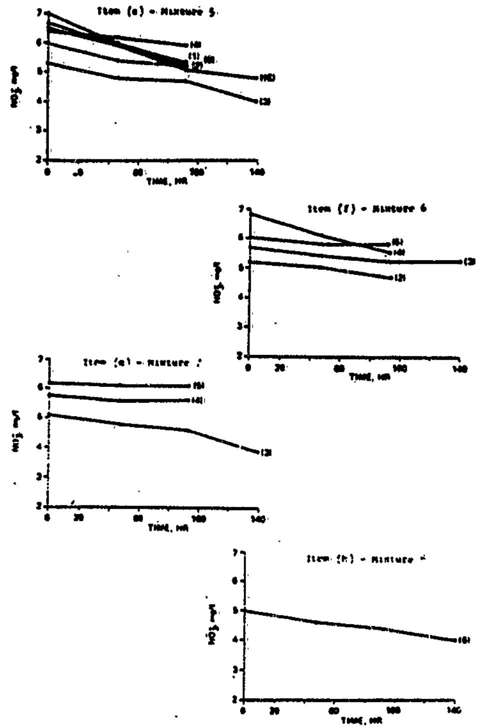


Figure 20 (Cont)

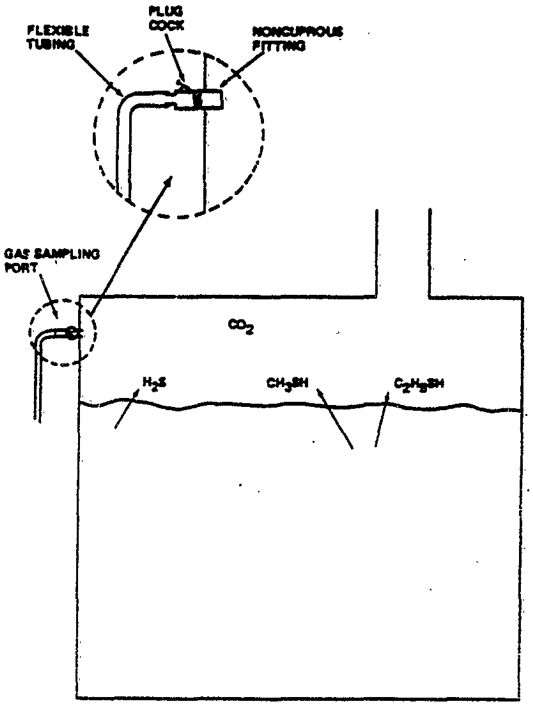


Figure 21
Gas Sampling Port

APPENDIX A
CHT GAS-GENERATION COMPUTER PROGRAM USER'S GUIDE

I. PROGRAM DESCRIPTION

Program Name: GASGEN

Description: This program uses a mathematical model to predict gas concentrations in the gas phase above the liquid in Navy CHT tanks. Predictions are made for carbon dioxide and hydrogen sulfide. Gas concentrations are given in parts per million for 0 to 10 days at 1-day intervals for tank temperatures of 25°, 35°, and 45° C and for both 30% and 60% of total tank capacity.

GASGEN is very flexible and can be used to predict gas concentrations in any CHT tank. The program has on file, tank volumes and influent characteristics for several ship classes and tanks. If the desired ship or tank is not on file, the program allows the user to input the necessary data manually.

II. USING THE PROGRAM

The program is stored in the PDP11 digital computer located at DTNSRDC, Building 182-1-F. After hookup to the computer, the lastoutput printed by the teletype will be:

RT - 11SJ	V02C - 02B
Date	Day-Month-Year

To run the program, follow this procedure:

1. After the period, type in R FORTRA and hit RETURN.

2. The computer will type A *. After it does, type in: GASGEN = GASGEN, hit return, and wait for the computer to come back with another *.

3. Now you are ready to "link" the program to the computer.

4. After the . simultaneously press CTRL and C. The computer will respond with [illegible] .

5. After the period, type in R Link, hit RETURN, and wait until the computer types another * before your next input. Now type GASGEN = GASGEN, SYSLIB/F and hit RETURN. The response to this will be another *.

6. After the *, again type CTRL and C. The computer will respond with a period.

7. Now we are ready to run the program. Type after the *, R GASGEN and hit RETURN. The program takes it from there.

III. VARIABLE LIST

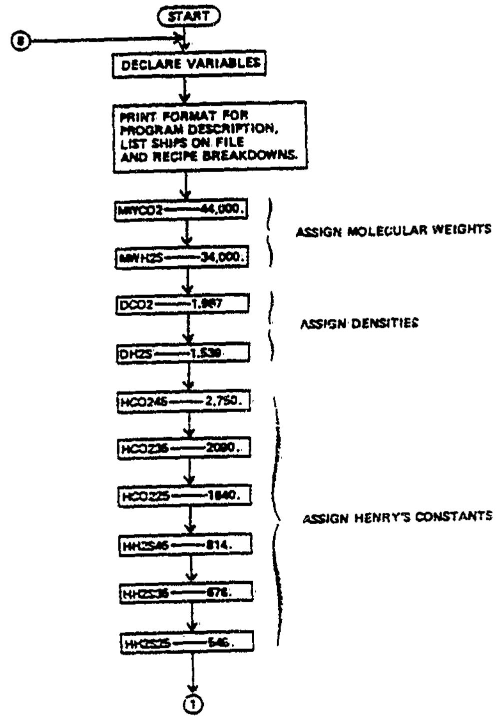
Variable Name	Type	Description	Value (If Constant)
MWCO2	Real	Molecular weight of carbon dioxide	44,000
MWH2S	Real	Molecular weight of hydrogen sulfide	34,000
DCO2	Real	Density of carbon dioxide at 0° C	1.977
DH2S	Real	Density of hydrogen sulfide at 0° C	1.539
HCO245	Real	Henry's constant for carbon dioxide at 45° C	2,570
HCO235	Real	Henry's constant for carbon dioxide at 35° C	2,090
HCO225	Real	Henry's constant for carbon dioxide at 25° C	1,640
HH2S45	Real	Henry's constant for hydrogen sulfide at 45° C	814
HH2S35	Real	Henry's constant for hydrogen sulfide at 35° C	676
HH2S25	Real	Henry's constant for hydrogen sulfide at 25° C	545
KCO245	Real	Gas-generation rate constant for carbon dioxide at 45° C	
KCO235	Real	Gas-generation rate constant for carbon dioxide at 35° C	
KCO225	Real	Gas-generation rate constant for carbon dioxide at 25° C	
KH2S45	Real	Gas-generation rate constant for hydrogen sulfide at 45° C	
KH2S35	Real	Gas-generation rate constant for hydrogen sulfide at 35° C	
KH2S25	Real	Gas-generation rate constant for hydrogen sulfide at 25° C	
K45	Real	Gas-generation rate constant at 45° C used in the prediction equation and depends on the gas in question	
K35	Real	Gas-generation rate constant at 35° C used in the prediction equation and depends on the gas in question	

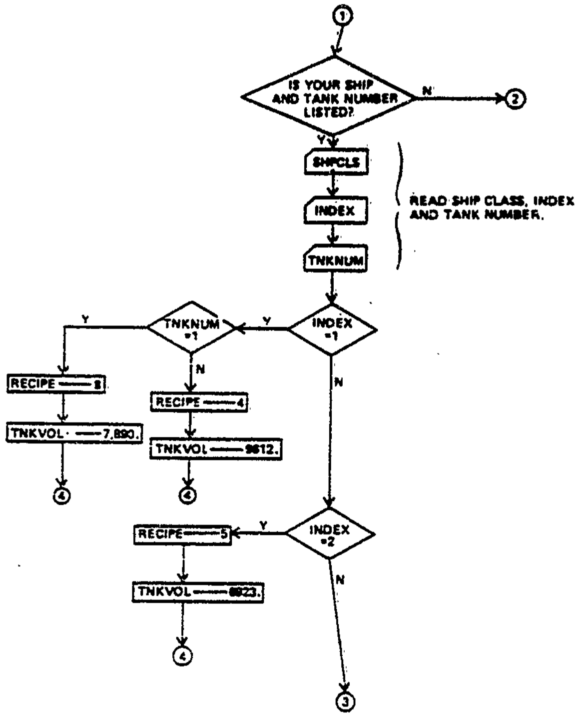
VARIABLE LIST (cont.)

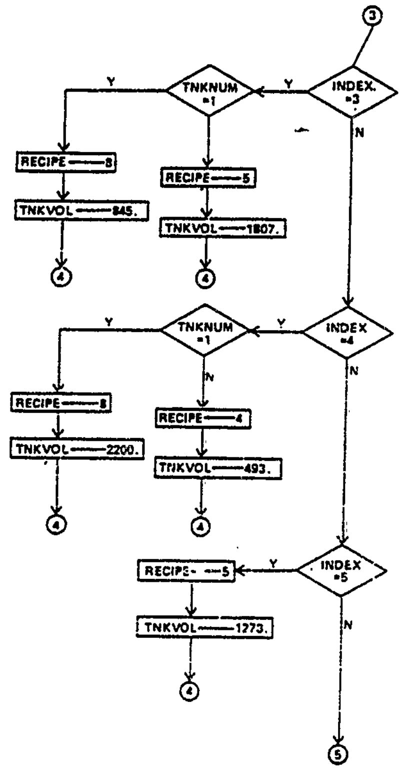
Variable Name	Type	Description	Value (If Constant)
D	Real	Density used in ppm calculation depends on the gas in question	
K25	Real	Gas-generation rate constant at 25° C used in the prediction equation and depends on the gas in question	
PPM45	Real	Total increase in gas concentration for a gas at 45° C	
PPM35	Real	Total increase in gas concentration for a gas at 35° C	
PPM25	Real	Total increase in gas concentration for a gas at 25° C	
VOLTNK	Real	Volume of sewage in the tank in liters, equals either 30% or 60% of total tank volume	
MW	Real	Molecular weight of the gas in mg used in the ppm prediction equation	
H	Real	Henry's constant for the gas used in the ppm prediction equation	
X45	Real	Has no physical meaning: is defined X45 = VOLTNK*EXP (K35*T)	
X35	Real	Has no physical meaning: is defined X35 = VOLTNK*EXP (K35*T)	
X25	Real	Has no physical meaning: is defined X25 = VOLTNK*EXP (K25*T)	
W	Real	Has no physical meaning: is defined W = VSTT*MW*55.6E-6	
Z	Real	Has no physical meaning: is defined Z = VFTT*D*DTC	
DTC	Real	Density temperature correction, depends on the reference temperature for the density of gas	
VSTT	Real	Volume of sewage in DTNSRDC test tank in liters	227
VFTT	Real	Volume of Freeboard in DTNSRDC test tank in liters	59
MIXTURE	Integer	Each mixture corresponds to a different combination of head, galley, and laundry wastes	[illegible] → [illegible]

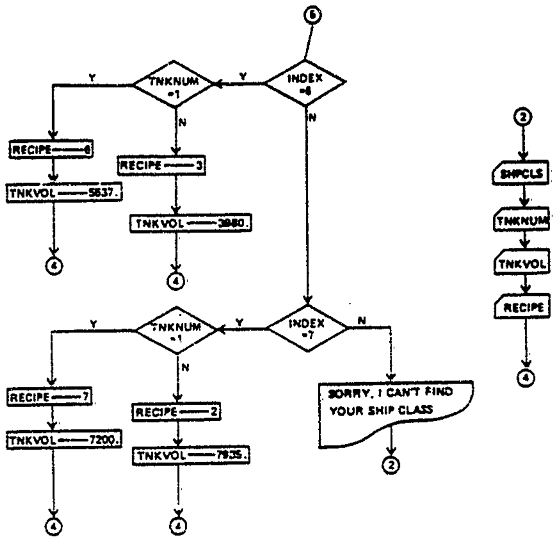
VARIABLE LIST (cont)

Variable Name	Type	Description	Value (If Constant)
TNKNUM	Integer	Number of the CHT tank in question; i.e., AD14 tank 1	
I	Integer	Loop counter which varies the gas under consideration	1, 2
J	Integer	Loop counter which varies the volume of sewage in the tank	30, 60
K	Integer	Loop counter which varies the time equals time in days plus 1	1 → 11
T	Integer	Time in days; T = K - 1	0 → 10
A	Integer	Corresponds to the gas in question, controls heading formats	1, 2
B	Integer	Answer to the question, "Is your ship listed?"	1 = yes 2 = no
C	Integer	Answer to the question, "Would you like to run again?"	1 = yes 2 = no
DD	Integer	Answer to the question, "Do you still want to run even though your ship is not listed?"	1 = yes 2 = no
INDEX	Integer	Corresponds to ship class	
TNKVOL	Integer	Corresponds to total tank capacity in gallons	
SHPCLS	Real	Holds alpha-numeric information corresponding to ship class	
H45	Real	Henry's constant used in prediction equation, depends on gas in question	
H35	Real	Henry's constant used in prediction equation, depends on gas in question	
H25	Real	Henry's constant used in prediction equation, depends on gas in question	

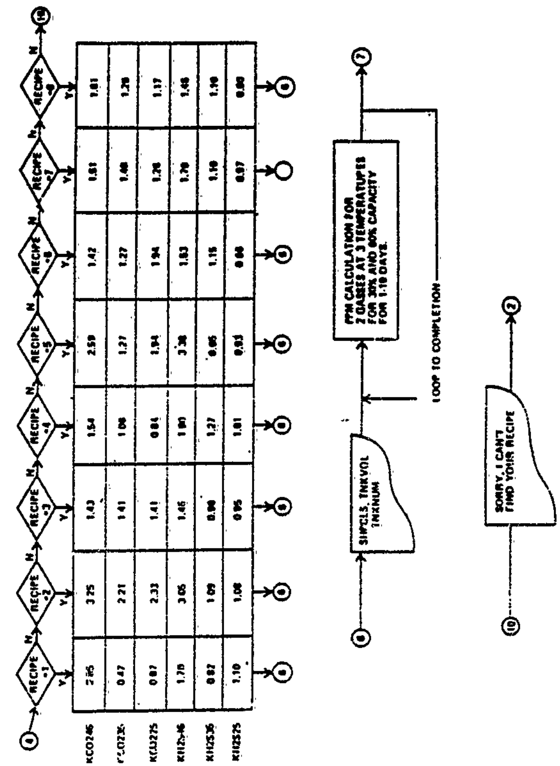



1
IS YOUR SHIP AND TANK NUMBER LISTED?
N
2
Y
SHPCLS
INDEX
TNKNUM
READ SHIP CLASS, INDEX AND TANK NUMBER.
INDEX =1
Y
TNKNUM =1
Y
RECIPE ——8
TNKVOL ——7,890.
4
N
RECIPE ——4
TNKVOL ——9612.
4
N
INDEX =2
Y
RECIPE ——5
TNKVOL ——6923.
4
N
3

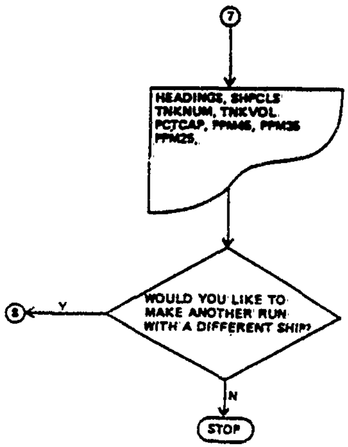

3
INDEX =3
Y
TNKNUM =1
Y
RECIPE ——8
TNKVOL ——845.
4
RECIPE ——5
TNKVOL ——1807.
4
N
INDEX =4
Y
TNKNUM =1
Y
RECIPE ——8
TNKVOL ——2200.
4
N
RECIPE ——4
TNKVOL ——493.
4
N
INDEX =5
Y
TNKVOL ——1273.
4
N
5



INDEX =6
TNKNUM =1
Y
N
RECIPE ← 6
TNKVOL ← 5637.
RECIPE ← 3
TNKVOL ← 3980.
INDEX =7
TNKNUM =1
RECIPE ← 7
TNKVOL ← 7200.
RECIPE ← 2
TNKVOL ← 7935.
SORRY, I CAN'T FIND YOUR SHIP CLASS
SHPCLS
TNKNUM
TNKVOL
RECIPE



RECIPE =1
RECIPE =2
RECIPE =3
RECIPE =4
RECIPE =5
RECIPE =6
RECIPE =7
RECIPE =8
KCO246
KH2S36
KH2S25
SHPCLS, TNKVOL TNKNUM
PPM CALCULATION FOR 2 GASES AT 3 TEMPERATUPES FOR 30% AND 60% CAPACITY FOR 1-10 DAYS.
LOOP TO COMPLETION
SORRY, I CAN'T FIND YOUR RECIPE




```
C       DECLARE ALL VARIABLES INTEGER OR REAL.
C
        REAL MMCO2,MMH2S,DCO2,DH2S,D,HCO24S,
     .  HCO23S,HCO22S,HH2S4S,HH2S3S,HH2S2S,
     .  KCO24S,KCO23S,KCO22S,KH2S4S,
     .  KH2S3S,KH2S2S,
     .  K4S,K3S,K2S,PPM4S,PPM3S,PPM2S,VOLTNK,MW,N,X4S,X3S,X2S,
     .  W,Z,
     .  WCO2,WH2S,DTC,VSTT,VFTT
C
        INTEGER RECIPE,TNKNUM,I,J,K,T,A,B,C,INDEX,TNKVOL,BD
        DOUBLE PRECISION SHPCLS
C
C       PRINT THE PROGRAM DESCRIPTION
        WRITE(7,200)
        WRITE(7,201)
        WRITE(7,202)
        WRITE(7,203)
        WRITE(7,204)
        WRITE(7,205)
        WRITE(7,206)
        WRITE(7,207)
        WRITE(7,208)
        WRITE(7,209)
        WRITE(7,216)
        WRITE(7,217)
        WRITE(7,211)
        WRITE(7,212)
        WRITE(7,213)
        WRITE(7,214)
        WRITE(7,215)
        WRITE(7,218)
        WRITE(7,219)
        WRITE(7,222)
        WRITE(7,223)
200     FORMAT(1H ,' THIS PROGRAM WILL CALCULATE THE GAS GENERATION IN'
     .,/,' PARTS PER MILLION IN NAVY CHT TANKS DURING STAGNANT
     .  CONDITIONS.')
201    FORMAT(1H ,'CONCENTRATIONS FOR CO2, AND HYDROGEN SULFIDE ARE
     .',/,' CALCULATED.  GENERATION RATES DEPEND ON GAS,TANK VOLUME
     .',/,',TEMPREATURE, AND TANK CONTENTS. TANK CONTENTS (PERCENTAGES')
202     FORMAT(1H ,'OF HEAD, GALLEY AND LAUNDRY WASTES) WILL VARY FROM
     .',/,' TANK TO TANK.  EIGHT DIFFERENT RECIPIES HAVE BEEN CHOSEN TO
     .',/,' APPROXIMATE THE CONTENTS OF ALL NAVY CHT TANKS.',//)
203     FORMAT(1H ,' THE RECIPIES ARE LISTED BELOW.
     .',//,' $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
     .',/,' RECIPE     PCT HEAD     PCT GALLEY     PCT LAUNDRY')
204     FORMAT(1H ,'______     ________     __________     __________
     .',/,'     1           30            70            --
     .',/,'     2           59            41            --')
205     FORMAT(1H ,'    3              --            54            46
     .',/,'     4           34            36            30
     .',/,'     5           45            32            24')
206     FORMAT(1H ,'    6              45            19            16
     .',/,'     7           29            20            51
     .',/,'     8           100           --            --',
207     FORMAT(1H ,'
     .',/,' ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
     .',//,' IN ORDER TO RUN THIS PROGRAM YOU MUST HAVE THE FOLLOWING')
208     FORMAT(1H ,'DATA AVAILABLE .  1. THE SHIP CLASS  2. THE TOTAL
     .',/,' TANK VOLUME IN GALLONS FOR THE TANK YOU WISH TO CONSIDER
     .',/,' AND 3. THE RECIPE WHICH APPROXIMATES THE TANK CONTENTS')
209     FORMAT(/,1H ,'BELOW IS SOME AVAILABLE DATA
```

```
     .'./.'---------------------------------------------------------------
     .'./.' SHIP CLASS    INDEX NUMBER    TANKNO.     VOLUME    RECIPE'/'
216      FORMAT(1H ,' AD14              1          1     .   7090        8
     .'./.'  AD14             1          2          9412      6
     .'./.'  AE26             2          1          6923      5')
217      FORMAT(1H ,' ,
     .'./.'  AO050            3          1          845       8
     .'./.'  AO050            3          2          1807      5')
211      FORMAT(1H ,' ,
     .'./.'  AS11             4          1          2200      8
     .'./.'  AS11             4          2          493       4')
212      FORMAT(1H ,' ,
     .'./.'  ATF76            5          1          1273      5')
213      FORMAT(1H ,' ,
     .'./.'  LST1179          6          1          5537      6
     .'./.'  LST1179          6          2          3980      3')
214      FORMAT(1H ,' ,
     .'./.'  LPD4             7          1          7200      7
     .'./.'  LPD4             7          2          7935      2')
215      FORMAT(1H ,' LPD4        ,    7          3          7935        2')
218      FORMAT(1H ,'.
     .'//.' IF THE CHT TANK YOU WISH TO CONSIDER IS NOT LISTED ABOVE
     .'./.' THEN THE COMPUTER WILL INSTRUCT YOU TO INPUT THE PROPER')
219      FORMAT(1H ,'SHIP CLASS, INDEX NUMBER, AND TANK NO. YOU WILL ALSO
     .'./.' NEED TO INPUT  THE APPROPRIATE TANK VOLUME AND RECIPE.
     .'///.' AFTER RUNNING, THE PROGRAM  RETURNS THE CONCENTRATIONS')
222      FORMAT(1H ,'OF CO2 AND H2S AT 25, 35, AND 45 DEGREES CENTEGRADE
     .'./.' AT INTERVALS OF ONE DAY FOR 0 TO 10 DAYS. CONCENTRATIONS ARE
     .'./.' CALCULATED FOR 30% AND 60% OF THE TANKS FULL CAPACITY.')
223      FORMAT(///,1H ,'                HERE WE GO!!!!!!',//)
C
C
8000     CONTINUE
C
C        ASSIGN THE MOLECULAR WEIGHTS TO THE APPROPRIATE VARIABLES
C
         MWCO2=44000.
         MWH2S=34000.
C
C        ASSIGN THE APPROPRIATE DENSITIES TO EACH GAS
C
         DCO2=1.977
         DH2S=1.539
C
C        ASSIGN THE APPROPRIATE HENRYS CONSTANTS TO THE GASES
C
         HCO245=2570.
         HCO235=2090.
         HCO225=1640.
         HH2S45=814.
         HH2S35=676.
         HH2S25=545.
C
C        ASK WEATHER SHIPCLASS AND TANK NUMBER ARE LISTED.
C
1000     WRITE(7,210)
210      FORMAT(1H ,5X,'IS YOUR SHIP CLASS AND TANK NUMBER LISTED ABOVE
         TYPE IN 1=YES OR 2=NO ')
C
C        READ THE REPLY AND SEND CONTROL TO THE PROPER STATMENT
C
         READ(5,100)B
100      FORMAT(I1)
         IF(B.EQ.1) GO TO 1030
         WRITE(7,226)
226      FORMAT(1H ,' IF YOU HAVE TANK VOLUMEIN GALLONS AND THE RECIPE
     .'./.' WHICH MOST CLOSELY APPROXIMATES THE CONTENTS OF YOUR TANK
     .'./.' YOU CAN STILL RUN THE PROGRAM.
     .'///.   DO YOU STILL WANT TO RUN ?  TYPE 1= YES OR 2= NO ')
```



```
         READ(5,112)BB
112      FORMAT(I1)
         IF(B.EQ.2) GO TO 7001
C
C        READ SHIP CLASS ,INDEX AND TANK NUMBER
C
1030     WRITE(7,220)
220      FORMAT(1H ,5X,'TYPE IN SHIP CLASS')
         READ(5,110)SHPCLS
         WRITE(7,225)
225      FORMAT(1H ,5X,'TYPE IN INDEX NUMBER.  IF THE SHIP IS NOT
        LISTED THEN INDEX=0')
         READ(5,111)INDEX
110      FORMAT(A6)
111      FORMAT(I3)
         WRITE(7,230)
230      FORMAT(1H ,5X,'TYPE IN TANK NUMBER')
         READ(5,120)TNKNUM
120      FORMAT(I2)
C
C        THIS CONDITIONAL IF WILL BYPASS READS FOR TANK VOLUME AND
C        RECIPE IF THE SHIP IS LISTED IN THE PROGRAM.
C
         IF(B.EQ.1) GO TO 1010
C
C        IF SHIP CLASS AND TANK NUMBER ARE NOT LISTED THEN THE PROGRAM
C        REQUESTS THAT TANK VOLUME AND RECIPE NUMBER BE ENTERED.
C
         WRITE(7,240)
240      FORMAT(1H ,5X,'TYPE IN TANK VOLUME IN GALLONS')
         READ(5,130)TNKVOL
130      FORMAT(I7)
         WRITE(7,250)
250      FORMAT(1H ,5X,'TYPE IN PROPER RECIPE NUMBER')
         READ(5,140)RECIPE
140      FORMAT(I1)
C
C        CONTROL IS SENT PAST A SEARCH FOR TANK VOLUME AND RECIPE
C
         GO TO 1020
1010     CONTINUE
C
C        NOW THE PROGRAM , GIVEN THE SHIP CLASS AND TANK NO. SEARCHES
C        THROUGH THE STORED DATA FOR THE PROPER TANK VOLUME AND RECIPE
C
         IF(INDEX.EQ.1) GO TO 2000
         IF(INDEX.EQ.2) GO TO 2010
         IF(INDEX.EQ.3) GO TO 2020
         IF(INDEX.EQ.4) GO TO 2030
         IF(INDEX.EQ.5) GO TO 2040
         IF(INDEX.EQ.6)  GO TO 2050
         IF(INDEX.EQ.7) GO TO 2060
C
C        IF SHIP CLASS IS NOT FOUND THEN PROGRAM ASKS FOR MANUAL INPUT
C
         WRITE(7,260)
260      FORMAT(1H ,5X,'SORRY BUT I CANNOT FIND YOUR SHIP PLEASE INPUT
          DATA MANUALLY AS INSTRUCTED')
         B=2
         GO TO 1030
C        NOW WE KNOW THE SHIP CLASS AND MUST FIND THE TANKNUMBER
C        WHICH WILL TELL US THE TANK VOLUME AND RECIPE
C
2000     CONTINUE
         IF(TNKNUM.EQ.1) GO TO 2001
```

```
      RECIPE=4
      TNKVOL=9612.
      GO TO 1020
2001  RECIPE=8
      TNKVOL=7090.
      GO TO 1020
2010  RECIPE=5
      TNKVOL=4923.
      GO TO 1020
2020  IF(TNKNUM.EQ.1) GO TO 2021
      RECIPE=5
      TNKVOL=1807.
      GO TO 1020
2021  RECIPE=8
      TNKVOL=845.
      GO TO 1020
2030  IF(TNKNUM.EQ.1) GO TO 2031
      RECIPE=4
      TNKVOL=493.
      GO TO 1020
2031  RECIPE=8
      TNKVOL=2200.
      GO TO 1020
2040  RECIPE=5
      TNKVOL=1273.
      GO TO 1020
2050  IF(TNKNUM.EQ.1)GO TO 2051
      RECIPE=3
      TNKVOL=3980.
      GO TO 1020
2051  RECIPE=6
      TNKVOL=5537.
      GO TO 1020
2060  IF(TNKNUM.EQ.1) GO TO 2061
      RECIPE=2
      TNKVOL=7935.
      GO TO 1020
2061  RECIPE=7
      TNKVOL=7200.
      GO TO 1020
C
C     NOW THAT THE RECIPE IS KNOWN  WE MUST ASSIGN THE GENERATION
C     RATES.
C
1020  CONTINUE
      IF(RECIPE.NE.1) GO TO 3010
      KCO245=2.85
      KCO235=0.47
C

      KCO225=0.87
      KH2S45=1.70
      KH2S35=0.82
      KH2S25=1.10
      GO TO 4000
3010  IF(RECIPE.NE.2) GO TO 3020
      KCO245=3.25
      KCO235=2.11
      KCO225=2.33
      KH2S45=3.65
      KH2S35=1.09
      KH2S25=1.08
      GO TO 4000
3020  IF(RECIPE.NE.3) GO TO 3030
      KCO245=1 43
      KCO235=1.41
      KCO225=1.41
```



```
      KH2S45=1.45
      KH2S35=0.98
      KH2S25=0.95
      GO TO 4000
3030  IF(RECIPE.NE.4) GO TO 3040
      KCO245=1.54
      KCO235=1.06
      KCO225=0.84
      KH2S45=1.80
      KH2S35=1.27
      KH2S25=1.01
      GO TO 4000
3040  IF(RECIPE.NE.5) GO TO 3050
      KCO245=2.59
      KCO235=1.27
      KCO225=1.94
      KH2S45=3.38
      KH2S35=0.45
      KH2S25=0.93
      GO TO 4000
3050  IF(RECIPE.NE.6) GO TO 3060
      KCO245=1.42
      KCO235=1.27
      KCO225=1.94
      KH2S45=1.53
      KH2S35=1.15
      KH2S25=0.66
      GO TO 4000
3060  IF(RECIPE.NE.7) GO TO 3070
      KCO245=1.51
      KCO235=1.48
      KCO225=1.28
      KH2S45=1.70
      KH2S35=1.10
      KH2S25=0.97
      GO TO 4000
3070  IF(RECIPE.NE.8) GO TO 3080
      KCO245=1.61
      KCO235=1.28
      KCO225=1.17
      KH2S45=1.45
      KH2S35=1.10
      KH2S25=0.80
      GO TO 4000
C
C     IF THE RECIPE IS NOT FOUND MANUAL INPUT IS REQUESTED
C     AND CONTROL IS SENT TO THE RECIPE SEARCH.
C
3080  WRITE(7,270)
270   FORMAT(1H ,5X,'SORRY, I CANT FIND YOUR RECIPE .  PLEASE TYPE
     .',/,'  IN THE RECIPE YOU DESIRE, PICK IT FROM THE LIST I GAVE
     .',/,' YOU BEFORE')
      READ(5,140)RECIPE
      GO TO 1020
C
C     ONCE THE RECIPE IS FOUND WE GO ON TO THE CALCULATION
C
4000  CONTINUE
C
C     THE THREE FOLLOWING DO LOOPS ENCLOSE OUR GAS INCREASE CAL
C     CULATIONS.  THE FIRST LOOP VARIES THE GAS FROM CO2 TO H2S
C     .  THE SECOND LOOP VARIES THE TANK LEVEL
C      FROM 30% FULL CAPACITY TO 60% OF FULL CAPACITY.  THE THIRD
C     LOOP VARIES THE TIME FROM 0 TO 10 DAYS.
C
C     PRINT A HEADING
C
```

```
      WRITE(7,6000)SHPCLS,TNKNUM
6000  FORMAT('1',5X,'SHIP CLASS: ',A6,10X,'TANK NUMBER: ',I2,/)
      WRITE(7,6010)TNKVOL
6010  FORMAT(1H ,5X,'TANK VOLUME: ',I7)
      WRITE(7,6011)
6011  FORMAT(1H ,'    ******************************************************')
C
C     BEGIN THE FIRST LOOP
C
      DO 4010 I=1,2,1
C
C     THESE CONDITIONAL IFS VARY THE GAS UNDER CONSIDERATION
C                         I=1  IMPLIES CO2
C                         I=2  IMPLIES H2S
C
      IF(I.EQ.1) GO TO 4040
      IF(I.EQ.2) GO TO 4050
C
C     DEPENDING ON THE GAS ; GENERATION RATES , MOLECULAR WEIGHTS,
C     DENSITIES, DENSITY TEMPERATURE CORRECTIONS AND HENRYS
C     CONSTANTS ARE ASSIGNED.  THEN THE CALCULATION IS STARTED.
C
4040  CONTINUE
      A=1
      B=DCO2
      MW=MWCO2
      H45=HCO245
      H35=HCO235
      H25=HCO225
      DTC=0.273
      K45=KCO245
      K35=KCO235
      K25=KCO225
      GO TO 5000
4050  CONTINUE
      A=2
      MW=MWH2S
      B=DH2S
      DTC=0.273
      H45=HH2S45
      H35=HH2S35
      H25=HH2S25
      K45=KH2S45
      K35=KH2S35
      K25=KH2S25
      GO TO 5000
C
C     NOW THE INCREASES IN GAS CONCENTRATIONS ARE CALCULATED, AFTER
C     THE TANK VOLUME IS CONVERTED TO LITERS,  AFTER A SECOND
C     HEADING IS PRINTED.
C
5000  CONTINUE
      IF(A.EQ.1) GO TO 9001
      WRITE(7,6016)
      GO TO 9002
9001  WRITE(7,6015)
9002  CONTINUE
6016  FORMAT(//,1H ,5X,'GAS: H2S')
6015  FORMAT(//,1H ,5X,'GAS: CO2')
C
C     BEGIN THE SECOND LOOP TO VARY THE TANK LEVEL.
C
      DO 4020 J=30,60,30
      WRITE(7,6018)J
6018  FORMAT(1H ,//,5X,' PERCENTAGE FULL CAPACITY: ',I2,/)
```



```
      WRITE(7,6020)
6020  FORMAT(1H ,5X,'TIME',3X,'PPM 45 C',4X,'PPM 35 C',4X,'PPM 25 C',/)
C
C     BEGIN THE INSIDE LOOP WHICH DOES THE REPETITIVE CALCULATION
C
      DO 4030 K=1,11,1
C
C     K IS EQUAL TO ONE PLUS DAYS SO T EQUALS K MINUS ONE.
C
      T=K-1
      VOLTNK=(TNKVOL*3.875)
      VSTT=227.
      VFTT=59.
      X45=VOLTNK*EXP(K45*T)
      X35=VOLTNK*EXP(K35*T)
      X25=VOLTNK*EXP(K25*T)
      W=VOLTNK*J*0.01*MW*55.6E-6
      Z=VOLTNK*(1.-J*0.01)*B*DTC
      PPM45=X45/(VSTT*(W/H45+Z/318.))
      PPM35=X35/(VSTT*(W/H35+Z/308.))
      PPM25=X25/(VSTT*(W/H25+Z/298.))
C
C     WRITE THE CALCULATED VALUES FOR PARTS PER MILLION INCREASE.
C
      WRITE(7,6030)T,PPM45,PPM35,PPM25
6030  FORMAT(1H ,5X,I2,4X,E10.3,2X,E10.3,2X,E10.3)
C
C     DO LABLES
C
4030  CONTINUE
      WRITE(7,6031)
6031  FORMAT(1H ,'    ---------------------------------------------')
4020  CONTINUE
      WRITE(7,6032)
6032  FORMAT(1H ,'    *********************************************')
4010  CONTINUE
C
C     NOW ASK THE OPERATOR IF HE WOULD LIKE TO MAKE ANOTHER RUN
C
7001  CONTINUE
      WRITE(7,7000)
7000  FORMAT(1H ,5X,'DO YOU WISH TO MAKE ANOTHER RUN WITH A DIFFERENT
     *',/,'  SHIP OR A DIFFERENT TANK?  TYPE 1=YES OR 2=NO')
      READ(5,7012)C
7012  FORMAT(I1)
      IF(C.EQ.1) GO TO 8000
      CONTINUE
      STOP
      END
```

APPENDIX B

GASGEN PROGRAM EXAMPLE RUN. (USS DIXON (AS 37), CHT TANK 1)

THIS PROGRAM WILL CALCULATE THE GAS GENERATION IN PARTS PER MILLION IN NAVY CHT TANKS DURING STAGNANT CONDITIONS. CONCENTRATIONS FOR CO2, AND HYDROGEN SULFIDE ARE CALCULATED. GENERATION RATES DEPEND ON GAS:TANK VOLUME TEMPERATURE, AND TANK CONTENTS. TANK CONTENTS (PERCENTAGES OF HEAD, GALLEY AND LAUNDRY WASTES) WILL VARY FROM TANK TO TANK. EIGHT DIFFERENT RECIPIES HAVE BEEN CHOSEN TO APPROXIMATE THE CONTENTS OF ALL NAVY CHT TANKS.

THE RECIPIES ARE LISTED BELOW.

RECIPE	PCT HEAD	PCT GALLEY	PCT LAUNDRY
1	30	70	--
2	59	41	--
3	--	54	46
4	34	36	30
5	45	32	24
6	65	19	16
7	29	20	51
8	100	--	--

IN ORDER TO RUN THIS PROGRAM YOU MUST HAVE THE FOLLOWING DATA AVAILABLE . 1. THE SHIP CLASS 2. THE TOTAL TANK VOLUME IN GALLONS FOR THE TANK YOU WISH TO CONSIDER AND 3. THE RECIPE WHICH APPROXIMATES THE TANK CONTENTS

BELOW IS SOME AVAILABLE DATA

SHIP CLASS	INDEX NUMBER	TANKNO.	VOLUME	RECIPE
AD14	1	1	7890	8
AD14	1	2	9612	4
AE26	2	1	6923	5
AO050	3	1	845	8
AO050	3	2	1807	5
AS11	4	1	2200	8
AS11	4	2	493	4
ATF76	5	1	1273	5
LST1179	6	1	5537	6
LST1179	6	2	3980	3
LPD4	7	1	7200	7
LPD4	7	2	7935	2
LPD4	7	3	7935	2

IF THE CHT TANK YOU WISH TO CONSIDER IS NOT LISTED ABOVE THEN THE COMPUTER WILL INSTRUCT YOU TO INPUT THE PROPER SHIP CLASS, INDEX NUMBER, AND TANK NO. YOU WILL ALSO NEED TO INPUT THE APPROPRIATE TANK VOLUME AND RECIPE.

AFTER RUNNING, THE PROGRAM RETURNS THE CONCENTRATIONS OF CO2 AND H2S AT 25, 35, AND 45 DEGREES CENTEGRADE AT INTERVALS OF ONE DAY FOR 0 TO 10 DAYS. CONCENTRATIONS ARE CALCULATED FOR 30% AND 60% OF THE TANKS FULL CAPACITY.

HERE WE GO!!!!!!

IS YOUR SHIP CLASS AND TANK NUMBER LISTED ABOVE ? TYPE IN 1=YES
2=NO

2

IF YOU HAVE TANK VOLUME IN GALLONS AND THE RECIPE WHICH MOST CLOSELY APPROXIMATES THE CONTENTS OF YOUR TANK YOU CAN STILL RUN THE PROGRAM.

DO YOU STILL WANT TO RUN ? TYPE IN 1=YES OR 2=NO

1

TYPE IN SHIP CLASS

AS37

TYPE IN INDEX NUMBER. IF THE SHIP IS NOT LISTED THEN INDEX=0

0

AS37
TYPE IN TANK NUMBER

1

TYPE IN TANK VOLUME IN GALLONS

5500

TYPE IN PROPER RECIPE NUMBER

5

SHIP CLASS: AS37 TANK NUMBER: 1

TANK VOLUME: 5500
****

GAS: CO2

PERCENTAGE FULL CAPACITY: 30

TIME	PPM 45 C	PPM 35 C	PPM 25 C
0	0.299E 01	0.279E 01	0.257E 01
1	0.398E 02	0.994E 01	0.179E 02
2	0.531E 03	0.354E 02	0.124E 03
3	0.708E 04	0.126E 03	0.865E 03
4	0.944E 05	0.449E 03	0.602E 04
5	0.126E 07	0.160E 04	0.419E 05
6	0.168E 08	0.569E 04	0.292E 06
7	0.224E 09	0.203E 05	0.203E 07
8	0.298E 10	0.722E 05	0.141E 08
9	0.397E 11	0.257E 06	0.983E 08
10	0.529E 12	0.915E 06	0.684E 09

PERCENTAGE FULL CAPACITY: 60

TIME	PPM 45 C	PPM 35 C	PPM 25 C
0	0.352E 01	0.314E 01	0.272E 01
1	0.470E 02	0.112E 02	0.189E 02
2	0.626E 03	0.398E 02	0.132E 03
3	0.835E 04	0.142E 03	0.917E 03
4	0.111E 06	0.505E 03	0.638E 04
5	0.148E 07	0.180E 04	0.444E 05
6	0.198E 08	0.640E 04	0.309E 06
7	0.264E 09	0.228E 05	0.215E 07
8	0.351E 10	0.811E 05	0.150E 08
9	0.468E 11	0.289E 06	0.104E 09
10	0.624E 12	0.103E 07	0.724E 09

****

GAS: H2S

PERCENTAGE FULL CAPACITY: 30

TIME	PPM 45 C	PPM 35 C	PPM 25 C
0	0.272E 01	0.246E 01	0.217E 01
1	0.798E 02	0.470E 01	0.551E 01
2	0.234E 04	0.901E 01	0.140E 02
3	0.688E 05	0.173E 02	0.354E 02
4	0.202E 07	0.331E 02	0.897E 02
5	0.594E 08	0.633E 02	0.227E 03
6	0.174E 10	0.121E 03	0.576E 03
7	0.512E 11	0.232E 03	0.146E 04
8	0.150E 13	0.445E 03	0.370E 04
9	0.442E 14	0.853E 03	0.938E 04
10	0.130E 16	0.163E 04	0.238E 05

PERCENTAGE FULL CAPACITY: 40

TIME	PPM 45 C	PPM 35 C	PPM 25 C
0	0.229E 01	0.198E 01	0.167E 01
1	0.673E 02	0.380E 01	0.422E 01
2	0.198E 04	0.727E 01	0.107E 02
3	0.581E 05	0.139E 02	0.271E 02
4	0.171E 07	0.267E 02	0.687E 02
5	0.501E 08	0.511E 02	0.174E 03
6	0.147E 10	0.979E 02	0.441E 03
7	0.432E 11	0.187E 03	0.112E 04
8	0.127E 13	0.359E 03	0.284E 04
9	0.373E 14	0.688E 03	0.719E 04
10	0.109E 16	0.133E 04	0.182E 05

DO YOU WISH TO MAKE ANOTHER RUN WITH A DIFFERENT SHIP OR A DIFFERENT TANK? TYPE 1=YES OR 2=NO

2

STOP - -

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APPENDIX I

Letters from the Minister for Defence to the Chairman of Public Accounts Committee, 9 June 1983 and 2 August 1983

COMMONWEALTH OF AUSTRALIA

MINISTER FOR DEFENCE
PARLIAMENT HOUSE
CANBERRA A.C.T. 2600

Dear Senator Georges,

9 JUN 1983

Thank you for your letter of 25 May, 1983 advising the decision of the Joint Parliamentary Committee of Public Accounts to reopen its inquiry into the matter of HMAS TOBRUK and of the request to my Department for further submissions, including the two Reports relating to the death of Naval Reserve Cadet Kenneth Dax.

Provision of the submissions sought from the Department are being progressed generally in the normal manner. However, because of special circumstances, I thought it appropriate that I explain certain aspects in respect to content of one of the Reports and seek your agreement as to how it might be handled.

A full copy of the Board of Inquiry Report is attached. A copy of this Report was released to the Dax family on 25 October, 1982 by the Deputy Chief of the Naval Staff, and there is no hindrance to its public release.

A copy of the Navy Office Review of the Board of Inquiry Report (which has been incorrectly referred to as the Fleet Maintenance Branch's Review) is also attached: the copy contains 18 deletions which are identical to those made to the copy released to the Dax family by me on 11 May, 1983.

Twelve of the deletions identify, by name or by rank, certain individuals, both Service personnel and civilian public servants, who have had no opportunity to respond to criticism of them in the Report. It would be unfair to identify them publicly because the chain of the events leading to the death of Naval Reserve Cadet Kenneth Dax is such that no single person or group of persons can be identified as having acted in such a way as to have directly caused his death. Although it is certain that Cadet Dax died as a result of exposure to a faulty on-board sewage system, lack of proper understanding by the ship's crew as to how to maintain it in a proper chemical balance and a failure to understand the potential lethality of the system in that state, death was due to a systems failure which could not be attributed in its result to any one person. Accordingly, in releasing the Report to the Dax family I authorised these deletions.

/Another

Another six deletions were made to protect the identity of the author of the report. The Report is an official RAN document on which action has already been taken by the Navy and its authorial origin was no longer relevant at the time that the Report was released. As an expert's Report and because at the time it was written it was not envisaged that it would be publicly released, the Report was frankly critical of some aspects of HMAS TOBRUK's construction. When preparing the Report for release one consideration leading to the decision to conceal the specific identity of the author was to protect the author from legal action directed to the author, rather than directed to the Department of Defence.

Copies of the Review of the Board of Inquiry Report, with the 18 deletions, were also sent to the Queensland Coroner and to the firm that built HMAS TOBRUK. As a result of the publicity following the original release of this Report, it has been the subject of Freedom of Information requests for access; and a further two copies have been released, with the same deletions, under the FOI Act.

In view of the deletions and the reasons for them, I ask the Public Accounts Committee to accept the Review of the Board of Inquiry Report with deletions. If it is the wish of the Committee, officers of my Department could address the aspect of public release of the identity of the people whose names and/or ranks and titles have been deleted from the Report at an in-camera hearing.

Yours sincerely,

(GORDON SCHOLES)

Senator G. Georges,
Chairman,
Joint Parliamentary Committee of Public Accounts,
Parliament House,
CANBERRA. ACT. 2600

COMMONWEALTH OF AUSTRALIA

MINISTER FOR DEFENCE
PARLIAMENT HOUSE
CANBERRA A.C.T. 2600

2 - AUG 1983

Dear Senator Georges,

I refer to your recent letter in which you requested a copy of the Navy Office Review of the Board of Inquiry into the Death of Naval Reserve Cadet Kenneth Dax, without deletions.

Please find enclosed such a copy which is submitted to you "in confidence", in accordance with Section 11 of the Public Accounts Committee Act 1951.

In respect to paragraph 168 of the Navy Office Review, reference is made to "errors of judgement" deemed by the author of the Review to be attributable to named individuals and organisations. The Review recommended that these individuals and organisations be informed accordingly by personal letter.

This was accepted and implemented in respect of five of the seven recommendations made (sub-paragraphs 168.c.-g. inclusive). It was not accepted in respect of the recommendations in sub-paragraphs 168.a. and b., which referred to the Project Design Manager in the context of the design changes to the sewage tank venting arrangements.

The investigations which followed from the Review confirmed that these design changes were contributing factors in the incident, but concluded that responsibility for them could not be attributed to any single individual. This conclusion was agreed by the Chief of Naval Technical Services and the Deputy Chief of Naval Staff.

Yours sincerely,

(GORDON SCHOLES)

Senator G. Georges,
National Bank House,
255 Adelaide Street,
BRISBANE. QLD. 4000