Report on Investigation

of explosion on

Lord Trenchard

in Poole Harbour on 30 June 1999

with one serious injury

Extract from

The Merchant Shipping

(Accident Reporting and Investigation)

Regulations 1999

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

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GLOSSARY OF ABBREVIATIONS

BS	-	British Standard
BST	-	British summer time
DETR	-	Department of the Environment, Transport and the Regions
DGFS(S)	-	Director General Fleet Support (Ships)
DTp	-	Department of Transport (now DETR)
GRP	-	Glass reinforced plastic
JSASTC	-	Joint Services Adventure Sail Training Centre
kg	-	kilogramme
kW	-	kilowatt
LPG	-	Liquefied petroleum gas
m	-	metre
mbar	-	millibar
mm	-	millimetre
MCA	-	Maritime and Coastguard Agency (of the DETR)
MRSC	-	Maritime Rescue Sub Centre
MSA	-	Marine Safety Agency (Now Maritime and Coastguard Agency)
RNLI	-	Royal National Lifeboat Institution
RYA	-	Royal Yachting Association
UTC	-	Universal Co-ordinated Time

SYNOPSIS

Four people were on board *Lord Trenchard* at her berth in Poole Harbour on the morning of 30 June 1999. When the skipper tried to start the diesel generator at 0710, an accumulation of liquefied petroleum gas (LPG) ignited, resulting in an explosion which seriously damaged the vessel. The skipper lost his left leg above the knee.

LPG had leaked from a slack connector on one of the pair of gas bottles in the ready-use locker and migrated into the hold space accommodating the generator, through various non gas-tight penetrations in the locker. The attempt to start the generator ignited the gas in the hold. The leakage was not detected by the vessel's gas alarm system.

Lord Trenchard was a sailing vessel of 13.54m registered length, constructed of glass reinforced plastic (GRP) and operated by the Joint Services Adventure Sail Training Centre (JSASTC), Gosport. She was owned by The Crown.

The vessel was modified during 1995/6 in order to comply with the requirements of *The Safety of Small Commercial Sailing Vessels - The Code of Practice* (the Code). She was then surveyed by the chosen certifying authority, Lloyds Register of Shipping (LR) who issued an interim certificate provisional on 29 October 1997. At the time of her accident, however, *Lord Trenchard*'s status under the Code was incomplete.

Several recommendations are directed to JSASTC and the Maritime and Coastguard Agency (MCA).

Figure 1

A Nicholson 55 of the JSASTC fleet (similar to *Lord Trenchard*)

SECTION I - FACTUAL INFORMATION

Note: All times quoted are British Summer Time (BST) = UTC +1.

1.1 Particulars of vessel and incident

Name	:	*Lord Trenchard*
Official number	:	359648
Port of Registry	:	Southampton
Type	:	Sailing, Nicholson 55
Crew	:	6 (at time of incident)
Registered length	:	3.54m
Overall length	:	16m
Gross tonnage	:	25.03
Method of Propulsion	:	Sail & Motor
Built	:	Camper & Nicholson, Southampton, 1972
Construction	:	Glass Reinforced Plastic
Owners	:	Her Majesty Represented by The Secretary of State for Defence Main Building Whitehall London
Status	:	Pleasure yacht
Position of accident	:	Jolly Sailor Berth, Town Quay, Poole, UK
Time and date	:	0710, 30 June 1999
Casualties	:	One major injury

1.2 History of voyage

14 to 20 June 1999

Sailing from Gosport Harbour on Monday 14 June, *Lord Trenchard* was used for an adventure training cruise between ports on the south coast of the UK and the Channel Islands.

During this cruise both propane gas bottles in the ready-use locker needed to be replaced. The bottles were disconnected from their hose couplings and replaced by full bottles taken from the starboard storage locker. After reconnecting the hoses to the full bottles, the valve on the forward bottle was opened. The low pressure shut-off valve was reset and the cooker returned to service. No problems were reported during this operation.

24 June

Lord Trenchard was used for a single day's cruising out of Gosport, with a different skipper in charge. There were no changes of gas bottles or system status.

28 June

A fresh skipper, a mate/trainee skipper and seven others boarded *Lord Trenchard* in Gosport. Following two crew safety briefings given by the skipper and mate, the vessel left for Cowes, Isle of Wight, arriving at about 1800.

29 June

At 0930 she left Cowes with the intention of heading for Weymouth. However, progress was slow and the decision was made to divert to Poole.

While on passage to Poole the gas alarm sounded once, possibly twice. Each sound was brief. Although skipper and crew were not unduly concerned, a complete bilge pumping and venting procedure was followed. Further routine bilge pumping procedures were carried out every hour.

Lord Trenchard arrived in Poole at about 1630. She berthed alongside another sailing vessel, *John Laing,* at the Jolly Sailor Berth, Town Quay. The *TS Royalist,* a third sailing vessel, arrived later. *Lord Trenchard* and *John Laing* moved to allow *Royalist* to berth alongside the quay. Once manoeuvring was complete, *Royalist* was alongside the quay, bows to the west, *Lord Trenchard* was berthed against her port side, also bows to the west, and *John Laing* was berthed on the port side of *Lord Trenchard* (**see Figure 2 chart**).

The crew of *Lord Trenchard* prepared an evening meal at about 1830. To gain access to provisions for this meal the starboard watertight hatch between cabin and hold space was opened. Once the necessary provisions had been removed, the watertight hatch was re-secured closed.

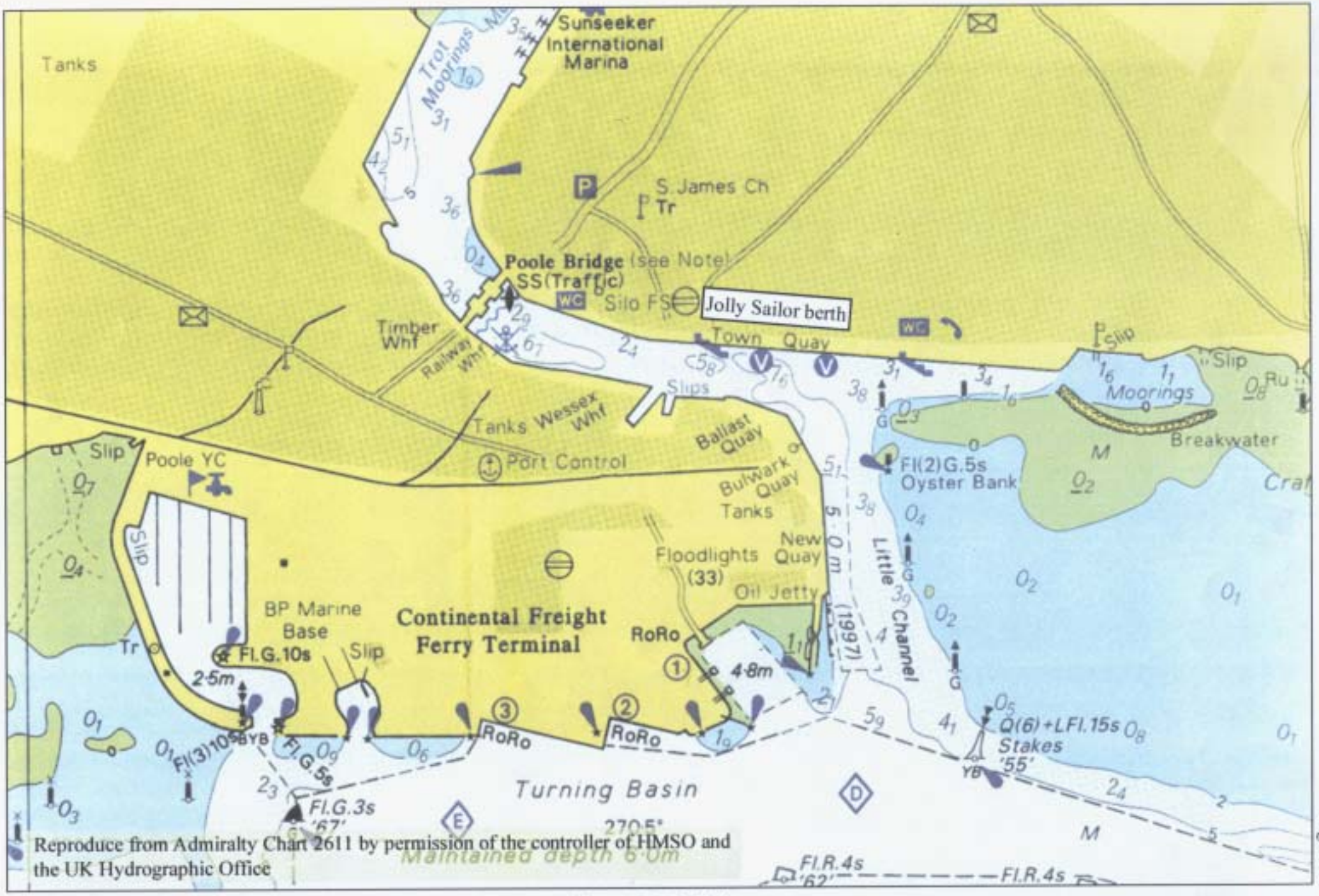


Figure 2

Chart of Poole Harbour

While the meal was cooking, the gas supply failed, indicating that the bottle in the ready-use locker needed changing. To do this, the mate removed the locker's cover, closed the valve on the forward bottle, and opened the aft bottle. He then replaced the locker's cover.

By 2130 all members of *Lord Trenchard*'s crew had gone ashore to meet in the Jolly Sailor public house. *Lord Trenchard* was left unattended, with the crew of *Royalist* keeping a gangway watch.

Between 2230 and 2300 some of *Lord Trenchard*'s crew left Poole for Weymouth, the remaining six returned to the vessel. Some of them used the cooker to prepare hot drinks, but had problems lighting it. They inspected the ready-use gas locker, and the valve on the aft gas bottle was turned fully in the open direction. A slight smell of gas was detected, but this gave no cause for serious concern and the locker's cover was replaced. The cooker then worked correctly and all six went to bed at about 2330.

30 June

At 0400 several on board *Lord Trenchard* were woken by the sounds of the crew of *John Laing* preparing their vessel for sailing. One of *Lord Trenchard*'s crew went on deck to help.

Once *John Laing* was clear, those on board *Lord Trenchard* who had been woken by the noise, returned to their slumbers.

Lord Trenchard's skipper left his bunk at about 0630 and, after dressing, going to the toilet and lighting the cooker, began to boil a kettle of water. Shortly after this, two other crewmen also got up and began to make their way ashore to have a shower in the quayside facilities. The other three remained in their bunks.

The skipper noticed that the battery voltage on the switchboard was down to 11½volts. He decided to recharge the batteries and began the starting procedure for the generator. After pushing the 'on' button he heard the fuel lift pump running. He then waited for the warning lights to extinguish before pushing the 'start' button. The generator cranked over once, but didn't start, and its display panel showed the message 'no output'.

The skipper pushed the 'on' button again and waited about 10 seconds with the fuel lift pump running. He then pushed the 'start' button again. The generator cranked over a second time, followed immediately by an explosion which affected the vessel and all on board. The skipper suffered major leg injuries, and later had to have his left leg amputated above the knee. The other crew suffered cuts, bruises and shock.

Major sections of the vessel's aft deck structure were displaced, and other debris was thrown upwards and outwards from the stern section. The forward gas bottle from the ready-use locker, and various pieces of debris landed on *Royalist*'s deck. Fragments of the generator's acoustic housing were thrown on to the quay. The aft gas bottle from the ready-use locker and the spare bottles from the two storage lockers were

thrown into the harbour. *Royalist*'s port quarter bulwark and deckhouse suffered minor impact damage from flying debris.

An "Urgency call" was received by the Maritime Rescue Sub Centre (MRSC) Portland at 0711. Units from police, fire and rescue, ambulance, coastguard, Royal National Lifeboat Institution (RNLI) and Poole Harbour Commissioners were alerted and attended. The injured skipper and one other person from *Lord Trenchard* were transferred to hospital.

Lord Trenchard was taking water through damaged sea water piping. Poole RNLI all-weather lifeboat came alongside and started efforts to salvage the vessel and prevent her foundering at the berth. Search and rescue operations were terminated at 1015.

The all-weather lifeboat towed *Lord Trenchard* successfully south across the harbour to a vacant berth. RNLI inshore lifeboat and other units, continued searching the harbour. Six gas bottles were recovered; the aft bottle from *Lord Trenchard*'s ready-use locker, and the rest from her spare bottle lockers.

Initial inspection

All structure, fittings and decking over and aft of the main cabin were severely damaged and displaced (**see Figure 3 photo taken in Poole**).

Port and starboard parts of the main hull skin were vertically fractured down to the waterline, abeam of the cockpit. As the extent of this hull damage could not be fully assessed with the vessel afloat, safety considerations prevented any detailed examination until the vessel was lifted from the water.

However, the two bottles which had been in the ready-use locker were identified. The valve on the aft bottle was found open and its outlet connector was slack. The valve on the forward bottle was closed and its outlet connector secure.

1.3 General arrangement of *Lord Trenchard* (Figures 4 & 5)

Lord Trenchard was one of the larger class of sailing vessels operated by Joint Services Adventure Sail Training Centre (JSASTC). She was built in 1972 of glass reinforced plastic (GRP). She was fitted with watertight bulkheads in order to comply with recommendations in the Code.

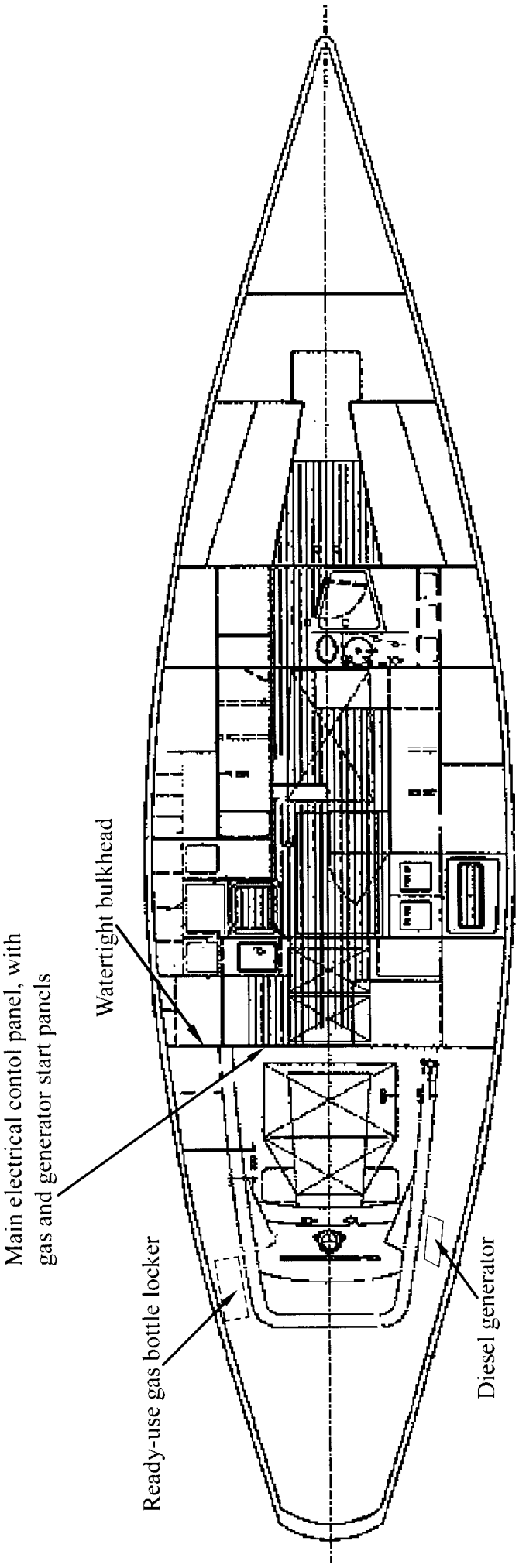
The bulkheads separated three major compartments. These, from forward to aft were: forward accommodation space, main cabin, and hold space. A smaller storage compartment, the lazarette, was formed aft of the hold.

On the starboard side between the main cabin and forward accommodation was a shower/toilet compartment. The galley area was at the port side of the main cabin and housed a cooker mounted on gimbals. At the aft end of the main cabin were steps up to the cockpit and the main structure of a watertight bulkhead. This was stepped at each side to accommodate the two quarter berths. These were usually used by skipper

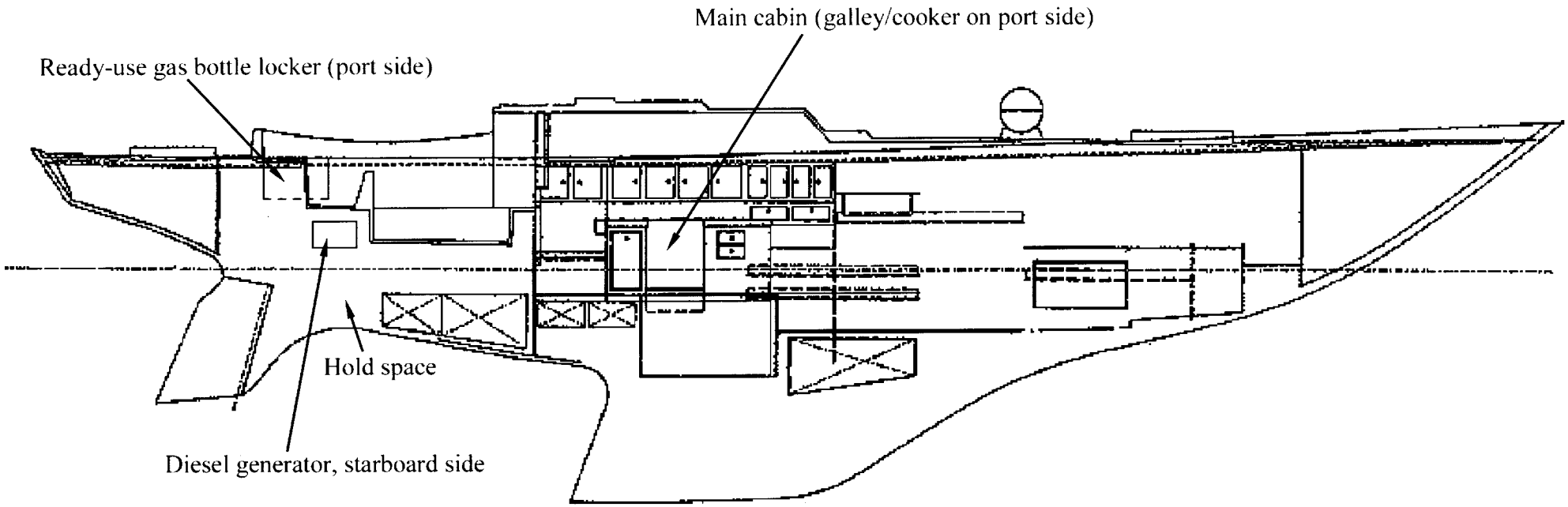
Figure 3

Aft end of *Lord Trenchard* shortly after the explosion

Figure 4



Plan of *Lord Trenchard*



Side elevation of *Lord Trenchard*

Figure 5

and mate. Set into the upper part of this bulkhead, just to port of the steps to the cockpit, was an electrical control panel for lights, generator starting etc, with a separate gas alarm control panel above.

The hold space of *Lord Trenchard,* and other vessels of its class, was the hull compartment below the cockpit. It housed water tanks, a diesel generator, bilge alarm sensor, gas sensor, electric bilge pump, rudder stock and gland. The compartment was often used for stowing provisions and other material.

1.4 Liquefied petroleum gas (LPG) installation (Figures 6, 7, 8, 9 & 10)

The only equipment on the vessel needing a gas supply, was the cooker unit at the port side of the main cabin.

Gas was supplied from one of a pair of gas bottles, each of 3.9kg capacity, and stowed in a ready-use locker at the port side of the cockpit. Access to this locker was by a lockable, flush non gas-tight hatch, set in the deck. The locker was a rectangular box GRP moulding, set into the deck and extending down into the hold space.

Stowage for spare gas bottles was arranged in two other lockers, one either side of the cockpit and each having space for three bottles. Access to each space was through another locker set into the sides of the cockpit, each housing a liferaft valise.

Fitted in the bottom of each of the three gas bottle lockers was a drain, connected to outlets in the hull. The drain pipes from the two lockers on the port side were connected at a point shortly before they entered an isolating valve on the hull's skin fitting. The single locker on the starboard side had its own drain line with a dedicated skin fitting and isolating valve.

Set in a recess on the inboard wall of the ready-use gas locker was a 'T' piece, or wall block. A flexible hose ran between the outlet connection of each gas bottle and one leg of this wall block. Each of these legs contained a non-return valve to allow gas bottles to be disconnected, and changed, without the need to de-pressurise the complete gas system. The third leg of the wall block passed gas to the inlet side of a pressure regulating valve, also positioned in the recess of the locker.

Low pressure gas was led from the regulator by a copper pipe which passed through the bottom of the locker via a drilled penetration. In the annular space between the pipe and the drilling was mastic sealant material. This pipe passed into the hold space before passing forward, through a watertight bulkhead, into the main cabin compartment. Slightly forward of this bulkhead, the pipe was connected to an automatic high/low pressure shut-off valve, situated beneath the port quarter bunk.

The gas pipe was connected to the gimbal mounted cooker by an armoured flexible hose, to accommodate relative motion. Before this connection a shut-off cock was screwed to a partial division just aft of the cooker.

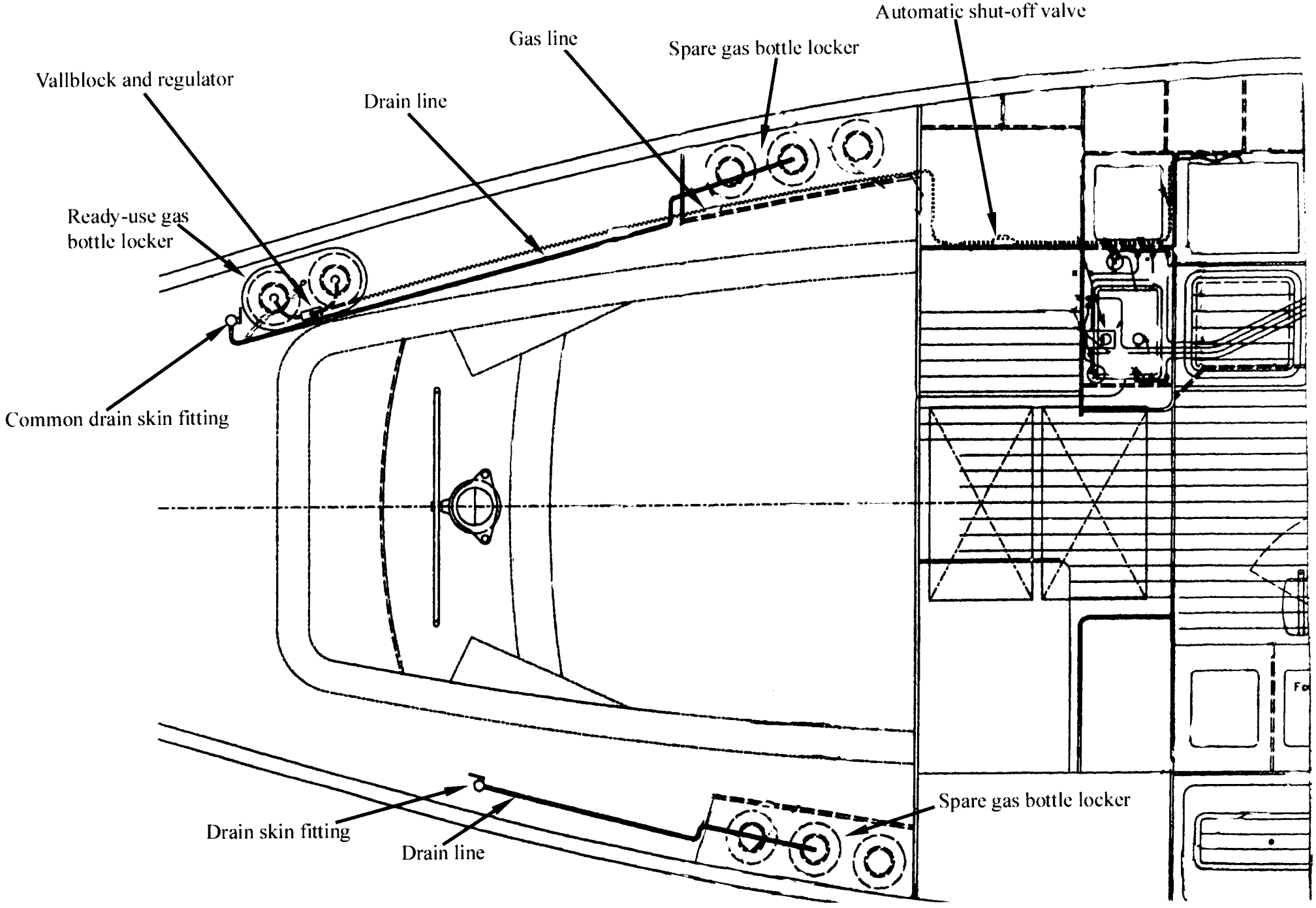


Figure 6

Gas installation

Figure 7

Cover to ready-use gas bottle locker

Figure 8

Interior of ready-use gas bottle locker with one bottle
and the bottles' securing arrangement removed

Figure 9

Spare gas bottle locker (one of two)

Figure 10

Moulded recess in ready-use gas locker accommodating
'T' piece wallblock and pressure regulator

1.5 Gas alarm

The gas detector system on *Lord Trenchard* served the main cabin and the hold. One detector head was positioned in the main cabin bilge, slightly beneath the cooker, the other at the aft end of the water tank structure in the hold.

The system's control panel was slightly above the main switch panel, to the port side of the main companionway. The two circuits were labelled No1 and No 2, but the markings on the control panel did not indicate which sensor served the hold bilge and which the cabin bilge. The control panel had a test facility.

Following a defect report stating that the gas alarm on *Lord Trenchard* sounded continuously, the hold space sensor element was renewed on 2 March 1999. The defective sensor was found to have been crushed.

Other Nicholson 55 vessels in the JSASTC fleet were fitted with similar gas sensing and alarm systems. Not all vessels had their sensors in their hold and cabin; some had both fitted in the cabin, or at least forward of the hold/cabin bulkhead. However, common to all vessels was a lack of labelling on the control panels indicating which sensor was being served by which circuit; No 1 or No 2.

1.6 Bilge pumping procedures

While at sea, standard operational procedure for this class of vessel require that all bilges be pumped every hour. Once all water has been pumped out, procedures require that the bilge pump be given thirty more strokes to remove any gas which might have accumulated.

Similar procedures are required to be followed in port; once first thing in the morning and once more during the day.

1.7 Diesel generator

At the starboard side of the hold a 2.2kW diesel driven generator was installed. The directly-coupled engine and generator units were encased in a common acoustic enclosure to minimise noise transmission.

Both engine and generator were water cooled by a sea water cooled air cooler placed within the acoustic enclosure. Sea water was circulated by an engine driven pump. Air within the enclosure was cooled by this unit and circulated over cooling surfaces of engine and generator.

The generator's engine was started by a conventional starter motor engaging with a ring gear. Control of starting and stopping procedures was from a small control panel set in the main electrical switchboard at the aft end of the main cabin, port side. This panel was equipped with pressure pad control buttons, warning lights and a simple liquid crystal message display.

The generator's diesel engine had its own fuel supply pump, but a second electrically powered fuel lift pump was fitted externally.

1.8 Vessel operations

Many of the Nicholson 55 class vessels operated by JSASTC are used for worldwide cruising, as allowed under the Code, by their classification for Category 0, unrestricted service. The unlimited operation allowed by this status is used to the full by JSASTC, as demonstrated by a round-the-world race between three of its vessels of this class during 1998/99. Any vessel intended for such service requires the highest standards of operation, manning, maintenance and repair.

1.9 Owner's operations

Lord Trenchard was one of a fleet of nine similar vessels operated by the JSASTC, Gosport, Hampshire. This class of vessel was constructed by Camper and Nicholson. JSASTC also operated 14 slightly smaller sailing vessels.

JSASTC has a group of maintenance personnel to care for all its vessels. Part of the maintenance process is the reporting of defects by skippers and crews, for which there is a formal reporting system. JSASTC's full-time staff are supported by other components of the MoD, particularly in matters involving major expenditure such as vessel refits.

One of the declared objectives of JSASTC is to promote the personal development of serving members of the armed forces. Although skippers are often permanent members of JSASTC staff, with civilian status, all crews are serving Royal Navy, Army or Royal Air Force personnel. Qualified service personnel may also skipper vessels instead of JSASTC staff.

1.10 JSASTC - crew qualification requirements

The Code is published by the Department of the Environment, Transport and the Regions (DETR). It requires skippers of vessels operating in unrestricted waters to hold a valid Royal Yachting Association/Department of Transport (RYA/DTp) Yachtmaster Certificate of Competency Ocean (Sailing). A second person with a similar qualification, or at least an RYA/DTp Certificate of Competency as a Yachtmaster Offshore (Sailing) must also be on board. Lesser certification standards are applicable for vessels operating in restricted areas.

In addition to the certification requirements of the Code, the JSASTC requires all potential skippers of its Nicholson 55 vessels to hold an RYA/DTp Yachtmaster Offshore certificate, attend an additional course, exceed a minimum level of experience on the vessels, and be assessed on their ability. Successful candidates are awarded a JSASTC Certificate of Competency as a Nicholson 55 skipper.

1.11 Crew

For the voyage starting on 28 June, *Lord Trenchard* had two JSASTC staff skippers on board. One of them had not skippered a JSASTC Nicholson 55 for several years, and was on board for a period of training/refresher experience. In this report he is referred to as the vessel's mate.

Skipper and mate each held a RYA/DTp Yachtmaster's Ocean-going Certificate of Competency (Sailing). These exceeded the requirements of the Code.

1.12 Survey and certification of *Lord Trenchard*

As a vessel owned by The Crown, *Lord Trenchard* was not required to be inspected or certificated by any regulations compiled under Merchant Shipping Acts. However, the managers of the vessel chose to subject the vessel to a compliance inspection as required by the Code.

The vessel's managers elected Lloyd's Register of Shipping as the certifying authority to survey and certify the vessel under the Code.

The most recent certificate issued to the vessel under the Code was an interim certificate provisional dated 29 October 1997, from the Southampton office of Lloyd's Register of Shipping. This certificate stated that a stability booklet, approved by the Marine Safety Agency (MSA), was the single item outstanding to complete certification.

No stability booklet for *Lord Trenchard* was submitted to MSA for approval.

1.13 Code requirements

The Code allows a certificate of compliance to be issued for a period not exceeding five years. However, vessels of 15m overall length and over, are required to be examined annually by the chosen certifying authority.

Examination of a vessel's gas installation is part of the survey requirements of the Code. Section 14.1.6 of the Code covers the general requirements, and makes reference to Annex 3 of the Code for more detailed requirements.

Section 2 of Annex 3 sets out requirements for the stowage of gas containers. Paragraph 2.1 specifies that *Gas containers should be stowed on the open deck or in a gas-tight enclosure opening on to the deck, so that any gas which may leak can disperse overboard.*

Remaining requirements of this section are:

2.2 *Stowage should be such that containers are positively secured against movement in any foreseeable event.*

2.3 *In multiple container installations, a non-return valve should be placed in the supply line near to the stop valve on each container. If a change-over device is used, it should be provided with non-return valves to isolate depleted containers.*

2.4 *When more than one container can supply a system, the system should not be used with a container removed.*

2.5 *Containers not in use or not being fitted into an installation should have the protecting cap in place over the container valve.*

1.14 History of *Lord Trenchard*

The vessel underwent major modifications and a refit in 1996, partly to comply with the requirements and recommendations of the Code. The refit's specification was compiled by Director General Fleet Support (Ships) (DGFS(S)).

Work performed then included the construction of several watertight bulkheads. One of these separated the main cabin from the hold space. A diesel generator was also fitted in the hold at that time.

Part of the refit specification required the gas installation to be inspected, and a certificate of compliance with BS 5482 issued. A certificate was issued indicating that a satisfactory pressure test had been performed, but it gave no indication of compliance with BS 5482.

1.15 Inspections and tests following the accident

Gas installation

The ready-use gas bottle locker was found torn from the surrounding deck structure (**see Figures 11 & 12**). It did not contain bottles or regulator, but the 'T' connector wall block was in place, with one length of flexible hose to the forward bottle, remaining connected. The separately moulded recess, which had accommodated the regulator, was totally displaced. No securing screws, or any significant amount of sealant, remained in place on the joint surfaces between the recess and locker's wall. The locker's drain connection was in place and unobstructed, but unattached to its flexible hose leading overboard (**see Figure 11**).

No copper gas piping remained in the locker, but the position of the pipe's penetration of the locker was identified. Mastic type sealant was partially attached to this penetration.

Figure 11

Ready-use gas bottle locker moulding following accident

Figure 12

Ready-use gas bottle locker moulding following accident

Other penetrations of the ready-use gas locker were for sliding bolts of the bottle securing arrangements (2) and latches for cover's locks (2). None of these penetrations was sealed, and each connected the interior of the ready-use locker to the vessel's hold space.

The drain/vent in the base of the port spare bottle locker was blanked off. However, the piping connection between the elbow of this drain and the overboard skin fitting was in place and undamaged. The valve on the skin fitting, shared with the drain of the ready-use locker, was open.

The lower part of the starboard spare bottle locker had separated from the surrounding structure during the explosion. As a result, the drain/vent line between the locker drain elbow and the skin fitting had separated at a clipped connection. All parts of this drain system were otherwise intact and clear of obstruction. The valve on the skin fitting was open.

The partial division aft of the cooker was displaced. The gas isolating tap previously attached to this division had been torn free but was found open and attached to its piping.

The low gas pressure shut-off valve was in place and attached to its gas piping. The compression joint nut on the inlet side of this valve was found ½ turn slack.

The control panel for the gas detector system had been displaced, and all associated wiring connections were broken. The gas sensor head serving the hold space could not be located.

Gas system components

All surviving components of the gas system, apart from the cooker and its attachments, were removed for inspection and testing by Calor Gas Ltd. The following points were noted:

- Wall block fitting:

  non-return valve fitted to each inlet leg of the 'T' piece. Both valves functioned as intended and were leak free at a test pressure of 30mb.

- Low pressure shut-off:

  functioned as intended when gas at a pressure of 30mb was applied and then removed.

- Isolating cock:

  found to be gas-tight at a test pressure of 30mb.

- Gas bottles:

valve heads, tail pipes and fittings were found to be in good condition and suitable for purpose. Nothing was found which could have prevented the pipe connection to the aft bottle from being properly tightened and making a gas-tight seal. The relief valve dust caps were in place on both bottles which had been in the ready-use locker.

- Flexible hoses:

  These were 4.8mm in diameter and dated June 1996. Apart from damage at their points of failure, they were in good condition.

- Gas piping:

  None of the copper gas piping was removed for testing. However, an in-situ inspection showed that it was in good visual condition and had not noticeably work hardened.

The generator (Figure 13)

The generator's control panel remained attached to the main switchboard, but all electrical wiring had broken.

No part of the generator's upper acoustic enclosure was in place. A large but badly damaged portion was adjacent to the generator. Other smaller parts were found on the quayside at Poole and on the deck of *Royalist* immediately following the accident.

The sea water cooled air cooler of the generator had come away from its mountings, but remained attached to the water hoses. A small end cover on the starter motor was displaced, as was a single electrical spade connector on the starter motor's solenoid. Various other small electrical components attached to the aft end of the alternator housing were also displaced and damaged.

1.16 General requirements for gas burning installations

The Merchant Shipping Notice, M.984, published by The Department of Trade in 1981, and reprinted by The Department of Transport in 1987, contains advice on the use of LPG on board various types of vessels. Apart from highlighting some of the dangers associated with the use of LPG, the notice indicates that LPG installations should at least comply with the requirements of British Standard BS 5482: Part 3: 1979.

Merchant Shipping Notice M.984 is directed at shipbuilders, owners, masters, skippers, officers and seamen of merchant ships and fishing vessels, owners and builders of pleasure craft, and to other users of marine craft.

For vessels complying with the Code, Annex 3 contains the requirements for LPG installations. No mention is made in the Annex of the British Standard or Merchant Shipping Notice.

Figure 13

The generator

However, Annex 3 specifies that gas containers should be stowed on the open deck or in a gas-tight enclosure opening on to the deck, so that any gas which may leak can disperse overboard.

BS 5482: Part 3: 1979 provides comprehensive information on gas installations on boats, yachts and other vessels. Section 9.4 of the British Standard covers the construction of cylinder lockers and compartments. Section 9.4(b) states:

A locker or compartment should be vapour-tight to the hull interior and openable only from the top except in the case of a deck locker which may be openable from the side.

The advice continues in Section 9.4(d):

The locker or compartment should be ventilated at low and high level to outside the hull. The low-level ventilation should be from the locker or compartment bottom above the deepest loaded water line. Drainage/vent pipes should be of not less than 13mm internal diameter for cylinders having a combined capacity of up to 15kg but they should be enlarged pro rata where additional gas is carried.

1.17 Ministry of Defence Board of Inquiry

Following this accident, a three-member board of inquiry was appointed to investigate on behalf of the Ministry of Defence. As the objectives of the Board were similar to those of the MAIB, board members and the MAIB inspector liaised during their parallel investigations. The MoD Board of Inquiry completed its work and produced its report subject to the findings of the MAIB.

SECTION II - ANALYSIS

2.1 Introduction

The preliminary stage of this investigation, which was the initial inspection of *Lord Trenchard* and associated debris, was performed in Poole during the late morning and afternoon on the day of the accident. Leakage of LPG from a slack gas bottle connection, and a potential source of ignition on the generator were identified. Later investigation work and evidence gathered, suggested that the explosion was caused by the gas igniting.

2.2 Safety Bulletin

The causes of this accident were quickly identified as being related to the escape of LPG into the vessel's hull. Although this type of accident is not new, it was considered appropriate that users of LPG systems on pleasure craft, in particular, were reminded of the potential dangers. Many such vessels were likely to be in use in the weeks and months following the accident on 30 June, possibly with skippers and crews who were unfamiliar with their vessels.

As a result, in advance of the report of the investigation, the MAIB released a *Safety Bulletin* highlighting the potential dangers associated with LPG installations. A copy of this *Safety Bulletin* can be seen in Annex A. Copies were distributed to a number of organisations, including JSASTC.

2.3 Gas leakage

There is no evidence to suggest that any of the high or low pressure parts of the gas system on *Lord Trenchard* were defective or unsuitable for their purpose. The single part of the gas system identified as being non gas-tight was the screwed connection between the flexible hose and the aft gas bottle.

No defects have been found, such as damaged threads, damaged sealing faces, debris between sealing faces etc, which might have prevented this connection from being properly tightened and made leak-free. This connection is considered to have been the site of a significant gas leakage from the high pressure side of the gas system between 1800 on 29 June, and 0710 on 30 June. In the absence of defects in this connection, the leakage is considered to have been because the connection was not properly tightened when the aft gas bottle was fitted during the cruise of 14 to 20 June.

If this loose connection had been the only defect in the complete gas installation, LPG would have dispersed overboard through the gas locker's ventilation arrangements, which were the non gas-tight locker cover and the locker's bottom drain line. These arrangements would appear to have complied with the Code and the recommendations of BS 5482.

However, dispersal of the leaked gas in this comparatively safe manner was not possible, owing to the lack of integrity of the ready-use gas locker.

2.4 Accumulation of gas in hold

Several penetrations of the ready-use gas locker clearly breached its integrity as a gas-tight division, between the gas bottles and the vessel's hold space. The female elements of the securing arrangements for the locker cover and bottle securing device, generated clear passages for gas leakage into the hold space. In addition, the fixing and sealing of the locker's recess moulding, and the sealing arrangement for the gas outlet pipe, were probably not effective as gas-tight barriers.

Some, or all, of these penetrations would have allowed gas from inside the locker to migrate into the hold space of the vessel. However, what proportion of the total quantity of gas which leaked from the aft gas bottle escaped to atmosphere, via the drain pipe, and how much entered the hold, is unknown. What is clear, is that there were several gas leakage paths from the ready-use gas locker into the hold space. It is concluded that gas entered the hold space by one or more of these routes.

As the ability to detect an accumulation of gas in the hold was an important safety feature on the vessel, these defects should not have resulted in the explosion on 30 June.

2.5 Failure to detect leakage

The accumulation of propane gas in the hold space of *Lord Trenchard* between 1800 on 29 June and 0710 on 30 June was not detected by the vessel's gas alarm system.

During the inspection of the wreck and debris, the gas sensor serving the hold was not recovered. It is possible that this sensor was ejected into Poole Harbour at the time of the explosion. Because of the probable damage suffered during the explosion, its recovery for testing is not considered critical. Any test result which showed a malfunction of the sensor would not necessarily indicate that it was defective before the explosion.

The gas detector system's control panel was recovered intact, but the electrical integrity of all of the system's wiring was destroyed in the explosion. As with the hold's gas sensor, any post-accident tests of the remaining components of this system were seen as of little value. The trauma suffered during the explosion probably introduced spurious faults, which were not present before.

The state of the gas detector system immediately before the explosion is unknown. However, reports from very reliable witnesses indicate that there was no alarm condition between 1800 on 29 June and 1710 on 30 June, the critical period. The system appears therefore to have not functioned correctly, so the reasons for this need to be established.

The gas sensor element in the hold space of *Lord Trenchard* was renewed in March 1999, four months before the accident. However, there are no records of any complete system checks being performed since then. Any likely checks would have been limited to tests at the control panel, and performed by skippers on a spontaneous and random basis. Such tests cannot be certain indicators that a system is functioning fully.

The hold's gas sensor was reportedly positioned some distance above the lowest part of the compartment. This was not the optimum position for detecting gas in the bilge space, towards which any gas, having a greater density than air, would tend to move. However, because gas had been leaking into the hold for 12 hours, enough was probably present to activate the sensor, despite it being positioned higher than it should have been. If this was the case, it is probable that the sensor was not functioning and the reason why no alarm was activated before the explosion.

The positioning of the two sensors was not uniform throughout JSASTC's Nicholson 55 fleet. Neither was there any uniformity in the relationship between control panel labels and sensor positions. Thus, on one vessel an alarm shown as No1 may be indicating gas in the hold space, whereas on another, the galley space. Clear and uniform labelling of the circuits would help skippers and crews to quickly identify and locate problems of gas accumulation.

Periodic testing of gas alarms enhances safety. Although partial tests can be performed at the alarms' panel, a test of the total system, using a butane sample injected into the sensors, would be a more certain and reliable indicator of a system's status. Because the maintenance programme relies on crews reporting defects, it would be sensible for these tests to be undertaken by skippers and crews. Defective systems should then be reported in the standard way. Testing would also ensure that skippers and crews became familiar with the positioning of sensors and their respective labelling on the panel. JSASTC should consider introducing suitable procedures.

2.6 Gas ignition

The skipper tried to start the generator twice at about 0710 on 30 June. It was during the second attempt that the explosion occurred.

Although fitted with an acoustic enclosure to reduce noise emission, the generator was not intended to operate in an explosive atmosphere. There is little doubt that a source of ignition was generated during these starting operations, probably by the commutator/brush gear of the starter motor.

Ignition was possible during either of the attempts to start the generator. The first one did not result in an explosion, probably because the gas/air mixture with the generator's enclosure was not within the explosive range of 2.15% and 9.6% by volume. Turning the generator during this attempted start may have disturbed and circulated gas and air inside the enclosure enough to have altered the mixture's ratio, in the region of the starter motor, to a 'favourable' explosive value ready for the second attempt.

For extended ocean-going passages, these vessels carry a water generator to produce drinking water. A unit of this type, which has various electrical components, was not on board *Lord Trenchard* at the time of the explosion. All vessels of this class also have permanent float-operated bilge alarms in their holds, containing electrical components. Although the generator has been identified as the source of ignition for this explosion, there are other possibilities which should be recognised by the vessel's managers. Various electrical equipment in the holds could be a source of ignition, so it is vital that ready-use gas lockers are gas-tight and gas alarms are fully operational.

2.7 Causes of the explosion

As with many accidents, the explosion on *Lord Trenchard* was not the result of a single error or action by an individual, or the failure of one piece of equipment or system. It was because a series of protective barriers, intended to prevent such an event, failed.

This explosion would not have occurred had the connection on the aft gas bottle been secured gas-tight when both bottles were replaced during the cruise of 14 to 20 June. This part of the gas system contained the only connections which a user would need to disturb. The chances of leakage from such connections would, therefore, in comparison to the remainder of the system, have been high. The installation should have been able to accommodate leakage from these connections without substantially increasing the risk of an accident.

The primary protection against this type of leakage was the gas-tightness of the ready-use gas locker, which should have had a high level of integrity because of the high risk of leakage from the bottles it contained. The insufficiently tightened connection on the aft gas bottle should not have been able to result in the accident. It was simply the event which identified the defects in the primary protective system; the non gas-tightness of the ready-use locker.

Because it contains the only routinely broken gas connections in the system, the ready-use gas locker on *Lord Trenchard* was a space where gas was possible at almost any time when the locker contained filled gas bottles. This is recognised by the requirements and advice contained in the Code, Merchant Shipping Notice and British Standard. The gas-tight integrity of the gas locker therefore, is seen as the primary barrier preventing gas migrating into the hull of the vessel.

Once gas entered the hold space it should have encountered the second barrier to the accident, the sensor for the gas detector system. This system failed to alert *Lord Trenchard*'s crew to the presence of gas in the hold space. The skipper and crew would then have made efforts to remove any sources of ignition, ventilate the space, and if unable to locate and cure the leak, shut off the gas bottle and/or evacuate the vessel.

With all safety barriers breached, it required only a source of ignition to result in an explosion. The source of ignition at 0710 on 30 June was the second attempt to start

the generator. However, any source of ignition would have been sufficient; either from the generator, other electrical equipment, or at the next opening of a watertight hatch to the hold allowing gas to enter the cabin where the cooker and other points of ignition were present. None of the electrical equipment on the vessel was classed as explosion proof, except the gas alarm, or designed to be suitable for use in an explosive atmosphere. The generator was, almost coincidentally, the first piece of equipment able to cause ignition of the 'correct' air and fuel mix.

2.8 Bilge pumping and ventilation

Normal bilge pumping procedures for the vessel required operation of the manually operated pump for a specified number of strokes after water had been removed from each bilge. These extra strokes were described by crew members, and the vessel's operations manual, as 20, 30 or 50 more. The objective of these extra pump strokes was to pump any accumulated gas from the bilge; a form of forced ventilation.

This procedure was followed during the vessel's passage from Cowes to Poole, the day before the accident, after the gas alarm briefly sounded. This procedure would probably have been followed even if the gas alarm had functioned correctly and identified the accumulation of gas in the hold during the night of 29/30 June.

The volume of gas handled this way is very limited in comparison to the total volume of the major compartments of the vessel. Depending on the number of pump strokes, the likely volume of gas or air pumped from a compartment by the bilge pump would be a few litres. However, the volume of the compartments served by the same bilge pump could be measured in cubic metres. Even recognising that LPG is heavier than air and accumulates in the lowest part of a compartment, the volume of air/gas which would need to be pumped to remove any significant accumulation is likely to be large. Although this volume might not need to be the total compartment volume, it will probably be many times the volume pumped, even by 50 strokes of the bilge pump.

These bilge pumping procedures may be suitable for clearing a small accumulation of gas resulting from lighting a cooker. They are not adequate, however, for clearing a large accumulation of gas which might result from a fault in the system. They may also have the undesirable effect of giving crews a false sense of security. JSASTC should set out these limitations in its vessels' operational documentation which is available to all skippers and crews.

These procedures were developed before the vessel was fitted with watertight bulkheads. Previously the common bilge configuration allowed leaked gas to migrate to the bilges beneath the main cabin where, almost certainly and even without a functioning gas alarm, it was likely to be quickly detected by the crew due to its odour. Watertight bulkheads, because of their primary function, will prevent passage of heavier-than-air gases between compartments. This fact needs to be recognised when ventilation arrangements and procedures are considered.

Installing forced ventilation arrangements on vessels of this type, although desirable, is likely to cause difficulties. When natural air flow is most likely to be unavailable, as

when in port, power for ventilation fans would need to be supplied from batteries, unless shore power was available. Except for very short periods, this arrangement would discharge the batteries and require the generator to be run for recharging. Although such a system is possible, it needs reliable sensing and testing of the atmosphere in the vented spaces, to monitor ventilation efficacy and thus safety.

The difficulty of installing a practical and effective forced ventilation system on vessels of this type makes it imperative that gas lockers are gas-tight, and gas alarms are functioning. While electrical equipment is likely to remain in the holds of these vessels, these two features remain the major barriers to a repetition of this accident. The greatest care must be taken to maintain their integrity.

2.9 Adequacy of Code requirements

Compliance with the requirements of the Code regarding gas installations, would have been sufficient to prevent the accident. Had the boundaries of the ready-use gas locker been gas-tight, gas would have been unable to seep into the hold space.

The Code requires that gas lockers are gas-tight and able to disperse any leakage overboard.

This accident offers nothing to suggest that an amendment to this part of the Code is required, or that any reference needs be made to other documents such as British Standards or Merchant Shipping Notices.

However, the Code's requirement on gas detection systems requires that:

In all cases, the arrangements should be such that the detection system can be tested frequently whilst the vessel is in service.

The gas alarm test procedure used on *Lord Trenchard* tested only the alarm's electrical circuitry, and not the sensors. They cannot be regarded therefore, as having tested the system, as required by the Code. Compliance with this requirement of the Code was inadequate on *Lord Trenchard*, and probably also on her sister vessels.

However, there is merit in clarifying the Code to remove any possible doubt as to the level of gas alarms testing in service. Any amendment could reasonably await the next edition of the Code but should set out the importance of regularly performing tests of the complete detection and alarm system, including sensors.

2.10 Vessel maintenance

Other Nicholson 55 vessels in the JSASTC fleet viewed by the MAIB inspector, exhibited a high standard of cleanliness and good housekeeping. There is nothing to indicate that *Lord Trenchard* had not been similarly treated.

The gas installation of a sister vessel was also examined. While items such as cookers, bottle lockers etc, were to a high standard of cleanliness and tidiness, details of installation gave cause for concern. The gas-tight integrity of the ready-use gas locker was poor, particularly where the gas piping penetrated its boundary. This points to a need for the gas installations on all of JSASTC's fleet to be inspected carefully for compliance with requirements and best practice.

2.11 Vessel management

Under the requirements of the Code, it is the responsibility of the owner/managing agent to ensure that a vessel is always maintained and operated in accordance with the requirements of the Code, the arrangements as documented in the Compliance Examination and Declaration report SCV2, and any conditions stated on the vessel's certificate. Compliance with the Code for vessels owned by the Crown, or not used for commercial purposes, such as *Lord Trenchard,* is not mandatory.

Efforts were made during 1995/6 to modify and equip the vessel in order to comply with the Code. The most recent certificate issued by the chosen certifying authority, Lloyd's Register of Shipping (LRS), was October 1997. LRS called this an interim certificate provisional. It had no expiry date. It indicated that she complied with Code requirements, with the exception that her stability booklet was to be approved by the MSA. No further certificate was issued to the vessel.

Although the interim certificate provisional had no expiry date, it clearly stated that the Small Commercial Vessel Certificate would have been issued once the outstanding item had been satisfactorily dealt with. As no stability booklet was submitted to MSA for its approval, this outstanding item was not completed before the accident. The reasons for the stability booklet not being submitted to MSA or MCA have not been established.

The work necessary for the vessel's refit in 1995/6 was set out in a specification document, which included a requirement that the gas installation was inspected by a competent gas engineer and a certificate of compliance with BS 5482 was supplied. Although a pressure test was performed, the test certificate which was issued made no mention of compliance with BS 5482. The vessel's managers thus had no indication that the installation complied with the standard set out in their refit specification. The reasons why this part of the specification was not satisfied have also not been established.

Whatever the managers' motives for wishing to introduce the vessel to the Code's regime, their initial substantial efforts to achieve compliance were not supported by adequate controls to ensure the policy of compliance with the Code was completed successfully. Had they done so, the vessel would probably have started the regime of annual inspections required by the Code.

Apart from JSASTC, Gosport, which performed the day-to-day tasks associated with vessel maintenance and operation, other sections of the MoD contributed to the vessel's management. As a result, responsibility appeared divided. Staff at JSASTC

appeared unaware of the progress being made with the submission of the vessel's stability data, and did not hold a comprehensive set of documentation setting out the vessel's status. Consequences were the failure to ensure the vessel's refit specification was satisfied, with regard to the provision of a certificate of compliance for the gas installation, and lack of effective follow-up action to progress the submission and approval of stability data.

The divided responsibility for the vessel's management was the root cause of this accident. It resulted in the initial objective of compliance with the Code not being achieved and, ultimately, caused important checks on the status of the gas installation to be overlooked. JSASTC and the MoD need to liaise on this matter with the aim of developing and employing an unambiguous system of vessel management.

2.12 The inspection regime

Many knowledgeable and experienced skippers, crews and maintenance personnel board, operate and repair this fleet of vessels. If not visiting skippers and crews, these people are mostly attached to the JSASTC at Gosport. As such they regularly and routinely board these vessels and become familiar with their shortcomings; possibly becoming uncritical of some.

During 1995/6 an effort was made to bring these vessels under the umbrella of the Code and apply its standards of construction, stability, equipment and operation. Once the necessary initial refit work was completed, this initiative was apparently allowed to lapse, and the programme of annual inspections required by the Code was not followed.

Although compliance with the Code is voluntary for JSASTC vessels, their survey and inspection according to the Code, or a similar standard, has value. The major benefit is regular and critical inspection of vessels by an independent body or person, who is removed from the day to day operation of the fleet. This is the inspection regime followed by every certificated seagoing commercial vessel worldwide.

Independent inspection arrangements might not guarantee that a non gas-tight gas locker will be identified. However, it is common for certifying authorities to require the inspection of gas installations by a specialist, and they will often not issue a certificate of compliance until a satisfactory report on the installation has been received.

JSASTC had included the requirement for an inspection of the gas installation, against the requirements of BS 5482, when the vessel was refitted in 1995/96. Although a certificate of component test was supplied by the refit yard, indicating that a pressure test was performed, JSASTC has no certificate of compliance with BS 5482.

The vessel's certifying authority (LR) issued the interim certificate provisional in October 1997 which made no mention of the gas system being an outstanding item. This implied, at the time of survey, the installation was acceptable to LR and that the installation was in compliance with the Code. However, it has not been possible to

establish how and when the defects developed, leading to the ready-use gas bottle locker becoming non gas-tight.

Managers of the vessel judged that operating under the Code had merit. However, once much of the preliminary work to achieve compliance had been performed, efforts appeared to lapse, and the vessel's status under the Code at the time of this accident was incomplete.

JSASTC should fully introduce its Nicholson 55s into the Code's inspection and certification regime, and maintain compliance.

SECTION III - CONCLUSIONS

3.1 Findings

Lord Trenchard arrived at Poole Harbour at about 1630 on 30 June 1999 with six people on board. [1.2]

The vessel berthed overnight alongside *TS Royalist* at the Jolly Sailor berth, Town Quay, Poole. [1.2]

During attempts to start the diesel generator positioned in the hold space, at about 0710 on 30 June 1999, a major explosion occurred. Four people were on board, two others had gone ashore shortly before. [1.2]

Catastrophic damage was caused to the aft part of the vessel and the skipper suffered major injuries. [1.2]

Lord Trenchard was inspected under the Code and an interim certificate provisional of compliance was issued on 29 October 1997. [1.12]

The experience and qualifications of the skipper and crew exceeded the Code requirements. [1.11]

Two full propane gas bottles were fitted in the ready-use gas locker during a cruise between 14 and 20 June 1999. [1.2]

The threaded connector on the aft gas bottle was not properly tightened, and did not make a gas-tight seal. [1.2]

There was no damage or defect in the connector which could have prevented proper tightening. [2.3]

The threaded connector on the forward bottle was tightened correctly. [1.2]

Once these gas bottles had been connected, the outlet valve on the forward bottle was opened to supply the gas system. [1.2]

The vessel started another cruise from Gosport on 28 June 1999 and arrived in Poole at 1600 the following day. [1.2]

The forward gas bottle remained in use until about 1800 on 29 June 1999, when its outlet valve was closed and the valve on the aft bottle was opened. [1.2]

The improperly secured connection on the aft gas bottle allowed gas to escape into the locker between 1800 on 29 June and 0710 on 30 June. [2.3]

The ready-use gas locker was not gas-tight as required by the Code or as recommended in other recognised standards. [2.4]

The gas drainage and venting arrangement for the ready-use gas locker was in place and unobstructed. [1.15]

Gas migrated from the ready-use gas locker into the hold space through one or more non gas-tight penetrations and fixings. [2.4]

The gas alarm system did not identify the accumulation of gas in the hold. [2.5]

The gas alarm system serving the hold compartment was probably not functioning during the 12 hours before the explosion. [2.5]

The accumulated gas in the hold formed an explosive mixture which was ignited during attempts to start the generator within the hold. [2.6]

The hold space contained, or was likely to contain, other electrical equipment capable of causing ignition. [2.7]

Components of the gas system such as piping, connectors, flexible hoses, non-return valves, low pressure shut-off valve and isolator tap, were in good order. [1.15]

Routine bilge pumping procedures were, in addition to clearing water from the vessel, used to remove accumulated gas from the hull. [1.6]

Bilge ventilation arrangements were unable to remove large volumes of accumulated gas. [2.8]

Procedures for testing the gas alarm system did not ensure that the sensor functions were tested. [2.5]

The gas installations on other vessels in the JSASTC fleet lacked gas-tight ready-use lockers. [2.10]

The vessel was inspected for compliance with the Code. [1.12]

The outstanding item required for full compliance with the Code in October 1997 was the approval of stability data by MCA. [2.11]

Stability data were not submitted to MCA for approval. [2.11]

3.2 Causal factors

The immediate causes of the accident were:

- the failure to properly tighten the connection on the aft gas bottle in the ready-use locker when the bottles were changed between 14 and 20 June 1999;

- the non gas-tightness of the ready-use locker allowing LPG to migrate into the hull of the vessel;

- the failure of the gas alarm system to identify the presence of gas in the hold space.

The root cause of this accident is considered to have been the divided responsibility for the management of the vessel between JSASTC and other parts of the MoD.

Underlying causes were:

- The procedures in place for testing the gas alarm system did not ensure that the sensors were tested;

- The vessel management system did not identify that the vessel's stability data had not been submitted to MSA for approval;

- The lack of stability approval by MSA resulted in the vessel not commencing the annual inspection programme required by the Code;

- The vessel management system did not identify that the documented inspection and testing of the gas installation during a refit in 1996 did not demonstrate compliance with the Code, British Standard or refit specification;

- The vessel management system did not identify a lack of progress on stability submission or non-compliance with refit specification;

- The lack of consistency in labelling gas sensors and the spaces they served generated doubt in the minds of skippers and crews;

- The bilge ventilation procedures, using bilge pumps, were not suitable for removing large volumes of gas.

SECTION IV - RECOMMENDATIONS

The Joint Services Adventurous Sail Training Centre is recommended to:

1. Liaise with the Ministry of Defence (MoD) with the objective of developing and employing an unambiguous system of vessel management.

2. Re-introduce its Nicholson 55s into the inspection and certification system of the Code and maintain compliance.

3. Ensure that the complete gas installations on all its *Nicholson 55s* are inspected for compliance with requirements of the Code, British Standard 5482 and best practice. These inspections should be repeated periodically.

4. Introduce suitable procedures for the routine functional testing of the complete gas alarm system, including sensors. These tests should generally and preferably be performed by skippers and crews.

5. Set out in vessels' operation manuals the limitations of employing bilge pumps to clear anything other than the very smallest quantity of gas from bilge spaces.

The Maritime and Coastguard Agency is recommended to:

6. Amend the next edition of the Code by setting out the importance of regularly performing functional tests on gas alarm systems which will test the complete system, including sensors.

Annex A

MAIB Safety Bulletin 1/99

Safety Bulletin

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MAIB SAFETY BULLETIN 1/99

Sail training vessel

LORD TRENCHARD

Explosion on board: four people injured

30 June 1999

Issued July 1999

MAIB is an INVESTOR IN PEOPLE

MAIB SAFETY BULLETIN 1/99

This document, containing a Safety Recommendation, has been produced for marine safety purposes only on the basis of information available to date.

The Merchant Shipping (Accident Reporting and Investigation) Regulations 1994 provide for the Chief Inspector of Marine Accidents to release information as to material facts at any time during the course of an investigation if, in his opinion, it is necessary or desirable to do so. Similarly, recommendations may also be made at any time during the course of an investigation.

The Marine Accident Investigation Branch (MAIB) is carrying out an Inspector's Investigation into the explosion onboard the sail training vessel *Lord Trenchard* in Poole harbour on 30 June 1999 in which four people were injured, one seriously. The MAIB will publish its findings within ten months of the accident and will make the report publicly available.

This Safety Bulletin is issued to draw the attention of owners, skippers and crews to the potential hazards associated with using Liquid Petroleum Gas (LPG) onboard craft and to draw attention to previously published advice from the Maritime and Coastguard Agency on the safety of LPG installations aboard pleasure craft and other vessels.

J S Lang
Rear Admiral
Chief Inspector of Marine Accidents

16 July 1999

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SAFETY RECOMMENDATION

Background

Early on the morning of Wednesday, 30 June, an explosion occurred in the 16.5 metre sail training vessel *Lord Trenchard* while berthed alongside in Poole Harbour. Four people were on board; all were injured, one very seriously. The vessel was badly damaged.

The investigation into the accident is progressing and details of the causes have yet to be confirmed. It appears, however, that leakage of liquid petroleum gas (LPG) was a crucial factor.

Lord Trenchard was being operated under the Maritime and Coastguard Agency's Code of Practice for Small Commercial Sailing Vessels. She was therefore required to comply with minimum standards of equipment, survey, maintenance and manning.

Large numbers of pleasure vessels (and other small vessels) with LPG (bottled gas) fuelled cookers, refrigerators and heaters are likely to be in use at this time of year. Many may not necessarily be equipped and maintained to the standards required of *Lord Trenchard* while others will have been chartered by skippers and crew who are unfamiliar with the installation of stored gas onboard. Others may need reminding of the basic procedures for using them.

It is therefore appropriate to publish this warning of some of the potential dangers associated with use of LPG in small craft. Little of this advice is new, and may be seen in earlier publications of the Maritime and Coastguard Agency and British Standards BS 5482 Part 3, but this tragic accident highlights its relevance.

Safety Recommendation

Owners and Skippers are advised to take careful note of the previously published advice from the Maritime and Coastguard Agency on the safety of LPG installations aboard pleasure craft and other vessels. In particular the MAIB wishes to highlight the following:

1. LPG is heavier than air and is highly flammable. A small quantity of gas in air can form an explosive mixture and any gas which leaks from the system will attempt to migrate to the lowest part of a compartment.

2. Where gas bottles are stored in a locker on deck, the locker should be vented to atmosphere at both low and high levels and in such a way that gas cannot enter the vessel's hull.

3. Where gas piping passes from bottles stored in a deck locker into the vessel's hull the penetration should be gas tight.

4. When empty bottles are replaced by full, care should be taken to ensure that pipe to bottle connections are properly tightened and leak free. It might help if a second competent person makes an independent check that this has been done.

5. A gas detector system is strongly recommended. Such a system should have its sensor head(s) positioned in the lowest part of the compartment(s) monitored.

6. Any gas detection system or instrument should receive adequate and expert maintenance in service.

7. Never use gas appliances without ventilation.

8. Always read and observe the appliance manufacturers instructions.

9. Naked lights should never be used as a means of locating gas leaks.