Report on the investigation of

explosion and fire

on

Border Heather

in Grangemouth

Firth of Forth, Scotland

31 October 2004

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Report No 5/2006
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Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

" The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purpose is to attribute or apportion liability or blame.

Extract from

The Isle of Man Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2001 – Regulation 4:

" The fundamental purpose of investigating a casualty, an accident, or an incident 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."

The following is a joint investigation report with the Isle of Man Marine Administration in which the MAIB has taken the lead role pursuant to the IMO Code for the Investigation of Marine Casualties and Incidents (Resolution A.849(20)).

CONTENTS

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AB	-	Able seaman
AIS	-	Automatic identification system
BA	-	Breathing apparatus
BP	-	British Petroleum
CSFB	-	Central Scotland Fire Brigade
gt	-	gross tonnage
HAZID	-	Hazard Identification
HAZOP	-	Hazard and Operability
ICS	-	International Chamber of Shipping
IEC	-	International Electrotechnical Commission
IMO	-	International Maritime Organization
ISGOTT	-	International safety guide for oil tankers and terminals
ISM Code	-	International Management Code for safe operation of ships and for pollution control
kW	-	kilowatt
LEL	-	Lower explosive limit
LPG	-	Liquefied petroleum gas
LR	-	Lloyd's Register of Shipping
m	-	metre
MCA	-	Maritime and Coastguard Agency
mm	-	millimetre
m/s	-	metre per second
MSC	-	Maritime Safety Committee
OCIMF	-	Oil Companies International Marine Forum

PIJR	-	Port information and jetty regulations
P/V	-	Pressure/vacuum
RLPG	-	Refrigerated liquid petroleum gas
RO	-	Recognised organisation
SMC	-	Safety management certificate
SMS	-	Safety management system
UHF	-	Ultra high frequency
UK	-	United Kingdom
ULSD	-	Ultra low sulphur diesel
ULSP	-	Ultra low sulphur petrol
UTC	-	Universal co-ordinated time

SYNOPSIS

At about 1823 UTC on 31 October 2004, the 2159gt Isle of Man registered tanker *Border Heather* suffered an explosion and fire in her forecastle while in Grangemouth. Significant damage was caused to the vessel's structure and systems but no-one was injured and there was no pollution.

The explosion happened after the ship loaded a volatile cargo of motor spirit (ultra low sulphur petrol or ULSP), some of which migrated into the forward space, housing the gas freeing fans, from the interconnected cargo and gas freeing systems. A spectacle plate between these systems had not been fitted in the blanked position, the associated isolating valves had not been closed and a non-return valve leaked.

Motor spirit and vapour then drained into the spaces beneath the gas freeing room through the scuppers and an open hatch. Once in the lowest space, the bow thruster room, vapour was ignited by electrical equipment not intended for use in an explosive atmosphere.

The fire was tackled by the vessel's crew and finally extinguished by shore-based firefighters about 40 minutes after ignition.

Several issues of concern have been identified. These include:

- crew familiarisation arrangements;
- fatigue aggravated by unfamiliar technology, equipment and systems;
- the lack of ship specific operational procedures in the vessel's safety management system;
- the reluctance of the vessel's deck officers to report the spill of ULSP to the master;
- the reluctance of the vessel's deck officers to report the spill of ULSP to the vessel's designated person;
- the specification of isolating arrangements on the gas freeing system;
- the classification of dangerous spaces;
- application of the terminal's emergency procedures;
- liaison between the terminal and the Central Scotland Fire Brigade.

Following their own examinations and investigations into this accident, the vessel’s managers, classification society, terminal managers and local fire brigade have taken action to address numerous issues. In addition, MAIB and the Isle of Man Marine Administration have made recommendations with the objective of improving safety.

A recommendation has been made to Lloyd's Register of Shipping to make proposals to the International Association of Classification Societies for the development of unified requirements for the classification of dangerous spaces.

Recommendations have been made to BP Grangemouth and Central Scotland Fire Brigade to co-operate on a review of their emergency procedures for the safe access of CSFB units to the Grangemouth site and the means of communications between BP Grangemouth and CSFB.

A recommendation has been made to The International Chamber of Shipping to highlight to its national ship owner associations the importance of having adequate procedures in place to safely introduce new, or newly acquired, vessels into commercial service.

Figure 1

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *BORDER HEATHER* AND ACCIDENT

Vessel details

Registered owner	:	Darwin Shipping Ltd Suite 1, 1 Britannia Place St Helier Jersey JE4 5PP
Manager(s)	:	BP Shipping Ltd
Port of registry	:	Douglas
Flag	:	Isle of Man
IMO number	:	9287833
Type	:	Coastal tanker
Built	:	2004, Galatz, Romania Delivered 13 September 2004
Classification society	:	Lloyd's Register
Construction	:	Steel, double skinned, strengthened to take the ground loaded
Length overall	:	75m
Gross tonnage	:	2159
Engine power and type	:	2400kW MAK 8M-25
Service speed	:	12 knots
Other relevant info	:	Bow thrusters

Accident details

Time and date	:	1823, 31 October 2004
Location of accident	:	Jetty 4, Grangemouth Docks
Number of crew	:	Nine
Injuries/fatalities	:	No physical injuries
Damage	:	Blast, heat and smoke damage to forward structure and equipment

1.2 INTRODUCTION

Border Heather is the first of a class of three vessels designated by BP Shipping to replace four older tankers which provide coastal services around Scotland and the Scottish islands **(Figure 1)**.

She was built in Romania, initially for delivery on 29 June 2004. The delivery date was later revised to 31 August 2004.

A crew of nine travelled to Romania to stand by the vessel from 15 August 2004. This arrangement was in accordance with programmed crew familiarisation of 2 weeks in the shipbuilder's yard, 2 weeks on passage and, for senior staff, 2 weeks commercial operation.

In the event, further delays resulted in the vessel being delivered on 13 September 2004.

One result of this delay was that the crew spent a total of 4 weeks in the shipbuilder's yard, becoming familiar with the vessel's layout and systems before they were required to take on operational responsibility. During this period, they had opportunities to witness demonstrations of equipment given by manufacturers and shipbuilder's staff.

None of the crew on board at the time of this accident had been on *Border Heather* while in the builder's yard. All joined the vessel following its arrival in the UK.

1.3 NARRATIVE

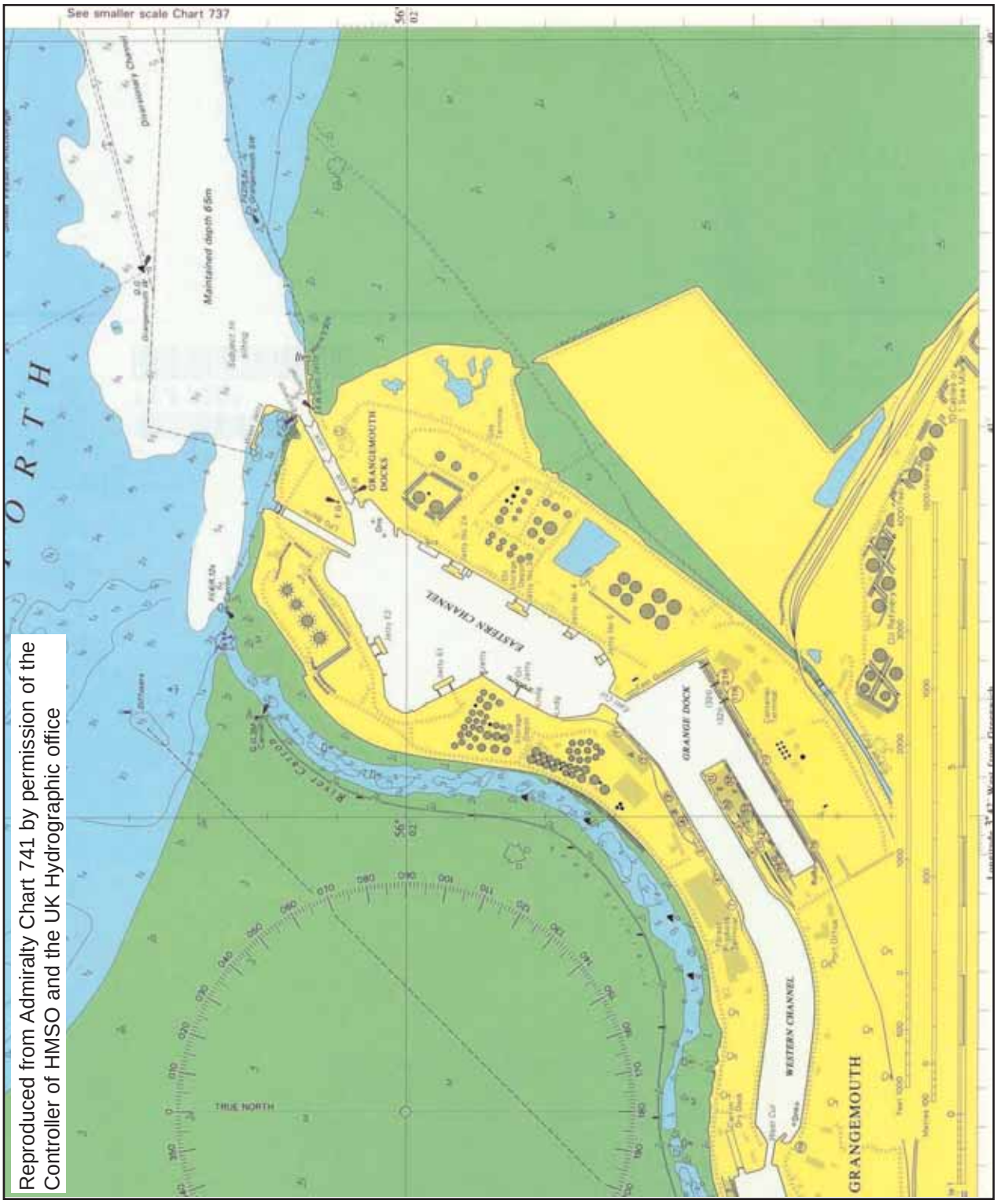
Note: All times are UTC

Following delivery to her charterers, BP Shipping, *Border Heather* arrived in Grangemouth on 30 September 2004. She loaded her first cargo of refined products in Grangemouth Docks **(Figure 2)** and left for the Orkney Islands on 2 October 2004. This, and two further cargoes were delivered to ports in the Scottish Islands and Highlands. Each was loaded at Grangemouth. On each occasion the vessel’s gas freeing system was used to prepare the cargo tanks for loading.

Problems with the vessel's fresh water cooling system were identified. Consequently, it was decided that the vessel would enter dry dock for repair to the fresh water heat exchangers in the sea chests. All cargo tanks were gas freed, using the vessel's gas freeing system, and on 27 October 2004 she entered Grangemouth dry dock.

The necessary repairs were completed by the evening of 30 October 2004 and the dry dock flooded. The vessel was afloat at about 2200.

Figure 2



To retrieve a piece of cargo sampling equipment from number four starboard cargo tank, the chief officer started one of the gas freeing fans. He ran the fan for 10 to 15 minutes to freshen the tank's atmosphere in order to make a safe entry.

In the event, he did not climb into the tank, but used a boathook arrangement to retrieve the sampler. He then stopped the gas freeing fan, but did not close the valve on the fan or the interconnecting valve to the cargo system; his intention was to do that the following day before loading cargo. By that stage, it was about 2400 and he went to bed.

The following morning, at 0900, the vessel left the dry dock and berthed, starboard side alongside, at jetty number 4 in Grangemouth Dock to load cargo. She was alongside at 1000 **(Figure 3)**.

Ship and terminal staff completed a ship/shore safety checklist, agreed a loading plan and loading of ultra low sulphur petrol (ULSP) into number one centre tank began at 1110 through number one manifold (foremost).

Loading ultra low sulphur diesel (ULSD) into tanks two centre, four port and starboard began at 1120 through number three manifold (aft).

Sometime after 1130, the duty second officer went into the purge air compressor room to shut down the compressor. As he left the compressor room, on the port side of the forecastle, he smelled petrol vapour. While investigating this smell he looked into the gas freeing room, on the starboard side of the forecastle, and noticed liquid coming from the casing of the forward gas freeing fan. He also saw a puddle at the forward end of the room, which he identified as ULSP. He then walked aft, to the cargo control room, and reported his findings to the chief officer. The two men returned forward, where the chief officer confirmed the second officer's report and, after they had both returned to the main deck, closed the cross connecting valves between the gas freeing and cargo systems.

Figure 3

Border Heather alongside

The two men returned to the gas freeing room. The rate at which liquid was coming from the fan casing had much reduced. The ventilation fan for the gas freeing room was started and the ventilation flaps for the space opened. The two men then returned to their cargo loading duties.

At 1155, loading of ULSP into number one tank was complete and the lines were blown through. Loading of kerosene began at 1220 into number three port and starboard tanks, initially using number two manifold (centre). A crossover valve downstream of the manifold valve was not fully opened, which resulted in a line pressure of 16bar being recorded ashore and caused a leak in the vessel's cargo system. As a result, cargo operations were stopped and it was decided to recommence loading the kerosene through number three manifold (aft). Ship's staff began to clean up the kerosene spill.

The forecastle was again visited by the duty second officer, together with the vessel's other second officer. They noticed that the amount of liquid in the gas freeing room had significantly reduced. They also visited the middle level of the forecastle and closed the hatch to the bow thrust room. Apart from the door of the gas freeing room, all other doors in the forecastle were closed.

Loading of ULSD was complete at 1320.

The duty second officer again visited the gas freeing room. He noticed only very small quantities of liquid coming from the fan casing. He placed a plastic drum underneath the fan to collect this and, after scooping some of the liquid into the drum, wiped the deck beneath the fan dry. At this stage he could see no liquid elsewhere on the deck of the fan room.

Loading of kerosene recommenced at 1350.

Shortly afterwards, the duty second officer again visited the fan room. He found about 50mm of liquid in the drum beneath the fan but the deck was dry, no liquid was coming from the fan and the smell had diminished.

Loading kerosene was completed at 1500.

The remaining cargo was also loaded through number three manifold. This consisted of gas oil into tanks number five port and starboard, between 1515 and 1615. Lines were blown through, and all cargo operations were finished by 1622.

Shortly before loading was finished, the duty second officer again visited the forecastle. This time he went down to the middle level. Here he found a puddle of ULSP on the port side of the deck. He reported this to the chief officer.

Throughout loading, the pressure recorded was between 1.9 and 2.1 bar (gauge) for all grades, except for the brief period shortly after loading kerosene began through number two manifold, when 16bar was recorded.

On completion of cargo work, the loading hoses were disconnected at 1630.

Bridge equipment and steering gear were tested and the main engine was ready by 1800. At about this time the crew attempted to stow the gangway. The deck crane was malfunctioning and so the gangway was manhandled onto the deck for later stowage.

The crew were at stations by 1820. The master was on the bridge, with the chief officer; two able seamen (ABs) were on the forecastle; two second officers on the stern; the two engineers in the machinery control room and the cook in the galley. Two boatmen were on the jetty head to handle the mooring lines ashore.

The main engine was clutched in. One of the ABs forward switched on power to the winches, using the switches just inside the forecastle access door.

Engine control was passed to the bridge and power was switched onto the bow thruster at about 1820. Fore and aft lines were singled up.

Shortly afterwards, at about 1823, the master noticed that the bow thruster's setting was not at zero. He gave the control a small nudge to correct this. Coincidentally with this adjustment there was an explosion within the forecastle head, throwing flame and burning material through the hatches, door and vents in the forecastle deckhouse.

One of the ABs on the forecastle head found himself hanging over the bulwark. He, and the second AB forward, decided they should clear the area and moved aft. The two boatmen on the jetty head turned away from the vessel and ran clear of the jetty area.

The vessel's fire alarm was sounding and the fire display panel on the bridge indicated a 'manual call' in the forecastle. The master halted all mooring operations and tried to contact the ABs forward. He then radioed Port Control to report the accident, requesting fire-fighting assistance, and rang finished with engines. He also arranged for the chief officer to go forward, and telephoned the engine room to request electrical power to be shut off the forecastle and to tell the engineers of the explosion.

Meanwhile, a member of the terminal's staff, at an adjacent jetty, had heard the explosion and seen the resultant smoke. He activated the terminal's shutdown procedure, which stopped cargo operations at jetty two, the only jetty working cargo. A colleague in the refrigerated liquid petroleum gas (RLPG) control room telephoned BP's fire and security control room using the dedicated on-site three digit emergency number. This call was timed at 1825. He reported that an accident had occurred at jetty 4 about “two minutes ago”, he was able to see smoke from *Border Heather* and had heard a loud “bang”.

After leaving the bridge, the chief officer collected overalls and other equipment from his cabin and went forward. The two second officers also made their way forward from the stern, as did the two ABs, the second engineer and the cook.

The telephone call from the RLPG control room, to BP's fire and security control room, automatically sounded a dedicated call tone throughout the fire/security complex. When this was heard by a first-aider in the adjacent medical centre, he moved to the fire and security control room to act as assistant to the controller, in accordance with standard emergency procedure.

Initially, about 3 minutes after the explosion, the vessel's forward foam monitor was activated by the crew. The master started the monitor's pump at the bridge console. The running light on the console did not illuminate and the master pressed the start button again. This second depression caused the pump to trip, and the flow of water to the monitor stopped after only a few seconds. The master again attempted to start this pump, but it failed again and the crew abandoned their efforts to use the monitor.

The master started the fire pump from the bridge console and two fire hoses were then rolled out and connected to the fire main. These were then used to cool the aft bulkhead and deck of the forecastle. One was also directed through the hatch in the top of the forecastle's deckhouse.

Smoke continued to issue from the hatch, door and vents of the forecastle deckhouse.

Having received an outline of the accident from the RLPG control room, the controller in the fire and security control room called out BP's on-site fire teams and alerted on-site mobile security units at 1826. The controller's assistant, without being instructed, activated the fire alarm that sounds only in the on-site fire station. The fire team members were then also called on their personal radios, which is in accordance with standard emergency procedure. However, the fire alarm did not sound in the on-site fire station.

Members of BP's own fire service arrived on jetty 4 about 1833.

Having confirmed details with BP's on-scene fire officer, the fire and security controller called the Central Scotland Fire Brigade (CSFB) at 1834.

BP's fire team was initially unable to board the vessel as no gangway was rigged. Three of the vessel's crew manhandled the gangway into position, because of the problems with the deck crane. The first firefighters, equipped with breathing apparatus (BA), were on board by 1842. Boundary cooling of the forecastle continued.

Ship's staff passed a Fire Plan to the fire team and assisted by supplying details of the forecastle arrangements.

Contact with the fire and security controller was made, using a private mobile telephone, by the fifth attending CSFB unit en-route to the accident at 1844. Thinking this was the first CSFB unit to attend, the controller requested that it approached jetty 4 by the south entrance, where a mobile patrol would be waiting and where they should hold.

Mobile security staff were sent to the south entrance to the jetty area to open the gate and brief the CSFB. The gate was opened but the CSFB vehicles did not stop, they were driven straight into the jetty area.

The first units from CSFB arrived at the jetty area at 1845. These were two appliances and one platform. Four firefighters were wearing breathing apparatus on arrival.

Four more CSFB units arrived between 1848 and 1908.

Firefighters equipped with BA entered the forecastle. On reaching the bottom of the first stairway, at main deck level, they identified the seat of the fire as being in the gas freeing room. Visibility was very poor because of smoke.

Very little flame could be seen in the gas freeing room, but heat levels were high and visibility very poor. Using a fire hose set to jet and spray, the fire was tackled by firefighters from the doorway to the space. The firefighters suffered from the high levels of heat generated.

The bow of the vessel began to slowly swing away from the head of the jetty. Initially this movement was not noticed.

The fire in the gas freeing room was completely extinguished by the teams of firefighters, using fire hoses only. Inspection of the other forward spaces found no other fires, and the fire was declared out at 1908.

Ambulance paramedics attended the vessel and assisted some of the crew who were showing ill effects from their recent experience.

Following these events, the spectacle plate between the discharge from the gas freeing fans and the cargo system was changed to the 'blanked' position **(Figure 4)**. Also, at about this time, the gap between the vessel's bow and the jetty was noticed and extra lines were put out to secure the vessel.

Fire-fighting units left the scene at 2310.

Overnight, the atmosphere of the forward spaces was monitored for hydrocarbons. High levels were recorded until ventilation was begun and the spaces were pumped free of the water used during the fire-fighting.

Figure 4

Spectacle plate in ‘blanked’ position

1.4 WEATHER CONDITIONS

At the time of the accident, weather conditions were good. It was dark, with good visibility and it was dry. Wind was about 5knots from the north-west. With the vessel parallel to jetty 4 a heading of 030°, the wind was blowing approximately from port to starboard.

1.5 NOTES ON CARGO

Of all the vessel's several grades of cargo, only ULSP had a flash point below ambient temperature. The other products on board would not be expected to generate a flammable vapour under ambient conditions.

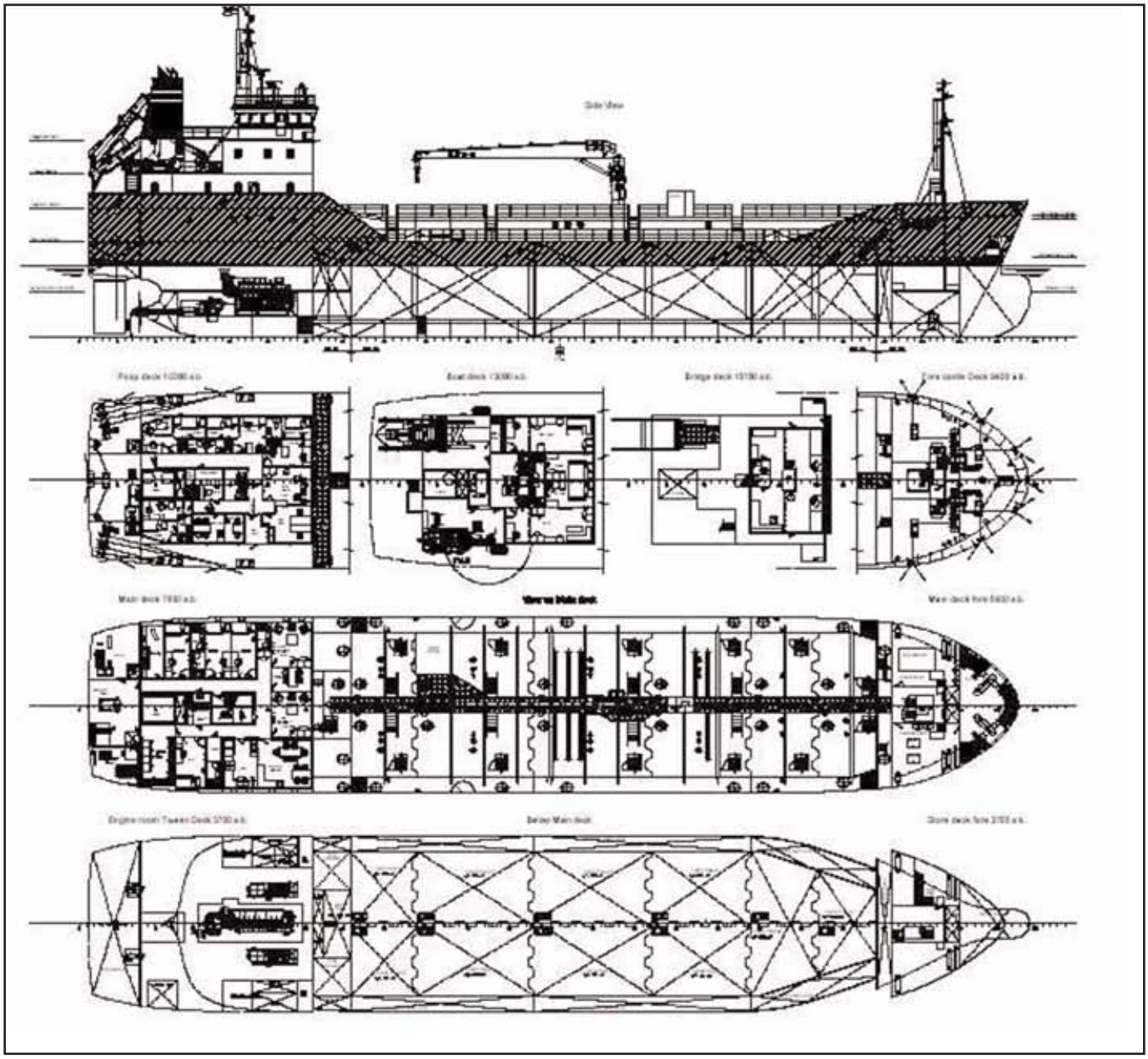
1.6 GENERAL ARRANGEMENT OF VESSEL

Border Heather is a double hulled chemical/oil tanker, strengthened to allow it to load or unload while aground. She has six sets of cargo tanks. The foremost, numbers one and two, are full width (centre tanks), numbers three, four, five and six are divided port and starboard. Water ballast may be carried in the double bottom and wing tanks, as well as in a full width tank forward of number one cargo tank and in forward and aft peak tanks **(Figure 5)**.

Aft of the cargo tanks are tanks for fuel, fresh water, tank wash water and slops.

A single eight cylinder MAK diesel main engine drives a controllable pitch propeller through a gearbox, with a power take-off that can drive a generator. The bow thruster is powered from this generator.

Figure 5



General arrangment

There are two further independent diesel driven generators in the engine room, and an emergency generator at boat deck level, starboard side.

Above the main machinery spaces aft are four deck levels: main, poop, boat and bridge decks.

The cargo control room is forward in the accommodation structure, offset to starboard at poop deck level. Connecting the poop deck to the forecastle head is a flying bridge. This runs above the cargo tanks, cargo piping system and fittings.

At about mid length of the flying bridge is a crane used for handling hoses, stores and the gangway.

Loading and discharge manifold arrangements are conventional. Arranged about amidships on each side of the vessel are three flanged connectors, each of which can be used to fill or discharge any of the cargo tanks. Double block and bleed isolating valves in the cargo piping system allow for simultaneous loading or discharging of different grades. The manifold connections, on each side, are referred to as numbers one, two and three from forward to aft.

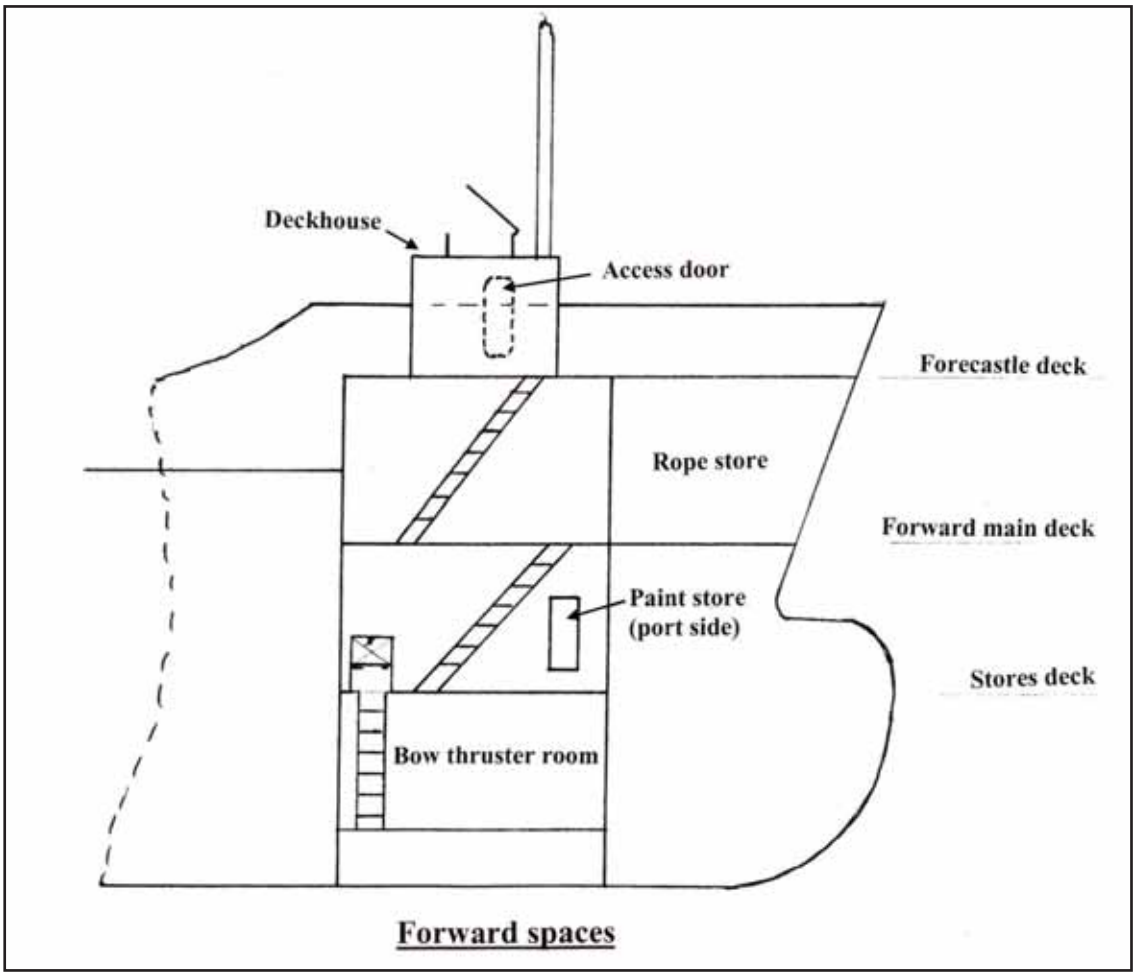
Forward of the cargo tanks and main working deck area is the forecastle.

1.7 THE FORECASTLE

The forecastle deck is one deck above the main or working deck level. On it is mounted a deckhouse containing an access door, and ventilation ducts serving the spaces below. On the roof of this deckhouse are the foremast and a stores access hatch down to the stairwell **(Figure 6)**.

A stairway leads down from the access door to main deck level. Here, through a watertight door on the port side, is the purge air compressor room housing an air compressor that supplies the cargo tanks' stripping pumps and line purging system. Through a similar door on the starboard side is the gas freeing room, housing the gas freeing fans. A watertight door at the forward end of this space leads to a rope store.

Figure 6



Forward spaces

A further stairway in the stairwell leads down to a stores space at intermediate or middle level. Access to the paint store from this level is through a watertight door. A watertight hatch at this level gives access to a vertical ladder down to the bow thruster machinery compartment.

The bilge space of the bow thruster room may be pumped out using the emergency fire pump located in the same space. The spaces in the forecastle at main deck level, gas freeing room, purge air compressor room and store, all drain to the intermediate level, which, in turn, drains into the bow thruster room via scuppers. The drain line between the intermediate level and the bow thruster room is fitted with a self-closing cock at its lower end.

Each of these spaces is independently ventilated by a motor driven fan. All ventilation trunks are fitted with fire control dampers.

1.8 VESSEL'S HISTORY

The delivery voyage to the UK was completed on 30 September 2004 when the vessel arrived in Grangemouth. On passage, the crew were able to practice cargo handling operations by pumping water through the system. However, owing to concerns about increased fuel consumption, caused by power requirements for cargo pumps etc. these exercises were restricted. The delivery crew also had access to a guarantee engineer, from the shipbuilders, who sailed on this voyage and was able to advise and clarify any uncertainties.

Border Heather began loading her first cargo during the evening following her arrival in Grangemouth.

Problems were experienced with accurately measuring the contents of the cargo tanks. On two occasions while loading cargo at jetty 4 in Grangemouth, this resulted in a cargo tank overflowing onto deck; on 2 October 2004, while loading her first cargo, and 21 October 2004, although on neither occasion did cargo go overboard. Adjustments were made to the tanks' high level alarms, and this prevented any further spills. However, there continued to be discrepancies between the readings obtained from the vessel's tank sounding system and figures supplied by one shore terminal. This problem continued until the date of this accident when the manufacturer's technicians were on board investigating the problem.

The vessel's deck officers also experienced problems with other systems. These included difficulties with a radar, VHF radio, Automatic Identification System (AIS) and numerous alarms from bridge equipment.

1.9 THE CREW

Border Heather carried nine crew, including the master, which was in excess of the minimum requirements of her Safe Manning Document.

The majority of the crew were employed through a manning agency. However, all had sailed on the BP managed coastal fleet around the Scottish islands for several years.

None of the crew on board at the time of the accident had been on the vessel while in the builder's yard. All had joined the vessel following her arrival in the UK.

Of this crew, the master, chief officer and chief engineer joined *Border Heather* on her arrival in Grangemouth at the end of the delivery voyage. They then began two weeks of familiarisation and handover from their opposite numbers who formed part of the delivery crew. Limited accommodation on board meant that the vessel sailed without second officers until the last members of the delivery crew left on 11/12 October 2004.

Thus, for the 2 weeks following her arrival in Grangemouth, the vessel had two masters and two chief officers on board. During this period, the chief officer, who was on board at the time of the accident, performed the duties of second officer, while also understudying the delivery chief officer. The delivery chief officer had sailed the vessel from the builder's yard as master and, in addition to the experience gained during the delivery voyage, had had the benefit of standing by the vessel for 4 weeks at the builders shipyard.

As the vessel sailed with no second officer for the first 2 weeks of operation after she arrived in the UK, the two second officers that joined her on 11 October 2004 had no opposite numbers able to give them a handover. These two second officers were on board at the time of the accident.

1.10 DAMAGE

All damage was confined to the forecastle structure and the systems and equipment contained therein.

Externally

Heat, blast, smoke or related damage was visible to:

- aft bulkhead of gas freeing room near main deck level
- air dampers and grills on ventilation inlets **(Figure 7)**
- hatch cover on deckhouse top; guard rails; fore mast and its ladder **(Figures 8 & 9)**.

Internally

At main deck level:

Gas freeing room:

- heat damage to access door and seal
- heat damage to aft bulkhead and electrical fittings and wiring
- heat damage to rope coils stowed beneath forward gas freeing fan **(Figure 10)**

- various electrical equipment heat and smoke damaged
- plastic position indicators on fan isolating valves heat damaged
- smoke damage throughout
- paintwork on casing of the forward gas freeing fan softened, as if by solvent action from (liquid petrol) found in the casing.

Forward store:

- no damage internally **(Figure 11)**

Purge air compressor room:

- access door set in
- pressure damage to compressor enclosure, fan motor mountings and air trunking **(Figure 12)**

Stair well:

- heat, pressure and smoke damage to electrical fittings and cabling.

Intermediate or middle level:

- smoke and pressure damage to electrical cabinets throughout
- hatch down to bow thruster room set up and broken from hinges **(Figure 13)**
- deck set up
- paint store door set in. No damage to paint store internally **(Figure 14)**

Bow Thruster Room:

- deckhead set up
- pressure damage to three electrical cabinets
- light smoke damage throughout **(Figures 15,16 & 17)**

Isolating valves

- isolating valve between the cargo system and gas freeing system found to be undamaged
- disc seal on the adjacent non-return valve found to be damaged (not damaged by the fire).

Figure 7

Vent flap

Figure 8

Hatch and fore mast ladder

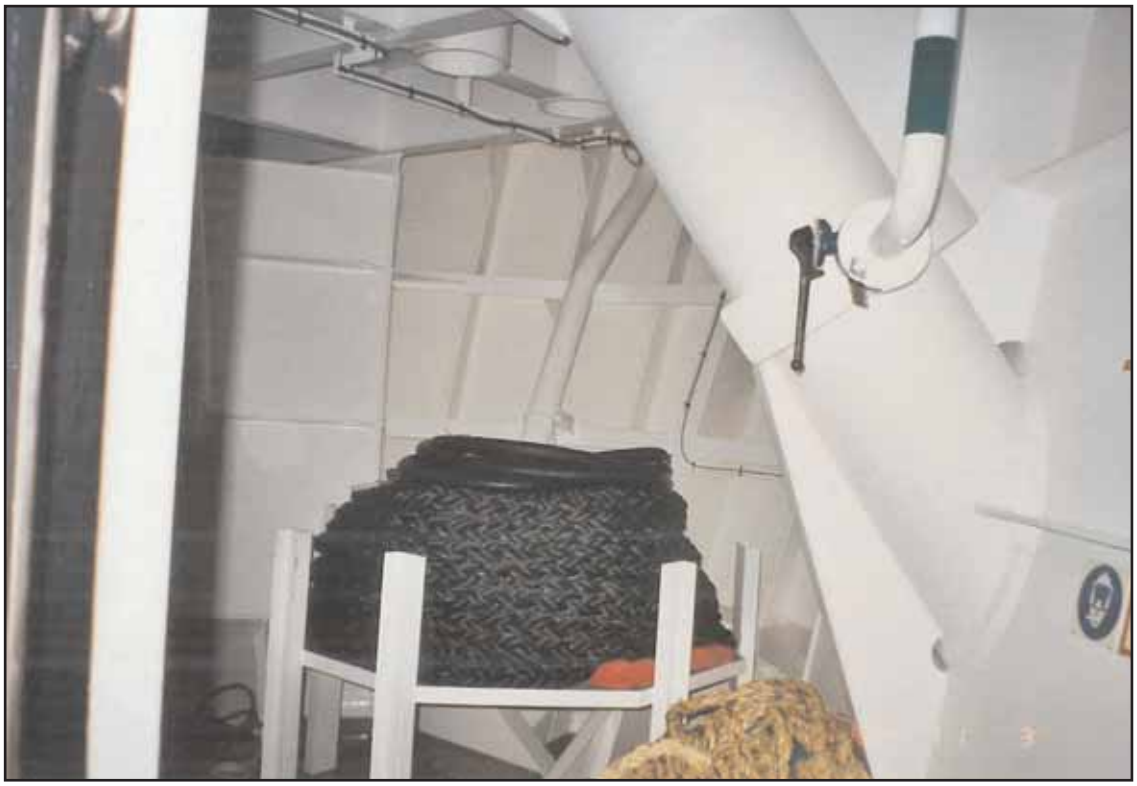
Figure 9

Hatch in deckhouse and guard rails

Figure 10

Rope coils

Figure 11



Forward store showing no internal damage

Figure 12

Pressure damage to compressor enclosure

Figure 13

Damage to hatch

Figure 14

No damage internally to paint store

Figure 15 and 16

Damage in bow thruster room

Figure 17

Damage in bow thruster room

1.11 FIRE DETECTION AND EXTINGUISHING SYSTEMS

Border Heather is fitted with an automatic fire detection and alarm system covering all significant spaces. Within the forecastle are smoke detector heads and one manual, break glass call point, positioned inside the deckhouse access door.

Covering the main working deck are three foam monitors. One each side at the aft end of the deck and one forward, on the flying bridge, over cargo tanks numbers two and three.

Additionally, the main working deck is fitted with conventional fire hydrants and foam nozzles for use with hoses. The forecastle is also equipped with portable extinguishers internally.

1.12 GAS FREEING AND CARGO SYSTEMS

In the gas freeing fan room, in the starboard side of the forecastle, main deck level, are two permanently connected gas freeing fans. Each fan has one butterfly type valve on its discharge. The discharge from each of these is connected to a 200mm diameter pipe, which passes through the aft bulkhead of the compartment.

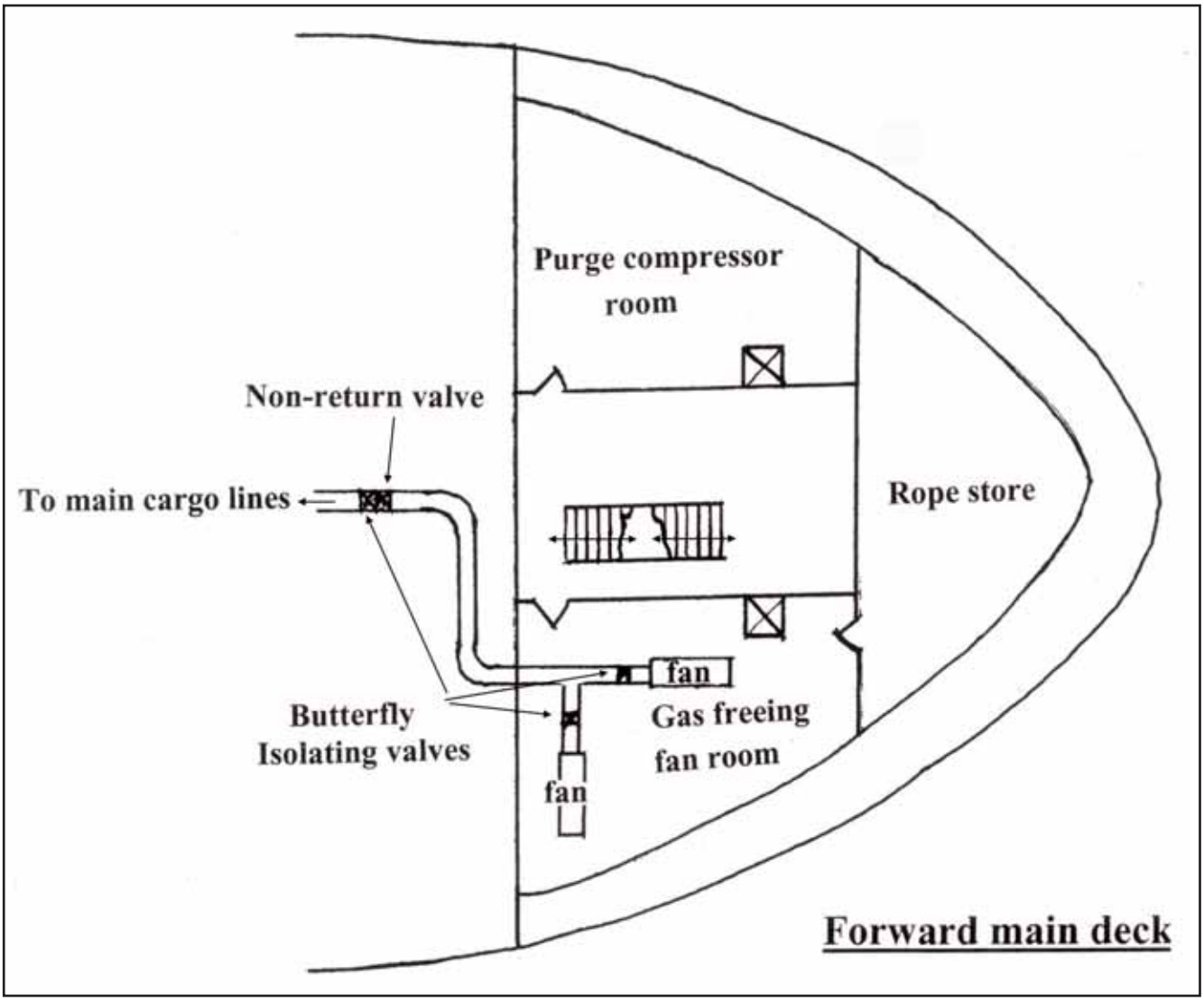
Aft of the bulkhead, this line is connected to the cargo filling and discharge piping system. Two further valves separate the fans from the cargo system, one non-return and one butterfly. These valves are outside the gas freeing room. The butterfly valve is locally operated **(Figure 18)**.

The non-return valve is a simple flap arrangement, has no external position indicator to show whether valve is open or closed, is rated at 10bar and relies on gravity to move to the closed position. After the accident, this valve was examined. It was found that the valve seat material was slightly dislodged.

The shipbuilder's specification included a non-return valve. It also stated that separation between cargo and gas freeing systems should be with a manually operated butterfly valve and a blanking spectacle flange or plate.

Drawings approved by the vessel's classification society, Lloyd’s Register of Shipping (LRS), show the butterfly valve and the non-return valve, but no spectacle plate is shown.

Figure 18



The gas freeing system is used to remove vapours from the cargo tanks. The fans draw air from the gas freeing compartment, blow it into the cargo piping system and then into the chosen tank. The increase of tank pressure, caused by the introduction of the air, causes the displaced vapour to be ejected through the high velocity vent valves in the tank's top. As these valves discharge about 2m above main deck level, vapour is carried clear of the working area.

This process is continued until the vapour content within the tank is below 30% of the lower explosive limit (LEL) when the venting may then be done directly to atmosphere, without passing through the high velocity vent valves, until the desired gas free condition is achieved.

The gas freeing system operates at a maximum pressure limited by the output of the gas freeing fans, in the order of 0.09bar. The system requires a connection between the low pressure gas freeing system and the cargo system that, when loading or discharging cargo, operates at a much higher pressure.

When loading, the cargo system typically operates at about 2bar, although it is designed with a maximum working pressure of 16bar during discharge using the vessel's cargo pumps.

1.13 THE OLDER COASTAL FLEET

For a number of years, four ships made up BP's coastal fleet serving the Scottish islands and coastal communities. These vessels were built between 1968 and 1972 and are generally referred to as the 'Border class' vessels in company documentation. These four ships are to be replaced by a class of three, *Border Heather* being the first of the class.

The older Border class vessels were seen by their crews as very simple and unsophisticated vessels, with limited automation or remote control, other than for main machinery, and no cargo control room. All cargo work was performed locally, on deck.

In particular, gas freeing of the cargo tanks was carried out using portable water powered fans. There were no fixed gas freeing fans or piping system.

Operating procedures on these vessels were well established and set out in the safety management documentation and associated operation manuals.

1.14 CLASSIFICATION SOCIETY REQUIREMENTS

Border Heather was built to the standards set out by Lloyd's Register of Shipping (LRS). These standards are given in the 'Rules and Regulations for the Classification of Ships', The Rules.

The Rules give definitions for the spaces that should be considered dangerous zones and spaces. From this classification, The Rules further set out the standard of the electrical systems and equipment that may be allowed in those spaces.

Part 6 Chapter 2 of The Rules covers electrical systems and the classification of spaces. Relevant extracts are set out in the **Annex**.

Also covered by The Rules, in Part 5 Chapter15, are aspects of piping systems on tankers. Again, relevant extracts are set out in the **Annex**.

1.15 CLASSIFICATION OF FORECASTLE SPACES AND EQUIPMENT

Lloyd's Register of Shipping classifies the gas freeing fan room of *Border Heather* as a safe space. Similarly, all other spaces in the forecastle, other than the paint locker, are also classified as safe.

Because of this classification, none of the electrical systems in the forecastle, outside of the paint locker, are required to be suitable for use in explosive atmospheres.

1.16 TERMINAL REQUIREMENTS

A copy of the Port Information and Jetty Regulations (PIJR) is placed on board all vessels which berth at any of the jetties in Grangemouth.

On the first page of PIJR is a note that states:

There is a minimum requirement at this terminal that the vessel complies at all times and in all respects with the latest edition of the International Safety Guide for Oil Tankers & Terminals (ISGOTT).

Further*, the terminal reserves the right to take action if any non-compliance is identified. This action may be to: reject the vessel; cease operations; suspend operations; remove the vessel from the berth; refuse completion of the intended operation; require attendance and/or assistance of marine or cargo expert(s) acceptable to the terminal.*

Associated with the PIJR is a ship/shore safety checklist. On this is recorded, among other data, records of the 6-hourly periodic checks made during cargo working and declarations that systems and procedures are in place and fully operational.

These declarations include:

- availability of fire-fighting equipment for immediate use
- emergency signal to be used.

The agreed emergency signal is a long blast on the ship's whistle.

1.17 INDUSTRY GUIDANCE

The International Safety Guide for Oil Tankers & Terminals (ISGOTT) is published by the International Chamber of Shipping (ICS) and the Oil Companies International Forum (OCIMF). The guide makes recommendations to tanker and terminal personnel on the safe carriage and handling of crude oil and petroleum products, on tankers and at terminals.

In Section 9.3, covering gas freeing, the guide offers recommendations on general procedures. In particular, Section 9.3.2(f) states:

Where cargo tanks are gas freed by means of one or more permanently installed blowers, all connections between the cargo tank system and blowers should be blanked except when the blowers are in use.

1.18 THE VESSEL'S SAFETY MANAGEMENT SYSTEM

Border Heather was issued with an Interim Safety Management Certificate (Interim SMC) by her Flag State, the Isle of Man Administration, on delivery at the builder's shipyard. This certificate was valid for 6 months to 12 March 2005.

The vessel's Safety Management System (SMS) is based on a system used throughout the fleet of BP Shipping, including vessels trading internationally. This system is approved by the Isle of Man Administration. It contains instructions covering all areas of vessel operation, although it does not contain detailed ship-specific instructions. Where relevant, sections of the SMS applicable only to vessels in the coastal fleet are identified.

The work instructions on gas freeing cargo tanks contained in the SMS of *Border Heather* had been deleted because they were applicable only to the older 'Border class' vessels of the coastal fleet. No substitute instructions had been inserted and no associated operations manual had been prepared for cargo operations.

The generic elements of the SMS arrived on board the vessel on 10 September 2004, after being held in Romanian Customs since their arrival at the shipbuilder's yard on 16 August 2004. The IoM surveyor left the vessel on 26 August 2004. He was, therefore, unable to examine this material when it arrived on board. However, the IoM Administration had approved a copy of BP Shipping’s generic SMS.

During his visit to the vessel, the IoM surveyor observed that the crew were making progress in becoming familiar with the vessel's systems and equipment. He also noted that the ship had been supplied with equipment manufacturer's instruction manuals and shipyard drawings covering critical systems.

On his departure from the ship, the IoM surveyor left the original, signed Interim SMC with the local LRS surveyor, and this was handed to the ship on her delivery on 13 September 2004.

1.19 ISM CODE REQUIREMENTS AND GUIDANCE

The purpose of the International Management Code for safe operation of ships and for pollution prevention (ISM Code) is to provide an international standard for the safe management and operation of ships and for pollution prevention.

Some of the objectives of the ISM Code, and the required safety management system (SMS), are set out in its Sections 1.2.2 and 1.2.3:

1.2.2 Safety-management objectives of the Company should, inter alia:

.1 provide for safe practices in ship operation and a safe working environment;

.2 establish safeguard against all identified risks; and

.3 continuously improve safety-management skills, of personnel ashore and aboard ships, including preparing for emergencies related to both safety and environmental protection.

1.2.3 The safety management system should ensure:

1 compliance with mandatory rules and regulations; and

2 that applicable codes, guidelines and standards recommended by the Organization, Administrations, classification societies and maritime industry organisations are taken into account.

On 29 November 2001 the International Maritime Organization (IMO) adopted revised guidelines on implementation of the ISM Code by administrations. These are contained in the Annex to Resolution A.913(22). An extract from this Annex is:

2.3.5 Administrations should ensure that the Company has:

1 taken into account the recommendations, as referred to in 1.2.3.2 of the ISM Code, when establishing the safety management system; and

2 developed procedures to ensure that these recommendations are implemented on shore and on board.

2.3.6 Within a safety management system, implementation of codes, guidelines and standards recommended by the Organization, Administrations, classification societies and other maritime industry organizations does not make these recommendations mandatory under the ISM Code. Nevertheless auditors should encourage companies to adopt these recommendations whenever applicable to the Company.

IMO adopted amendments to the ISM Code on 5 December 2000 contained in Resolution MSC.104(73). In Chapter 14 of these amendments is guidance on the issue of interim certification under the ISM Code, in those cases where a new ship is delivered, or a Company takes responsibility for a ship new to the Company or when a ship changes flag. For such cases the guidance is in Section 14.4:

14.4 An Interim Safety Management Certificate may be issued following verification that instructions, which have been identified as being essential, are provided prior to sailing.

However, the requirement that *instructions which are essential to be provided prior to sailing should be identified, documented and given* has been a requirement of the ISM Code since it came into force on 1 July 1998.

1.20 GRANGEMOUTH DOCKS

The Grangemouth Docks complex is on the south side of the River Carron, where it enters the River Forth on the east coast of Scotland.

The docks have three separate berthing areas, lying in a north-east/south-west direction for 1.5 miles. The entrance from the River Forth is by a lock leading into the Eastern Channel, which leads into Grange Dock via East Cut. Western Channel runs west from Grange Dock into Carron Dock via West Cut **(Figure 2)**.

A single dry dock leads off the north-east corner of Carron Dock, capable of taking vessels up to about 100m length overall.

All tanker berths, operated by BP Grangemouth, are in the Eastern Channel. There are four on the south-east side and three on the north-west side. The berths on the south-east side are numbered two, three, four and five from the north-east towards the south-west. Jetty five has been removed from service.

There is a control room on each side of the Eastern Channel. The one on the north-east side is referred to as the refrigerated LPG (RLPG) control room. The other, on the south-east side, is the tank farm control room.

The oil terminal activities within Grangemouth Docks is one part of the total activity falling under the umbrella of the BP Grangemouth oil refining and processing complex. The nature of many of the processes performed on the site involves the handling of dangerous substances. Monitoring of fire and security matters on the complete site is performed at a dedicated fire and security control room, which is permanently manned.

1.21 JETTY NUMBER FOUR

At the south-western end of the Eastern Channel lies jetty number 4. This is used for the smallest vessels visiting the Grangemouth facility.

Because jetty number 4 is not connected to the terminal shut down system, it is manned continually during cargo operations.

Several years ago, jetty 4 was refurbished and a jetty-based gangway was installed. This, however, fell into disuse because the vessels using the berth are generally too small to have sufficient free deck space to land this gangway. The gangway was removed as a result.

There are break glass fire alarm points at the head of jetty 4 and at its landward end. Activation starts a fire pump supplying two oscillating fire monitors on the jetty head and sounds the fire alarm covering the jetty area.

1.22 TERMINAL MANNING

A total of ten technician staff operate the BP berths; two in the tank farm control room; two in the RLPG control room; three mobile staff on the south-east side; three mobile staff on the north-west side.

All the jetties on the south-east side, except jetty 4, are connected to a shut down system that can be activated remotely. This allows them to be left unattended during periods of steady state operations. However, a dedicated communications system is placed on board each vessel, which includes an emergency stop facility so that ship's staff can shut down operations. It also includes a hard wired telephone and a 'dead man's handle' shut down device set at 20 minutes to ensure loading is frequently monitored by ship's staff.

During loading or discharging operations, one technician permanently mans jetty 4. He is in permanent communication with the vessel at jetty number 4 by dedicated UHF radio. This radio is placed on board the vessel before cargo operations begin, and is removed when operations are complete.

1.23 TERMINAL EMERGENCY PLAN AND RESPONSE

The Emergency Procedures for the jetty asset area set out actions to be taken by jetty staff in the event of a number of incident types. For a fire on board a vessel alongside, the procedures are:

Activate Jetty Area fire alarm

Inform refrigerated LPG (RLPG) Control Room of location and nature of fire

Activate Emergency Shutdown System to stop all loading operations

Request vessel to cease all discharge, ballasting/deballasting, tank cleaning, gas freeing and/or purging operations

Offer assistance if safe to do so

Disconnect loading arms if safe to do so

Liaise with Master of vessel and co-ordinator of outside response as required

Request vessel to vacate jetty if directed by Grangemouth Harbourmaster - Forth Ports plc.

Two tugs having fire-fighting capability are stationed within the Grangemouth Docks complex. These are not fully manned permanently. They require one hour's notice for the two tugs to be fully manned and operational. However, it is possible for one of the two to be ready within 30 minutes, if required. Neither of these was requested during this accident.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 FATIGUE

To undertake work in her seawater inlet chests, *Border Heather* spent the 3 days before this accident in Grangemouth dry dock. No work was done on any cargo tank, but some minor work was done on the cargo manifolds by shore staff.

In comparison to 'normal' dry docking periods, when a vessel's crew might be heavily involved in preparing cargo and ballast tanks etc. for survey, these few days might have provided a time of relatively low workload to the crew.

Although it is a requirement that records of working hours are kept, none were available for *Border Heather* up to the date of this accident. This has been attributed, by ship's staff, to the lack of a suitable computer on board on which this data could be recorded. The failure to maintain these records meant that any excessive hours of work went unrecognised. No consideration appears to have been given to keeping these records manually.

On the day before the vessel left Grangemouth dry dock, the chief officer did not finish work until 2400 and was again awake at 0600 the following morning. These were not particularly remarkable events, as he had a reputation for sleeping very little and, on his own admission, tended to need little sleep.

The chief officer had operated for several years following a pattern of taking limited sleep, and it appeared to suit his character and physical requirements. During recent years, however, this regime had been followed on the older ‘Border class’ coastal vessels, where operating procedures were well established, all was very familiar to him, he was confident of his knowledge of the ships, and any problems were comparatively easy to overcome. In short, his service on the older vessels was unchallenging and reasonably free of stress and anxiety.

This was in contrast to his experience on board *Border Heather* during the 4 weeks before this accident. He was faced with modern equipment, the operation of which was foreign to him and which had its own teething problems, together with difficulties associated with cargo operations that resulted in spillages and incorrect ship/shore figures.

During the 2 weeks while the delivery voyage master was on board, the chief officer was not in an ideal position to take advantage of that officer's experience. Owing to the shortage of accommodation, the chief officer was undertaking the duties of second officer as well as understudying the delivery voyage master in

the duties of chief officer. Recognising the increased level of technology over the older Border class coastal vessels, one of these roles alone was probably more than sufficient to fully consume the energies of one person. Performing both of these roles almost certainly overloaded the chief officer. As a result, he was unable to gain best advantage from the handover period.

During the following 2 weeks, he no longer had the benefit of advice and experience of the delivery voyage master. He was also joined by two second officers who were totally new to the vessel and whose recent tanker experience had also been on just the older Border class vessels. They were thus unable to advise him to any great degree and, to some extent, expected guidance and advice from him.

There is little doubt that the chief officer was overloaded and, to some degree, fatigued by the evening before the accident when he used the gas freeing system and decided to delay the proper shutting down of the system until the following morning. The forgetfulness of the chief officer, in not properly closing down the system the following morning, was just one consequence of this fatigue.

2.3 IGNITION

The pattern of damage in the forward spaces points to high pressure being generated in the bow thrust compartment, setting up the deckhead and blowing off the hatchcover in this deck.

This is clear indication that ignition occurred in the bow thrust compartment. Once this hatchcover was blown open, vapour in the upper spaces was then exposed to the still burning gas passing through the hatch. Thus, combustion spread throughout the stairwell and, through its open door, into the gas freeing room. The increase of pressure generated by the hot gasses blew open the door to the purge air compressor room and the hatch in the top of the deckhouse, and caused other damage to doors and vent flaps.

Although the space where ignition began is clear, the cause of ignition is less certain. From the recollection of witnesses, the explosion appeared to coincide with the activation of the bow thruster's control lever by the vessel's master, which suggests the bow thruster's electrical system might have been the culprit. However, the control box of the emergency fire pump in the bow thruster room showed some signs of being subjected to internal pressure, the only such item in that space to show these symptoms. It is thus possible that the contents of this unit caused the ignition.

Whatever the actual cause of ignition, it must be recognised that none of the electrical equipment in the bow thruster room is suitable for use in an explosive atmosphere. Although the most likely cause of ignition appears to be either the electrical system associated with the bow thrusters, or that of the emergency fire pump; almost any electrical system within the space had the potential to have provided a source of ignition. Which one, is not considered critical.

2.4 EXPLOSIVE VAPOUR

The presence of an explosive atmosphere within the forward spaces gives cause for great concern. These were spaces that had been assessed as “safe”.

An examination of the gas freeing fan casings, supported by witness evidence, clearly showed that a significant quantity of ULSP had passed from the cargo system into the gas freeing line. Once in the fan casing, there was a free passage for the ULSP to spill into the gas freeing room through the normal air inlet to the fan casing. ULSP was the only cargo loaded with a flashpoint below the ambient temperature. It is thus the only parcel of cargo that could have generated an explosive vapour under ambient conditions.

Passage of cargo into the gas freeing fans was due to liquid passing the isolating and non-return valves between the cargo and gas freeing systems. This was due to the isolating valves on the fans, and between the gas freeing and cargo systems, not being closed and the non-return valve not sealing properly. The need to close the isolating valves, after the chief officer had used the gas freeing system during the previous evening, was forgotten. Also forgotten, even though he had been made aware of its importance by the delivery voyage master, was the need to close the spectacle blank adjacent to the cross connecting valve. Although these omissions are seen as symptoms of the chief officer's fatigue, it must be recognised that this was the first occasion he had sailed with this type of gas freeing system.

Any ULSP that escaped from the fan casing was able to fall to the deck and run aft towards the scuppers. As the scupper from the gas freeing room opened onto the next lower level, the store/stairwell, that space, too, became filled with quantities of ULSP and associated vapour.

This cascading of ULSP continued through the scupper from the store/stairwell space into the bow thruster room. However, there it was partially arrested by the self-closing cock on the scupper between the store/stairwell and the bow thruster room.

The self-closing cock served the function of maintaining the watertight integrity of the deck over the bowthruster **(Figure 17)**. It is unlikely this cock was intended to prevent the passage of small quantities of ULSP. Examination showed it passed small quantities of liquid when closed. Had this liquid been ULSP, as is presumed, this would have introduced a small quantity of ULSP and associated vapour into the bow thruster room.

Petrol vapour might also have entered the bow thruster room through the open hatch in the deck at the middle level, before it was closed by the second officer after the spill was discovered.

Whichever mechanism was predominant, sufficient heavier than air petrol vapour entered the bow thrust room to form an explosive concentration. In the absence of any significant ventilation to this space, and the fan serving this space was not running, an accumulation of vapour resulted. Eventually, this vapour was ignited, giving the resultant explosion.

2.5 THE CLEAN UP

Once the duty second officer had found the ULSP leaking into the gas freeing room, he quite properly told the chief officer. After the chief officer had confirmed this report for himself, he closed the cross connection between the gas freeing and cargo systems. He also started the ventilation fan for the gas freeing room; a potentially hazardous act in view of the classification of the electrical systems in that space and the known presence of ULSP vapour.

The chief officer felt unable to report the situation to the master, largely because he was uncertain of the response he would receive. Having made this decision, the chief officer then judged he had little alternative but to attempt to remedy the situation himself. He judged that the leakage was confined to the gas freeing room and could be cleaned up before the vessel sailed.

He made a similar judgment when he was later told that ULSP had migrated to the middle level of the forecastle, although on that occasion he estimated that there would be insufficient time to complete the clean up before the vessel sailed. However, he failed to recognise the significance of the spread of the ULSP beyond the gas freeing room to the middle level, and thus the possibility that it might have spread even further. This was, most probably, because he lacked the mental alertness to fully consider the implications of this development; a further symptom of his fatigue. Partly because he had been unable to fully analyse the situation, he failed to recognise its significance and did not tell the master.

These were serious misjudgements, particularly with regard to his failure to understand the significance of ULSP finding its way to at least one level below the gas freeing room, and again are seen as symptoms of the chief officer's fatigue. His failure to keep the master informed was also a misjudgement; although this was one that, at least in part, had origins in the chief officer's working relationship with the master, which was one that the chief officer found rather difficult.

In the event, efforts to clean up the leakage failed and the vessel began to leave her berth with flammable vapour in her forecastle.

2.6 THE EXPLOSION AND FIRE

The explosion caused a substantial, but brief, discharge of flame from the openings of the forecastle's deckhouse. The two crewmen on the foredeck only narrowly missed being engulfed by this flame. They avoided this fate by good fortune alone. Their clothing was not designed to resist fire. Tanker operators, in particular, need to consider the type of clothing supplied to their crews and whether this offers an acceptable level of protection given the risks they may face.

Following the explosion, a fire became established in the gas freeing room and was not confirmed extinguished until about 40 minutes later. This fire centred on coils of rope temporarily stowed beneath the aft gas freeing fan.

These ropes were on wooden pallets and had been earlier stowed in that position by the chief officer, with the intention of moving them to the forward store when the vessel had cleared Grangemouth.

Although the burning ropes contributed to the amount of heat generated, and certainly extended the duration of the accident, because the gas freeing room was effectively a vestibule for the forward rope store their temporary stowage in that space was not unreasonable.

2.7 THE GAS FREEING SYSTEM

The vessel's classification society, Lloyd's Register, approved the specification of *Border Heather*'s gas freeing system without a spectacle plate capable of separating the cargo system from the gas freeing system. In the absence of this plate, the system could not be operated in accordance with ISGOTT guidance and the terminal's requirements.

The safe operation of the system as approved by LRS relied on the operators closing the isolating valves on every occasion, when the system was shut down. It further relied on these valves not leaking.

In the event of human error, resulting in the isolating valves being left open, the only device that could maintain the system's integrity was the non-return valve between the two systems. Failure of this valve could then, while loading cargo, result in leakage of cargo into the gas freeing room. This is what happened on *Border Heather* on 31 October 2004.

The chief officer was subjected to various pressures, which significantly contributed to his failure to close the isolating valves on the gas freeing system after he used it the previous evening. Although he did not make the conscious decision to rely on the integrity of the non-return valve to keep the system 'safe', it might be reasonable to expect that this valve, as a newly fitted piece of equipment, would function as intended.

Clearly the failure of this valve was one in a series that ended with the explosion. Had the isolating valve been correctly closed, and sealed correctly, and/or the spectacle plate been fitted in the blanked position, it would have been unnecessary to rely on the non-return valve to function correctly. Unfortunately, total reliance was placed on the non-return valve, albeit unconsciously, and because of its failure the accident happened.

While this valve should never have been seen as the sole isolator between the gas freeing and cargo systems, it was used in that way, albeit by default.

Further, the design of this valve is of concern. It relied on gravity for correct operation and, as fitted, the disc of this valve could hang in the slightly open position when the ship had a large stern trim, and could swing open if the ship was moving in a seaway. Its failure, so early in its working life, suggests that consideration should be given to a change of design or specification for this item. It also suggests a need for an amendment to classification society rules to better ensure that isolation arrangements are effective.

2.8 PROCEDURES AND GUIDANCE

The spectacle plate between the gas freeing line and cargo system was fitted while the vessel was in the shipbuilder's yard. Its fitment was intended as part of the shipbuilder’s specification. However, it was not included on the system drawing approved by LRS and, as a result, was not initially fitted by the shipyard. The spectacle plate was installed at a late stage of construction, at the request of the attending manager’s superintendent.

However, the spectacle plate could make no contribution to safety unless it was used. Although ISGOTT contains clear advice that connections between permanently installed gas freeing fans and cargo systems should be blanked when not gas freeing, and in spite of the Grangemouth terminal's requirement that ISGOTT should be fully complied with, the ISGOTT recommendation could not be satisfied by the 'as built' arrangement of the gas freeing system on *Border Heather* without the spectacle plate being put in the blanked position after the gas freeing fans were last used.

The guidance contained in ISGOTT would, if followed, have prevented cargo leakage into the gas freeing system and thus, also, prevented this accident. Amendment to classification society rules to incorporate ISGOTT guidance on the use of blanks for this application would enhance the safety of these systems. This policy would, however, because of its reliance on crew rigidly following procedures, produce systems with no greater level of safety than given by that on *Border Heather*.

The vessel's SMS contained generic procedural instructions that

> *portable bends and spools must only be connected when required for a particular operation*. *They must be removed and blanks fitted when the operation has been completed.*

This instruction was not contained in the section of the SMS covering use of the gas freeing system and, although its contents are sensible in the operation of any tanker, its relationship to the use of this blanking plate is seen as non-specific.

The generic SMS did include some information pertinent to the older Border class vessels. However, this had been deleted as it had no relevance to *Border Heather.* Thus, any reference to the use of blanks and spool pieces was not specific to gas freeing systems, it was little more than general advice that gave the crew only limited appreciation of the critical nature of this particular blanking plate.

Ship's staff looking for instruction on the use of the gas freeing system on *Border Heather* would have found no other guidance in the generic SMS. However, she carried shipbuilder's drawing of all critical systems, including the gas freeing system. Unfortunately, the drawing for this system was the version approved by LRS, showing no spectacle plate. Any reference to this drawing would, for anybody as unfamiliar with this type of system as this crew, give little indication of the importance of the spectacle plate, even for those crew who knew of its presence.

Effectively, the three deck officers relied entirely on information given orally by other staff, their own experience and initiative. They had no, or only very limited, recent experience beyond the old Border class of vessels. Their service pattern meant they had repeatedly returned to these older vessels, with which they were very familiar, so removing any requirement to regularly investigate and learn about strange systems. They were then placed on a new vessel, equipped with more modern equipment, having fairly typical teething problems and expected to seamlessly take over the operation of the vessel. This was generally beyond their recent experience and a more formal induction on board this new class of vessel would have benefited them greatly.

From their experience on the older Border class coastal vessels, the crew of *Border Heather* were also accustomed to having a ship-specific operations manual covering cargo operations. This, together with a navigation manual, was seen as essential reading for any newly joined deck officer. Similar manuals had not been provided to *Border Heather* at the time of the accident.

There is little evidence that any of the deck officers on *Border Heather* attempted to find guidance in the SMS on the use of any of the vessel's systems. This was attributed, by some of them, to their high workload forcing

them to take a 'first aid' approach to learning about the vessel. From interviews with the deck officers, it was clear that they did not have the time to worry about any system or equipment, other than the ones that were essential to the immediate task in hand. This appears to be confirmed not just by the error that resulted in leakage of ULSP into the gas freeing room, but also by the failure to open a crossover valve when attempting to load kerosene, resulting in an excess pressure and leakage of cargo onto the deck.

This crew were certainly familiar with the use of convenient reference material contained in operation manuals. The ready availability and accessibility of a cargo operation manual would have been of assistance to the three deck officers on *Border Heather*, particularly the second officers who had not had the benefit of a handover.

However, as *Border Heather* was the first in a class of three similar vessels, there was no opportunity to use relevant operational material from any similar vessel. BP's usual practice is to employ consultants to prepare operations manuals for newly introduced classes of vessel. This accident happened before this process began.

This suggests that, at a very early stage in the process of commissioning a newly acquired vessel, there may be benefit in identifying safety and pollution critical systems, and making efforts to compile easily accessible guidance on the fundamentals of operating these systems. That such guidance is prepared, and available on board, is an objective of the ISM Code. There is great value in surveyors representing flag administrations encouraging vessel managers to have as much as possible of this guidance in place when a vessel first enters service. *Border Heather* probably had all the information on board that would form this guidance, but the three deck officers on board at the time of the accident were clearly too busy to retrieve it from the numerous sources available.

It is possible that the delivery crew, having no cargo work to perform during the 2 weeks of the delivery voyage, might have had some opportunity to begin the task. However, they were given no guidance by the vessel's managers on what was expected of them in the way of compiling documented operational procedures. Although the company's shore managers had some expectation that the delivery crew should at least begin this process by undertaking risk assessments, without such guidance the crew were unclear who should undertake the task and, consequently, no start was made on this process.

2.9 THE GAS FREEING ROOM

Lloyd's Register’s Rules require spaces on tankers, likely to contain hazardous atmospheres, to be categorised according to the *International Electrotechnical Commission, IEC 60092-502 Electrical Installations in Ships - Tankers - Special Features.* This standard covers the spaces on board *Border Heather* and,

according to the criteria of this standard it appears that the gas freeing room was correctly classified as non-hazardous. Accordingly, none of the electrical equipment in the gas freeing room was suitable for use in an explosive, or hazardous, atmosphere.

However, Lloyd's Rules offer further guidance in Part 6 Chapter 2 Section 13.4, **(Annex)** where it is stated that a dangerous zone may arise from flammable gas being present in any piping system or system containing vapour having openings through which leakage may occur.

This accident clearly demonstrated that liquid cargo, and associated vapour, was able to leak from the cargo system into the gas freeing fans and hence into the gas freeing room. This was clearly because isolating valves were not closed and the non-return valve failed. As such leakage must be considered likely in any valve/piping system containing flammable vapour, this possibility should, according to the Inspectors' interpretation of LR's Rules, have resulted in the gas freeing room being classified as hazardous. This interpretation requires the electrical equipment contained in this space to be suitable for use in a hazardous atmosphere.

Therefore, the vessel's managers and LR should revisit the issue of the classification of the gas freeing room and, if the review concludes it justified, make suitable amendments to the classification of equipment contained therein. It is accepted that if this re-examination does result in the re-classification of the gas freeing room, modifications, other than just to electrical equipment, might be necessary in order to make the forward spaces of the vessel safe ie scuppers.

While the Inspectors' interpretation of LR's Rules concludes the gas freeing room may be a dangerous space, LR clearly came to a differing conclusion. If the gas freeing room had been classified as dangerous, it is reasonable to suppose that electrical and drainage systems in that part of the vessel would have been specified and built differently. Such arrangements would more than likely have prevented this accident.

This diversity of interpretation suggests clarification is needed, either in the wording of the Rule or in guidance on its interpretation, in order to reduce the chances of similar accidents occurring.

2.10 FIRE-FIGHTING

The initial reaction of the two crewmen working on the forecastle was perfectly natural and understandable. They had been standing over the spaces affected by the blast and been close to the flames issuing from vents, hatches and doors. Their sense of shock and bewilderment was probably substantial and quite sufficient to justify them clearing the area and making their way aft. It is to their credit that they soon returned to the area to make a significant contribution to the fire-fighting.

The first fire-fighting activity was an attempt to deploy the forward foam monitor. Evidence clearly shows that the crew had briefly run the monitor within 3 minutes of the explosion. It is unfortunate that the system's supply pump stopped at this stage.

The master had started the foam monitor's pump at the bridge console. This was, however, the first occasion he had attempted to use this system. He was thus unprepared for the running light not illuminating promptly. Although the initial discharge from the monitor showed that the pump had started at this first attempt, the master interpreted the non-illumination of the running light as a 'failure to start'. He thus made a second attempt, which caused the pump starter to 'trip out'. Although the chief engineer reset the trip, and the master attempted to restart the pump again, the same procedure was followed with similar results.

Later tests found no defect in the pump's system. However, the arrangement of the pump's running light could usefully be improved so that any operator has a clear indication that the system's starting sequence has been activated. Notwithstanding the advisability of making such an improvement to the system, this failure indicates a lack of familiarity of the crew with the vessel's equipment and reinforces the importance of ensuring everybody on board is familiar with the operation of fire-fighting and other critical systems.

Once their efforts to deploy the foam monitor had proven unsuccessful, the crew resorted to using fire hoses to apply boundary cooling to the forecastle, and tackling the fire through the hatch in the top of the deckhouse.

In the sense that any fire was being contained, these were sensible steps, but it did require some significant strength of purpose to perform these activities adjacent to a cargo tank loaded with volatile spirit. Although training probably played a part in shaping their response, no little amount of physical courage was required; even if the individuals involved did not fully recognise what they had done until after the events.

2.11 OTHER ON-BOARD RESPONSE

The force of the explosion activated the vessel's fire alarm system by damaging the manual call point fitted at the entrance to the forecastle deckhouse. This alerted anybody in the accommodation who might not have been aware of the explosion. In the event, because all on board, apart from the cook, were at their stand-by stations for leaving the berth, everybody was awake, dressed and in a position to respond to the sound of the explosion. The main engine and steering gear were also ready for immediate use.

The prompt and spontaneous response of the crew to the sounds of the explosion and fire alarm, was probably sufficient justification for the master not to sound the general alarm. To do so, could have added to the level of noise and might have resulted in confusion.

However, others also needed to be aware of the vessel's situation. Shore authorities were contacted by radio, but vessels on the adjacent berths might not have intercepted these messages.

The terminal's requirements are that a vessel on fire when at a berth should sound long blasts on her whistle. The whistle of *Border Heather* was not sounded. Since this was the recognised signal to be given by any vessel on fire at this terminal, other vessels would have understood its significance. This would have allowed their respective masters to initiate any action they might have thought prudent to ensure the wellbeing of their vessel and crew. This type of emergency signal is one commonly required by oil terminals internationally; indeed, it is the one suggested by ISGOTT.

In mitigation, the workload on the master in the few minutes following the explosion was high. Once he had halted mooring operations, given instructions to his chief officer, ensured that his crew were taking the necessary action and called the port authority, events were already well established and shore fire-fighting teams were in transit. By that stage, it may be judged that further noise could have generated confusion.

There were no adverse consequences of the failure to sound the vessel's whistle, and there is little evidence to suggest that it was not sounded due to anything other than a very human omission on the part of the master. However, users of the terminal may need to be reminded of the importance of complying with the terminal's emergency arrangements.

Two of the vessel's crew donned breathing apparatus. One entered the forward spaces to guide and assist the shore firefighters. This was valuable assistance. Notwithstanding the value of these actions, it must be recorded that at least one of the BA sets was initially put on incorrectly. This error was quickly recognised and corrected, but again points to a need for the crew to be given more practice in using the safety equipment on board.

2.12 THE VESSEL'S SAFETY MANAGEMENT SYSTEM

When a vessel is first introduced into service, either when new or on change of managers, it has no operating history on which an audit of her Safety Management System can be based. For this reason, the ISM Code allows for an Interim Safety Management Certificate to be issued by the administration or a recognised organisation.

During the period of validity of an Interim SMC, documented evidence of the working of the SMS is expected to be accumulated. This material may then be considered at the expiry of the Interim SMC as evidence that the system is working as intended and, normally, allow a full term SMC to be issued.

IMO issues guidance to administrations on the parts of the SMS that should be in place before issuing an Interim SMC. The objective is to ensure that essential safety critical operations have been considered by a vessel's managers, and procedures have been introduced, to ensure safe operation of a vessel prior to sailing.

Essential safety critical operations on *Border Heather,* an oil tanker, can reasonably be considered to include: preparing the vessel for loading cargo; loading cargo; discharging cargo; gas freeing tanks. As a new vessel, *Border Heather's* procedures for these operations should, ideally, have been set out as part of her safety management system, before she loaded her first cargo. This was not done, and the files containing her safety management system did not contain any ship specific guidance on any of these operations.

Any limitations in the contents of the vessel's SMS were not too significant to the vessel's first crew. They had had the benefit of a lengthy familiarisation period while the vessel was still in the builder's yard and during the delivery voyage.

However, deck officers who joined after the vessel arrived in the UK were in a less fortunate position. The chief officer had a handover from his predecessor, during which he was able to make notes, but he did not have access to reference material with the level of detail he was accustomed to finding in the operations manual of his previous ships. Similarly, when the two second officers joined, they, too, had no documented guidance to refer to and so relied on the chief officer and their own experience.

This shortcoming was not identified before *Border Heather* was allowed to enter service. The failure to fully consider the safety of critical operations and introduce procedures to ensure they were performed in a safe manner before the vessel entered service, is considered to be a factor in this accident.

In spite of this conclusion, the contribution that the lack of SMS procedures made to this accident is probably limited. This conclusion is based on the very limited efforts made by the deck officers to consult the SMS on cargo operations.

Contributing to the development of this attitude was the SMS remaining in the boxes in which it had been shipped to the builder's yard; it remained unpacked and almost inaccessible for a significant proportion of the vessel's first few weeks in service. However, their approach was probably, at least in part, prompted by them knowing there was no cargo operations manual on board; a reference that they had been used to on the older 'Border' class vessels in the coastal fleet.

2.13 AWARD OF THE INTERIM SMC

As a member of the Red Ensign Group, the Isle of Man Marine Administration has a policy, shared with the UK's Maritime and Coastguard Agency (MCA), of using its own surveying staff to do the work required when issuing certificates under the ISM Code.

However, a Recognised Organisation (RO) may be used, under a written agreement, provided only authorised surveyors are employed for the work. LR is one of the Recognised Organisations that may be appointed. Lloyd's Register, as an RO, was not requested to undertake any ISM work on behalf of the Isle of Man.

Following its policy of using its own surveyors for ISM work, an Isle of Man Marine Administration surveyor attended on board *Border Heather* during 24 and 25 August 2004. Unfortunately, because the files that made up the SMS were still impounded by the Romanian Customs, he was unable to examine them before he left the vessel. However, he had been able to examine BP's approved generic SMS at his headquarter's office.

In part, the absence of the safety management manuals until just before the vessel was delivered, contributed to inadequate emphasis being placed on the importance of commissioning the SMS, as it applied to *Border Heather.* Had the crew and the vessel's managers given sufficient priority, at the time of delivery, to the need to carry out important initial processes, such as risk assessments, proper and safe operational procedures could have been drafted before the vessel loaded its first cargo. These could have been of great assistance to later crews.

Clearly, all ships need to be operated safely from their first day in service with a new owner. The present arrangements in The ISM Code, which do not explicitly require an owner's safety management system to cover the safe introduction of a vessel into service, do not encourage owners to take all possible steps to anticipate hazards and safely manage the risks associated with a vessel new to their fleet.

There is little doubt that had greater thought been given to the hazards associated with the introduction of *Border Heather* into service, it is probable that this accident would not have happened. All shipowners should be encouraged, or required, to give consideration to this aspect of their business.

Owners should adopt suitable procedures for the safe introduction of a vessel to their fleet in order to overcome such shortcomings. The inclusion of these procedures in an owner's SMS should ideally be assessed during audit for their Document of Compliance (DOC).

2.14 ACCIDENT REPORTING SYSTEMS

BP Shipping, the manager of *Border Heather,* has a well-established generic safety management/quality assurance system for vessels under its control.

As is required by the ISM Code, this system sets out the role of the designated person and his link between ship's staff and senior company management.

To emphasise this connection, notices were posted in public spaces of *Border Heather*, giving contact details, such as name and telephone number, of the designated person indicating that he may be contacted by any crew member.

There is no doubt that a call to the designated person, giving brief details of the cargo spill on 31 October, would have resulted in all operations being stopped and the vessel being made safe. None of the deck officers aware of the problem considered this as a possible course of action.

Critically, none of the deck officers seriously considered the possibility of telling the master of the accident, which again would have resulted in the operations being stopped and the vessel made safe. Almost certainly, this was due to a misplaced sense of loyalty to the chief officer, on the part of the two second officers, and the reluctance of the chief officer to confront the master with any serious problem, because of concern over his likely response.

The chief officer anticipated that the master would respond very robustly to any news of the spillage. This was a very unfortunate working relationship between master and chief officer. Both were, to some degree, aware of the brittle nature of their working relationship, and there is evidence that the master made some attempt to correct for what the chief officer saw as a short temper. However, these efforts proved unsuccessful, and the cargo spillage went unreported, with unfortunate consequences.

There appeared to be no similar difficulties in the working relationships between the master and the two second officers. However, even they were reluctant to by-pass the chief officer to report the spillage to the master.

Better understanding of the company's reporting system, and its objectives, might have prompted one or both of these officers to have reported the spill of ULSP to a person who had the authority to halt cargo operations and provide time to make the vessel safe. Alternatively, a revision of the company's present reporting system might make it more friendly to any user.

2.15 CREW FAMILIARISATION

The vessel's first crew, who joined while *Border Heather* was still in the shipbuilder's yard in Romania, had the benefit of 4 weeks to become familiar with the vessel before taking delivery. Apart from allowing the crew time to study the vessel's layout and systems, this period included demonstrations of systems by the shipbuilder and equipment manufacturer's staff.

Following this introduction to the vessel, this crew then had a 2 week delivery voyage before the first cargo was loaded. This was valuable experience for them.

In contrast, of the deck officers that were on board at the time of the explosion, only the master and chief officer had more than 2 weeks experience on board, all of which was during a period when the vessel was fully engaged in the transport of oil cargoes. The need to keep the vessel operating commercially, while overcoming problems with important systems and learning about the vessel's comparatively sophisticated systems and equipment, was sufficient to overload some; it appears the chief officer suffered in this way.

Both crews had a similar level of operational experience on the older 'Border' class of coastal tankers. All were, therefore, more accustomed to the relatively low level of technology found on the older vessels. The similarity of their background, and the size of the jump in technology that faced them, suggests they would have gained the same benefit from similar familiarisation programmes. They did not, and this resulted in the deck officers on board at the time of the accident, in particular the chief officer, being loaded with a learning experience that was compounded by problems associated with equipment defects.

Any consequences of the differences in familiarisation programmes between these two sets of officers might have been reduced if readily accessible operational data had been available on board in the form of operation manuals. These were not available, and were not yet prepared, but their potential value to staff unfamiliar with a vessel cannot be overlooked. The crews of vessels in this class that are delivered later will undoubtedly benefit from operational manuals produced as a result of the early operational experience of *Border Heather.*

Experience from this accident suggests that the crew that replaced the delivery voyage crew had the greatest need for reliable, easily accessible operational data. This further suggests that ship managers should make efforts to have this material prepared while a significant proportion of the senior staff that make the delivery voyage on a newly acquired vessel remain on board. Indeed, they are likely to be able to make a significant contribution to this process.

2.16 THE TERMINAL

Cargo work had finished, and hoses disconnected well before the explosion. Consequently, there was no longer any requirement for the jetty technician to be on the jetty. The only shore-based personnel on the jetty at the time of the accident were two boatmen, assisting with the mooring lines. These were not employees of the terminal and follow no training in emergency procedures, other than a basic induction briefing. They were not expected to take any action to raise the alarm or assist in fire-fighting. Their reaction to the explosion, in rapidly evacuating the jetty area, is therefore understandable. However, they did not follow the mustering procedures of the terminal and this had the potential to give an inaccurate count of personnel on site.

As *Border Heather* was in the process of clearing her berth at jetty number 4, her gangway had been hauled on board. This caused some difficulty when the first shore-based firefighters arrived at the jetty, as they were unable to board until the crew had manhandled the ship's gangway into place. This removed some of the ship's crew from fire-fighting activities.

For several years, jetty number 4 had a gangway at its head, but this was removed due to lack of use; the vessels that use this jetty, being the smallest that call at Grangemouth, rarely had sufficient deck space to deploy it. Had this gangway still been serviceable and in place, it is likely that at least one of the ship's crew would still have needed to assist in securing it in position. In the event, the effect of needing to use the ship's gangway to provide access for the shore-based firefighters, was that two extra crew were briefly removed from the on board fire-fighting activities.

On balance, and largely because crew assistance would still have been required, it is considered unlikely that a jetty-based gangway would have made any significant difference to the speed with which shore-based firefighters were able to board. Further, because the explosion occurred in that very brief period between recovery of the ship's gangway and letting go the last moorings, it is seen as unreasonable to expect provision to be made for a jetty based gangway. Notwithstanding the evidence of this accident, the probability is that fires and explosions are most unlikely to occur during the brief interval between landing the gangway and a vessel clearing her berth.

The possible consequences of the vessel's whistle not being sounded as an emergency alarm has already been considered. However, the terminal's own fire alarm was also not sounded. This did not appear to hamper the terminal's response to the accident. Nevertheless, the terminal's own emergency procedures require that the fire alarm is sounded in the event of a fire on a vessel at a berth. Although events were not obviously affected by the lack of an alarm signal, the operators of the terminal should review their procedures and staff training to ensure that emergency procedures are relevant and are followed.

The terminal's own fire service was activated using the portable radio carried by each member of the duty fire team. The fire/security controller's assistant also attempted to call the terminal’s fire service using the push button fire alarm in the fire/security control room. This alarm did not sound. Later tests proved it was fully operational, and no explanation can be offered as to why it did not work. However, it is suggested that the assistant took this action on his own initiative. Although the motive was commendable, such individual actions might lead to disruption of the terminal’s emergency procedures and hamper the ability of the terminal to respond effectively. The role and responsibilities of the controller's assistant therefore need to be reviewed.

2.17 RESPONSE OF SHORE AGENCIES

Once the emergency had been confirmed to the site's fire and security control room, the CSFB were alerted. The first three CSFB units to arrive at the jetty area approached it by its south gate. This gate is normally unattended and kept closed, but was opened by a mobile security unit that had instructions to stop the CSFB units in order to give directions.

On seeing the south gates already open, the CSFB units were driven past the security staff without giving them the opportunity to pass on any information or guidance. The CSFB appliances arrived in the correct area, probably using the lights of the on-site fire brigade vehicles already at the scene as a guide. In the event, the failure of the first CSFB to stop at the south gate had no significant consequences.

Without being advised of the situation, these vehicles were approaching an area where there had been an explosion, where there was still a fire in progress, where there was a substantial quantity of dangerous substances, in the dark and where the safety of both the ship and immediate area was uncertain. Under different circumstances, to have halted at the south gate and be briefed by BP staff might have alerted CSFB units that they were entering an area where there might be major hazards from escaping vapours and liquids.

Whether or not it was imprudent for CSFB units to drive directly to Jetty 4 is probably a judgment that only professional fire officers should make. The fire and security controller, however, expected the CSFB unit to hold at the south gate. His expectations of the CSFB's movements were thus not in accordance with CSFB's procedures. This points to the need for review and/or clarification of procedures to be followed when CSFB units enter any secure area of the Grangemouth complex, to remove any uncertainty as to the role of security staff and what CSFB can expect from them.

It is unfortunate that part way through this accident, a member of the CSFB was observed smoking and using a mobile telephone within the jetty area. This was in contravention of the strictly applied safety rules for the area. It is understood that senior fire officers have dealt with this issue. However, the incident suggests some lack of familiarity with the dangers and safety precautions within the Grangemouth complex, and gives grounds for enhancing training for any CSFB staff that may be required to attend accidents within the complex.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES

The following are the safety issues which were identified as a result of the investigation. They are not listed in any order of priority:

1. There is little doubt that the chief officer was overloaded and fatigued by the evening before the accident, when he used the gas freeing system and decided to delay the proper shutting down of the system until the following morning. The forgetfulness of the chief officer, in not properly closing down the system the following morning, was just one consequence of this fatigue. [2.2]

2. Whatever the actual cause of ignition, it must be recognised that none of the electrical equipment in the bow thruster room is suitable for use in an explosive atmosphere. Although the most likely cause of ignition appears to be either the electrical system associated with the bow thrusters, or that of the emergency fire pump; almost any electrical system within the space had the potential to have provided a source of ignition. Which one, is not considered critical. [2.3]

3. ULSP cargo entered the gas freeing room of *Border Heather*, from the vessel's cargo system, while the vessel was loading cargo. This was the result of isolation valves between the cargo and gas freeing systems not being closed and a non-return valve leaking. ULSP was then able to pass into the middle level and then, unnoticed, into the bow thrust space through the scuppers.[2.4]

4. The chief offer's failure to tell the master of the leakage of ULSP into the gas freeing room was a misjudgement which, at least in part, was caused by a combination of his fatigue and his working relationship with the master; one that the chief officer found rather difficult. [2.5]

5. The symptoms of the chief officer's fatigue were again evident when ULSP was found to have drained to a lower level, and he decided that the forecastle could be cleaned up and made safe, without the need to report the situation to the master. [2.5]

6. Although the burning of the ropes contributed to the amount of heat generated, and certainly extended the duration of the accident, because the gas freeing room was effectively a vestibule for the forward rope store their temporary stowage in that space was not unreasonable. [2.6]

7. The non-return valve between the cargo and gas freeing systems was approved by LRS and fitted to perform the role of an ultimate safety device to separate the two systems and prevent the type of accident that did happen. Its failure so early in its working life suggests that consideration should be given to a change of design or specification for this item. While this valve should never have been seen as the sole isolator between the gas freeing and cargo systems, it was used in that way, albeit by default. However, it proved unable to serve the purpose for which it was fitted. [2.7]

8. A spectacle blanking plate, intended to separate the cargo system from the gas freeing system, had not been put in the blanked position after the gas freeing system was last used. [2.8]

9. The guidance contained in ISGOTT would, if followed, have prevented cargo leakage into the gas freeing system and thus, also, prevented this accident. Amendment to classification society rules to incorporate ISGOTT guidance on the use of blanks for this application would enhance the safety of these systems. [2.8]

10. Ship's staff looking for guidance on the use of the gas freeing system on *Border Heather* would have found only limited guidance in the SMS. They had to rely on information given by other staff, their own experience and initiative. [2.8]

11. There is little evidence that any of the deck officers on *Border Heather* attempted to find guidance in the SMS on the use of the gas freeing system. This was attributed, by some of them, to their high workload forcing them to take a 'first aid' approach to learning about the vessel. [2.8]

12. The company's shore managers had some expectation that the delivery crew would begin the process of compiling operational data by undertaking risk assessments. Without guidance, the crew were unclear who should undertake this task and, consequently, no start was made on the process. [2.8]

13. Lloyd’s Register Rules on the classification of forward spaces of this vessel might be interpreted as requiring the gas freeing room to be classified as a 'dangerous space'. Clarification of the Rules is needed to ensure that spaces, similar to the gas freeing room, are classified as dangerous in order to enhance the safety of similar installations. [2.9]

14. Fire-fighting action by the crew required some significant strength of purpose to perform adjacent to a cargo tank loaded with volatile spirit. Although training probably played a part in shaping the crew's response, no little amount of physical courage was required; even if the individuals involved did not fully recognise what they had done until after the events. [2.10]

15. The crew were reluctant to consult the vessel's SMS for guidance, which was largely because the SMS remained in the boxes in which it had been shipped to the builder's yard; it remained unpacked and almost inaccessible for a significant proportion of the vessel's first few weeks in service. [2.12]

16. Inadequate emphasis was placed on the importance of commissioning the SMS, as it applied to *Border Heather.* Had the crew and the vessel's managers given sufficient priority, at the time of delivery, to the need to carry out important initial processes, such as risk assessments, proper and safe operational procedures could have been drafted before the vessel loaded its first cargo. These could have been of great assistance to later crews. [2.13]

17. Better understanding of the company's reporting system, and its objectives, might have prompted one or both of the deck officers to have reported the spill of ULSP to a person who had the authority to halt operations and so provided time to make the vessel safe. [2.14]

18. The crew on *Border Heather* at the time of this accident did not have the advantage of the extended period of familiarisation enjoyed by their predecessors. They were expected to overcome various problems and learn about a comparatively sophisticated vessel while operating her commercially. [2.15]

19. Following the explosion, one or two actions by the crew indicated a lack of familiarity with fire-fighting equipment, namely the incorrect donning of breathing apparatus and the problems experienced when attempting to start the pump of the foam monitor. [2.10, 2,11]

20. Terminal regulations require the jetty area fire alarm to be sounded and for a casualty vessel's whistle to be sounded in the event of a ship fire whilst alongside a jetty. During this accident, neither of these alarms was raised. [2.11, 2.16]

21. The failure of the fire alarm to sound in the on-site fire station caused no delay to the response of the fire team. However, the spontaneous action of the controller's assistant had the potential to adversely impact on the ability of the terminal to respond effectively to an emergency. [2.16]

22. Fire and security staff at BP Grangemouth expected the CSFB appliances to stop at the south gate to the jetty area, at the request of the mobile security unit, before entering the jetty area. However, on seeing the south gate already open, the CSFB units were driven past the security staff without giving them the opportunity to pass on any information or guidance. In the event, no adverse consequences resulted from this failure to stop. [2.17]

23. Another indicator that there is room for improved liaison between BP Grangemouth, and CSFB, is an unfortunate accident where a firefighter was found smoking and using a mobile telephone in the jetty area, in contravention of the site's requirements. [2.17]

SECTION 4 - ACTION TAKEN

4.1 Lloyd's Register of Shipping has issued the following Technical Notice:

OIL TANKERS – ISOLATION ARRANGEMENTS FOR CONNECTIONS BETWEEN DANGEROUS ZONES AND NON-DANGEROUS SPACES

1. An accident has recently occurred on a products tanker at a loading terminal where clean petroleum products were inadvertently transferred, via a gas freeing line, into a non-dangerous forward space. The cargo eventually drained down from the gas freeing fans into the bow thrusters room and when manoeuvring away from the jetty an explosion and fire resulted.
2. In this case a spectacle plate and non-return valve had been fitted immediately aft of an isolation valve. However, the spectacle plate and isolating valve had been left in the open position and the non-return valve failed to function correctly.
3. Special attention must always be given to such connections from non-dangerous spaces to cargo tanks and cargo piping systems forming a dangerous zone. This applies to both plan approval surveyors and surveyors attending for the new building or any modification work.
4. Where connections are required between non-dangerous spaces and dangerous zones, two non-return devices are to be fitted for isolation purposes. One of these devices is to provide positive separation by means of a spool piece or flexible hose which is to be removed when the line is not in use and blank flanges fitted. The other device is to be a non-return valve in accordance with an acceptable national or international standard appropriate for the design conditions of the piping system.
5. It is the intention to revise the Rules Part 5, Chapter 15 in this respect.
6. In the meantime plan approval surveyors should ensure that when plans are submitted showing such connections a suitable note to this effect is included in the covering Design Appraisal Document.

4.2 Lloyd's Register of Shipping is to highlight this accident at a forthcoming meeting with the International Association of Classification Societies, with a proposal for the introduction of an interim unified requirement that will provide for effective isolation between dangerous and non-dangerous zones and spaces.

4.3 BP Shipping is introducing an Integrity Management Standard which will make HAZOP/HAZID process for critical systems mandatory for all new build vessels, or for existing vessels being taken on, that will be managed under the ISM DOC held by BPF Shipping. Critical systems will include:

- Power to essential services
- Propulsion

- Steering
- Cargo
- Ballasting
- Tank washing
- Gas freeing.

4.4 BP Shipping has now introduced, and is using, a standard 5 day “hold” period between delivery of the ship and it sailing/entering commercial service. This period will allow comprehensive safety and security drills and testing of ship critical systems by ship’s staff, beyond those carried out and witnessed during builder’s trials. The 5 day “hold” period is in addition to the existing pre-delivery familiarization period that ship’s staff spend in the builder’s yard prior to delivery.

4.5 BP Shipping has accelerated its existing programme of developing ship specific Operations Manuals. These manuals are in addition to the as built drawings and vendor’s manuals already placed on board. The Operations Manuals do not replace approved drawings or vendor’s manuals, and must always be used in conjunction with the approved drawings etc., but the Operations Manuals will provide the operator with a source of quick reference into the use of complete systems rather than individual components.

4.6 BP Shipping has modified the isolation and operation of the cargo/gas freeing system on *Border Heather* by:

- Replacing 10 bar butterfly isolating valve on deck with 20 bar working pressure double block and bleed valve.
- Replacing the non-return valve with one of a more suitable design.
- Replacing the simple spectacle plate blind with a swinging blind type, for easier use.
- Introducing a removable spool piece with adjacent signage requiring it to be out removed unless the gas freeing system is in use.
- Including an isolation verification step in the pre-cargo start up check-list.
- Introducing a permit system (Head Office approval required) for operating the gas freeing system (i.e. making the interconnection between the wet cargo system and the dry gas freeing system).
- Fitting a fixed gas detection system in the gas freeing fan room, with remote readout/alarm in the cargo control room.
- Including details of the new arrangements in the Cargo Operations Manual.

4.7 BP Shipping is considering further modifications to the forward spaces of *Border Heather* at the next scheduled repair period. These changes would re-arrange and re-classify the gas freeing room as a hazardous area so as to be compatible with the deck cargo system.

4.8 BP Shipping is beginning a 6 month period with an additional chief officer on each of the new vessels of the Border class, until the impact of the new vessels is better understood.

4.9 BP Shipping is investigating options to increase the number of berths on board, up to the limit of the LSA (12). This will ease existing restrictions to onboard training and familiarisation of staff.

4.10 BP Shipping is evaluating fire protective clothing (boiler suits) for use by ship's staff. After trials on board, a final specification is being developed for adoption across both domestic and international fleets.

4.11 BP Shipping has launched a staff Code of Conduct, which includes guidance to staff on confidentially reporting unsafe conditions and practices.

4.12 BP Grangemouth has clarified and reinforced to staff the role of the assistant to the Fire and Security Controller.

4.13 BP Grangemouth has revised its Emergency Procedures, to include action plans for vessels to follow in the event of an emergency. These are to be re-issued by the end of September 2005.

4.14 BP Grangemouth has held a series of 'toolbox' talks with their technicians, highlighting the need to follow proper procedures during an emergency.

4.15 Senior CSFB staff have given instructions and guidance to members of the fire teams attending this accident, on the safety precautions to be followed by all personnel when within the Grangemouth complex.

4.16 BP Grangemouth and CSFB have agreed that selected officers from CSFB will attend BP site familiarisation courses and they will cascade the site safety requirements to potential attending firefighters. A quick reference card will also be produced by BP Grangemouth for CSFB staff. This initiative will be completed by the end of September 2005.

SECTION 5 - RECOMMENDATIONS

Lloyd's Register of Shipping is recommended to:

2006/113 Submit a proposal to the International Association of Classification Societies (IACS), that a unified requirement be developed for any space associated with or containing piping that is, at any time, connected to a tanker's cargo system to be considered as a dangerous space. IACS should also be requested to give consideration to introducing requirements for the inclusion of suitable monitoring systems for explosive atmospheres in such spaces.

BP Grangemouth and Central Scotland Fire Brigades are jointly recommended to:

2006/114
2006/115 Co-operate on a review of their emergency procedures for the safe access of CSFB units to the Grangemouth oil terminal and the means of communications between BP Grangemouth and CSFB.

The International Chamber of Shipping is recommended to:

2006/116 Highlight to its national ship owner associations, the importance of having adequate procedures in place to safely introduce new, or newly acquired, vessels into commercial service. Such procedures should be included within ISM documentation, and should include:

- Selection, numbers, familiarisation and briefing of crews
- Identification of operational hazards
- Minimising risks, and
- Preparing safe operational procedures.

Marine Accident Investigation Branch
and Isle of Man Marine Administration

February 2006

EXTRACTS FROM PART 6, CHAPTER 2 OF LLOYD'S REGISTER *RULES AND REGULATIONS FOR CLASSIFICATION OF SHIPS*

Electrical Engineering

13.4.2 A dangerous zone or space may arise from the presence of any of the following:

a) spaces or tanks containing either:

(i) flammable liquid having a flashpoint (closed-cup test), not exceeding 60ºC;

(ii) flammable liquid having a flashpoint exceeding 60ºC, heated or raised by ambient conditions to a temperature within 15ºC of its flashpoint;

(iii) flammable gas

b) piping systems or equipment containing fluid defined by (a) and having flanged joints or glands or other openings through which leakage of fluid may occur under normal operating conditions.

13.4.3 The following zones or spaces are regarded as dangerous:

(a) the interiors of those spaces, tanks, piping systems and equipment defined by 13.4.2(a)

(c) enclosed or semi-enclosed spaces containing pipe work or equipment defined by 13.4.2(b)

The Rules cover other areas that may be dangerous owing to their proximity to cargo spaces or the vapour outlets from cargo spaces.

EXTRACTS FROM PART 5, CHAPTER 15, OF LLOYD'S REGISTER *RULES AND REGULATIONS FOR THE CLASSIFICATION OF SHIPS*

Piping systems for oil tankers

The parts covering gas freeing systems are:

4.2 Cargo tank purging and/or gas freeing

4.2.1 Arrangements for purging and/or gas freeing are to be such as to minimize the hazards due to the dispersal of flammable vapours in the atmosphere and to flammable mixtures in cargo tanks.

4.2.2 Applicable only to vessels fitted with inert gas systems, (thus not applicable in this case).

4.2.3 When the ship is not provided with an inert gas system, the operation is to be such that the flammable vapour is initially discharged either:

(a) through specified vent outlets

(b) through outlets at least 2m above the cargo tank deck level with a vertical efflux velocity of at least 30m/sec. maintained during gas freeing operation or

(c) through outlets at least 2m above the cargo tank deck level with an efflux velocity of at least 20m/sec. and which are protected by suitable devices to prevent the passage of flame.

4.2.4 When the flammable vapour concentration at the outlet has been reduced to 30 per cent of the lower flammable limit, gas freeing may thereafter be continued at the cargo tank deck level.