Report on the investigation

of the parting of the mooring line

between the Tetney buoy and the North Sea shuttle tanker

Randgrid

resulting in the discharge of 12 tonnes

of crude oil into the Humber Estuary

on 20 December 2000

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Regulations 1999

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

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AB	-	Able seaman
BLS	-	Bow loading system
BM	-	Berthing master
CCR	-	Cargo control room
DGPS	-	Differential global positioning system
DPS	-	Dynamic positioning system
dwt	-	Deadweight tonnes
ESD	-	Emergency shut down
FPSO	-	Floating Production, Storage and Offloading vessel
IMO	-	International Maritime Organization
ISM Code	-	International Safety Management Code
kV	-	kilovolts
kW	-	kilowatts
m^3	-	cubic metres
OLS	-	Offshore loading system
PLC	-	Process logic control
SGS	-	Société Générale de Surveillance
SMS	-	Safety management system
SPM	-	Single point mooring
UHF	-	Ultra high frequency
UTC	-	Universal co-ordinated time
VHF	-	Very high frequency
VTS	-	Vessel traffic services

GLOSSARY OF TERMS

Chafing chain	-	Short piece of chain inserted within mooring line to act at the fulcrum point. Highly resistant to damage from rubbing.
Chain stopper	-	In this case, an hydraulically-operated clamp securing mooring chafing chain.
Class	-	Classification Society
Load cell	-	A form of strain gauge used for measuring the amount of deformation (or tension) in a material when subjected to mechanical stress.

SYNOPSIS

This incident was reported to the MAIB by the vessel's owner, Conoco Shipping, on 20 December 2000.

Randgrid arrived in the area of the Tetney monobuoy at 0055 on 20 December 2000, where she was met by the service boat *Spurn Haven,* and the tug *Lady Debbie*. Two Conoco berthing masters and two SGS cargo inspectors boarded while *Lady Debbie* was secured astern. With the pilot on board, and in south-east winds of 30 knots and seas 1.5 to 2.0m, the vessel proceeded to her berth using her dynamic positioning system (DPS) during the final stages of approach to the buoy. Despite the difficult working conditions, berthing was carried out safely, and *Randgrid* was secured at 0135. Both berthing masters confirmed that the chain stopper was fully closed on to the chain before arranging for the messenger rope to be slacked back as usual.

The chief officer discussed the discharge with the cargo surveyors and went to supervise the pump and line set-up. The first discharge hose was connected at 0210, and discharge started at 0245 with a line pressure of 11 bar. A small leak caused a delay, but by 0350 the discharge pressure was back to 11 bar. At that time the bridge berthing master became concerned about the vessel's movements under wind and tide, so arranged for the steering control to be changed from DP to manual. The chain stopper was also checked. Between about 0415 and 0430, the chief officer went to the bridge and shut down the hydraulic pumps controlling the power systems forward. Before going to his cabin, he told the duty AB to check the mooring at regular intervals. This was carried out between 0500 and 0730; the mooring being confirmed secure. By 0715, with the flood tide due, the berthing master arranged for the tug astern to maintain a slow astern speed.

At 0753, the aft discharge hose pulled away. The duty cargo officer stopped the pumps and started to close the valves. Shortly afterwards, the forward hoses broke away. On the bridge, the berthing master became aware that something was wrong with the mooring, looked up, and saw the first of the hoses pulling free. Tetney Terminal was informed, and the standard terminal emergency arrangements were implemented. The astern tug was brought into play while *Randgrid's* main engines were started, and by 0812 the vessel was able to manoeuvre under her own power. *Randgrid* then went to an anchorage, while terminal vessels contained and dealt with the oil spillage.

An investigation revealed that both spool pieces and flanges were damaged on the hoses, with slight deformation and cracking in weld flanges. The chain stopper was found in the closed position, but the chafing chain was missing. Subsequently, it was established that the chafing chain had been released from the chain stopper because the chain stopper controls had been operated accidentally. The pickup rope held the vessel until the lashing, securing the chafing chain to the pickup rope, failed at about 0750.

No staff were injured, but an estimated oil spill of about 12 tonnes occurred.

This report recommends that the owner changes the design of the chain stopper control and alarm system, as well as bridge management procedures.

Photograph courtesy of Conoco

Randgrid

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF VESSEL AND INCIDENT

Name	:	*Randgrid*
Type	:	Shuttle tanker, bow loading
Port of registry	:	Stavanger, Norway
IMO number	:	9075345
Built	:	1995 Korea
Owner	:	Conoco Shipping Norge NR2 AS
Ship manager	:	Conoco Shipping, Norway
Class	:	American Bureau of Shipping
Gross tonnage	:	75,273
Length overall	:	265.88m
Breadth	:	46.0m
Depth	:	22.6m
Propulsion	:	4 diesel electric drive. Single fixed propeller 20,000kW
Injuries	:	None
Damage	:	Side railings bent with some damage to manifold fittings. 12 tonnes of crude oil discharged into the Humber Estuary.
Time and date	:	0753 on 20 December 2000
Place of incident	:	Tetney monobuoy, off Spurn Head

1.2 BACKGROUND

1.2.1 The Tetney monobuoy (53° 32.3'N, 0° 06.8'E) is a lit mooring buoy lying south of Spurn Head in the Humber Estuary, and about 3 miles to the north-west of Tetney Haven oil terminal. It is designed to allow crude oil carriers of around 130,000dwt, or with a maximum draught of 15.24m, to discharge to the Tetney Terminal without the need for them to dock at the terminal.

The buoy is connected to the terminal by a pipe 8km in length installed partly over land and about 6km under the sea. The subsea section of the pipe is coated in concrete and lies on the seabed. The buoy, which has an 8-point mooring, is connected to the subsea pipe by a sheathed rubber steel reinforced pipe.

The 8-point mooring arrangement not only secures the 7m-diameter buoy to the seabed, but also prevents the base from turning. The top of the buoy is designed to rotate through 360° on a roller bearing to allow the attached tanker to weather vane in the wind and tide **(Figure 1)**.

1.2.2 The tanker is attached to the buoy using a hawser constructed of nylon based material **(Figure 2)**. This is shackled to a length of anchor cable chain which passes over a bow roller to a chain stopper assembly mounted on a raised centre section of the forecastle. The chain is pulled into the chain stopper with a polypropylene messenger, drawn on board by a traction winch. Once the section of chain is within the chain stopper, hydraulic power is applied and the arm of the chain stopper is lowered into the closed position, clamping the chain into position. Once the chain stopper has been operated and the mooring is secure, the messenger line is slacked back to ensure that all the weight of the vessel is on the mooring line. The workboat *Monogirl* assists with mooring the tanker and cable handling.

After the tanker has been secured to the buoy, the 290m-long crude oil discharge floating flexible hoses are manoeuvred alongside under the port amidships cargo manifolds by the supply vessel *Spurn Haven II* **(Figure 3)**. The hose is lifted on board the tanker using the tanker's own hydraulic crane, and coupled to the manifold using standard bolted flange-type spool pieces. There is no quick release system. The hose divides into two sections before leaving the water, enabling two manifold connections to be used.

1.2.3 For the duration of the discharge a loading master, or his deputy, is on the bridge of the tanker to keep watch on the vessel. A Humber pilot is also aboard the tanker during this time. A 50 tonne bollard pull tug is permanently attached to the tanker's stern to prevent it from bearing down on the monobuoy.

The berthing master brings on board, as standard practice, equipment which enables him to read the tension weight on the buoy, oil pressure within the cargo hoses at the buoy, and flow rate. He is also able to read the tension weight of the chain stopper from a display panel mounted on the bridge.

The discharge pressure from the tanker to the terminal is provided entirely by the tanker's own cargo pumps at about 10 bar. Tankers have a trip system which stops the cargo pumps in the event of loss of back pressure, eg fracture of a discharge hose.

Figure 1

The Tetney monobuoy

Figure 2

Vessel secured to buoy with hawser and chafing chain, the chain passing over bow roller and locked into the chain stopper

Figure 3

A single floating flexible discharge hose connected between the monobuoy and vessel's discharge manifold

1.3 NARRATIVE

1.3.1 *Randgrid* arrived in the area of the Tetney monobuoy at 0055 on 20 December 2000, and was met by the service boat *Spurn Haven* and the tug *Lady Debbie* close by No 3 chequer buoy. Two Conoco berthing masters, and two SGS cargo inspectors, boarded from *Spurn Haven* while the tug *Lady Debbie* was made fast astern by 0056. The Humber pilot was already on board, having joined the vessel off the Humber light vessel. (One additional pilot was on board, and he departed upon completion of the mooring operation). All connecting equipment and inline sampling equipment was aboard by 0105. Weather conditions at the time of the mooring were south-east winds of 30 knots with seas 1.5 to 2.0m. Although some reservations about the weather conditions were expressed during a brief meeting between the master, the lead berthing master (BM1) and pilot, it was agreed to continue with the berthing.

During the latter stages of the approach, the vessel was manoeuvred using the dynamic positioning system; the pilot giving the plotted course. The vessel was making 2.8 knots on approach to the buoy when both berthing masters arrived on the forecastle. *Randgrid* was then about 400 metres from the buoy. During the mooring operation both first and second officers, plus four ABs, were in the bow area. *Monogirl,* a small boat used for mooring at the bow, was in position with the mooring and pickup rope and, despite the difficult working conditions, the berthing was carried out safely and the vessel was secured at 0135.

Both berthing masters checked the chain stopper thoroughly, ensuring that it was fully closed on to the chain.

1.3.2 Berthing master (BM1) asked the first officer, who was on the forecastle, to contact the bridge and arrange for the messenger rope to be slacked back as usual. The chief officer carried out this operation using the bridge control position for the traction winch **(Figure 4)**.

Shortly after, the vessel settled fairly gently to the mooring. BM1 told the pilot that all was well and that he was returning to the bridge. When he reached it, he and the master attended to the usual ship's business regarding cargo documentation and discharge procedures. The chief officer went down to the CCR to discuss discharge with the cargo surveyors, and to supervise pump and line set-up. Meanwhile, the second berthing master (BM2) concentrated on the hose connections at the manifold area.

Figure 4

Inboard view of chain stopper showing messenger rope

1.3.3 The first discharge hose was connected at 0210, the second at 0225. At 0230 the tanks on board were inspected with the hose end valves open. Tetney oil terminal was told, and by 0233 the lines were open for discharge. BM2 passed this information to the chief officer in the CCR who, at 0245, confirmed that the first cargo was online and that discharge had started. When the chief officer was told that Tetney terminal had confirmed that cargo was being received ashore, further cargo pumps were started and the line pressure was increased to 11 bar. At that time there was a small problem in that an equal flow rate was not being achieved at both manifolds. Discharge was stopped at 0305 as a small leak was seen in the area of the blind flange of No 2 cargo line. The leakage was found to be in a partly open drain valve on No 2 cargo line. At 0335 discharge operations resumed. This time the flow rate at each manifold equalised, with a maximum discharge pressure of 11 bar being reported by the chief officer at 0350.

At about the same time, BM1, who was on the bridge, realised that the vessel was swinging more into the tide because of the effect of the SE wind on the port quarter. This was making her difficult to handle. The buoy was 4 to 5 points on the starboard bow with a weight of 25 to 30 tonne on the mooring, with the result that the vessel was showing a tendency to run up on the buoy. BM1, finding that he could not vary the rudder angle to realign the vessel, asked the first officer to activate the rudder control system. The first officer turned on the hydraulic steering system and switched over from DP control to manual. With maximum discharge pressure confirmed, BM2 went forward to visually check the mooring and chain stopper. Once he had confirmed that all was satisfactory, he returned to the bridge.

Between 0415-0430, with the discharge operation now well under way, the chief officer handed over the CCR watch to the first officer and went up to the bridge to shut down the hydraulic pumps controlling the forward power systems. These should have been shut down immediately after the mooring operation had been completed, but this part of the routine had been overlooked during the pressure to start the discharge. On entering the bridge the chief officer was aware that a BM was present but he did not speak to him. Instead, he went straight to the operational panel where he shut down the two pumps. He then returned to the CCR, where he instructed the duty AB to check both the mooring and the manifold areas at regular intervals, before retiring to his cabin at about 0530.

By about 0500, BM1 had, by varying the rudder angles, manoeuvred *Randgrid* until she was lying with the buoy at about 1 or 2 points on the starboard bow, with 12 to 20 tonne of weight on the mooring.

1.3.4 During the duty AB's half hourly rounds of the deck between 0500 and 0730, he checked both moorings and discharge manifolds. On each occasion he confirmed that the mooring chain was on board. At 0600 the first officer was relieved in the CCR by the second officer, and, presumably, then retired to his cabin. By 0715, the tide had slackened off and BM1 saw that it was no longer necessary to use the vessel's rudder to maintain the right aspect of vessel to monobuoy. The vessel was gently yawing about 10° from 260° to 270°, indicating to him that the swing to the flood tide would soon begin. It was unclear, however, which direction the swing would take the vessel. Standard practice in such circumstances is to increase the tug's speed so that the extra weight on the mooring causes the vessel to realign itself with the monobuoy ready for swinging on the next tide. BM1 requested the tug *Lady Debbie* to put her engines on 'slow ahead', and within minutes the vessel had started to swing clockwise. When BM2 arrived on the bridge at 0725 the vessel was heading 300° and swinging quite quickly.

BM1 left the bridge at 0730, leaving BM2 to monitor the situation. Five minutes later, the duty AB checked the mooring as usual, saw the chain in what appeared to be the correct position, and continued on his deck rounds. During the next 10 minutes *Randgrid* continued to swing steadily to starboard, with the monobuoy apparently right ahead showing a load of 10 to 20 tonne. When BM1 returned to the bridge at 0745 the vessel was still swinging fairly quickly. Before leaving the bridge, BM2 reported that the compass heading was through north. At this time the swing was entirely consistent with other vessels at anchor in the vicinity.

At 0748, the duty AB checked the pump room before returning on deck to inspect the discharge pressure at the manifolds. Just as he approached the area he heard a bang and saw that the safety chain for the aft discharge hose had snapped **(Figure 5)**. Almost immediately, oil started to leak around the manifold flange. Using his UHF radio, the AB then called the second officer in the CCR, telling him that the pumps should be stopped. The second officer immediately used the emergency shutdown procedure on the pumps, and started to close the manifold valves (this took about 20 seconds). Meanwhile, the aft discharge hose bolts broke, and the hose was pulled overboard. A few seconds later, the forward hose coupling broke in a similar manner. At 0753, the second officer, having closed the valves, called the master and the chief officer. The latter said he would come down to the CCR straightaway. Soon after this the AB called again, saying that both discharge hoses had pulled free from the manifold.

1.3.5 On the bridge, BM1 had been checking the tanker's heading, had found it to be 010°, and had then looked at the DGPS. This had been referred to regularly earlier in the morning to assist in deciding on rudder movements to control the movement of the vessel. The DGPS showed the vessel to be moving at 0.75 knots astern, which BM1 considered to be highly unlikely and to be dismissed as a not infrequent spurious reading. He then noticed that the top of the monobuoy could be seen on *Randgrid*'s port bow, with the load on the mooring showing as 4 tonne. Such a small load is very unusual, but possible, bearing in mind that the vessel was swinging very quickly. He then took a pair of binoculars and went to the port wing of the bridge to observe the monobuoy. Looking through them, all appeared to be normal. The monobuoy appeared to be in its usual place, with the mooring platform pointing towards *Randgrid's* bow but, as shown by the load monitor, the mooring was indeed slack and appeared to be floating on the water.

This was not an ideal situation, so BM1 returned to the inside of the bridge to consider asking the tug to use her engines to put more load on the mooring. When he reached the centre of the bridge, one of the rail hoses was pulled off the vessel's manifold, making a loud noise. The flow of oil appeared to stop almost immediately, and no oil gush was seen. Immediately BM1 used his UHF berthing radio to instruct BM2 to return to the bridge. The second rail hose then pulled off the manifold, followed by a large gush of crude oil before the flow ceased. The alarm monitor recorded that the cargo pumps had shut down at 0753.

Figure 5

Discharge manifold showing couplings and safety chain

1.3.6 BM1 used his UHF radio to call Tetney terminal, informing them that there was a 'disaster' situation, to close all their valves and instigate the 'Emergency Call Out' procedure. During this period, BM2 made his way to the manifold area to check if there were any casualties in the immediate area, and see the extent of the oil spill. Much of the spilt oil appeared to have been contained within the drip tray, and although the surrounding deck area was covered in oil, it was not widespread. All scupper plugs were in position, preventing the oil on deck flowing over the side. At about 0800, the chief officer, having arrived at the CCR in response to the first call concerning oil pressure loss, saw that the hoses were missing and went forward to join the duty AB. Realising that the real problem was in the bow area, he ran forward to inspect the chain stopper and mooring, meeting BM2 on the forecastle.

Meanwhile, BM1 had been talking to *Lady Debbie* regarding the level of astern pull they were exerting on the mooring, when he realised that the vessel had broken away from the monobuoy mooring. He told the tug master to stop towing and to await instructions. While BM2 made his way forward, BM1 told him that the vessel was free of the mooring because he could see the monobuoy straight ahead from the bridge. At the same time he called the second officer in the CCR to tell him the vessel was adrift and that the main engines should be started. The time was about 0748. On arriving on the forecastle, BM2 confirmed that the vessel had broken away from the berth. His initial reaction was that the mooring had slipped, rather than parted, as a visual inspection appeared to show the chain stopper in the closed position. The chief officer, however, saw that although the chain stopper was closed, the chafing chain was no longer in the stopper.

By this time BM1 had called VTS (Vessel Traffic Services) Humber, and informed the pilot and the master that the rail hoses had come off the vessel and that a significant quantity of crude oil had escaped into the Humber Estuary. He then told the workboat *Spurn Haven* to weigh anchor and head for the monobuoy to aid *Randgrid,* while he went down to the accommodation to call the pilot and the master.

1.3.7 Having been called by the second officer from the CCR about an oil leak, the master had been under the impression that the leak was a line pressure problem, such as had occurred earlier. He therefore told the duty cargo officer to stop the discharge. At that time, the vessel had discharged 26,000 tonne of the 117,000 tonne of crude on board. Shortly after this, at about 0758, just as the second officer called again to say *Randgrid* was adrift, BM1 arrived at the cabin door with similar news. Both BM1 and the master went immediately to the bridge, arriving there at about 0800. The pilot followed a few minutes later. Having told the master that the vessel was adrift, the second officer called the engine room and warned them that the main engines would be required within the next few minutes. Shortly after arriving on the bridge, at about 0803 the master ordered that both main engines should be started and made ready for immediate manoeuvring.

By that time the loading buoy was on *Randgrid*'s starboard bow, some 100m away, with the distance increasing. The pilot told the master that, although the water in the area was relatively deep, the low state of the tide combined with the draught of the vessel meant that, apart from the approach channel, the vessel would not need to drift far before grounding became a distinct possibility. The vessel was drifting astern very slowly, with the tug *Lady Debbie* still secured at the stern, keeping *Randgrid* away from other vessels anchored in the vicinity.

By 0812 the engine room advised the bridge that both main engines were operational. *Randgrid's* drift aft was stopped by use of the main engines, before increasing the revolutions to give her forward headway. The master advised *Randgrid's* owner in Stavanger, Norway, through the established emergency response procedure, of the incident at 0820. With the vessel now under way and operational, the towline from the tug *Lady Debbie* was released at 0823. The second officer, who had been called to the bridge by the master, had been told to go aft to assist in releasing the tug, but found this had already been done. He therefore returned to the bridge to assist in the navigation of the vessel to a convenient anchoring site. The chief officer saw that there was nothing further he could do forward, so returned to the bridge where he undertook his usual duties in connection with sailing out from the monobuoy.

1.3.8 The pilot advised the master that with low water having occurred less than an hour previously, the immediate necessity was to keep *Randgrid* in deep water as she still had a deep draught. Calculations on the rate of the rising tide were made, and at 0830 at a very slow speed (approximately 1 knot), the vessel passed the monobuoy on the starboard side making for the H1 anchorage. The pilot took her slowly out to the Humber anchorage, constantly monitoring the tide flow, and seeking deep water channels while passing through shallow water areas.

While *Randgrid* was manoeuvring, BM1 updated a shoreside berthing master on what was required of *Spurn Haven,* as well as confirming with VTS Humber that their estimate of the spillage was in the order of 30m^3. Following this, *Spurn Haven* was readied to spray oil dispersant in the designated area, and to close the pipeline valves on the Tetney monobuoy. The monobuoy valves were closed at 0845, with *Spurn Haven* on site and spraying dispersant at about 0900.

At about 1240 the vessel anchored, and, at 1545, both berthing masters, the pilot, and the cargo inspectors left her by pilot launch. The master did not communicate directly with either Humber VTS or any shoreside authorities; situation updates etc were passed to them by the loading master and the pilot.

1.3.9 Once *Randgrid* was clear of the monobuoy, both berthing masters went forward to the manifold area to inspect the damage. They found both hoses had been carried away, together with both ship's reducers and SGS auto sampler spool pieces. All bolts had been sheared off between the ship's reducer and the manifold. Damage to the forward end of the hose rail, and the ship's rail forward of this, indicated that the hoses had been subjected to a pull from ahead, rather than from below or outward.

Subsequent pressure-testing of the valve and spool piece on cargo oil lines No 1 and No 3 showed that deformation, and/or cracking, had occurred in weld flanges.

A closer inspection of the chain stopper found the chafing chain missing, but with the pickup rope still aboard, with two or three turns of rope still on the traction winch and the brake still applied. A small piece of the lashing, securing the chafing chain to the pickup rope, also lay on deck. The chain stopper itself was in the closed position.

1.4 CREW PARTICULARS

Randgrid had a crew of 19, all Norwegian nationals and qualified for the positions held on board. The crew consisted of four deck officers, including the master, four engineers including the chief engineer, four ABs, three engine room staff, three catering staff, and a secretary.

The master has worked on shuttle tankers since 1986, eventually sailing as chief officer for about five years before being promoted to master some four years ago. He had previously sailed on *Randgrid* as chief officer, but rejoined the vessel as master in 1998. He has continued to sail as master on *Randgrid* since that time. During his service, he has made numerous trips to Tetney; the one before this incident being in September 2000. He is familiar, therefore, with the terminal requirements and monobuoy procedures.

The chief officer had sailed on board another large tanker, initially as first officer, and subsequently as chief officer, until he joined *Randgrid* in 1998 as chief officer. He has continued to sail in that rank since then.

Details of the first officer's career and experience are not known.

After attending a maritime college for three years, the second officer served as second officer on *Randgrid* from January 1999 until the summer of that year. In the autumn of 2000 he returned to sea, initially serving as relief second officer on another large tanker before rejoining *Randgrid* as second officer in September 2000.

All senior staff were experienced on tankers and had been involved in monobuoy operations before this visit to the Tetney terminal.

1.5 DESCRIPTION OF VESSEL

Randgrid is a steel-hulled segregated-ballast tanker built in 1995 at the Samsung shipyard, South Korea. She is of double hull construction with accommodation and engine aft, and is driven by a single fixed pitch propeller. The liquid cargo capacity is 140,866m^3 and is carried in six central, and twelve wing, cargo tanks. She is fitted with bow-loading facilities, and has four cargo pumps with a total capacity of 12,000 tonnes per hour.

She is fitted with five controllable pitch 1700kW transverse thrusters: three forward and two aft. Main propulsion is diesel electric, with the prime movers being four Wartsila diesel generators having a combined output of 28,956kW.

The propeller is powered via two shaft-mounted electric motors which can be operated independently. This offers stepless control from 0 to 110 revs/min.

The vessel is controlled from the bridge, with the option of operating in the dynamic positioning mode.

1.6 PARTICULARS OF BLS CHAIN STOPPER SYSTEM

1.6.1 The BLS control system fitted on board *Randgrid*, was designed by Hitec Marine, and was installed during the vessel's construction. The chain stopper element consists of the basic chain stopper assembly fitted on a raised section of the forecastle, with a master hydraulic control panel on the bridge, together with three other control positions. Hydraulic power is drawn from a common system supplying power to the forward deck machinery.

The chain stopper is essentially an hydraulically-operated steel claw and a shaped steel anvil. With one link in the chain positioned horizontally on the anvil, the claw is lowered on to that horizontal link. In that position the claw face sits on the horizontal link, while the aft claw face prevents the next chain link (in the vertical position) passing forward. By virtue of the claw rotating round a pivot point slightly aft of the chain lock point ("over centre"), any forward pull on the chain causes the claw to exert a greater mechanical clamping force. Once closed hydraulically, it can only be released by applying hydraulic pressure, either from accumulator bottles or when the hydraulic system is operational **(Figure 6)**.

The chain stopper can be opened or closed from the bridge, or from the local position forward (using the local process logic control (PLC) system). The hydraulic system needs to be operating for this level of control.

The chain stopper can be opened from the bridge, cargo control room, and from the local cabinet using the ESD II button. This latter control is for emergency use only. It uses hydraulic accumulator power.

The chain stopper can also be opened from the bridge using a manually-operated switch. This also uses hydraulic accumulator power.

The chain stopper can be opened from the watchman's cabin at the bow using a manually-operated valve under a protective cover. It is for emergency use only. This also uses hydraulic accumulator power.

1.6.2 Operational control from the bridge (the master control) uses a PLC system incorporating a monitor screen and a function control panel. The BLS control has three operating modes: two modes for offshore loading, SPM (single point mooring) and OLS (offshore loading system), and one "no mode" response. The SPM is used on FPSO's, loading towers etc, while OLS is used on subsea systems like Statfjord A and B.

Figure 6

Chain stopper with hydraulically-operated claw in the locked shut position

In SPM mode, the chain stopper is used to moor the vessel, while in the OLS mode, the vessel is kept in position by the DPS. When connecting to an offshore loading terminal, the computer system will automatically select the correct loading mode and the correct disconnection sequence for the ESD system (emergency shutdown). On releasing the hose and opening the chain stopper, the system will revert to the “no mode” condition. The “no mode” is the normal/common stage when sailing or when manoeuvring in port.

1.6.3 When the vessel is at a terminal, there are a number of computer-controlled hydraulic interlocks which prevent accidental release. These include prevention of the opening of the chain stopper or the disconnection of the loading hose.

When connecting or disconnecting, the bridge screen will show an appropriate message with the screen background varying in colour to emphasise the condition:

GREEN	chain stopper closed
YELLOW	chain stopper operating
WHITE	chain stopper open

1.6.4 Like many other computer systems, the bridge monitor has been installed with a multi-functional screen system, ie No 1 screen will show a number of differing controls and systems, some of which can be operated using the function keys, F1, F2, etc. When switched to No 2 screen, a different set of systems and controls will be displayed, BUT using the <u>same</u> set of function keys: F1, F2, etc.

SCREEN 1 chain stopper open/closed
chain stopper operating
coupler valve open/closed
crude line valve open/closed
loading on/off
buzzer off

SCREEN 2 hydraulic pump No 1 on/off
hydraulic pump No 2 on/off
hydraulic pump No 3 on/off
dog clutch engaged
pressure selection for pump station
buzzer off

An example of the dual operation of the function keys is as follows:

SCREEN 1	chain stopper open	F9
SCREEN 2	hydraulic pump No 1 off	F9

Under this installation it is important, therefore, that the operator is aware at all times in which screen he is currently operating.

1.6.5 A load cell is fitted to the chain stopper so that the loading master on the bridge can monitor the tension in the mooring line to the SBM. A proximity switch is also fitted to the chain stopper to supply the condition input to the chain stopper monitor screen ie open, closed, or in operation.

1.7 INSPECTION REPORT BY HITEC MARINE

Following this incident, the designers of the BLS chain stopper system were invited on board *Randgrid* to carry out a systems check. On arrival they found that the chain stopper was in the closed position and had been so since the vessel left Tetney, the scene of the incident.

A visual inspection of the chain stopper found no material damage which would prevent the successful operation. The chain stopper was operated through a normal work cycle using a section of 76mm chain, and no defects were found in either the actual operation of the system, or visual display on the bridge monitor screen.

The PLC programme was checked, as were the 24-volt control valve solenoids for emergency release. Again no defects were found. Similarly, the positional sensors for the chain stopper were checked and were found fully operational. An oversize chain bar was placed on the chain stopper anvil and the system operated. The system correctly identified the oversize bar and failed to close, showing the correct message “chain stopper operating” on the bridge screen.

The ability of the system to remember the last instruction after a manual intervention, and repeat it when hydraulic power was restored, was also confirmed.

1.8 INVESTIGATION REPORT BY CONOCO

1.8.1 Following this accident, an investigation was carried out on board *Randgrid* on 22 December 2000, when the vessel arrived in Norway. The investigative team appointed by Conoco management, and the company’s safety management team, examined all the evidence and considered two possible scenarios:

(1) Slippage of the chain from the chain stopper; or

(2) Release of the chain from the chain stopper.

1.8.2 As to point (1), the team rapidly concluded that, based on the available information and the on-site inspection, slippage was a very remote possibility, if not impossible.

Regarding point (2), this situation was further broken down into four possible sub-scenes:

a. Equipment malfunction
b. Operation of the emergency ESD II unit
c. Total manual operation
d. Incorrect operation of system controls

Equipment malfunction - all tested and checked with no defects or abnormalities found. Discounted.

Operation of the Emergency ESD II unit - discounted as any operation would have caused operation of a deck water spray and an alarm printout, neither of which occurred.

<u>Total manual operation</u> - only one valve, fitted right forward in the watchman's cabin, would be needed but it required knowledge, opportunity, and the hydraulic system to be running, for the chain stopper to return to the closed position after the chain had been released. At 0400 BM2 saw the chain in position, but it was generally agreed that by 0430 the hydraulic pump had been turned off. If the valve had been operated after that, a low pressure alarm would have sounded on the bridge. This did not happen. Given the professionalism of the crew, a deliberate action of this sort is not considered likely.

<u>Incorrect operation of system controls</u> - an examination of the PLC system showed that if the wrong screen was displayed at the time the hydraulic pump was shut down, the operation of function key F9 would cause the chain stopper to open. When the error was seen, corrective action was taken to close the chain stopper, but by then the chain had moved out of the anvil and the vessel was held by the pickup rope.

1.8.3 The Executive Summary of the investigation, containing details of team make-up, approach, resultant conclusions and recommendations is shown below:

A Root Cause Failure Analysis team was formed and met on the vessel 22 December 2000. The team utilised expertise from the maker of the mooring system Hitec Marine, Bridge Management/Incident investigation expertise from the Danish Maritime Institute, a surveyor from the American Bureau of Shipping and Conoco marine personnel from the vessel, Houston office and Tetney. The analysis process used by the team included testing – inspection of all related equipment and systems, conducting interviews of all persons involved in the incident, review of statements given by others and examination of factual evidence.

The team found that this incident was the direct result of human failure in that the opening of the chain stopper, which was activated from the bridge. This human error was the primary factor in the release of the vessel. *The team has concluded the operator most likely meant to turn off the hydraulic pump when the wrong screen for this task was displayed. Without looking at the screen for verification, the operator depressed the function key and the chain stopper "open" command was sent. Alternative, but similar causes of the release of the chain stopper are the operator activated the chain stopper release while trying to silence one of several routine engine room alarms sounding on the bridge or by accidentally depressing the release button (the button is not covered).*

Recommendations

Vessel

1. *Review and determine chain stopper system human – equipment interface design (based on the Hitec System modification recommendation report). For example, addition of an acknowledgement prompt for chain stopper release.*

2. *Procedural modifications to improve the effectiveness of:*
    - *Operational tag out system*
    - *Personnel authorised to operate vessel systems*
    - *Roles, responsibilities and communications specific to SBM operations*
    - *Equipment usage, such as elimination of crane to bridle hoses after connections made fast.*

3. *Installation or repositioning of chain stopper camera.*

4. *Consider installation of a secondary alarm system on the chain stopper.*

5. *Sharing lessons learned with other vessel owners.*

6. *Synergistic discussions between vessel operators and terminal operators to discuss procedural changes.*

Terminal

Request initiation of a feasibility study for the installation of a buoy reference system for utilisation by vessels equipped with a Dynamic Positioning System.

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, if any, with the aim of preventing similar accidents occurring again.

2.2 FAILURE OF CHAIN STOPPER MOORING

2.2.1 The loss of the monobuoy mooring line was caused by a temporary opening of the chain stopper, and the movement of the chafing chain to a position forward of the chain stopper assembly.

Once the chain had moved forward (and it could only have done so by the chain stopper opening), the mooring connection to the buoy was through the pickup rope on to the traction winch.

It is assumed that the subsequent failure occurred when the lashing, securing the pickup rope to the chafing chain, either became frayed because of rubbing on part of the chain stopper assembly when under tension, or parted under shock loading. During the period between 0730 and 0753, the tidal effects caused the vessel to swing fairly quickly as well as to yaw. This, together with the increasing tension on the mooring line, resulted in the failure of the lashing and release of the pickup rope. The pickup rope itself did not appear to be damaged.

The chain stopper assembly and its control system were fully operational at all times. No system defects were found.

2.2.2 Two technical operations involving bridge controls were operated during the time between the start of the discharge process and rupture of the hoses. This covered a period between 0245 and 0753. These were the starting of the steering gear system and the stopping of the hydraulic pump system forward.

Although there is some confusion as to when the operating mode of the steering gear system was changed to allow BM1 to operate the rudder, there is no doubt that the first officer was the instigator. As no statement was obtained from him before he left the company, the best guess given by the master is that the changeover occurred sometime between 0245 and 0415. This is before the first officer took over the CCR watch between 0415 and 0430.

With the control panel for the steering gear physically separate from the forward hydraulic pump and chain stopper controls, if the first officer had shut down the steering system, the condition of the mooring arrangements would have been unchanged.

2.2.3 The chief officer has stated that he should have shut down the forward hydraulic system earlier, and immediately after mooring had been completed, However, with cargo surveyors on board, and anxious to start the discharge, that took priority. This late shutdown meant that it was technically possible to operate the chain stopper from the bridge at any time between 0235 and when the chief officer shut it down.

To turn the hydraulic pumps off, five function keys have to be operated; actions which require the operator to maintain eye contact with the screen. If F9 was pressed by mistake, when the operating screen for the chain stopper was still in place, the background screen colour of green would start to change to yellow, and then to white. The full colour change takes about 5 to 6 seconds, although the intermediate yellow stage, indicating the stopper is in operation, will start to show almost immediately. The chain stopper claw will have opened sufficiently to allow movement of the chafing chain within 2 to 3 seconds of the start. If the wrong sequence of events had been started, there would have been a very visible change in the lighting colour on the bridge at that time. Allowing for a system change delay of about 1 to 2 seconds, any immediate error correction is unlikely to prevent the claw opening enough to allow chain slippage. With the chain support buoy applying a constant gravitational pull, even if the vessel was momentarily not exerting any tension, the mooring line would tend to move forward until the slackness in the pickup line had taken up. From the information supplied, this would be a forward movement of about 2 to 3 metres. This is sufficient for the chafing chain to pull clear of chain stopper.

At some time between 0430 and 0500, the chief officer arrived on the bridge to shut down the hydraulic power system forward. The chief officer has said that when he entered the bridge, it was in a darkened state and although he did not speak to him, he was conscious that BM1 was present. He cannot say for certain, but thinks that the screen background colour was green. This means that the chain stopper was in the closed position. After studying the display, he then proceeded to shut down the hydraulic pumps operating the five necessary keys in sequence before returning to the CCR. This was the last time before the incident that the control panel was known to have been operated.

When, or by whom, function key F9 was accidentally depressed cannot be established with certainty, but once operated, the chain stopper would immediately start to open and the screen would change colour. An immediate correction by pressing the close key would stop the opening process, reclose the chain stopper, and cause the screen colour to change. As the screen reverted to its original colour, indicating that the chain stopper had closed, it would be easy to assume that no harm had been done and that all was well. The only visual indication on the bridge that all was not well would be the readings on the mooring tension meters: whereas, before, the tension reading would have been only on the chain stopper, it would now show on the traction winch.

2.2.4 A berthing master (BM) was on the bridge at all times, presumably monitoring the mooring system and keeping a general watch on vessel/buoy movement. At this time of night the sudden and unexpected appearance of a crew member on the bridge would normally have been an excuse for comment, but neither BM1 nor the chief officer spoke to each other. Whatever the lighting levels within the bridge, any change of screen colour, and this must have happened when the wrong key was pressed, would have reflected quite strongly in the immediate area. The absence of any comment by BM1 suggests that he was either unaware of the implications of this, or that he was concentrating on his other duties at the time.

2.2.5 As far as the AB, who had been patrolling the deck and inspecting the chain stopper at half hourly intervals since 0500, was aware, the chafing chain was still in place at 0735. For safety reasons he carried out this visual check from a distance of about 2 to 4 metres. This was because it is too dangerous to be close to, or in front of, the chain stopper when the vessel is moored. When the AB was carrying out this check he stood by the crane on the platform deck. The view from the forecastle deck is restricted, and it is unlikely that the presence of the chafing chain within the stopper could be seen. The pickup rope could only have been seen if it was under tension, something that should not happen once mooring had been completed. If, however, he checked from the platform deck, the position of the chafing chain and the pickup rope would have been seen.

If, as has been suggested, the chafing chain was released at about 0430, then it is highly likely that the pickup rope was under tension and should have been readily visible from either the forecastle or platform deck. BM2, who had inspected the chain at 0350, did not carry out any further checks until 0753, after the hoses had been pulled off the manifold.

2.3 ACTIONS OF TERMINAL STAFF

2.3.1 The terminal staff’s response to the break out was immediate, professional, and followed standard procedure. *Spurn Haven* was notified as soon as the extent of the accident was known, and she was on her way to the monobuoy shortly after 0800. By 0830 she was preparing her dispersant spray equipment, and by 0845 the monobuoy valves were shut.

These actions were in line with the Tetney oil terminal, *Emergency Procedures, Section 13.5 and 13.7*.

2.3.2 One of the significant limiting conditions under which the monobuoy can be used is that imposed by the weather. The terminal operators, Conoco, state that the basic design operating conditions are:

Wave height	4.57 metres
Significant wave height	2.62 metres
Tidal range	7.47 metres
Wind velocity	60 knots
Current	3.6 knots

The weather conditions under which *Randgrid* was discharging were within these parameters.

2.3.3 One or the other of the BMs had been on the bridge throughout the mooring and discharge, up to the time of the incident, as required by the Terminal Regulations. After the vessel had securely moored at 0135, BM2 became involved in securing the cargo hoses to the ship's manifold. This was completed at 0225. A discharge pressure problem occurred some time later, but this was sorted out by 0350 in the presence of BM2. It was shortly after this, at about 0400, that BM2 went forward and inspected both the mooring and the bow stopper. He confirmed that all was in order. This was the last time the mooring was checked by terminal staff until the mooring was lost at about 0753.

2.3.4 Following the loss of the mooring, BM2 carried out an inspection forward and told BM1 on the bridge that the mooring had not parted, but had slipped. This was subsequently clarified as meaning that the mooring had been let go freely, rather than it had slipped because of a mechanical failure of some sort.

2.4 ACTIONS OF CREW

The actions and procedures followed by the master and crew of *Randgrid* on arrival conformed to the standard Tetney oil terminal requirements. Neither the company, nor the master's standing orders, make any reference to the condition of the steering system or the BLS hydraulic pumps once mooring has been completed. The fact that the chief officer failed to shut down the BLS hydraulic system forward, immediately following completion of the mooring was, in itself, not of major significance. As stated earlier, the presence of cargo surveyors on board seeking documentation, samples, and a discharge programme to suit the terminal, placed a heavy but not unusual load on the chief officer.

On this occasion he became distracted enough to concentrate on the business of cargo discharge first, leaving the shutdown of the hydraulic pumps until later. That he remained aware of this outstanding action is confirmed by the fact that once the cargo discharge was flowing successfully, he handed over the CCR watch to the first officer, and then returned to the bridge to rectify his omission.

This shutdown procedure has subsequently been included as a stated operational requirement in a new *Bridge Mooring Check List Tetney - Item No 13,* issued as a result of this incident. Similarly, switching rudder control from DP to manual has also been included as *Item 14* in the new bridge checklist.

The actions of the master and crew in response to the incident were prompt, professional, and followed agreed company procedures.

2.5 OWNER'S INVESTIGATION

2.5.1 The investigation carried out by the Root Cause Failure Analysis Team was thorough, and included both physical examination and testing of the chain stopper and system, as well as extensive interviewing of various personnel who were involved in the incident.

The report originally supplied to the MAIB contained considerable information about the circumstances of the incident and the team's conclusions as to the cause. The suggested explanation for the accidental opening of the chain stopper, and the sequence of events that followed, were fully recorded. No reference was made to any crew involvement, as this did not form part of Conoco's " Root Cause Failure Analysis Report".

This omission was rectified later, with copies of crew statements and further details as to their actions, and the individuals most likely to have been involved, being made available.

2.5.2 With the possible exception of No 5, all of the recommendations arising from the owner's/terminal investigation should already be covered under the ISM Code of Practice.

As will be seen under "Objectives", paragraph 1.2.2:
Safety management objectives of the Company should be:

.1 provide for safe practices in ship operation and a safe working environment;
.2 establish safeguards against all identified risks; and
.3 continuously improve safety-management skills of personnel ashore and aboard ships, including preparing for emergencies related both to safety and environmental protection.

Also under "Objectives", is paragraph 1.4:

Every company should develop, implement and maintain a Safety Management System (SMS) which includes the following functional requirements:

.1 a safety and environmental protection policy;
.2 instructions and procedures to ensure safe operation of ships and protection of the environment in compliance with relevant international and flag state legislation;

.3 defined levels of authority and lines of communication between, and amongst, shore and ship board personnel;
.4 procedures for reporting accidents and non-conformities with provisions;
.5 procedures to prepare and respond to emergency situations; and
.6 procedures for internal audits and management reviews.

In the context of this accident, these extracts from the objectives form the basis from which corrective measures to both procedures, and system engineering, should flow.

2.6 OTHER COMMENTS

2.6.1 One of the key requirements of a control station is that it, together with the equipment within it, should be ergonomically designed to minimise the risk of error during operation. The current system, whereby the same function key controls two different but interrelated systems, depending on what screen level is selected, is not good practice.

Entering or leaving harbour, followed immediately by cargo loading or discharge, demands a high level of concentration by the crew on both the technical and commercial sides of the operations. It is especially important during these periods of high workloads, and varying stress levels, that operational systems are both as simple as possible, and reliable.

The chain stopper itself is both simple and reliable, but at the time of the incident the control system contained three weak points:

1. The same function key operated two differing, but critically interrelated, control actions depending on what screen was displayed at the time.

2. The system did not contain a chain stopper operating aural alarm, nor a visual alarm indicator on the mooring tension indicators fitted on the bridge panel.

3. Visual inspection, by personnel, of the chafing chain within the chain stopper, was not considered possible because of perceived safety concerns, yet was included in monitoring routines.

Regarding the first point, although an additional acknowledgement prompt could be programmed in, a completely separate display screen and set of function keys would significantly reduce the chances of such an event occurring again. The second point would require a suitable modification to the bridge control panel, and should incorporate both visual and aural alarms.

The third point requires further study, either to provide an additional viewing point aft of the chain stopper but high enough to enable sight of the chafing chain and pickup rope, or to provide a chain stopper camera. Failure of the latter, however, could result in the same difficulty in visual monitoring of the chain stopper.

2.6.2 The owner's investigative team has made certain recommendations based on its analysis of the incident as outlined in paragraph 1.8.3. These recommendations identify similar concerns to those listed above, as well as drawing attention to human factor considerations in the bridge management system.

The report failed however to identify when, and how, the chain stopper was accidentally operated. It was pointed out that, although the manufacturers were under the impression that a protective cover was fitted over the function key panel, one had not been fitted. The accidental operation of a key, which just happened to be the critical one, followed by the immediate operation of the correct one to counteract the first accidental operation, requires an intimate knowledge of the system. It also follows that if the first action had been carried out by accidentally leaning on, putting a book down on keys etc, possibly there would have been a lengthy period before the person became aware of what had happened. By then, a full screen colour change would have occurred, and it should have been obvious to anyone on the bridge that something had changed.

It has to be considered that the chief officer might have operated F9 accidentally when he returned to the bridge between 0415 and 0430 to shut down the hydraulic pumps forward. By then he had been on duty for some time. He was up and around during the evening of 19 December so as to be ready for arrival, and was in attendance well before the pilot was picked up at 2227. By 0415 on 20 December, he would be suffering from the combined effects of fatigue and the low point in mental alertness due to the early hours. It is during these low points that mistakes are likely to be made. The mistake is recognised almost immediately, and corrections applied; but the actions have been put into motion. In this case, if this had been done, the system would have responded and shown an apparently reversed error. Such would be the relief at retrieving the situation that the transfer of the tension reading, from the chain stopper to the traction winch, would not have been noticed.

2.6.3 Tiredness is increasingly recognised as a major contributor to errors, and it can often only be countered on a case by case basis. In this incident, the fact that the chief officer was unsure if the chain stopper was in the locked or "green" condition when he approached the control panel, suggests that his recollection of events three days later was still clouded. With the system as installed, it would have been easy to make a mistake when in a fatigued state and at a point of low concentration. With suitable modifications to the system, plus the revised standing orders, the likelihood of a similar situation developing will be significantly reduced.

2.6.4 The master raises the point that during the early part of the emergency, he was unaware of what action the berthing masters had taken in response to the oil spillage. Although it can be argued that he should have been fully aware after studying the terminal regulations of what was likely to happen, there does seem to have been a breakdown in communication between the berthing masters and the master.

Although both parties have their own and distinct responsibilities, it is important that both are kept informed of what is going on, particularly when differing vessels are manoeuvring within the confines of a monobuoy and anchorage area. This apparent lack of aural communication between parties on the bridge can very easily lead to indecision and disputes as to who is in command of the situation at any one time. Both the terminal management, and vessel owners/managers, should consider this point carefully.

SECTION 3 - CONCLUSIONS

3.1 FINDINGS

1. The loss of the monobuoy mooring line was caused by a temporary opening of the chain stopper and the movement of the chafing chain to a position forward of the chain stopper assembly. Once the chain had moved forward the mooring connection to the buoy was through the pickup rope on to the traction winch. [2.2.1]

2. The chain stopper assembly and its control system were fully operational at all times. No system defects were found. [2.2.1]

3. Two technical operations involving bridge controls were operated during the time between the start of the discharge process and rupture of the hoses. This covered a period between 0245 and 0753. These were the starting of the steering gear system and the stopping of the hydraulic pump system forward. [2.2.2]

4. With the control panel for the steering gear physically separate from that which contains the forward hydraulic pump and chain stopper controls, shutting down the steering system by the first officer would not change the condition of the mooring arrangements. [2.2.2]

5. Like many other computer systems, the bridge monitor has been installed with a multi-functional screen system, ie No 1 screen will show a number of differing controls and systems, some of which can be operated using the function keys F1, F2, etc. When switched to No 2 screen, a different set of systems and controls will be displayed, but using the same set of function keys, F1, F2, etc.

For example;	SCREEN 1	chain stopper open	F9	
	SCREEN 2	hydraulic pump No 1 off	F9	[1.6.4]

6. To turn the hydraulic pumps off calls for the operation of five function keys; actions which would require the operator to maintain eye contact with the screen. [2.2.3]

7. If F9 was pressed when the operating screen for the chain stopper was still in place, the background screen colour of green would change to yellow and then white. The full colour change would take about 5 to 6 seconds. [2.2.3]

8. The chain stopper claw will have opened sufficiently to allow movement of the chafing chain within 2 to 3 seconds of the start. Allowing for a system change delay of about 1 to 2 seconds, any immediate error correction is unlikely to prevent the claw opening enough to allow chain slippage. Allowing for the slackness in the pickup rope, there would be a forward movement of about 2 to 3 metres. This would be sufficient for the chafing chain to pull clear of chain stopper. [2.2.3]

9. When, or by whom, function key F9 was accidentally depressed cannot be established with certainty but, once operated, the chain stopper would immediately start to open and the screen would change colour. Immediate correction would stop the opening process, reclose the chain stopper, and cause the screen to revert to the green colour. This would indicate the chain stopper had closed, allowing an assumption to be made that no harm had been done and all was well. The only change on the bridge mooring tension meters would be that the tension reading would be on the traction winch and not on the chain stopper. [2.2.3]

10. The AB, who had been patrolling the deck at half hourly intervals from 0500 until 0735, states that during this time the chafing chain was in place. It is known that he stood by the crane, but it is not known whether he was on the forecastle or the platform decks. The view from the forecastle deck will be restricted, and it is unlikely that the presence of the chafing chain within the stopper could be seen. From the platform deck, the position of the chafing chain and the pickup rope could be seen. [2.2.5]

11. The terminal staff's response to the break out was immediate, professional, and followed standard procedure. These actions were in line with the Tetney Oil terminal, Emergency Procedures, Section 13.5 and 13.7. [2.3.1]

12. The weather conditions, under which *Randgrid* was discharging, were within the basic design operating conditions for the monobuoy. [2.3.2]

13. The actions of the master and crew in response to the incident were prompt, professional, and followed agreed company procedures. [2.5.1]

14. The investigation carried out by the owner's Root Cause Failure Analysis Team was thorough, and included both physical examination and testing of the chain stopper and system, as well as extensive interviewing of various personnel who were involved in the incident. [2.5.1]

15. One of the key requirements of a control station is that it, together with the equipment within it, is ergonomically designed to minimise the risk of error during operation. The current system whereby the same function key controls two different but interrelated systems, depending on what screen level is selected, is not good practice. [2.6.1]

16. The chain stopper itself is both simple and reliable, but at the time of the incident the control system contained three weak points:

    1. The same function key operated two differing but critically interrelated control actions depending on what screen was displayed at the time.

2. The system did not contain a chain stopper operating aural alarm nor a visual alarm indicator on the mooring tension indicators fitted on the bridge panel.

3. Visual inspection, by personnel, of the chafing chain within the chain stopper, was not considered possible because of perceived safety concerns, yet was included in monitoring routines. [2.6.1]

3.2 CAUSE OF MOORING FAILURE

The cause of the mooring failure was the lashing, securing the chafing chain to the pickup rope, chafing on the structure of the chain stopper. This led to the failure of the connection between chafing chain and pickup rope. The chafing was caused by movement of the vessel under the influence of wind and tide. [2.2.1]

3.3 CONTRIBUTORY CAUSES

1. A major contributory cause was the accidental and momentary opening of the chain stopper, some time between 0350 and failure at 0753. This allowed the chafing chain to be pulled forward out of the chain stopper, which left the vessel moored by the pickup rope to the traction winch. [2.2.1]

2. The use of a system using a multi-functional screen requiring the use of the same function key to operate two differing but critically interrelated control actions, depending on what screen was displayed at the time. [2.6.1]

3. The system not containing a chain stopper operating aural alarm nor a visual alarm indicator on the mooring tension indicators fitted on the bridge panel. [2.6.1]

4. Visual inspection, by personnel, of the chafing chain within the chain stopper, not considered possible because of perceived safety concerns, although included in monitoring routines. [2.2.5]

5. The possibility that the chief officer accidentally operated F9 while in the wrong screen mode, caused by the effects of fatigue when at a low point in his concentration. [2.6.2]

SECTION 4 - RECOMMENDATIONS

Conoco Shipping Norge, with respect to *Randgrid* is recommended to:

1. Review the current bridge control system of the chain stopper whereby a multi-functional screen uses the same function key to operate two differing, but critically interrelated, control actions. The object of the review being to ensure that there is positive separation between the two systems such that the likelihood of a similar error is either removed or significantly reduced.

2. Fit a chain stopper operating aural and/or visual alarm on the mooring tension indicators fitted on the bridge panel.

3. Install an additional viewing point aft of the chain stopper assembly, but high enough to enable a watchkeeper to sight the chafing chain and pickup rope.

4. Review the SMS operating on board *Randgrid* to ensure that the system complies with, and contains, all the functional requirements for effective and safe operation of the Code. Particular reference should be made to establish authority and communication between ship and shore during an emergency.

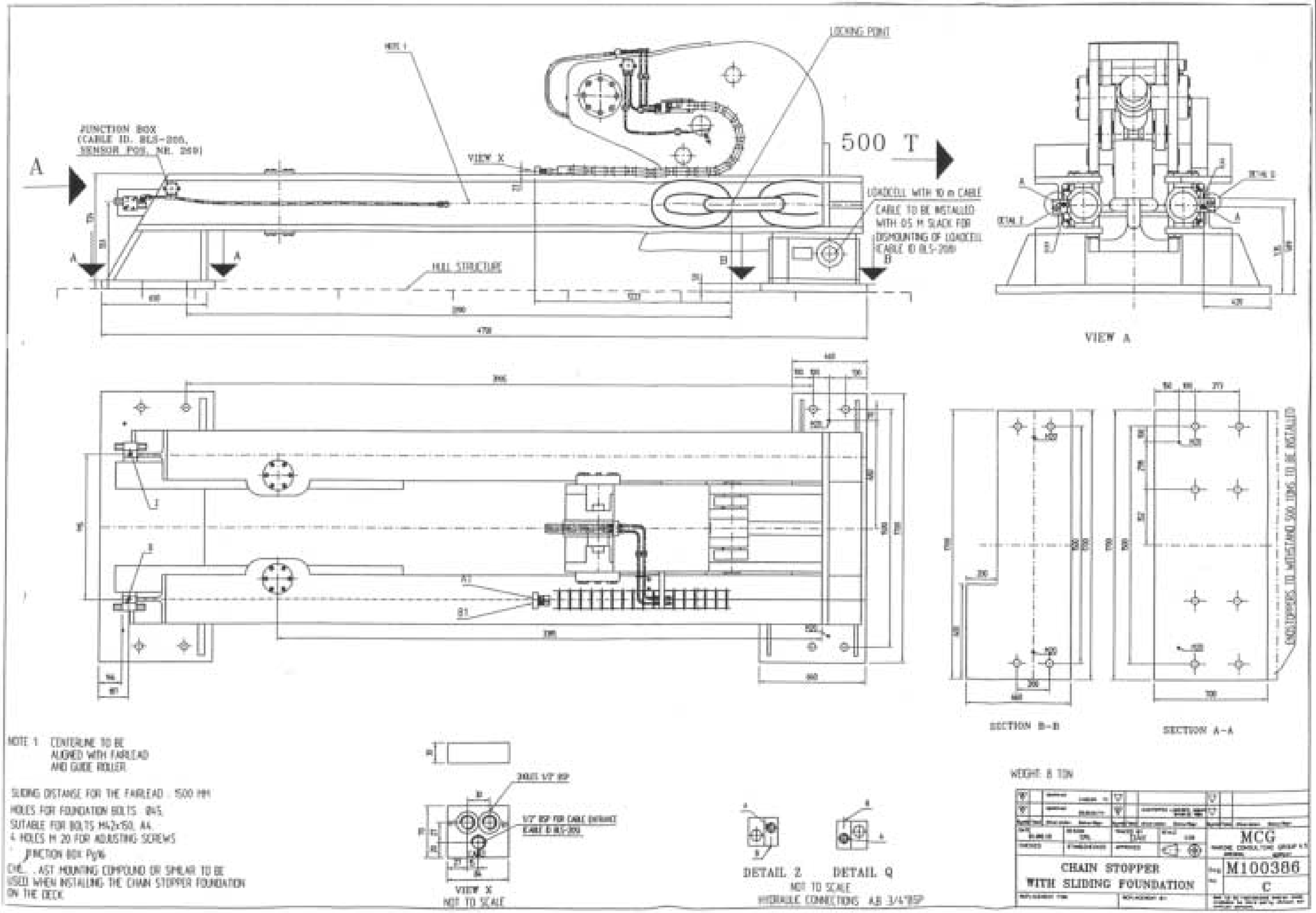
Conoco Ltd, Tetney Oil Terminal is recommended to:

5. Review current practices regarding onboard liaison between ship masters and berthing masters, to ensure that both parties are fully aware of each other's responsibilities, and that a full and open dialogue is maintained at all times between the two parties.

Marine Accident Investigation Branch
February 2002

ANNEX 1

Drawing of chain stopper assembly



NOTE 1 CENTERLINE TO BE ALIGNED WITH FAIRLEAD AND GUIDE ROLLER.

SLIDING DISTANSE FOR THE FAIRLEAD : 1500 MM

HOLES FOR FOUNDATION BOLTS Ø45, SUTABLE FOR BOLTS M42x150, A4.

4 HOLES M 20 FOR ADJUSTING SCREWS

JUNCTION BOX Pg16

CHE... AST MOUNTING COMPOUND OR SIMILAR TO BE USED WHEN INSTALLING THE CHAIN STOPPER FOUNDATION ON THE DECK

ANNEX 2

Copies of company standing orders issued after the event

conoco

DE/T "Randgrid"

PROCEDURES

Rev.no.:	2	Rev.date:	28.02.01	Issued by:	SEC/OSH	Approved by:	SMT
Implemented:	23.01.01	References:	Investigation team Tetney incident 20.12.00			Page:	1
Dockument Title:	**Master's Standing Tetney Orders**						

Voyage No: _________ **Date:**____________ **Time:**___________

Without exception in emergency, call Master (phone 25) and / or On Duty Officer in CCR (phone 61).

1. No bridge system to be operated unless authorized by Master.
2. Bridge area and instruments tagged out should not be entered or operated without permission from master.
3. No silencing / acknowledgment of alarms on bridge unless specifically insructed by Master or by duty officer.
4. Communication between bridge and CCR at all times on VHF / UHF____and Telephone no. 61.
5. **CCR: 61 - Captain: 25 - ECR: 24 - Emergency sound telephone.**
6. Rudder to be operated after general instruction by master or duty deck officer.
7. Engine (one PM) is ready at all time and can instantly be switched to bridge control. Call ECR (phone 24) to switch to bridge control. *(Do not switch to bridge control without master's knowledge).*
8. In case of abnormal or sudden weather change, position problems or all other problem which might require masters attention, do not hesitate to call master on phone 25.
9. Master is responsible for the vessel's safety according to Tetney Safety Booklet and international law. Pilot and berthing master roles and responsibilty onboard is described in same booklet.

Ship crew and Tetney personnel must follow internal instruction as stated and at all times be in compliance with instructions in Tetney Terminal Safety Booklet. Violation from these instruction should be reported master and berhting master without delay.

Roles, responsibilty and communication is herby understood and "Master's standing Tetney Orders" is read and understood by all undersigned persons.

Master   Chief Officer   1st. Officer   2nd. Officer

Pilot 1   Pilot 2   Berthing master 1   Berthing master 2

conoco

DE/T "Randgrid"
PROCEDURES

Rev.no.:	3	Rev.date:	16.03.01	Issued by:	SEC/OSH	Approved by:	SMT
Implemented:	23.01.01	References:	Investigation team Tetney incident 20.12.00			Page:	1
Dockument Title:	**Bridge Mooring Check List Tetney**						

Voyage No: __________ **Date:**_____________ **Time:**__________

No.	Tag.	Check Points
1		Start three hydraulic pumps.
2		Select BLS Mode on the MCG panel from the sub menu. Make sure that "No Mode" is not activated.
3		Make sure that the forrunner is run through the traction winch, the chain stopper and led down to the port side of the forcastle with sufficient slack.
4		Make sure that the hose in position signal is dis-engaged and the "test flange" is off and the coupler claws are open (BLS manifold)
5		Test run the chain stopper open - close – open
6		Check communication UHF / VHF internal and external, ship's officer on forcastle, BM on forcastle, Spurnhaven and the tug aft.
7		Line up Camera: Camera 16 on Monitor 6, C 03 on M 7 and C 12 on M 8
8		Line up PC logger for BLS loading. (Not working proper on Randgrid and Hitech is working with a modification. Tetney terminal logging during discharging.)
9		Arrival check list ready
10		Engine check list ready
11		When the chain is in position and the chain stopper is closed, Make sure the hose in posion is engaged and replace the "test flange" and close the coupler claws (BLS manifold). Recommended by Navion.
12		Slack off traction winch / mooring line
13		Shut down all three hydraulic pumps and leave the MCG panel in the main menu
14		Switch control from DP to Manual mode
15		Stop main engine and thrusters
16		Tag out Hitech panel
17		Tag out port bridge off-shore panels and mount the sign "Autorized Personnel Only".
18		Make sure that the BM/pilots and officers have checked out and signed Master's Standing Tetney Orders

MASTER SIGNATURE: **CHIEF OFFICER SIGNATUR:**

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DE/T "Randgrid"

PROCEDURES

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Implemented:	04.01.01	References:				Page:	1-1
Dockument Title:	CHECK LIST ARRIVAL/DEPARTURE HARBOUR						

ARRIVAL / DEPARTURE PORT: DATE : TIME:

1	Check inert gas pressure minimum 250 mm	
2	Check level/temperature on fuel day tanks	
3	Check pumps in stand-by	
4	Check correct temperature on high pressure freshwater main generator	
5	Start forward seawater cooling pumps	
6	SIMRAD-AVM: *All alarms signed out. *Both net-systems in order (A+B) *Check system status. *Printer for alarmmessages on	
7	Minimum one main generator in stand-by	
8	All lateral propellers in "ATC" mode	
9	Evaporators shut down in closed water	
10	Emergency Gen. and Port Use Gen. in stand-by	
11	Firepumps ready for use	
12	Check communication to bridge, telephone , VHF and em'cy telephone	
13	Visual check of steering engine	
14	Boiler: Heating control in auto position	
15	Seawater inlet: Low suction on ballasted voyage HIGH suction when arrival TETNEY	
16	Before discharging: Check O2 meter and the photo cells	
17	Before departure: Check correct seal-tank for outher sleeve bearing	
18	Test steering gear from bridge and enter this test in Engine Log Book.	
19	When completed this checklist – make a notice in Engine Log Book	

DUTY ENGINEER: CHIEF ENGINEER:

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PROCEDURES

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Dockument Title:

ENGINE PROCEDURES TETNEY

DUTY ENGINEER & DUTY SHIP MECK.

DATE: TIME:

1	CHECK THAT "SEA WATER SUCTION" IS ON **HIGH SUCTION**	
2	**TWO MAIN GENERATORS** HAS TO BE IN SERVICE DURING DISCHARGEING	
3	**ONE MAIN GENERATOR** TO BE IN ST.BY MODE	
4	**ALL AUX. MACINERY** ON THE PM'S RUNNING	
5	CHECK THAT THE VALVE "**SERVICE -AIR TO DECK**" IS IN OPEN POSSISON	
6	CHECK **UHF COMMUNICATION,** (LISTENING TO THE MESSAGE GIVEN ON THE UHF)	
7	DUTY ENGINEER HAS TO BE IN THE **ENGINE CONTROL-ROOM**	
8	DUTY SHIP MECK TO CARRYING OUT THE ROUTINE IN ENGINE ROOM	
9	IF DUTY MATE / MASTER GIVE ORDER TO START UP, **ONE PM IS STARTED** AT ONCE AND THE OTHER AS SOON AS NECESSARY MGE IS CONNECTED TO THE MSB	
10	THRUSTHERS CAN BE **STARTED DIRECT** IN AN EMERGENCY SITUATION	
11	CHIEF ENGINEER AND/OR ELECTICIAN TO BE NOTIFIED DIRECT	
12	IF DUTY ENGINEER HAS TO LEAVE THE ECR, CH.ENG. TO BE NOTYFIED	
13	IF AN ALARM SITUATION OCCUR, CONTACT CH.ENG. OR ELECTR.	
14	IF, **ONE MAIN GENERATOR FOR** SOME REASON NOT IS AVAILABLE, CH.ENG. TO BE NOTIFIED	

Engine officer on duty: ____________________ Ship. meck on duty: ____________________.

CHIEF ENGINEER SIGNATURE: