Marine Safety Investigation Unit

Transport Malta

MARINE SAFETY INVESTIGATION REPORT

Safety investigation into the over-pressurisation of a cargo tank on board the Maltese registered chemical tanker

UMAR 1

in Fos sur Mer, France

on 19 October 2013

201310/016

MARINE SAFETY INVESTIGATION REPORT NO. 27/2014

FINAL

Investigations into marine casualties are conducted under the provisions of the Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011 and therefore in accordance with Regulation XI-I/6 of the International Convention for the Safety of Life at Sea (SOLAS), and Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009, establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council.

This safety investigation report is not written, in terms of content and style, with litigation in mind and pursuant to Regulation 13(7) of the Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011, shall be inadmissible in any judicial proceedings whose purpose or one of whose purposes is to attribute or apportion liability or blame, unless, under prescribed conditions, a Court determines otherwise.

The objective of this safety investigation report is precautionary and seeks to avoid a repeat occurrence through an understanding of the events of 19 October 2013. Its sole purpose is confined to the promulgation of safety lessons and therefore may be misleading if used for other purposes.

The findings of the safety investigation are not binding on any party and the conclusions reached and recommendations made shall in no case create a presumption of liability (criminal and/or civil) or blame. It should be therefore noted that the content of this safety investigation report does not constitute legal advice in any way and should not be construed as such.

MARINE SAFETY INVESTIGATION UNIT
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LIST OF REFERENCES AND SOURCES OF INFORMATION

Master and crew members MT *Umar 1*

Managers of MT *Umar 1*

Topsafe Co. Ltd.

Topsafe (2006). Instruction Manual for High Velocity Vent & Vacuum Relief Valve. Korea: Author

GLOSSARY OF TERMS AND ABBREVIATIONS

FAME	Fatty Acid Methyl Ester
GT	Gross tonnage
IMO	International Maritime Organization
kW	Kilowatt
m	Metres
m^3	Cubic metres
mbar	Millibars
mm	Millimetres
mmWg	Millilitres of water gauge
m^3hr^{-1}	Cubic metres per hour
MT	Motor tanker
MTBE	Methyl Tertiary Butyl Ether
NOR	Notice of Readiness
PV valves	Pressure/vacuum relief valves
RPM	Revolutions per Minute
SOLAS	The International Convention for the Safety of Life at Sea, 1974, as amended
Type II chemical tanker	A chemical tanker intended to transport Chapter 17 products with appreciably severe environmental and safety hazards which require significant preventive measures to preclude an escape of such cargo
Type III chemical tanker	A chemical tanker intended to transport Chapter 17 products with sufficiently severe environmental and safety hazards which require a moderate degree of containment to increase survival capability in a damaged condition.

SUMMARY

On 19 October 2013, the Marine Safety Investigation Unit was informed of an accident on board the Maltese registered chemical tanker *Umar 1* at Fos sur Mer, France. Preliminary information indicated over-pressurisation of one of the vessel's cargo tanks during loading of Methyl Tertiary Butyl Ether. The accident resulted in significant structural damage in way of the vessel's cargo length area.

The safety investigation identified a number of contributing factors which led to the accident. At the time, the pressure/vacuum valves were not operating as designed. Moreover, there were no pressure gauges fitted locally on the main deck for the duty crew member to check the pressure inside the cargo tank. Remotely, inside the cargo room, the audible pressure alarm had been muted and a loading rate in excess of the cargo tank designed rate was not addressed.

The safety investigation also concluded that in a complex dynamic environment, hazards during the cargo loading operations went undetected by the crew members.

As a result of the safety investigation, the Marine Safety Investigation Unit has made one safety recommendation to the PV valve manufacturers to issue an alert to their clients, notifying them of the potential hazards, should the check lift lever be left permanently fitted to the valve tops.

No recommendations have been made to the ISM managers due to the safety actions already taken as a result of the accident. One recommendation was made to Topsafe Co. Ltd. to alert its clients on the importance of removing the check lift lever from the lifting bush immediately after the opening test is carried out.

1 FACTUAL INFORMATION

1.1 Vessel, Voyage and Marine Casualty Particulars

Name	*Umar 1*
Flag	Malta
Classification Society	Bureau Veritas
IMO Number	9521411
Type	Chemical / Oil Tanker
Registered Owner	United Mariners Corporation
Managers	Chemfleet
Construction	Steel (Double hull)
Length overall	96.75 m
Registered Length	96.75 m
Gross Tonnage	3280
Minimum Safe Manning	13 (11 UMS notation)
Authorised Cargo	Liquid in bulk
Port of Departure	Port La Nouvelle, France
Port of Arrival	Fos sur Mer, France
Type of Voyage	Coastal
Cargo Information	Not Applicable
Manning	14
Date and Time	19 October 2013 at 0540
Type of Marine Casualty	Serious Marine Casualty
Place on Board	Ship – Cargo tanks
Injuries/Fatalities	None
Damage/Environmental Impact	No environmental impact was reported. However, the vessel sustained structural damages in way of her cargo length area.
Ship Operation	Normal Service – Alongside
Voyage Segment	Arrival - Moored
External & Internal Environment	Southeasterly wind force 5 and calm seas. Weather was overcast with an air temperature of 15°C.
Persons on Board	15

1.2 Description of Vessel

Umar 1, a 3280gt Type II chemical /oil tanker was built in 2010 and is registered in Malta. She is owned by United Mariners Corporation, managed by Chemfleet, Turkey and classed with Bureau Veritas. The vessel has an overall length of 96.75 m and a beam of 15.00 m.

The vessel is fitted with segregated ballast tanks and its cargo tank area is divided into twelve cargo tanks, arranged in six pairs by means of longitudinal and transverse corrugated bulkheads. The total volumetric capacity is 5021.0 m^3 (at 98% filling). All cargo tanks are fitted with stainless steel heating coils. *Umar 1* is also fitted with designated slop tanks (total capacity is 138 m^3). A nitrogen inert gas system is also fitted on board for inerting the cargo tanks.

The design of the cargo manifold system is such that it allows for the carriage of 13 different cargo grades. The vessel was designed for closed loading and had a vapour recovery system installed. Each cargo tank had a separate electrical driven deepwell pump[1] with a capacity of 150 m^3hr^{-1}.

Figure 1: MT *Umar 1*

[1] *Vide* section 1.3.

Propulsive power is provided by an eight-cylinder MAN B&W 8L28/32A, medium speed, four-stroke, single acting internal combustion diesel engine, developing 1,960 kW at 775 rpm. The engine drives a variable pitch propeller through a reduction gearbox, giving a service speed of 14.0 knots.

1.3 Cargo Tank Equipment

Each cargo tank was fitted with the following:

i. a Hamworthy electric driven deepwell pump rated at 150 m^3hr^{-1} (Figure 2) and cargo tank loading and discharge valves remotely operated from the bridge cargo control panel;

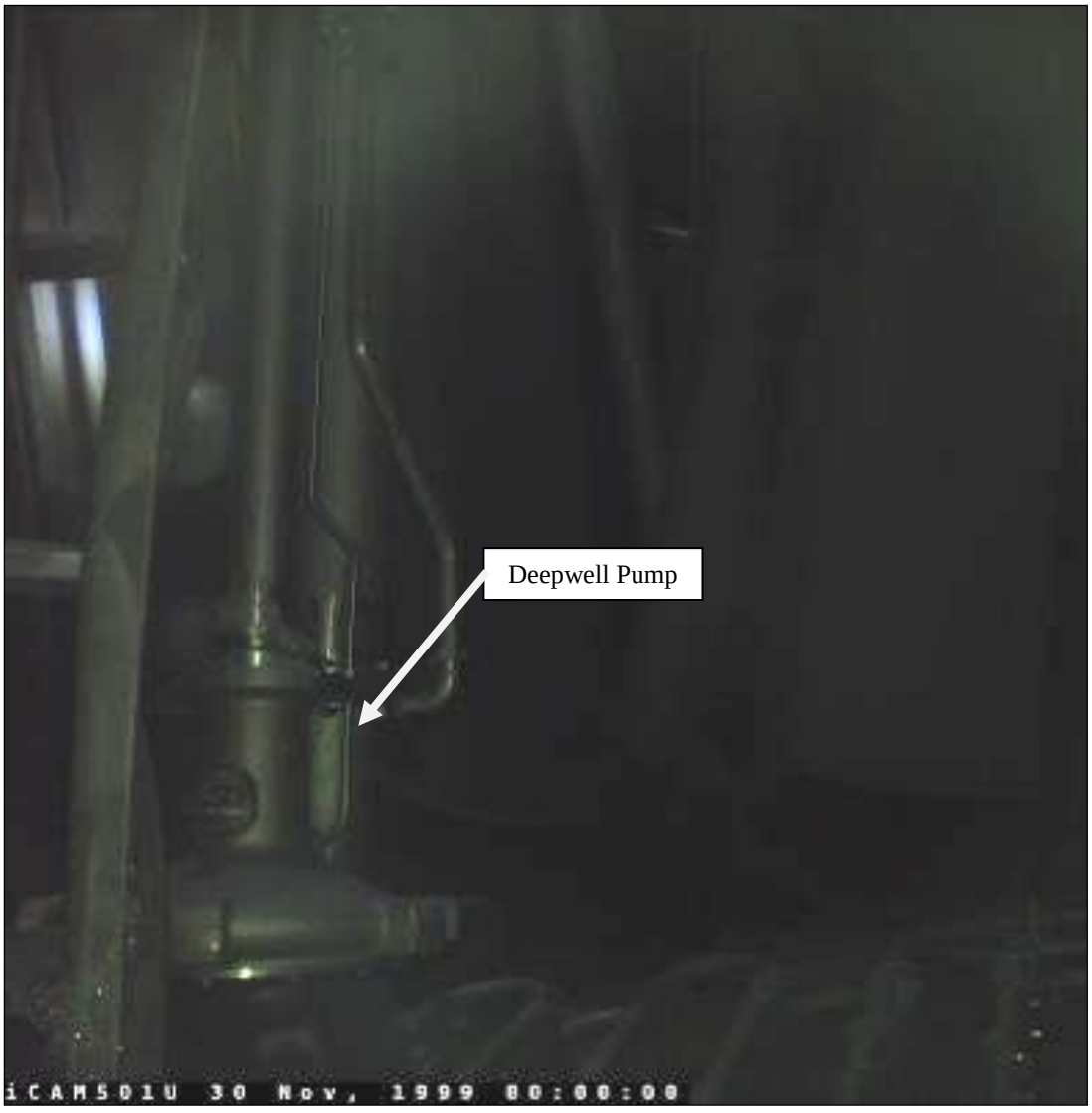


Figure 2: A deepwell pump in one of the cargo tanks

ii. Unitech[2], high velocity vent and vacuum relief valve (Figures 3a, 3b and 3c) connected by piping directly to the hatch coaming and also connected to a common vent line via the isolation valves. The pressure/vacuum (PV) valves were positioned as two main clusters on the centre line of the main deck next to the catwalk[3];

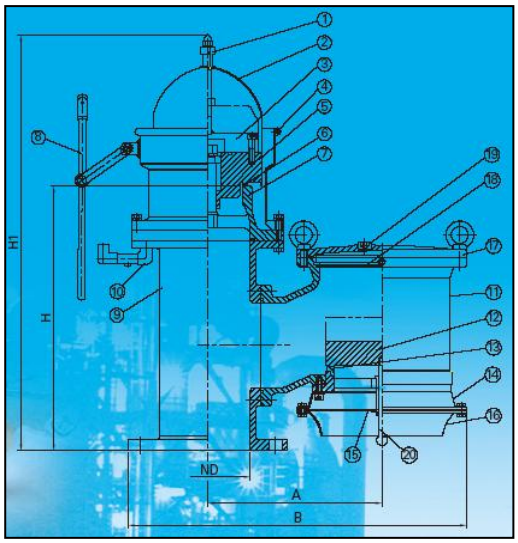


Figure 3a and 3b: The Topsafe PV valves fitted *Umar 1*

Figure 3c: PV valves fitted on the main deck

[2] Now 'Topsafe'.

[3] The PV valves fitted on the vessel were approved for crude oil products and IMO Type II and Type III chemical tankers. The function of the PV valves is to protect the cargo tanks. Cargo tanks may be subjected to gas/vapour pressure or vacuum outside their design parameters during cargo loading, discharge, ballasting and thermal variations. The PV valves were the primary means of venting the cargo tank. The venting of each cargo tank could either be independent or connected to a common venting line for vapour return ashore.

iii. a back-up pressure alarm sensor in each cargo tank, manufactured by Enraf Marine Systems and connected to the bridge loading computer;

iv. a cargo tank gauging system with two high level and two low level alarms, interfaced with the bridge loading computer (Figure 4); and

v. cargo and ballast tank valves, which could be remotely operated from the bridge (Figure 5).

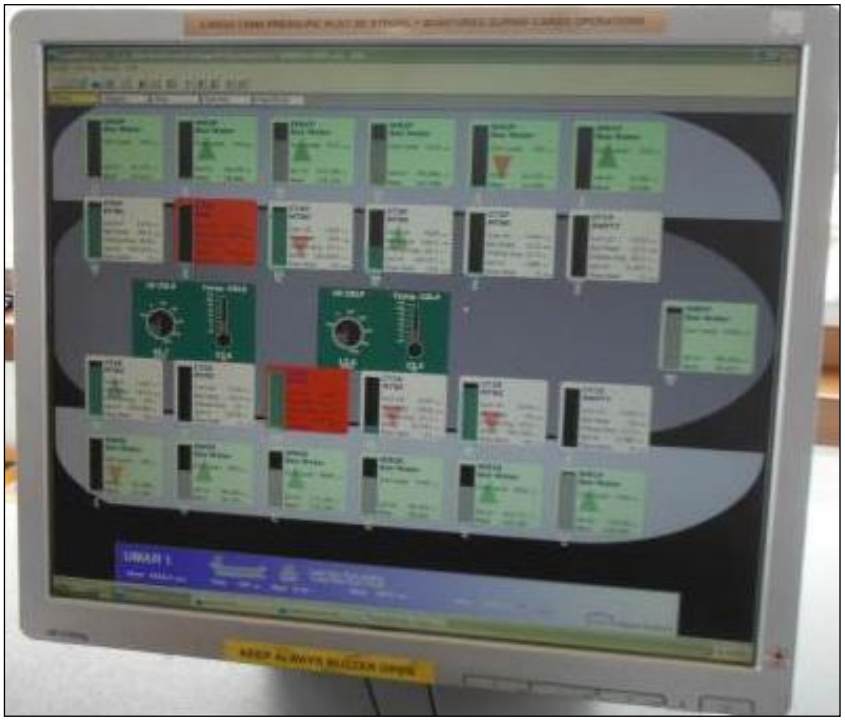


Figure 4: Loading computer

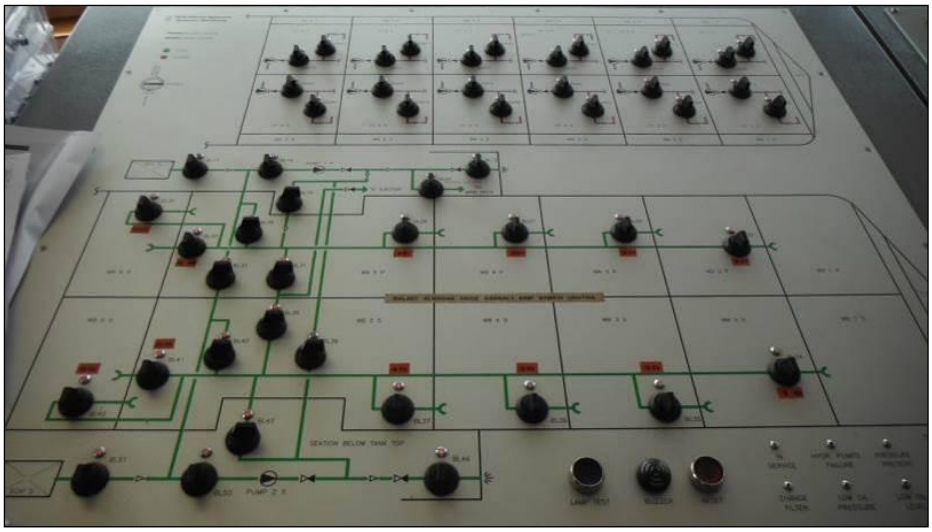


Figure 5: Cargo and ballast tanks remote operation of valves

Umar 1 was equipped in accordance with SOLAS regulation II-2/11.6. As already stated, the system fitted on *Umar 1* was Unitech PV valves as the primary means for pressure/vacuum relief. Cargo tank pressure sensors served as the alternative secondary means[4]. The sensors would trigger an alarm on the cargo control room computer situated on the bridge, where the deck officers maintained their cargo watch (Figure 6).

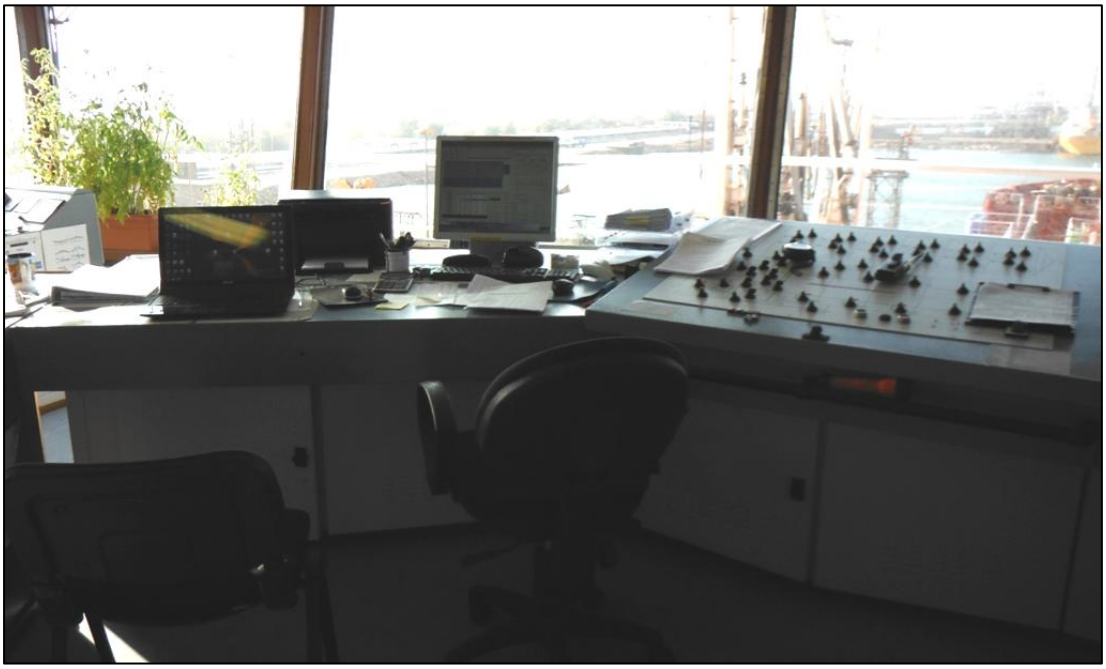


Figure 6: Cargo control room on the bridge

1.4 Manning

The vessel was manned by a crew of 14 persons, all Turkish nationals.

The ship's officer compliment consisted of the master, the chief mate, two deck officers, the chief engineer and the second engineer. In addition, there were six deck and engine-room ratings and two hotel crew members.

[4] SOLAS regulation II-2/11.6.3.2 requires a secondary means of allowing full flow relief of vapour, air, or inert gas, in the event that the primary arrangement failed, or alternatively, the regulation allows for pressure sensors, which may be fitted to each cargo tank, with their outputs routed to a monitoring system in the cargo control room to provide an alarm in the event of over / under pressure condition.

The master had about 12 years sea service, of which 9 years were served on tankers. He had spent about three years as a master and two years with the Company. At the time of the accident, he had been on board *Umar 1* for about three months.

The chief mate had been at sea for about seven years, of which five years were served on tankers. He had spent about two years as chief mate and had been with the Company for the past three years. At the time of the accident, he had been on board *Umar 1* for about one month.

The second mate had about four years sea service, all served with the Company. He had been working on tankers for about three years and had been serving as a second mate for six months. At the time of the accident, he had been on board *Umar 1* for less than a month.

The rating on duty had 30 years sea service, six years of which were on tankers. This was his first voyage with the Company and he had been on board for about a month.

1.5 Loading & Discharging - Plan & Standing Orders: Form 2902

The chief mate prepared and completed the 'Loading & Discharging - Plan & Standing Orders': Form 2902 dated 18 October 2013 for Berth 0 Bis, Fos sur Mer [**Annex A**]. The Form detailed the duties of the deck officer, prior loading/discharging checks, cargo disposition and loading plan, ballasting operations, standing orders, details of the cargo to be loaded and any ship/shore interface requirements.

Form 2902, which was written in English and Turkish, required the checking of various pieces of cargo equipment, including the PV valves. The standing orders required the OOW to call the chief mate, if in doubt.

The Form had been signed by the master, the chief mate, the two deck officers and the duty ratings.

1.6 Hours of Work

There were sufficient officers and ratings on board to safely maintain the required bridge and deck watches during cargo tank preparations as well as during the loading operations. There did not appear to be any concerns with the hours of work recorded and fatigue did not appear to be an issue in the cause of the accident.

1.7 Drug and Alcohol Testing

The Company operated a zero alcohol policy. A post accident alcohol test indicated negative results.

1.8 Narrative

On 18 October at 2300, *Umar 1* berthed portside alongside at Fos sur Mer, France to load a cargo of Methyl Tertiary Butyl Ether (MTBE), having just completed cargo tank cleaning operations from a previous cargo of Fatty Acid Methyl Ester (FAME).

At 2340, her cargo tanks were accepted for loading by the Terminal and then purged with nitrogen. The loading arm was connected at 0001 on 19 October 2013 to a common ship's manifold. The Notice of Readiness (NOR) was received by the Terminal.

Umar 1 commenced loading at 0055 into cargo tanks nos. 2 port and starboard, and cargo tanks nos. 6 port and starboard. The initial agreed loading rate was 100 m^3hr^{-1}. The maximum loading rate per cargo tank was stated as being 200 m^3hr^{-1}. Eventually, the loading rate was increased to the shore rate of 560 m^3hr^{-1}, although the vessel had initially requested a rate of 800 m^3hr^{-1}.

When cargo tanks nos. 6 port and starboard reached the 90% level, loading was transferred to cargo tanks nos. 3 port and starboard and then continued in cargo tanks nos. 2 port and starboard. The duty officer, who was monitoring the ullages of the cargo tanks on the loading computer on the bridge, requested the duty deck watchman on the main deck to adjust the manifold drop valves into cargo tanks nos. 3 port and starboard so as to restrict their loading rate and to increase the loading rate into cargo

tanks nos. 2 port and starboard. However, cargo tank no. 2 port ullages still appeared to be fairly static, indicating a much slower loading rate.

Loading in cargo tank no. 2 starboard was completed at about 0525 and the loading valve was closed. Cargo loading continued into cargo tank no. 2 port, with the loading valve fully open, and the loading valves for cargo tanks nos. 3 port and starboard kept half closed.

At about 0540, a loud noise/bang was heard coming from the fore deck. Spray was also sighted forward by the bridge team. The duty deck watchman went forward to investigate. A few minutes after the explosion, the chief mate and the master ascended to the bridge to investigate the matter. The chief mate noticed a change in the cargo disposition displayed on the loading computer. The vessel was not upright any longer. The chief mate therefore requested the Terminal to stop all cargo operations.

The chief mate noticed that there was cargo in cargo tank no. 1 port, which was supposed to be empty. Moreover, a deck inspection indicated structural damage to the main deck between cargo tanks no. 1 port and no. 2 port, in way of the transverse bulkhead. The main deck in way of cargo tank no. 2 port had domed.

After ensuring that the main deck was safe, and after checking all the cargo tanks, cargo was transferred from cargo tanks no. 1 port and no. 2 port to cargo tanks nos. 4 port and starboard. Cargo tanks no. 1 port and no. 2 port were inerted and then ventilated to enable tank entry to survey the damage.

1.9 Sustained Damages

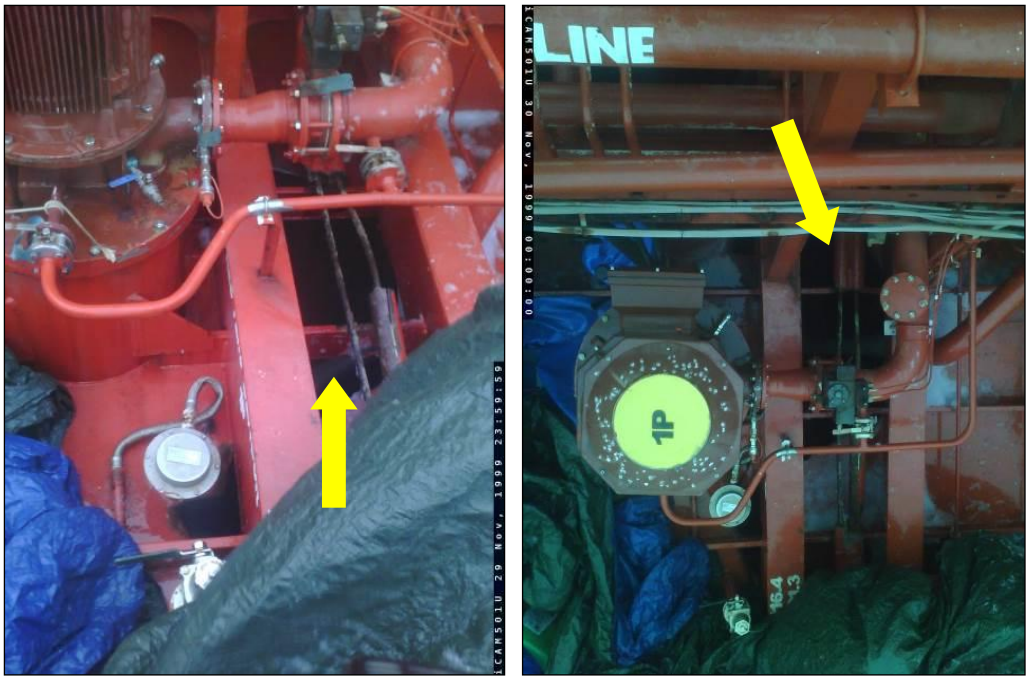
1.9.1 Main deck

It would appear that the main deck above cargo tank no. 2 port had risen by over 500 mm and caused the distortion of the deck catwalk (Figure 7), deck framing (Figure 8) and associated pipework. The deck transverse framing in way of cargo tank no. 2 port had crumpled around the edges of the cargo tank.

Figure 7: Damage to the deck catwalk

Figure 8: Distorted framing

A section of the main deck between frames 110 and 113, measuring about 1000 mm by 500 mm, in way of the transverse bulkhead between cargo tanks no. 1 port and no. 2 port, had been torn and set into the cargo tanks (Figures 9a and 9b).



Figures 9a and 9b: Missing deck plating

1.9.2 Transverse bulkhead

The transverse bulkhead between cargo tanks no. 1 port and no. 2 port had split from the main deck right down to the double bottom tank tops (Figure 10) and collapsed into cargo tank no. 1 port, damaging cargo pump no. 1 port, pipes and the access ladder. In addition, the transverse bulkhead had ruptured the welding at the top and bottom on several corrugated bays.

The cargo pump and associated pipework in cargo tank no. 1 port, which was attached and secured to the bulkhead, was also damaged as the bulkhead imploded into cargo tank no. 1 port.

Figure 10: Damaged transverse corrugated bulkhead between cargo tanks nos. 1 port and 2 port

1.9.3 Tank top

The tank top between frames 110 and 112 to double bottom ballast tanks no. 1 port and no. 2 port, in way of the transverse bulkhead had been ripped away by the bulkhead when it imploded into cargo tank no. 1 port (Figure 11). Both double bottom tanks were contaminated with MTBE.

Figure 11: Damage to the tank top

2 ANALYSIS

2.1 Purpose

The purpose of a marine safety investigation is to determine the circumstances and safety factors of the accident as a basis for making recommendations, and to prevent marine casualties or incidents from occurring in the future.

2.2 PV Valves

2.2.1 Operational tasks

During the course of the safety investigation, it transpired that the Unitech PV valves had last been tested ashore on 28 February 2013 and had been set to open at +210 mbar pressure and -35 mbar vacuum (Figure 12). The test date was stencilled on the vent stacks on deck.

Figure 12: PV valve test date and pressures marked on the vent stacks

However, according to the Chemfleet 'Test of PV Valves: Form 3406' [**Annex B**], the PV valves were tested in millimetres of water gauge (mmWg) between operating

parameters of 2100 mmWg pressure and -350 mmWg of vacuum on 28 February 2013 and all found to be satisfactory.

The conversion factor between 'mbars' and 'mmwg' is approximately a factor of 10; thus, 206 mbars equate to about 2100.6 mmWg; or 210 mbars being about 2141 mmWg and 35 mbars approximately equate to 356.9 mmWg. It would seem the ship had used a factor of 10 to simplify the conversion between the two units of pressure measurement. The conversion factor, however, was not considered to be contributory to the accident.

It is not clear from the Chemfleet 'Loading & Discharging Plan & Standing Orders' Form 2902, (p. 2 of 8), when the PV valves were in fact tested. However, according to the chief mate, he had tested and confirmed that the PV valves were operational before loading any cargo. On this occasion, they were tested during the cargo tank cleaning operations, just prior to berthing at Fos sur Mer to load MTBE.

The safety investigation was unable to obtain any confirmation from the officers or the ratings that the PV valves were in fact checked operational:

- during the loading operation;
- at the commencement of loading in any cargo tank; and / or
- during loading or whenever a pressure alarm sounded on the bridge cargo computer.

2.2.2 Check lift levers on the PV valves

The vacuum side of each PV valve was checked by pushing up the button below the vacuum side of the valve (Figure 13). This side of the PV valve appeared to have also been checked by using a pole from the catwalk and not locally by climbing up the vent stack and physically operating it by hand.

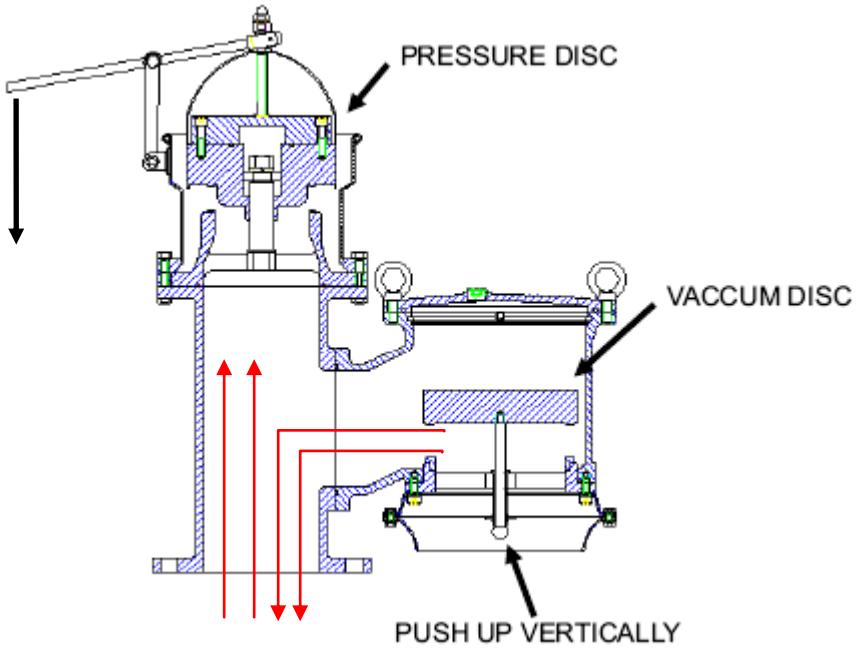


Figure 13: Testing of the PV valves

During the course of the safety investigation and the interviews with the crew members, it seemed that a pole was normally used from the catwalk level to check the PV valves, rather than climbing up to the PV valve platform and physically test the PV valves by hand.

The PV valves had the check lift levers permanently fitted to the valve tops and the connecting linkage on the valve body (Figure 14).

Figure 14: Check lift levers permanently fitted to the valve tops

The check lift lever was restricted in movement as the linkage appeared to be hard up against the body valve and in some cases, it also appeared seized in position[5].

Following repairs to the damaged cargo tanks at Tuzla and the testing of the PV valves, it was discovered that the check lift levers should not have been permanently connected as this restricted the movement of the valve top when it lifted during venting operations. This issue was also confirmed by the manufacturers, although the instruction manual did not clearly highlight this potential dangerous situation. In fact, as indicated in Figure 15, the Instruction Manual showed that the check lift lever had to be inserted in the lifting bush. This was implying, albeit not clearly, that during normal operations, check lift lever was not normally in the inserted position.

Figure 15: Check lift of pressure valve procedure as presented in the Instruction Manual

The safety investigation was unable to determine whether the 'permanent' fixing of the check lift levers was to allow the use of the pole for the free movement test of the valves or whether the check lift levers had always been permanently fitted.

As part of the safety investigation, all of the check lift levers were checked and tested. Although several valve spindles had been found slightly bent, all of the PV valves lifted *relatively* easily except for the one fitted on cargo tank no. 2 port. It was not clear, however, if the PV valve had been damaged by the over-pressurisation during the course of the accident. However, it was noted that some of the other PV valves and check lift levers were stiffer than others to operate and required additional effort to lift. After several attempts to rotate and manipulate the cargo tank no. 2 port valve top, it lifted with some effort, but jammed every time it was released.

[5] It was also noted that some of the PV valve drains appeared inverted and were in different positions. However, it did not seem that poor drainage could have caused problems in the operation of the bullet/stem top.

It was also noted that at the bottom of each cargo tank vent pipe stack, situated at the catwalk height, just above the isolation valves to the common vent line, a boss was available to enable the fitting of a manual pressure gauge (Figure 16). It would appear that all of the bosses had not been used in a very long time. This was confirmed by the chief mate and although there were some pressure gauges available on board, none had been used.

Figure 16: Location of boss fitting for pressure gauges

As this was a homogenous cargo, there was no risk assessment or consideration by the crew to make use of the common vent/vapour return line. Had there been a system in place to check whether or not the PV valves were actually operating correctly, then, if any valve failed to open, the situation could have been mitigated by the opening of the isolating valves to the common venting line, and the PV valve of another cargo tank would have been made available. The operation of the suspect PV valve could then have been checked after cargo operations would have been completed.

2.3 Loading Operations

Initially, the chief mate and the second mate were on cargo watch for the start of the loading and completed the pre-loading formalities with the Terminal representative. Chemfleet's 'Loading Protocol Form: oprs 07' [**Annex C**], had been completed and signed by the chief mate and the Terminal representative at 0015 on 19 October 2013. The Terminal representative was also stationed on the bridge with some shore-based equipment and a telephone. The Emergency Stop Button was within reach.

'Form: oprs 07' recorded an agreed initial loading rate of 100 m^3hr^{-1}, a maximum rate of 560 m^3hr^{-1} and a topping off rate of 200 m^3hr^{-1}. The safety investigation was aware that the maximum loading rate for any cargo tank was 233 m^3hr^{-1}. It was also noticed that the agreed emergency stop was a "Turn Button" with two minutes elapsed time before cargo loading stopped.

At 0055, loading commenced simultaneously into cargo tanks nos. 2 port and starboard and nos. 6 port and starboard at a slow rate of 100 m^3hr^{-1}, then increased to the requested 560 m^3hr^{-1} after 25 minutes. It is considered good practice to load one cargo tank or one pair of cargo wing tanks initially to check the pipeline set up, check that the PV valves operate, and the loading rate is as agreed before increasing the loading rate to maximum.

In 25 minutes, the loading of four cargo tanks at 100 m^3hr^{-1} would only reach about 50 m^3 of cargo dispersed amongst the four cargo tanks and possibly not activate all PV valves. There did not appear to be any records to show whether the initial loading rate was actually checked or the cargo system set up was correct and operational before increasing the pressure to the maximum load rate. Moreover, there was no evidence to indicate whether or not cargo tank no. 2 port PV valve had ever lifted. However, considering the damage observed on the spindle, as explained elsewhere, it was very probable that the problem with the lifting of the PV valve was caused by the bent spindle.

At about 0140, the chief mate left the bridge to get some rest, leaving the second mate in charge of the cargo operation. Ullages were taken on the hour and the loading rate was calculated as being 364.8 m^3hr^{-1} at 0200, 500.2 m^3hr^{-1} at 0300, and 470 m^3hr^{-1} at

0400. Records did not indicate whether or not the individual cargo tank loading rates were checked along with the total loading rate [**Annex D**].

Cargo loading transfer from cargo tanks nos. 6 port and starboard (90% full) to cargo tanks nos. 3 port and starboard was carried out at 0445. The loading rate at 0500 was calculated to be 426 m^3hr^{-1}. Between 0448 and 0535 (time of the accident), the second mate instructed the deck watch to half close the manifold drop valves to cargo tanks nos. 3 port and starboard in order to increase the cargo flow into cargo tanks nos. 2 port and starboard.

The second mate completed loading cargo tanks nos. 2 starboard at 0525 and continued loading into cargo tanks no. 2 port (loading valve fully open) and cargo tanks nos. 3 port and starboard (valves half closed). Following the adjustments to the drop valves for cargo tanks nos. 3 port and starboard and after stopping cargo tanks no. 2 starboard, there appeared to be no further ullage calculations to determine the actual loading rates into either cargo tank no. 2 port or cargo tanks nos. 3 port and starboard.

With an estimated loading rate of between 426 m^3hr^{-1} and 470 m^3hr^{-1} from 0500, and the maximum rate per cargo tank was stated as 233 m^3hr^{-1}, it is not known if the actual loading rate into cargo tank no. 2 port had exceeded the maximum permitted. Moreover, the safety investigation did not find evidence of any pre-loading instructions from the deck officer to the deck watch to check on the operation of any PV valve - neither initially (when loading into any cargo tank), nor whenever the pressure alarm went off on the bridge cargo computer.

Even more, the deck officer neither recorded whenever a pressure alarm activated on the cargo loading computer, nor recorded / instructed the deck watch to check if the PV valves were operating. If the PV valves had been confirmed operational, then the alarm would have indicated excess pressure and the OOW should then have stopped cargo, reduced the loading rate, or even opened an empty cargo tank.

By conferring with the computer, the deck officer was the only person who knew what the cargo tank conditions were at any time. On the other hand, the deck watchman was oblivious to the loading condition of any cargo tank, unless advised by the deck officer by VHF radio.

Although between 0448 and 0500 (when ullages had been taken), the second mate reportedly had concerns about the ullages in cargo tank no. 2 port (as the cargo tank appeared to be taking much longer than originally planned[6]), it was still unclear to the deck officer that cargo tank no. 2 port did not appear to be loading as planned (especially if the individual cargo tank rates had been calculated).

The deck officer had half-closed the loading valves to cargo tank nos. 3 port and starboard to increase the loading into cargo tanks nos. 2 port and starboard. When cargo tank no. 2 starboard was completed and the valve closed, this further increased the loading rate into cargo tank no. 2 port. The total cargo loading rate was completed without checking and calculating the individual loading rates into each cargo tank to ensure that the maximum rate of any cargo tank was not exceeded.

It is the view of the safety investigation that the deck officer's actions in trying to increase the loading in cargo tank no. 2 port showed that he was not fully aware of the dangerous situation which was unfolding (inside the cargo tank). It would seem that there was doubt as to what was happening in cargo tank no. 2 port, to which the deck officer should have called the chief mate sooner in accordance with Chemfleet Form 2902 'Loading & Discharging Plan & Standing Orders'. Under the heading 'Duty Officer' (p. 3 of 8), the Form carries clear instructions to *"[c]all C. Officer when in doubt and report any abnormalities of cargo operation"* [**Annex A**].

2.4 Pressure Alarm System

As explained elsewhere, the vessel was equipped with a pressure sensor in each cargo tank. Each sensor was connected to an alarm system as an alternative to a secondary PV valve. According to the chief mate, the alarm system was tested before loading and during the purging of the cargo tanks.

The safety investigation noted from the printout of the pressure alarms [**Annex E**] that cargo tank no. 6 port 'high' alarmed at about 0123, was acknowledged a few seconds later, then the 'high-high' alarmed four minutes later and would appear to have been reset at 0130 when the alarms' printout indicated an 'off' status.

[6] The concern was legitimate, given that pairs of cargo tanks are normally loaded and completed almost simultaneously to maintain the ship upright.

This was one of the cargo tanks in which it was noted that the check lift test lever was harder to operate than the others. This cargo tank appeared to have alarmed several times during the cargo loading operation. There were no comments or entry into the logbook as to whether or not the PV valve was checked operational, or if the deck watchman had been asked by the deck officer to check if it was operating correctly and to confirm its status.

Since there were no manual gauges fitted to the bosses at the base of the vent stacks, the deck watchman was unable to advise the deck officer on the pressure in cargo tank no. 6 port, and thereby check if the alarm system /sensor was operating correctly.

At about 0142, the 'high' and 'high-high' pressure alarms for cargo tank no. 2 port activated and both were acknowledged almost immediately. It was not clear who was on watch at the time as the chief mate handed over the watch at about 0140. It would appear that the alarms were not reset to 'off' until 0333, *i.e.,* almost two hours later. This indicated that either the alarm console was not being monitored, and/or the audible alarm was muted and therefore not acted upon correctly until the tank pressure changed two hours later.

It is the understanding of the safety investigation that the alarms do not reset to 'off' until the pressure drops, although the tank screen remained 'red'. Testing of the pressure sensors by the owners after the accident indicated that an excessive pressure of 950 mbar caused the 'red' tank screen to turn 'white' *i.e.* normal as if the alarm had been reset. Then, when the pressure dropped below 950 mbar, the alarm system reactivated and the tank screen turned 'red'.

Anyone looking at the cargo screen may not realise that a high pressure condition existed in a cargo tank, especially if:

- the colour had changed from 'red' to 'white';
- did not notice the alarm message; and / or
- the alarms had been muted.

It was not clear whether the deck officer was trying to deal with cargo tank no. 2 port loading but was unaware that the colour of the cargo tank had changed from 'red' to 'white' - giving a false impression that the cargo tank was now safe except that the

alarm message was still active, and the alarms were also muted. This appeared an unsafe system to operate when (against to on board procedures (Figure 17)), alarms were muted and the screen visual effects not monitored constantly or acted upon immediately. It would seem that this led to a blurred situation awareness, as a result of inadequate cargo watch and the disabling of the audible component of a preventive barrier.

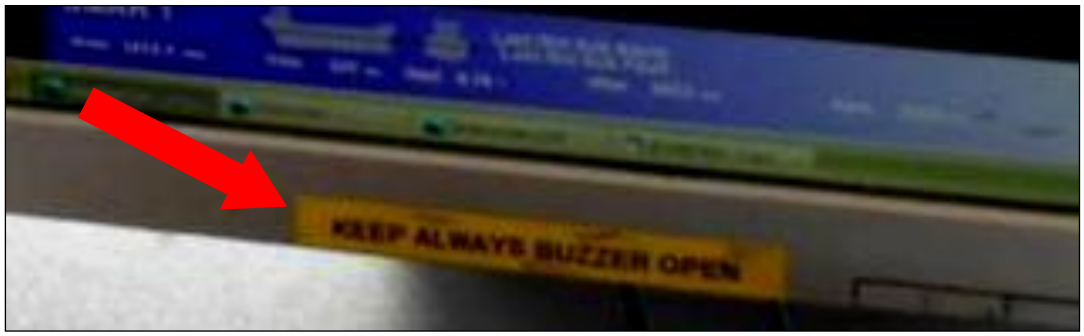


Figure 17: Buzzer notice affixed on the loading computer screen

The high alarms for cargo tank no. 6 port went off again at about 0152 / 0155 but were not acknowledged until 0318. This would indicate that either the bridge was unmanned between 0155 and 0318 (given that the audible alarm was not being responded to), or the alarm had been turned off / muted after about 0142 when the cargo tank no. 2 port alarms activated.

The second mate confirmed turning the audible alarm off but did not state when he did so. Nevertheless, with the audible alarm off, he should have still seen the 'red' cargo tank screen on the computer (Figure 18), which should have prompted him to check that the PV valve was operational, check the ullages and calculate the loading rates. The second mate stated that at the time he was trying to keep the ship upright and adjusted the loading into different cargo tanks as cargo tanks nos. 2 port and starboard appeared to be lagging behind.

If the alarm had been muted before noticing the condition of cargo tank no. 2 port, and if the screen colour for cargo tank no. 2 port tank had changed from 'red' to 'white', he may not have been aware that cargo tank no. 2 port was in fact in a dangerous condition. The safety investigation concluded that these conditions would have led to poor cargo monitoring.

Moreover, it was also established that he had managed to take the ullage / rate readings at 0200 and 0300. Therefore, he must have consulted the screen to calculate the rate. As yet, he still did not appreciate the 'red' warnings, even if he had muted the audible alarm on the bridge; unless, of course, the cargo tank colour had changed from 'red' to 'white' when the pressure exceeded 950 mbars.

Figure 18: Cargo tank information on the loading computer screen

2.5 Testing of the Pressure Sensors

Information provided by the managers indicated that following the repairs to the affected areas at Tuzla, Istanbul, the pressure sensor in cargo tank no. 2 port was tested and the following was discovered:

- when the pressure sensor was subjected to a test pressure of 220 mbar, it alarmed on the cargo monitor and was acknowledged;
- cargo tank no. 2 port was then displayed in 'red' condition on the cargo monitor; and
- when more pressure was applied up to 950 mbar, the 'red' condition changed to 'white'. The pressure alarm switched off and the sensor was unable to indicate the pressure above 950 mbar. The system activated the *invalid measure fault* alarm on the bottom right of the cargo monitor.

The alarm in cargo tank no. 2 port appeared to reset at 0333. Had this been due to excessive pressure, then on the basis of the above findings, the alarm which activated at 0534 would have been the alarm as the pressure fell below 950 mbar and was probably when the bulkhead collapsed into cargo tank no. 1 port.

Whilst the above gives a reasonable explanation on how the sensor and screen outputs behaved when subjected to excessive pressure, it did not transpire that the second mate, (who should have been monitoring the screen at 0200 and 0300 for the ullages), responded to the 'red' cargo tank screen or the audible alarm which he then muted.

2.6 Ullaging

Cargo operations started at 0055 in four cargo tanks. Information on the cargo tank ullages and respective volumes was obtained from the loading computer.

Chemfleet Form 2903 'Hourly Loading/Discharging Back Pressure & Rate Monitoring Sheet' was used to record the cargo loading figures/ ullages. However, there appeared to be no checks on what the initial loading rate was, except that after the first 65 minutes, a total of 364.8 m^3 of cargo had been loaded into cargo tanks nos. 2 and 6 port and starboard. Taking into consideration the ullages recorded at 0200 and 0300 and the pressure testing results, it was probable that cargo tank no. 2 port was in the 'red' alarm condition according to the pressure testing results.

According to the ullages' record, the loading rate at 0400 was faster in cargo tanks nos. 6 port and starboard (at about 339 m^3hr^{-1}), but only 131 m^3hr^{-1} in cargo tanks nos. 2 port and starboard.

At 0445, cargo loading was transferred from cargo tanks nos. 6 port and starboard to cargo tanks nos. 3 port and starboard. The loading rates at 0500 were as follows:

- cargo tanks nos. 2 port and starboard - 112 m^3hr^{-1};
- cargo tanks nos. 3 port and starboard - 91 m^3hr^{-1} in 15 minutes (effective rate of 364 m^3hr^{-1}); and
- cargo tanks nos. 6 port and starboard - 223 m^3hr^{-1} in 45 minutes (effective rate of 297 m^3hr^{-1}).

On closer examination of cargo tanks nos. 3 port and starboard, no. 3 port loaded 59 m^3 in 15 minutes (effective rate of 236 m^3hr^{-1}), *i.e.* about maximum rate for that cargo tank.

There were no further ullages/rates recorded after 0500. After starting the loading of cargo tanks nos. 3 port and starboard, the deck officer adjusted the valves to increase the flow in cargo tanks no. 2 port and instructed the deck watchman to half close cargo tanks nos. 3 port and starboard drop valves. This action would have probably increased the loading rate in cargo tank no. 2 port. However, if the screen for cargo tank no. 2 port was now in the excessive pressure mode, the deck officer would have been unaware of the alarm/pressure status of this cargo tank, and the duty deck watch (unless instructed) would not report whether or not the PV valve was operating.

The deck officer did not appear to have monitored the actual loading rate of any of the cargo tanks, once he adjusted the drop valves to cargo tanks nos. 3 port and starboard and completed cargo tanks no. 2 starboard. Having restricted cargo tanks nos. 3 port and starboard, he would have increased the flow rates into cargo tanks nos. 2 port and starboard. Once cargo tank no. 2 starboard was completed, cargo tank no. 2 port would have experienced an even greater load pressure.

2.7 Hazard Detection

The fact that risk materialised into an accident is indicative that the relevant crew members neither detected the hazards, nor predicted accurately the dangers involved. Given that the hazards were not detected (to the extent that an over-pressurisation of one of the cargo tanks has happened), the way in which the crew members missed the hazards is important. The factors identified in the previous sections (which mainly relate to preventive barriers), were signals whose intensity was either not strong enough to be captured or be perceived as crucial. Research in this field suggested that there is a statistical correlation between the time frame workers would have been on the workplace and the ability to identify hazards.

Both the chief mate and the second mate had only been on board for a number of weeks when the accident happened and therefore it was not excluded that this may have influenced their ability to detect the ineffective preventive barriers. Naturally,

hazards will become only too obvious when an accident happens. Otherwise, they rarely threaten the crew members. The collateral effect was that the crew members were less able to anticipate the complex interactions involved, say, during the cargo operations; and with ineffective preventive barriers, the situation would have only become more complex.

THE FOLLOWING CONCLUSIONS, SAFETY ACTIONS AND RECOMMENDATIONS SHALL IN NO CASE CREATE A PRESUMPTION OF BLAME OR LIABILITY. NEITHER ARE THEY BINDING NOR LISTED IN ANY ORDER OF PRIORITY.

3 CONCLUSIONS

Findings and safety factors are not listed in any order of priority.

3.1 Immediate Safety Factor

.1 The cause of the structural damage was over pressurisation of cargo tank no. 2 port during cargo loading operations.

3.2 Latent Conditions and other Safety Factors

.1 The PV valve check lift levers, which had been fitted to the valve tops, caused damage to the valve spindles and thus prevented several of them from operating correctly at the pre-set pressure.

.2 No manual pressure gauges had been fitted to the bosses at the base of the vent stacks, which would have enabled the duty deck watch to monitor and report cargo tank pressures and compare/check if the cargo tank pressure sensors were operating correctly.

.3 There was an established onboard system whereby the PV valves were not positively reported to be operating whenever cargo was initially loaded, during loading into any cargo tank, or whenever an alarm sounded on the bridge.

.4 The audible pressure alarm on the cargo monitor had been muted and thus did not warn the OOW whenever a cargo tank went into alarm mode or its status changed.

.5 The monitoring of the loading rate of each cargo tank as well as the total loading rate during multiple cargo tank loading, at a total loading rate that exceeded the maximum load rate for one tank, was inadequate.

.6 There was lack of appreciation by the deck officer of the effect on loading cargo tank no. 2 port, when half closing the drop valves to cargo tanks nos. 3 wings and completing loading of cargo tank no. 2 starboard.

.7 The deck officer did not comply with the Standing Orders on the Loading Form and rather than calling the chief mate when he was in doubt, he continued with the cargo operations.

.8 There was no consideration for the use of the common vent /vapour return line to provide access to multiple pressure vacuum valves.

3.3 Other Findings

.1 The testing of the PV valves was carried out by using a pole instead of manually operating the check lift levers from the platform at the top of the valve stack.

.2 It is not known if the PV valve to cargo tank no. 2 port was operational at any time *i.e.* jammed shut or fully open at the time of cargo tank failure and thus unable to cope with the excessive pressure due to the changes in loading cargo tanks.

4 ACTIONS TAKEN

4.1 Safety actions taken during the course of the safety investigation

Following the accident, the Company has taken the following actions:

- Information on the correct use of the check lift lever has been shared with the fleet. A safety poster was prepared and posted in the mess rooms and cargo control room;
- A model of the PV valve has been placed in the Company's training room;
- Three of fleet vessels which have same type / model of PV valve, have been visited by superintendents and crew given field training on the correct operation of the PV valves. Moreover, the Company has plans for further visits to all the ships, focusing on good leadership practices, the Company's safety culture, and safe practice during cargo operations. This requirement has been added to the Company's procedures on "Superintendent ship visit work plan";
- All vessels have been informed of the accident and the dangers of over pressurisation of cargo tanks highlighted;

- All PV valves on board the *Umar 1* have been replaced with a newer model of PV valve;
- A new Appendix has been added to the Cargo Loading Rate Pressure in the cargo tanks, which is now being recorded every 30 minutes. These records include both data from the cargo monitoring system and the manometers on the PV line;
- A new requirement has been adopted, which now requires the master and chief officer to be notified immediately when a high pressure alarm has activated. A related notice has been posted in the cargo control room and added to Form 2902 'Loading Discharging Standing Orders';
- Deactivation of the buzzer has been prohibited unless authorised by the master. A notice stating that 'Turning-Off the Alarm Buzzer without Master's Permission is Prohibited' has been sent to all vessels and posted in the cargo control rooms;
- An 'Alarm Logs Record and Action Book' has been added to the safety management system manual. The duty officer is now required to record the time of alarm, time of acknowledgement, and actions taken;
- A Safety Alert on this accident has been issued and safety lessons shared with all the vessels;
- A manometer has been connected to each PV line. The critical range on the manometer scale has been marked in red. The duty watchman rating is required to check the cargo tanks' internal pressures during his watch and report abnormalities to the cargo control room. These requirements were also added to the relevant section of Ship's Operations Manual;
- It is required that all joining officers are trained on the appropriate actions to be taken in case of an alarm handling and on the PV valves operational parameters. This training has been added to all the officers' pre-joining training programme (Form CREW 002_Officer's pre-joining Briefing familiarisation);
- The Company also intends to contact the manufacturer of the PV valves and recommend that more information is added to the PV valve operations manual,

and to issue a technical letter on the correct use of ‘check lifting devices’ for the subject type of PV valves.

5 RECOMMENDATIONS

In view of the conclusions reached and taking into consideration the safety actions taken during the course of the safety investigation no recommendations have been issued to the Company. The recommendation below has been made to the PV valves’ manufacturers.

Topsafe Co. Ltd. is recommended to:

27/2014_R1 issue an alert to all its clients in order to highlight the importance of removing the check lift lever from the lifting bush immediately after the opening test is carried out.

LIST OF ANNEXES

Annex A Standing Orders

Chemfleet	LOADING&DISCHARGING PLAN&STANDING ORDERS	Form No 2902 Date 03.10.2013 Revision 14 Page 1 of 8

Vessel's Name :UMAR 1	Date/Time of Completion: 18.10.13 –
Port :FOS	Berth : 0 Bis

- Duty watch officer's are to read, understand and sign the relevant loading / discharging plan.
  Görevli vardiya zabitleri ilgili yükleme/tahliye planlarını okuyup anlamalı ve imzalamalıdır.

- On taking over the watch, relieving duty officer must check that the valves been correctly set for the operation(s) in progress.
  Sorumlu zabit Vardiya tesliminde operasyondaki valflerin konumlarından haberdar olmalıdır.

- Duty watch officer, throughout his watch period must check in regular intervals that the valves in operations are remaining correctly positioned.
  Görevli zabit vardiyası boyunca valflerin gerekli pozisyonda kaldığından emin olmalıdır.

- Duty officer must maintain an adequate number of men on deck at all times to meet the operational requirements.
  Görevli zabit güvertede her zaman operasyon için yeterli sayıda personel kalmasını sağlamalıdır.

- Stability and stress calculation shall be carried out as per sea condition criteria.
  In the case of vessel does not meet sea condition criteria in port, vessel subject to company confirmation to make calculation as per harbour condition
  Yuk hesaplamaları butun durumlarda deniz durumuna gore yapılmalıdır.
  Eger deniz durumuna gore yapılan hesaplamalar kriterleri karşılamaz ise, liman durumunda yapmak için sirketten onay alınalıdır.

- Do not relieve watch while topping off tanks. Offer to assist the officer who is topping off, wait until the operation is complete before offering relieved him.
  Vardiya süresi bitse dahi ayrılacak vardiya zabiti ilgili tankların kesimi sırasında vardiyadan ayrılamayarak kesimi yapacak zabite yardım etmeli ve ayrılmak için operasyonun tamamen bitmesini beklemelidir.

- Cargo tanks **NEVER** to be loaded more than overfill alarm level. (overfill alarm shall not be raised) In the case of overfill alarm raised the cargo operation **SHALL BE STOPPED** immediately. Relevant tank level shall be reduced to less than overfill alarm limit. Loading plan shall be planned to avoid activating of HHL alarms under no circumstances during the loading, voyage and discharging. Cargo expansion ratio due to heating or environmental conditions shall be considered. OOW shall aware that reaching the HHLA makes a safety device inoperative.
  *Kargo tankları **HİÇBİR ZAMAN** %98 alarmları çalacak şekilde yüklenmeyecektir. Eğer operasyon sırasında %98 ALARMI ÇALARSA operasyon hemen **STOP** edilecektir. Alarmı çalmış tank seviyesi, tanktan mal transferi yapılarak %98 altına düşürülecektir. Yükleme planı yapılırken tankların yükleme sırasında, seferde, tahliye sırasında yükün ısıtılması veya çevresel sıcaklıklardan ısınması dikkate alınarak %98 alarm seviyesi aktif olmayacak şekilde yüklenmelidir. Vardiya zabiti %98 alarmları aktif olduğunda başka bir emniyet sistemi kalmadığının farkında olacak ve bu şekilde operasyona devam etmeyecektir.*

- The remote hydraulic valves' status shall be checked by visually after each remote operation then to be reported to the OOW.
  CCR den kumanda edilen valfler açılıp kapandığında güverteden valfin tam olarak açılıp açılmadığı gözle kontrol edilip vardiya zabitine teyit edilecektir.

- Arrangement of Cargo valves, lines, manifold connections, PV valves and vapour lines connection should be prepared by Boatswain (Bosun) or Pumpman according to Chief officer's instructions and supervision. After completion of connections-arrangementsproper completion of the work should be checked by OOW. But all of them SHALL be checked by Chief officer Finally to prevent 'one-man error' before commence loading/discharging operations. Final check responsibility of Chief officer MAY not be delegated any other position under no circumstances.
  Kargo Valflerinin, devrelerinin, manifold baglantılarının, PV valflerinin ve gaz donus devresinin baglantıları Guverte Lostromosu veya Pompacı tarafından Birinci Zabitin talimatlarına gore ve onun gözetimi altında yapılacaktır. Manifoldun, valflerin ve devrelerin hazırlanmasından sonra uygunlugu gorevli zabit tarafından kontrol edilemelidir. Fakat yapılan tüm baglantılar ve ayarlamalar, tek adam hatasını engellemek amacıyla MUTLAKA son olarak bizaat birinci zabit tarafından kontrol edilecektir. Birinci zabitin son kontrol görevi hiç bir şekilde başka birisine devredilemez.

- Cargo lines and valves, drains, blinds, hatches are to be checked by Chief Officer before hose connection to ensure valves, blind flanges, drains, tank openings and hatches are secured properly, there is no any open part, defected unit
  Birinci zabit kargo Hortumu bağlanmadan once Kargo devrelerinin, valflerin, drainlerin, körlerin, kapakların uygun şekilde kapatıldığından, herhangi bir açık kalmadığından ve hasarlı bir aksam olmadığından emin olmalıdır.

Chemfleet	**LOADING&DISCHARGING PLAN&STANDING ORDERS**	Form No 2902 Date 03.10.2013 Revision 14 Page 2 of 8

Prior Loading / Discharging	Pre check OOW	Final check Chf Off
Be sure that cargo ventilation fan fully segregated from cargo tanks with blind flanges or taking spool piece out (NA for vessel no direct connection to the cargo tanks ex:flexible duct) *Havalandırma sistemini kargo tanklarından tamamen ayırmak için spool piece çıkarıldığından veya bıçak körle körlendiğinden emin ol (Eğer körüklü system varsa NA)*	3/0 ✓	✓
Check that p/v valves are properly operating *P/V valflerinin düzgün şekilde çalıştığından emin ol*	✓	✓
Test all cargo valves tightness with air before entering loading port. *Kargo valflerinin kaçırmadığını limana varış öncesi havayla test et.*	✓	✓
Ship/shore cargo hoses are properly connected and supported / Confirm that connections are are controls intended for the cargo compartments to be loaded. *Sahil – gemi kargo hortumunun uygun şekilde bağlanarak desteklendimi ve devreler ilgili kargoyu doldurulacak tanklara ulaştırmak üzere gerekli şekilde hazırmı.*	✓	✓
If Terminal Arm Connecting, ensure that Arm hinges/joints well greased and working/moving freely, support stands of Arm have fixed and secured to carry vertical weight of Arm. Where supported Arm jack shall be check places able to weight. *Eger Terminal Kol baglayacaksa, kolun mafsallarının yaglanma durumunun iyi oldugunun onayını al. Kolun iyi durumda rahat sekilde hareket ettiginden, bacaklarının yere iyice sabitlendiginden ve dikey ağırlığın gemi manifolduna yansımayacak şekilde emniyete alındığından emin ol.* *Kolun bacaklarının sabitlediği bolgenin kol ağırlığı dayanacagından emin ol.*	✓	✓
Verify that manifold connections are marked for the intended cargo t0 be loaded/discharged. *Yüklenecek yada tahliye edilecek cargoların manifold bağlantılarının markalandığından emin ol.*	✓	✓
Heating coils are tested and free of leaks and blanked when loaded with non-heated cargo. *Isıtma kangalları test edildilip kaçak olmadığı ve eğer alınacak kargo ısıtmalı değilse körlendiğinden emin ol.*	✓	✓
Cargo valves are properly aligned and set open ready to receive cargo or pump cargo. *Kargo valfleri gerektiği şekilde düzenlenerek kargoyu basmak yada almak üzere açık durumda hazırlandımı.*	✓	✓
Cargo lines drain valves are properly closed. Cargo tanks and BW hatches fully closed (all nuts) *Drain valfleri uygun şekilde kapatıldımı. Kargo ve BW kapakları kapalımı, tüm kelebekler sıkılı mı*	✓	✓
Cargo compartments to be loaded are free of rags and other foreign materials. *Yüklenecek kargo tankları üstüpü, bez vs. yabancı maddelerden arındırıldımı.*	✓	✓
Scuppers and spill trays are properly plugged. *Frengi delikleri ve taşıntı tavaları uygun şekilde tapalandımı.*	✓	✓
Eye wash/Emergency showers are tested, water valve open and working at required pressure. Acil duş ve göz yıkama sistemi test edildi, su valfi açık ve ve gerekli basıncda çalıştığı görüldü.	✓	i
Overflow and high level alarms are check and working satisfactory. *%95 ve %98 seviye alarmları control edildimi ve tatmin edici derecede çalışıyormu.*	✓	✓
Level gauges are checked and found working satisfactory. *Cargo seviye (aleç) ölçüm ekipmanları kontrol edildımı ve tatmin edici şekilde çalışıyormu.*	✓	✓
Location of emergency stops are identified. *Acil durum kapatma istasyonları tanımlandımı.*	N/A	N/A
(Bch-ibc) scba and fire extinguishers are deployed near the manifold for immediate use. *Acil kullanıma hazır olarak B.A. set ve yangın söndürücüler manifold yanında kullanıma hazırmı.*	✓	✓
Verify that anti-pollution equipment are ready for immediate use. *Kirlilik-taşıntı müdehale setleri acil kullanıma hazırmı.*	✓	✓
Check/Test the air driven spillage pump, air supply valve open and pump ready for immediate use. Taşıntı havalı wilden pompası havası açık ve acil kullanıma hazırmı	✓	✓
Fire hoses is rigged near the manifold with constant pressure on the line Yangın hortumları basınç altında olarak manifold yanına roda edildimi.	✓	✓
Vapour return line are connected or blanked if not used. *Gaz dönüş hattı bağlandımı veya eğer kullanımda değilse körlendimi.*	✓	✓
Establish communication and verify that hand held radios are in good working order. *Gerekli iletişim tesis edildimi ve el telsizleri iyi durumda çalışıyormu.*	✓	✓
MSDS sheets received from terminal/shipper, are posted on the bulletin board. *Terminalden veya Shipper dan alınan MSDS sayfaları ilan panosuna asıldımı.*	✓	✓
Terminal regulations has obtained from Loading Master and posted to bulletin board. Terminal Kuralları yukleme amirinden temin edildi ve ilan panosuna asıldımı?	✓	✓
Cargo tanks and vapour retun line secondary system alarm settings adjusted acc to SOM 6.3.15 Kargo tank ve gaz dönüş devresi alarmları SOM 6.3.15 e gore ayarlandı mı?	✓	✓
After Loading / Discharging (Including N2 Purging)		
Ship/Shore Cargo Hoses Are Disconnected		

Hortum Sökülüp Emniyete Alındı Mı?		
Cargo Valves Are Properly Closed And Manifolds Are Blanked Tightly as Gas/Liquid Proof. Kargo Valfleri Kapatıldımı Ve Manifoldun Kör Flenci Gaz/Sıvı Sızdırmaz Sekilde Vuruldu Mu?		
Cargo Hatches and Ullage Pipes are properly closed tight After Completion Of Ullaging *Tank Kapakları ve Ulage Kapakları Ölçümler bitince Kapatılıp Emniyetli Hale Getirildi Mi ?*		

Chief Officer:

* Cargo Operation In-Charged
  Cargo Operasyonundan Tamamiyla Sorumludur.
* Prior Loading/Discharging Conduct Conference With The Duty Officer,Bosun &Pumpman
  Yükleme Öncesinde Diğer Zabitler/Gemici/Pompaci İle Konuşarak Operasyonon Nasil Yapilacağı Hakkinda Bilgi Verir,Personelini Bilgilendirir.
* Must Verify That All Other Cargo Control Preparations Are Properly Completed .
  Diger Bütün Cargo Kontrol Hazirliklarinin Tamamlandiğini Kontrol Eder.

Duty Officer:

* Assist Chief Officer Ullaging Cargo
  2.Kaptana Ullage Aliminda Yardimci Olur
* Assist Chief Officer Attending Surveyor And Cargo Calculations.
  Yük Hesaplanmasinda Ve Surveyörle İlgilenilmesinde 2. Kaptana Yardimci Olur.
* Tending Mooring Lines And Visitor Safety
  Halatlarin Boşunu Alir,Gemiye Gelip/Gidenlerin Takibi Ve Emniyetinden Sorumludur.
* Check Loading Rate And Cargo Quantity
  Yükleme Süratini Ve Miktarini Kontrol Eder.
* Call C. Officer When In Doubt And Report Any Abnormalities Of Cargo Operations
  Kargo Operasyonu Esnasinda Anormal Durumlardan 2.Kaptani Haberdar Eder,Süpheye Düştüğünde Hemen Haber Verir.

Product To Load / Discharge

No	Product	Qty Mts	Qty M3	S.G	%	Ullage	Stowage
1.	MTBE	285	385	0,74	95		2P
2.	MTBE	285	385	0,74	95		2S
3.	MTBE	345	330	0,74	95		3P
4.	MTBE	245	330	0,74	95		3S
5.	MTBE	430	580	0,74	95		4P
6.	MTBE	430	580	0,74	95		4S
7.	MTBE	225	305	0,74	95		5S
8.	MTBE	430	580	0,74	95		6P
9.	MTBE	430	580	0,74	95		6S
10.							

Loading / Discharging Sequence

ARRIVAL CONDITION:

Df: 3,20 M / Da:4,35 M / TRIM: 1,20 M /BM: % 74 / SF: % 26

STEP 1:
LOAD C.T. 2 P/S ULLAGES: 280CM -6 P/S ULLAGES:370 CM TILL %50 VOLUME
Df: 3,75 M / Da:5,10 M / TRIM: 1,40 M /BM: % 74 / SF: % 20
STEP 2:
LOAD C.T. 2 P/S ULLAGES: 130CM -6 P/S ULLAGES: 116CM TILL %90 VOLUME
Df: 4,20 M / Da:5,65 M / TRIM: 1,45 M /BM: % 74 / SF: % 21
STEP 3:
LOAD C.T. 3 P/S ULLAGES: 385CM -4 P/S ULLAGES: 385CM -5S ULLAGES: 385 CM TILL %50 VOLUME
Df: 5,20 M / Da:5,90 M / TRIM: 0,70 M /BM: % 46 / SF: % 11
STEP 4:
LOAD C.T. 3 P/S ULLAGES: 130CM -4 P/S ULLAGES: 125CM -5S ULLAGES: 125CM TILL %90 VOLUME
Df: 5,20 M / Da:6,05 M / TRIM: 0,85 M /BM: % 43 / SF: % 10
STEP 5:
LOAD C.T. 2 P/S ULLAGES: 100CM -3 P/S ULLAGES: 100CM - 4P/S- 5S ULLAGES: 98CM – 6P/S ULLAGES: 95 CM TILL %95 VOLUME
Df: 5,30 M / Da:6,10 M / TRIM: 0,80 M /BM: % 41 / SF: % 9

DEPARTURE CONDITION:
Df: 5,30 M / Da:6,10 M / TRIM: 0,80 M /BM: % 41 / SF: % 9

Ballast De-Ballast

STEP 1:
NO BALLAST OPERATION

STEP2:
NO BALLAST OPERATION- ONLY FOR KEEPING VESSEL UP RIGHT IF NEED

STEP3:
DE-BALLAST WBT 5S TILL %55

STEP4:
DE-BALLAST WBT 3 P/S -4 P/S TILL EMPTY

STEP5:

NO BALLAST OPERATION- ONLY FOR KEEPING VESSEL UP RIGHT IF NEED

DEPARTURE CONDITION :

NO BALLAST OPERATION

Chemfleet	LOADING&DISCHARGING PLAN&STANDING ORDERS	Form No 2902 Date 03.10.2013 Revision 14 Page 5 of 8

Other Standing Orders:

DURING LOADING KEEP THE VESSEL UPRIGHT,MAX HEEL SHOULD BE **1 DEGREES TO EACH SIDE.**

-CHECK THE DRAFTS **EVERY 2 HOURS VISUALLY** AND COMPARE WITH THE LOADMASTER.

-CHECK THE **S.F AND B.M EVERY HOUR** AND RECORD TO THE RATE LOG.
-IF ANY **DISAGREEMENT BETWEEN CALCULATED STEPS**, AND LIVE CONDITION OF LOADING INFORM C/O. AND IF ANY STRESS **VALUE IS OVER 95 %** (AT SEA CONDITION) INFORM C/O.

-CARRY OUT REGULAR **SAFETY AND SECURITY PATROLS ON DECK 2 HOURSLY.**

-KEEP TIGHT THE MOORING ROPES.

-KEEP FULLY CLOSED THE NON-OPERATIONAL VALVES DURING OPERATION.

-MONITOR CARGO TANK PREESURE VALUES CONTINUOUSLY.

-SECURE ALL CARGO VALVES WHEN THE TANKS ARE NOT UNDER OPERATION.

-DUTY OFF, DUTY PUMPMAN AND A/B MUST STAY ON DECK AND DUTY/OFF **EVERY HRS TAKE ULLAGES** AND WILL CALCULATE LOADING RATE, STABILITY, SHEARING FORCE AND BENDING MOMENT.

-NEVER EXCEED TRIM 2,50M BY STERN

-MONITOR SEA SURFACE REGULARLY.

-AT ALL TIME 2 PERSONS WILL STAND ON DECK AND ONE OF THEM STAND NEAR THE GANGWAY ALWAYS CHECK ROPES AND CARGO LINE, SEASIDE AND SHORE SIDE SHOULD CHECED AT ALL TIMES.

-IN ANY DOUBT INFORM TO CHF.OFF.

Notices :

Following items should be tested as necessary		
Prior loading / discharging		**Time**
High level alarms tested (before loading and discharging)	18.10.13	16 OCT
Cargo pumps hydrolics emergency shutdown tested (before discharging)	-	~~18 OCT~~
Ex-meter / ox-meter calibrated	〃	18 OCT clear

LOAD / DISCH	#1	#2
Product name in the COF	METHYL TERT BUTHYL ETHER	

Any special requirement in the COF	~~Yes / No~~	Yes / No
Compatibility of tank coating material	Yes / No	Yes / No
USCG compatibility group	41-ETHERS	
Precautions for drip tray for non compatible cargoes (if non compatible cargoes on board please specify precautions)	N/A	
Check FOSFA list when required	~~Yes / No~~	Yes / No
Cargo miscibility	COMPLETE IN WATER	
Fire fighting agents	FOAM / DRY CHEMICAL/CO2	
Hazardous, delete as appropriate	~~Toxic / Flammable / Corrosive~~	Toxic / Flammable / Corrosive
MSDS supplied from shipper	Yes / ~~No~~	Yes / No
Marpol Category	ANNEX II - CATZ	
Cargo viscosity	N/A	
Cargo melting point	-109 C	
MARPOL prewash required	~~Yes~~ / No	Yes / No
Static accumulator cargoes (*)	~~Yes~~ / No	Yes / No
If static accumulator cargo, what is the max rate for each tank in first foot (tank by tank)	cbm	cbm
If static accumulator cargo, what is the relaxing period time before sampling	N/A	
Inhibitor required (check from COF)	Yes / No	Yes / No
Control of PV valves	~~Open~~ / controlled	Open / controlled
Vapour return line connected	Yes / no	Yes / no
N2 Padding in transit	Yes / ~~No~~	Yes / No
Heating required; min/max	°C	°C
Any cooling requirements	~~Yes~~ / No	Yes / No
If non heating cargo, heating coils blanked	Yes / No	Yes / No
Antidote, USCG Appendix B	~~Yes~~ / No	Yes / No
Carcinogens, USCG Appendix B	~~Yes~~ / No	Yes / No

Density of cargo (15 °C - 20 °C)	0,74	
Correction Factor for 1 °C	-	
Shore tank temp. °C	32 °C	
Max. rate of initial/bulk/topping for loading	100MT 600 MT 100 M/T	MT MT M/T
Notice time to need for rate of change for loading	30 min.	
Max. pressure permitted	~~kg/cm~~	kg/cm
Standby time/response needed for normal stop	2-3 mins.	
If loading; quantity in the line/arm/ hose, that will be blown towards the ship after completion	(Yes) No ~~cbm~~ 500 ltrs	Yes / No cbm
If discharging: any requirement for shore line cleaning	~~Yes / No~~	Yes / No
Any notification needed for shore line displacement regarding time or volume	~~Yes~~ / No	Yes / No

Quantities of requested for loading, by vessel	3000 MT MAX	MT	
Quantities of cargo to be load by shore	3900 MT	MT	
Loading will be completed by	~~Ship stop~~ / shore stop	Ship stop / shore stop	
N2 Purging Before and/or After	Before and/or After	Before and/or After	
Procedure of emergency stop	STOP 3 TIMES		
Any stoppage needed for changing shore tank / connection	~~Yes~~ / No	Yes / No	
Primary communication system.	WATCHMAN – TELEPHONE		
Emergency communication system	VHF CH 14 PORT OPS.		
If bunkering from terminal, state qty, whether ship stop or shore stop?	~~Yes~~ / No	Yes / No	

Max draft during stay at the jetty	6.20 M
Minimum water depths in the jetty	17.8 M
Minimum UKC	11.6 M

Hazards of the cargoes	SEE MSDS&CARGO INFO SHEET
Protective equipments to be used	SEE MSDS&CARGO INFO SHEET
Fire hazards (from IMDG Code supplement)	SEE MSDS&CARGO INFO SHEET
Action to be taken in the event of spillage (from IMDG Code Supplement)	SEE MSDS&CARGO INFO SHEET

WATCH LIST

Following section should be signed that every duty person has knowledge about cargo properties and the current operation.

Working Hours From / To	Duty Officer name and signature	Duty Key Person name and signature	Duty Rating name and signature
0000 – 0400	[redacted]	[redacted]	[redacted]

0400 – 0800	[redacted]	[redacted]	[redacted]
0800 – 1200			
1200 – 1600			
1600 – 2000			
2000 – 2400			

Prepared By:
Ch. Officer

Verified By:
Master

* Cargo lines distribution plan should be attached.

*In the case of any update / changes in the pre planning, Chief Officer shall brief involved crewmembers, for updates.
İlk planlamadan sonra operasyonda bir değişiklik veya ek bilgi varsa, operasyona katılan personel bilgilendirilecek ve aşağıdaki bölüm imzalanacaktır.

UPDATES

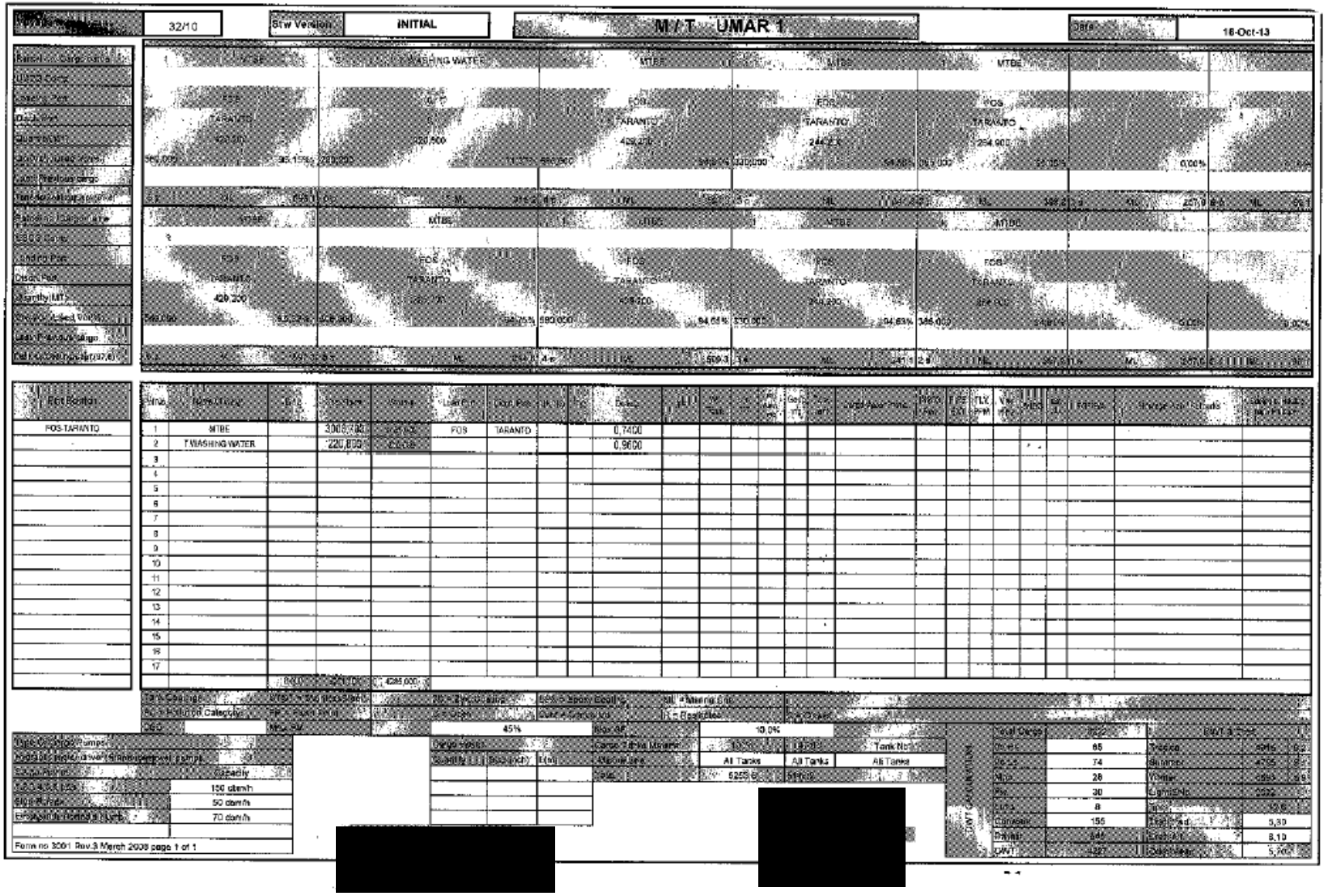
Date and Time	Duty Officer name and signature	Duty Key Person name and signature	Duty Rating name and signature

Prepared By:
Ch. Officer

[redacted]

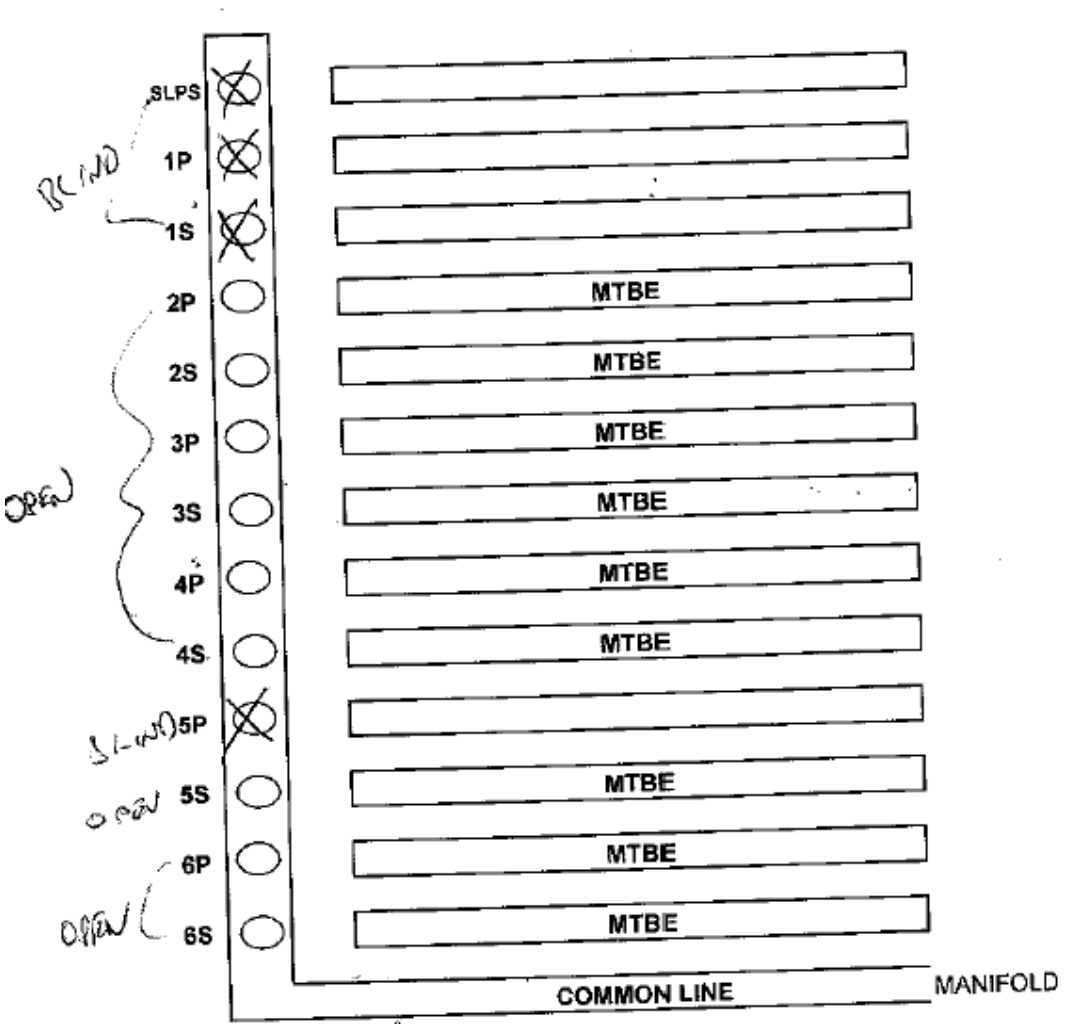
Verified By:
Master

[redacted]


32/10
Stw Version
INITIAL
M / T UMAR 1
Date
16-Oct-13
MTBE
WASHING WATER
FOS
TARANTO
FOS TARANTO

M/T UMAR 1

Voy No: 32/13



Annex B Test of PV Valves

Chemfleet

TEST OF PV VALVES

Form No 3406
Date 15.03.2006
Revision 1
Page 1 of 1

All PV valves on board should be tested with margins of working pressure (negative / positive) and record to this file per 12 months. Working pressure margins should be marked on the PV valves.

Date	P/V Identification	Operating Pressure/Vacuum Margins	Observed Negative Working Pressure	Observed Positive Working Pressure	Result Of Test At Positive Pressure Setting	Result Of Test At Vacuum Setting	Name & Signature Of Chief Officer
28.02.2013	COT 1P	2100 mmwg/ -350mmwg	-340 mmwg	2050 mmwg	SATISFACTORY	SATISFACTORY	[redacted]
28.02.2013	COT 1S	2100 mmwg/ -350mmwg	-350 mmwg	2080 mmwg	SATISFACTORY	SATISFACTORY	
28.02.2013	COT 2P	2100 mmwg/ -350mmwg	-350 mmwg	2070 mmwg	SATISFACTORY	SATISFACTORY	
28.02.2013	COT 2S	2100 mmwg/ -350mmwg	-350 mmwg	2060 mmwg	SATISFACTORY	SATISFACTORY	
28.02.2013	COT 3P	2100 mmwg/ -350mmwg	-340 mmwg	2060 mmwg	SATISFACTORY	SATISFACTORY	
28.02.2013	COT 3S	2100 mmwg/ -350mmwg	-360 mmwg	2050 mmwg	SATISFACTORY	SATISFACTORY	
28.02.2013	COT 4P	2100 mmwg/ -350mmwg	-350 mmwg	2100 mmwg	SATISFACTORY	SATISFACTORY	[redacted]
28.02.2013	COT 4S	2100 mmwg/ -350mmwg	-350 mmwg	2100 mmwg	SATISFACTORY	SATISFACTORY	[redacted]
28.02.2013	COT 5P	2100 mmwg/ -350mmwg	-360 mmwg	2090 mmwg	SATISFACTORY	SATISFACTORY	[redacted]
28.02.2013	COT 5S	2100 mmwg/ -350mmwg	-350 mmwg	2090 mmwg	SATISFACTORY	SATISFACTORY	[redacted]
28.02.2013	COT 6P	2100 mmwg/ -350mmwg	-350 mmwg	2090 mmwg	SATISFACTORY	SATISFACTORY	[redacted]
28.02.2013	COT 6S	2100 mmwg/ -350mmwg	-350 mmwg	2090 mmwg	SATISFACTORY	SATISFACTORY	[redacted]
28.02.2013	SLOP P	2100 mmwg/ -350mmwg	-360 mmwg	2080 mmwg	SATISFACTORY	SATISFACTORY	[redacted]
28.02.2013	SLOP S	2100 mmwg/ -350mmwg	-350 mmwg	2080 mmwg	SATISFACTORY	SATISFACTORY	[redacted]

Annex C Loading Protocol

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Tel + 90 216 352 50 00
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website www.chemfleet.org

LOADING PROTOCOL

Vessel : UMAR 1
Port : FOS
**Terminal : **

Voyage No : 32/13
C / P Date : 15.10.13
Cargo:METHYL TERT BUTHYL ETHER

	VESSEL	TERMINAL	
CARGO GRADE NAME	M.T.B.E.	MTBE	
QUANTITY IN MTS	MAX 3000 MT	3000T air mea	
STOWAGE/TANK NUMBERS SHIP AND SHORE	2W-3W-4W-5S-6W	2W-3W-4W-5S-6W	
DENSITY @ 15/20C	-		
CORRECTION FACTOR	-		
SHORE TANKS AVERAGE CARGO TEMPERATURE	-		
INITIAL LOADING RATE (cbm)	100CBM	100 CBM	
MAXIMUM LOADING RATE (cbm)	800CBM	560 CBM	
TOPPING OF RATE (cbm)	200 CBM	200 CBM	
MAXIMUM MANIFOLD PRESSURE (bars)	8 BARS	10,5 Bars	
NUMBER, SIZE AND STD OF MANIFOLD CONNECTION	10"	12"	
MANIFOLD IDENTIFICATION	COMMON LINE	COMMON LINE	
BLOWING QUANTITY INTO THE VESSEL TANKS	-	500 Liters	
MEANS OF BLOWING (AIR/NITROGEN/PIGGING)	-		
REQUIRED NOTICE FOR TOPPING OFF	30 MIN	30mn	
REQUIRED NOTICE FOR FINAL STOP ON COMPLETION	15 MIN	15mn	
EMCY STOP METHOD	3 TIMES "STOP"	TURN BUTTON	
ESTIMATED ELAPSED TIME AFTER EMCY STOP SIGNAL	-	2 min	
LOADING TO BE STOPPED BY (SHIP OR SHORE)	SHORE	SHORE	

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website www.chemfleet.org

REMARKS:

Date : 19/10/2013

Time : 0014 15

SIGNATURE OF CHIEF OFFICER **SIGNATURE OF LOADING MASTER**

Annex D **Hourly Loading / Discharging Back Pressure & Rate Monitoring Sheet**

Chemfleet

HOURLY LOADING / DISCHARGING BACK PRESSURE & RATE MONITORING SHEET

Form No	2903
Date	15.03.2006
Revision	1
Page	1 of 1

VESSEL'S NAME	:	M/T UMAR 1
DATE	:	19-Oct-13
PORT	:	FOS
CARGO	:	[illegible]
SPECIFIED DENSITY	:	0,7457 at 15 C in Vac

CARGO TEMPRATURE	:	25 C
CORR. FACTOR	:	[illegible]
CARGO DENSITY	:	0,746
TOTAL CARGO	:	

DATE & TIME	TRIM & BACK P.	BM	SF		1P	1S	2P	2S	3P	3S	4P	4S	5P	5S	6P	6S	SLPP	SLPS	T.O.B cbm	T.O.B m/t	RATE cbm	RATE m/t	E.T.C.
[illegible]	1,10	76%	31%	ULLAGE			7144	7140	7145	7143	7142	7140		7144	7165	7057			0,0	0,0			
0:56	0,00			VOLUME			[illegible]	0,0	0,0	0,0	0,0	0,0		0,0	0,0	0,0							
[illegible]	1,25	74%	26%	ULLAGE			5922	5419	7145	7143	7142	7140		7144	5816	5773			364,8	272,1	364,8	272,1	
2:00	0,00			VOLUME			71,0	[illegible]	0,0	0,0	0,0	0,0		0,0	116,0	112,0							
[illegible]	1,43	73%	21%	ULLAGE			4702	4066	7145	7143	7142	7140		7144	4215	4108			865,0	645,0	500,2	373,0	
3:00	0,00			VOLUME			146,0	183,0	0,0	0,0	[illegible]	0,0		0,0	257,0	269,0							
[illegible]	1,73	72%	17%	ULLAGE			3394	3332	7145	7143	7142	7140		7144	2485	2288			1335,0	995,5	470,0	350,5	
4:00	0,00			VOLUME			[illegible]	239,0	0,0	0,0	0,0	0,0		0,0	[illegible]	[illegible]							
[illegible]	1,75	70%	17%	ULLAGE			2852	2120	6041	6527	7142	7140		7144	1274	1165			1761,0	1313,2	426,0	317,7	
5:00	0,00			VOLUME			[illegible]	[illegible]	[illegible]	32,0	0,0	0,0		0,0	[illegible]	[illegible]							
[illegible]				ULLAGE															0,0	0,0	-1761,0	-1313,2	
6:00				VOLUME																			
																			0,0	0,0	0,0	0,0	
																			0,0	0,0	0,0	0,0	
				ULLAGE																			
				VOLUME																			

Annex E Log of Pressure Alarms[7]

alarms.2013.10.19

```
19/10/2013  01:23:16 - on  - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  01:23:34 - ack - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  01:27:25 - on  - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  01:27:58 - ack - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  01:30:26 - off - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  01:30:51 - off - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  01:41:51 - on  - Alarm on CT2P - Relative Pressure - highhigh (High
High)
19/10/2013  01:41:51 - on  - Alarm on CT2P - Relative Pressure - high (High)
19/10/2013  01:41:59 - ack - Alarm on CT2P - Relative Pressure - high (High)
19/10/2013  01:42:00 - ack - Alarm on CT2P - Relative Pressure - highhigh (High
High)
19/10/2013  01:51:44 - on  - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  01:55:03 - on  - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  03:18:25 - ack - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  03:18:25 - off - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  03:18:26 - ack - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  03:18:26 - off - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  03:21:54 - on  - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  03:22:52 - on  - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  03:33:54 - off - Alarm on CT2P - Relative Pressure - highhigh (High
High)
19/10/2013  03:33:54 - off - Alarm on CT2P - Relative Pressure - high (High)
19/10/2013  04:48:35 - ack - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  04:48:35 - off - Alarm on CT6P - Relative Pressure - highhigh (High
High)
19/10/2013  04:48:35 - ack - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  04:48:35 - off - Alarm on CT6P - Relative Pressure - high (High)
19/10/2013  04:49:43 - on  - Alarm on CT3S - Relative Pressure - highhigh (High
High)
19/10/2013  04:49:43 - on  - Alarm on CT3S - Relative Pressure - high (High)
19/10/2013  04:50:28 - on  - Alarm on CT3P - Relative Pressure - highhigh (High
High)
19/10/2013  04:50:28 - on  - Alarm on CT3P - Relative Pressure - high (High)
19/10/2013  05:03:20 - ack - Alarm on CT3P - Relative Pressure - high (High)
19/10/2013  05:03:20 - off - Alarm on CT3P - Relative Pressure - high (High)
19/10/2013  05:03:21 - ack - Alarm on CT3P - Relative Pressure - highhigh (High
High)
19/10/2013  05:03:21 - off - Alarm on CT3P - Relative Pressure - highhigh (High
High)
19/10/2013  05:03:21 - ack - Alarm on CT3S - Relative Pressure - high (High)
19/10/2013  05:03:21 - off - Alarm on CT3S - Relative Pressure - high (High)
19/10/2013  05:03:22 - ack - Alarm on CT3S - Relative Pressure - highhigh (High
High)
19/10/2013  05:03:22 - off - Alarm on CT3S - Relative Pressure - highhigh (High
High)
19/10/2013  05:04:51 - on  - Alarm on CT3P - Relative Pressure - highhigh (High
High)
19/10/2013  05:04:51 - on  - Alarm on CT3P - Relative Pressure - high (High)
19/10/2013  05:34:36 - on  - Alarm on CT2P - Relative Pressure - highhigh (High
High)
19/10/2013  05:34:36 - on  - Alarm on CT2P - Relative Pressure - high (High)
19/10/2013  05:38:10 - on  - Alarm on CT3S - Relative Pressure - highhigh (High
High)
19/10/2013  05:38:10 - on  - Alarm on CT3S - Relative Pressure - high (High)
                                  Page 1
```

[7] The log of pressure alarms has been extracted from the cargo computer. It has been established that the time on the VDR and the cargo computer are out of synch by 19 seconds. Since the VDR clock is more accurate than the cargo computer clock, it may be concluded that actually, the explosion happened at about 05:34:52.

alarms.2013.10.19

```
19/10/2013  05:58:35 - ack - Alarm on CT3S - Relative Pressure - high (High)
19/10/2013  05:58:35 - off - Alarm on CT3S - Relative Pressure - high (High)
19/10/2013  05:58:35 - ack - Alarm on CT3S - Relative Pressure - highhigh (High
High)
19/10/2013  05:58:35 - off - Alarm on CT3S - Relative Pressure - highhigh (High
High)
19/10/2013  05:58:35 - ack - Alarm on CT2P - Relative Pressure - high (High)
19/10/2013  05:58:35 - off - Alarm on CT2P - Relative Pressure - high (High)
19/10/2013  05:58:36 - ack - Alarm on CT2P - Relative Pressure - highhigh (High
High)
19/10/2013  05:58:36 - off - Alarm on CT2P - Relative Pressure - highhigh (High
High)
19/10/2013  05:58:36 - ack - Alarm on CT3P - Relative Pressure - high (High)
19/10/2013  05:58:36 - off - Alarm on CT3P - Relative Pressure - high (High)
19/10/2013  05:58:37 - ack - Alarm on CT3P - Relative Pressure - highhigh (High
High)
19/10/2013  05:58:37 - off - Alarm on CT3P - Relative Pressure - highhigh (High
High)
19/10/2013  06:06:00 - on  - Alarm on CT5P - Relative Pressure - low (Low)
19/10/2013  06:06:00 - on  - Alarm on CT5P - Relative Pressure - lowlow (Low Low)
19/10/2013  06:06:53 - ack - Alarm on CT5P - Relative Pressure - lowlow (Low Low)
19/10/2013  06:06:53 - ack - Alarm on CT5P - Relative Pressure - low (Low)
```