

**Report on casualty investigation into the incident in cargo tank no. 6 Port.****SUMMARY**

The chemical tanker "Rheinstern" was anchored off Rotterdam on 4<sup>th</sup> September 2001, awaiting voyage orders. Whilst at anchor, the cargo tanks were being prepared for the next cargo.

A decision was taken to eject the remaining Naptha cargo residues in the cargo tanks into the slop tanks without cleaning the tanks with water. In order to eject the tanks, the normal procedure was for men to enter the tanks to put the suction hose of the air driven pump being used under the foot of the deepwell main cargo pump.

After a period of ventilation the crew were entering the tanks wearing Filter Masks, not Self Contained Breathing Apparatus (SCBA sets)

At 1645 whilst the Deck Cadet was on watch at Cargo Tank 6 Port, he saw one of the crew members down the tank collapse, he immediately informed the Second Officer who was on the bridge and the general alarm was sounded.

During the tank rescue operation the Master, who had gone from the bridge to the tank to assist, collapsed on deck. Despite repeated and prolonged attempts to revive him he was pronounced dead by the doctor when he arrived by helicopter at 1835.

**INQUIRY AND EVIDENCE**

The Isle of Man Marine Administration were advised of the incident by the Netherlands Shipping Inspectorate on morning of 5<sup>th</sup> September 2001. They had been asked to assist the Rotterdam River Police as the vessel returned into port after the Master had collapsed and died during an incident onboard. Their initial investigation showed there to be unsafe working practices onboard and advised this office. Two Marine Administration Surveyors travelled to Rotterdam and attended the vessel that evening and the following day.

Voluntary witness statements were taken from persons involved in the tank cleaning and in the rescue operation.

Evidence was also obtained from the ship's safety management system, log book entries, familiarisation training records and cargo records.

### **Ship Details**

The Rheinstern is a Type 1 Chemical Tanker delivered in August 1993 and registered on the Isle of Man flag on 23<sup>rd</sup> March 1997.

Details as listed below:-

POR	Douglas
GRT:	11423
NRT:	9420
DWT:	17080
IMO No.	9053191
Tanks	16
LOA	161.36m

### **Cargo Tanks and Pumping System**

The Rheinstern has 8 pairs of epoxy coated inner wing cargo tanks and 2 centre tanks (3 & 6). Tanks 1,4 & 7 (P&S) have to be drained into adjacent tanks through gate (sluice) valves. The cargo tanks are discharged by using deepwell pumps in tanks 2,3,5,6 & 8 (P&S), 3C and 6C. The slop tanks are discharged by using a deepwell pump in the Port slop tank with a gate valve between the two tanks.

The pumping system is fitted with a stripping system capable of stripping the tanks to the standard required by Type 1 Chemical Tankers. This should result in a very small quantity of cargo being left in each tank at end of discharge.

All cargo tanks had been utilised for the previous cargo of Naptha.

### **The Cargo**

Naptha also known as Coal Tar is a Chapter 17 cargo as contained in the International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk and Index of Dangerous Chemicals carried in Bulk (IBC Code) 1998 Edition.

Naptha is included in Chapter 17 because of its Safety and Pollution Hazards under column "d" as "S/P". The hazards of Naptha are listed as Flammable, Dangerous Fire Risk, Explosive Limits in air 1 - 6%. The cargo is highly dangerous requiring the most stringent precautions to be taken before any tank cleaning operations are undertaken.

## SEQUENCE OF EVENTS

The Master and Chief Officer decided to commence tank cleaning operations whilst the ship was at anchor off Rotterdam awaiting voyage orders.

As there were no voyage orders, hence no instructions on how to clean the cargo tanks after the Naptha cargo was discharged for the next cargo, the Master, according to the Chief Officer, instructed him to prepare the cargo tanks by ejecting without washing.

The tank cleaning operation started at about 1000 on 4<sup>th</sup> September 2001, at tank 8S by ventilating the tank. At about 1030 - 1045 the Chief Officer took readings of 8S by the use of the portable monitoring equipment. Readings were 15-25% of LEL and around 20% oxygen. No written record of readings taken were kept by the Chief Officer at time of monitoring.

The Chief Officer did not see the crew members enter tank 8S, but he did see them leave the tank, wearing filter masks. He told them that the Captain had given clear instructions that breathing apparatus should be used when entering cargo tanks during cleaning operations. The crew member spoken to by the Chief Officer said that he would prefer to wear the filter mask as it was easier to wear and not as heavy as the breathing apparatus. No time was given for either entering or leaving the tank.

The crew then entered tank 6S after transferring the pump and hoses. Prior to entry, 6S was not monitored for flammable or oxygen levels by the Chief Officer as the responsible officer in charge of the operation, nor by anyone else. The reason given was that the atmosphere in 6S would be the same as 8S. The Chief Officer did not see the crew members enter 6S, nor what they were wearing as protection against the toxic gas atmosphere in the tank. He did not stay to supervise the crew to ensure that they were wearing the breathing apparatus as required by the Master.

The ventilation of each tank was carried out by using large bore flexible ducting connected to the main blower line led to the Butterworth access in each tank. The hoses were not pushed down to a low level in the tank but were left at the top of each tank. The time for each ventilation cycle was not standard, nor was it recorded. The tank lids were kept cracked open to create a back pressure. There was a maximum of three tanks being ventilated at any one time.

There were no recordings of tank entries in the Tank Entry Log Book maintained on the bridge by the watchkeeping officer until 1130 when the crew were entering tank 5S.

The time was recorded by the 3<sup>rd</sup> Officer who was on anchor watch on the bridge. The Cadet who went on watch on the bridge with the 2<sup>nd</sup> Officer at 1200 asked his permission to go on deck as there was little happening on the bridge.

The Deck Cadet arrived on deck about 1230, he saw no-one on deck, but he saw the breathing apparatus on deck beside tank 5S. He looked down and saw two men working in the tank. The Cadet then stayed with the crew members who were ejecting the tanks.

Entry and exit from cargo tanks continued as recorded below:

Tank	Time of entry	Exit	
5S	1130	1155	
5S	1200	1243	change of watch
3S	1255	1310	
2S	1312	1330	
2P	1303	1400	
3P	1405	1435	
3C	1530	1555	
5P	1600	1630	
6P	1635	-	

The times were reported by the Deck Cadet to the bridge and recorded by the 2<sup>nd</sup> Officer in the Tank Entry Log Book. The names of the crew members entering each tank were also recorded.

At the time of the watch change at 1200 neither the 3<sup>rd</sup> Officer nor the 2<sup>nd</sup> Officer saw anyone on deck, even though the Tank Entry Log Book had an entry indicating that two men were recorded as being in tank 5S.

During the afternoon at 1430 the Chief Officer left the deck to get some rest, as he had been on duty for over 12 hours. He stated that he had asked permission from the Master to leave the deck operations though he did not inform anyone on deck that he was leaving to get some rest.

At 1635 3 crew members, all wearing filter masks, entered tank 6P though no atmospheric checks had been made. One man placed the hose from the portable Wilden near the pump suction and the other two were "squeegying" cargo residue towards the suction.

At 1645 the Deck Cadet reported to the bridge that a crew member with the hose had collapsed in tank 6P. On receipt of the report the 2<sup>nd</sup> Officer sounded the General Alarm. Almost immediately, the Master arrived on the bridge; on being told of the incident, the Master left the bridge to go to 6P. On the way he met the 3<sup>rd</sup> Officer who he instructed to get the rescue line and harness from the top of the aft deck store on the main deck.

Meanwhile, one of the two crew members still standing in tank 6P left the tank to get a breathing apparatus, while the other crew member stayed with the man who had collapsed. The Deck Cadet took the filter mask from the crew member who left the tank, put it on and entered the tank taking a breathing apparatus set down to the collapsed crew member, he then immediately left the tank. The crew member fitted the breathing apparatus to the collapsed man and heard that the man was breathing. The crew member who initially left the tank re-entered wearing a breathing apparatus and stayed with the collapsed man. The crew member who had remained down the tank throughout, with only a filter mask, then left the tank.

As the crew member arrived at the tank top, the Master took the filter mask from him, put it on himself and entered the tank. On reaching the bottom, he tried to help the

crew member move the collapsed crew member. He could not help and then left the tank.

The 3<sup>rd</sup> Officer had arrived with the rescue line and harness, the 2<sup>nd</sup> Officer had arrived with the oxygen resuscitator and most of the crew had arrived on deck at tank 6P.

Two more crew members had donned breathing apparatus and entered tank 6P under the orders of the Master. There were now three crew members down 6P wearing breathing apparatus with the collapsed crew member also wearing a breathing apparatus.

The rescue operation was being carried out using the rescue line and harness that had been lowered and placed on the collapsed crew member.

Whilst the rescue operation was being carried out the Master, who was assisting in pulling on the rescue rope was seen to collapse and he was caught by the engine room fitter.

The Master was carried by a number of the crew and laid on the port catwalk where CPR was administered by the 2<sup>nd</sup> Engineer, other officers and crew members.

The 2<sup>nd</sup> Officer on the bridge called for assistance from the Netherlands Coastguard and he was given medical advice, which he passed on to the personnel on deck by radio. He was then told to contact Maas Centre to arrange a boat as a helicopter was not ready and would take time to organise. After a period of time it was agreed that a helicopter would be sent, as the sea conditions would not allow a boat to come alongside.

The ship prepared to heave up anchor and at 1815 was underway towards Rotterdam port. At 1830 a helicopter arrived with the doctor and two pilots. The doctor checked the Master and he was pronounced as dead.

The Rheinstern then entered Rotterdam, being fast alongside at 2140.

The crew member who was rescued from the cargo tank returned to the vessel the next morning after examination at a local hospital.

## ANALYSIS AND COMMENTS

The incident occurred as a result of the following:

- a. Not following tank entry procedures as laid down in the Company Employee Hand Book.
- b. Wearing filter type masks in enclosed spaces against company instructions as laid down in the Company Employee Hand Book and IBC Code.
- c. Not following the correct tank cleaning procedures for the cargo carried.
- d. Lack of supervision of crew by the senior officer in charge of the tank cleaning operation.
- e. Lack of monitoring and recording of the tank atmosphere before entry for oxygen and explosive content.
- f. No plan of how to carry out the tank cleaning operation being put in place.

### a. Tank Entry Procedures

The company requires a procedure to be completed prior to tank entry, by the responsible officer, which includes completing and complying with the items as laid down in Company Procedure Entry into enclosed space Form P-4.4-20 - Enclosed Space Entry Permit as stated on page 30 of the Employee's Hand Book. The explanation on page 30 is an emergency procedure as well as the normal entry procedure. This includes wearing breathing apparatus. The Permit was not completed by the responsible officer, in this case the Chief Officer, prior to entry into each tank which indicates that the procedures required by the Permit were not complied with. There were no completed Permits available for inspection. The Enclosed Space Entry Permits for the previous operation were not completed until after the operation was completed, as reported by the Chief Officer. The requirements of the Code of Safe Working Practices for Merchant Seamen were not complied with by the Chief Officer.

The Enclosed space entry procedure on P30 of the Employee's Hand Book states "It may be necessary for you to enter an atmosphere which is unsafe, either under normal circumstances or to save life".

**There should never be a normal circumstance where persons have to enter an unsafe atmosphere. Safe operating procedures should ensure that tanks are cleaned and fully gas freed before normal entry.**

### b. Wearing Filter Masks

Wearing of filter masks is prohibited by the company for use in enclosed spaces, as stated on page 23 of the Employee's Hand Book. The Chief Officer saw the crew members leaving the first tank to be ejected, tank 8S, wearing filter masks. He told the crew members that they had to wear breathing apparatus for tank entry as this had been an instruction from the Master. There were breathing apparatus sets available at each tank ready for use by the crew. They did not want to use them as they were heavy to use whilst entering, leaving and working down the tanks. Procedure P-4.4-20 refers to IBC Code 16.4.2 as guidance for tank entry.

IBC Code Chapter 16.4.2 states "Personnel should not enter cargo tanks, void spaces around such spaces, cargo-handling spaces or other enclosed spaces unless:-

1. The compartment is free of toxic vapours and not deficient in oxygen; or.
2. Personnel wear breathing apparatus and other necessary protective equipment, and the entire operation is under the close supervision of a responsible officer. The Chief Officer did not keep close supervision of the tank cleaning operation as he was not aware of who was down the tanks, if they were wearing breathing apparatus or who was keeping watch on the crew members working down the tanks. The crew members working in the tanks did not wear breathing apparatus as instructed and would decide themselves by the smell whether to wear filter masks or breathing apparatus. The filter masks being used onboard were fitted with filters capable of effective operation in up to 2% LEL in fresh air. The tanks being entered had an LEL of 15% to 20%.

**Safe operating procedures should ensure that tanks are cleaned and fully gas freed before entry. If this is carried out then there should be no need for filter masks.**

### **c. Correct Tank Cleaning Procedures**

Company tank cleaning procedures in the Safety Management System do not exist. The tank cleaning matrix from an oil major used onboard was picked up by staff as a useful guide. A copy of Dr. Verweys Tank Cleaning Guide is onboard though the instructions for cleaning after Naptha were not used.

The vessel had no cargo orders and the recommended tank cleaning requirements after a cargo of Naptha is dependant on the next cargo to be loaded. This could include just draining, or a bottom flush with water, a minimum of 2 cycles of tank washing, gas freeing and stripping, or a combination of these.

The correct tank cleaning procedure for cleaning after this Naptha cargo was not followed by the Chief Officer as he had been instructed verbally by the Master to eject the residues from the tanks without washing. The stated routine for tank cleaning without specific tank cleaning instructions from charterers or cargo owners was to eject without tank washing. This was done to reduce the amount of water that would be pumped to the slop tanks. According to the Chief Officer, the Company did not like too much water in the slop tanks as it meant a larger quantity of liquid to be pumped ashore to reception facilities

The Rheinstern is a Type 1 Chemical Tanker, required to be capable of pumping tanks to comply with MARPOL Annex II Regulation 5A (2)(b), for Naptha, which is a Category B cargo, the maximum allowed is  $0.1\text{m}^3$  in the tank's associated piping and in the immediate vicinity of the tank's suction point. The amount of residue in tank 6P calculated by the relief Master and Chief Officer was estimated as being  $1.5\text{m}^3$ . Stripping of the cargo tanks to this requirement was not normally carried out onboard due to the time it took to strip each tank. This resulted in the relatively large quantity being in 6P than is allowed.



#### **d. Lack of Supervision of the Crew**

The crew members after being seen and spoken to by the Chief Officer at tank 8S were not supervised to ensure that they complied with the Master's instructions about wearing breathing apparatus for tank entry. The reporting of crew members entering each tank, which is required by the company tank entry procedures was not always carried out, as indicated by the records in the Tank Entry Log Book maintained by the officer on watch, in this case on the bridge.

The requirements to have a person at the entrance to the tank to keep watch on the crew members working in the tank was not always followed. Both officers on watch on the bridge saw no-one on deck, neither did the Deck Cadet when he arrived on deck at 1230, even though there were two men working down tank 5S. No-one, including the Chief Officer was on deck.

#### **e. Lack of Monitoring and Recording of Tank Atmospheres**

Monitoring of tank atmospheres both before and during entry in cargo tanks is required by the Company as stated in the Employee's Hand Book when referring to Procedure P-4.4-20 "Entry in to enclosed space, Section 1 - Pre-Entry Preparations". Also arrangements for frequent atmosphere checks are required to be put in place.

The Chief Officer stated that he carried out monitoring of some of the tanks, but not all, as they would be the same as the ones monitored. No frequent monitoring checks of the tank atmospheres while personnel were working were taken at all. No records of the readings, were reported as being taken prior to entry. The Enclosed Entry Permits for this particular operation had not been started.

From statements taken onboard from the Chief Officer the following has been created as a table of tank atmospheres

Tank entered	Atmosphere checked	Stated reading	
		OXYGEN	LEL
8S	YES	21%	15 to 25%
6S	NO		
5S	YES	not reported	15 to 35%
3S	NO		
2S	YES	not reported	15 to 35%
2P	NO		
3P	YES	not reported	15 to 35%
3C	not stated		
5P	NO		
6P	NO		

In tanks where no atmosphere was checked it was believed that the atmosphere would be the same as the other tanks checked.

Tank 8S was the first tank to be entered that day and is the only tank where a clear indication of the time taken to ventilate a tank can be taken. The tank was gas freed for 30 minutes and the atmosphere checked and the readings were as stated above, 21% oxygen and 15 to 25% LEL. The crew entered the tank approximately 10 minutes

after the readings were taken. In tank 5S the crew entered approximately 15 to 20 minutes after the readings were taken.

During the investigation the opportunity was taken to try and gas free tank 6P, where the incident happened, as it would have been during the tank cleaning operation. The tank still contained the cargo residues that the crew were trying to eject. This was commenced at 1500 and readings taken at 1624 showing 21% O<sub>2</sub> and 30% LEL. Further readings were taken at 1840 and the LEL was 17%.

**The time taken to ventilate tanks prior to entry was unrealistic and allowing crew members to enter these tanks either with or without supervision was grossly irresponsible.**

**As stated previously there should never be a normal circumstance where persons have to enter an unsafe atmosphere. Safe operating procedures should ensure that tanks are cleaned and fully gas freed before normal entry.**

#### **f. Tank Cleaning Operation Plan**

There was no agreed plan for tank cleaning prior to the start of the tank cleaning operation, no particular crew member was detailed as the "Authorised Team Leader" of the team entering the tanks, nor was a person detailed as the "responsible person supervising entry".

There are no instructions in the Company General Operations Manual (GOM) on tank cleaning operations. There is no reference to a tank cleaning operation plan in the Employee's Hand Book on page 30 "Enclosed Space Entry - Emergency Procedures". This section although titled as above, gives instructions for entry under normal circumstances and emergency.

None of the precautions listed on page 30 were agreed prior to or during the tank cleaning operations.

## CONCLUSIONS

On the basis of the sequence of events and the analysis within this report the following conclusions are reached:

The crew members involved were given no clear instructions as to what their duties were, safety matters involved in tank entry, nor were they supervised by the Chief Officer

Basic safety procedures were ignored by all concerned involved in the tank cleaning operations.

The use of filter masks was prohibited by the Company though this was not known by the persons interviewed. The prohibition is only mentioned on p23 of the Employee Hand Book and should have been better promulgated.

The Chief Officer did not carry out his function as the responsible officer during the tank cleaning operation, in that he did not ensure that the crew members wore breathing apparatus during tank entry.

The Chief Officer was grossly negligent in not ensuring that safe working practices were carried out by the crew members.

The Chief Officer did not ensure that the requirements of the Enclosed Space Entry Permit and the IBC Code in that he did not monitor the tank atmosphere as required before and during entry into cargo tanks by crew members. The Chief Officer was grossly negligent in this respect.

The time taken to ventilate tanks prior to entry was unrealistic.

Company tank cleaning procedures and cargo operating procedures in the Safety Management System do not exist. With no clear instructions there were various operating practices being carried out that were believed to be the Company's requirements.

Tank cleaning by bottom flushing and/or washing should be kept to a minimum to avoid retention of water in slop tanks for discharge ashore.

There was a perceived need to keep port time to a minimum and time was not taken to drain tank residues to the vessel's capability.

There was a perceived need to have the vessel ready for the next cargo as soon as possible, even without any confirmed cargo orders.

## **Tank Cleaning Operation**

The general attitude to tank cleaning was casual in that there was no structured way in which the operation was carried out and supervised by the senior officers on board. The crew members involved were given no clear instructions as to what their duties were, safety matters involved in tank entry, nor were they supervised by the Chief Officer. Company instructions, as sparse as they were, were not followed by either the Master or the Chief Officer. Basic safety procedures were ignored by all concerned involved in the tank cleaning operations. This style of operation was prevalent on board as evidenced from crew interviews. The Master and Chief Officer were negligent in not making sure that the crew members followed their clear instructions and company procedures.

## **Use of Filter Masks**

The use of filter masks was prohibited by the Company, this was not known by the persons interviewed, nor did it appear to be known by the relief Master or Superintendent. The Chief Officer did not carry out his function as the responsible officer during the tank cleaning operation, in that he did not ensure that the crew members wore breathing apparatus during tank entry. The Chief Officer was grossly negligent in not ensuring that safe working practices were not carried out by the crew members.

## **Tank Entry**

The Chief Officer did not ensure that the requirements of the Enclosed Space Entry Permit and the IBC Code which required entry into cargo tanks by crew members, in that he did not monitor the tank atmosphere. The Chief Officer was grossly negligent in this respect, in not making sure the tanks were safe for entry, particularly that the atmosphere was outside the explosive limits.

In the IBC Code Chapter 16.4 Opening of and entry into cargo tanks, Section 16.4.3 "Personnel should not enter such spaces when the only hazard is of a purely flammable nature, except under the close supervision of a responsible officer". The Chief Officer admitted that he was busy working on deck and could not keep a close watch on the crew members during tank entry. Due to the dangerous toxic and flammable atmosphere in the tanks, his close supervision was essential. In this respect he was grossly negligent.

## **Company Procedures**

Company Tank Cleaning procedures were not complied with by the Master and Chief Officer with regard to the tank cleaning requirements for Naptha, in that washing with water to reduce the concentration of the cargo residue to allow proper ventilation, is a requirement under the reference to "Dr. Verweys Tank Cleaning Guide".

The Chief Officer did not follow the tank cleaning procedures, because, as reported by him, he was instructed by the Master to clean the tanks by ejecting the residues and

not to pre-wash the tanks to reduce the concentration of the Naptha residues before ventilation. As Naptha (Coal Tar Naptha Solvent) is an IBC Code Chapter 17 cargo with F-T notation in Column k, it should be regarded as a highly toxic and flammable cargo, with all the attendant hazards.

The Master was negligent in instructing the Chief Officer not to comply with the Company procedures.

The Chief Officer was negligent in not complying with the Company procedures.

### **Enclosed Space Entry Permit System**

The Permit used by the Company is a direct copy of the International Safety Guide for Oil Tankers & Terminals (ISGOTT) in Appendix I. This Permit is perfectly satisfactory, but due to the non-compliance of the requirements needed to ensure a safe working environment, the Permit system was not used correctly and subsequently failed.

## **RECOMMENDATIONS**

### **Company Policy**

As there are no company policies or instructions in the Safety Management System (SMS), contained in the General Operation Manual for the Master and Officers on how to carry out the operations connected with tank cleaning and tank entry the following is recommended:-

1. The Company policy should state the requirements with regard to Tank Cleaning, which should include how the tanks are to be cleaned after each cargo in an easy to follow way to allow an unambiguous procedure to be followed by all persons on board, and not at the whim or discretion of any one person.
2. The Company should emphasise that time or money is not an issue when it comes to following correct and safe procedures for tank cleaning.
3. The Company should provide a clear and simple procedure for tank entry, separate from the hot and cold work procedures, to allow all personnel to be thoroughly familiar with the procedures.

Company cargo discharge policy appears to be commercially driven, in that stripping is limited so as not to keep the vessel alongside more than is necessary.

### **Training of Crew Members**

Tank entry training should be more frequent. Crew members have not been trained in tank entry procedures since joining, which was up to 10 months. The ship has a full portfolio of videos on training covering many subjects. The log of videos shown to crew members indicates that the video titled "Entering into Enclosed Spaces" was last shown on 3<sup>rd</sup> October 1997, nearly 4 years ago. The Company should establish and maintain procedures for training of ship's personnel to be followed by all ships, as required by Section 6 - Resources and Personnel - of the International Safety Management Code (ISM), with frequent reporting back to the Company Head Office that the training has been carried out.

### **Responsibilities of Personnel on board**

The Company presently has not established detailed responsibilities for personnel who manage, perform and verify work relating to and affecting safety and pollution prevention. The responsibilities of personnel on board is contained in a two page matrix at the beginning of the Procedures Manual, P-4.1-10, where responsibilities are indicated by an X in a box. As a result, none of the Officers interviewed were aware of what the specific duties were or what they entailed. The Company should define and document the responsibility, authority and interrelation of all personnel who manage, perform and verify work relating to and affecting safety and pollution prevention as required by Section 3 of the ISM Code - Company Responsibilities and Authority .