Bahamas Maritime Authority

Report of the investigation into the constructive total loss of the Bahamas registered chemical tanker "Panam Serena" at the port of Porto Torres in Sardinia, Italy
on 01 January 2004

FOREWORD

The investigation into the explosions and subsequent fire on board the Bahamas Registered chemical tanker "Panam Serena" was conducted, to the greatest possible extent, under the provisions of The Merchant Shipping Act of the Commonwealth of The Bahamas.

The casualty occurred in the port of Porto Torres in Sardinia, Italy on the 01 January 2004 and the Flag State investigation has been severely hampered by the legal process adopted immediately after the casualty by the Italian Criminal Court of Inquiry into the accident, which imposed severe restrictions on all aspects of the casualty, including related data and personnel involved. Therefore, this report relies upon the limited access Bahamas Inspectors were able to gain to the terminal, vessel and crew immediately following the casualty, prior to the Court restrictions being imposed, the good cooperation of the owners and the Italian Court Surveyors Report published in July 2005. The Bahamas Maritime Authority arranged for a technical review of the Italian Court Surveyors Report, which was published in Italian and for relevant sections to be translated from Italian to English, as appropriate.

The Bahamas Maritime Authority investigates incidents at sea for the purpose of discovering lessons which may be learned with a view to preventing any repetition. It is not the purpose of the investigation to establish liability or to apportion blame, except in so far as it emerges as part of the process of investigating the incident.

It should be noted that section 170(2) of the Merchant Shipping Act requires officers of a ship involved in an accident to answer an Inspector's questions fully and truthfully. If the contents of a report were subsequently submitted as evidence in court proceedings relating to an accident this would offend the principle that a person cannot be required to give evidence against himself. The Bahamas Maritime Authority makes this report available to interested parties on the strict understanding that it will not be used as evidence in any court proceedings anywhere in the world.

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GLOSSARY OF ABBREVIATIONS

CTL	Constructive Total Loss
CCR	Cargo Control Room
C6	Cut C6 - a Benzene type product
VRL	Vapour Return Line

1 SUMMARY

1.1 **The Bahamas registered chemical tanker "Panam Serena"** which was built in Turkey, entered service in June 2003, exploded and caught fire at Porto Torres, Sardinia in Italy on 01 January 2004. The catastrophic damage caused resulted in the vessel being declared a constructive total loss (CTL), two crew members were tragically killed and one was injured.

1.2 **The "Panam Serena" had arrived at Porto Torres** on 31 December 2003 with a cargo of Benzene and Cut C6 (C6), the Benzene discharge had been complete and the vessel was close to completion of discharge of the C6. All cargo tanks were loaded upon arrival at Porto Torres, except No.4C tank which was washed, clean and dry.

1.3 **At approximately 11:55 on 01 January 2004**, as the cargo deck watch was changing, the vessel was shaken by the first in a series of violent explosions, which resulted in an intense fire amidships, within the cargo tank area of the vessel.

1.4 **The duty 3rd Mate and relieving 2nd Mate** were handing over the cargo watch in the cargo control room (CCR), which overlooked the main deck at the time of the first explosion. The seaman on duty and the seaman taking over the deck watch were outside on the main deck and were both tragically killed in the series of explosions. The Chief Mate, who was resting in his cabin at the time, was injured.

1.5 **The Master** and remainder of the crew who were all within the aft accommodation area managed to escape from the vessel by jumping over the stern into the water, then climbing into the stern launch freefall lifeboat, which had automatically launched due to the extreme force of the explosions which wracked the vessel.

1.6 **The fire** was eventually brought under control by the shore based emergency fire services, however they were unable to save the two seamen on the maindeck or prevent extensive damage to the vessel and the terminal jetty due to the intense nature of the fire which followed the series of explosions.

1.7 **Due to the catastrophic damage** caused to the vessel (which can be seen in the photographs attached to this report) it has been extremely difficult to identify the exact cause of the initial explosion; however a number of possible causes were identified and are covered within this report.

2 PARTICULARS OF VESSEL

2.1 **"Panam Serena" was a Type 2 Chemical Tanker** registered at Nassau, Bahamas, of welded steel construction having a raised forecastle. The accommodation and machinery spaces were situated at the after end of the vessel. She had the following principal particulars:

- Official Number - 8000650
- IMO Number - 9282687
- Length overall - 118.37 metres
- Length BP - 112.06 metres
- Breadth - 19.00 metres
- Depth - 10.10 metres
- Gross Tonnage - 6522 tonnes
- Net Tonnage - 3220 tonnes
- Deadweight - 10018 tonnes
- Call Sign - C6SY9

2.2 **She was powered by MAN B&W diesel main engine,** Type 6535 MC that developed 4440 kW (3265 bhp), which drove a single fixed-bladed propeller and generated an estimated vessel speed of 14 kts. She had 3 auxiliary generators and 1 shaft generator that developed a total of 2000 kW.

2.3 **The cargo** was carried in 12 tanks that were arranged as per the enclosed plans (see page 6). Each tank was fitted with an individual Marflex deep-well pump, as per the diagram in Appendix II.

2.4 **The vessel was built in 2003** at Tuzla, Turkey and was formerly named "Clipper Leander". At the time of the incident she was owned by Leander Shipping Co. Ltd., and managed by BR Marine A/S.

2.5 **The new vessel was first registered** under the Bahamas Flag in June 2003 and was entered with ABS Classification Society. At the time of the casualty she complied with all the statutory and international requirements and certification.

2.6 **"Panam Serena"** was last subjected to a Bahamas Maritime Authority Annual Inspection at the Port of Rotterdam on 18 December 2003, while loading her last cargo and just prior to the casualty. The following observations were made:

- Nil deficiencies.

2.7 **Being a relatively new ship** there were no Port State Control inspections records for the vessel within the Paris MOU database.

2.8 "Clipper Legend" (sister vessel):-

3 NARRATIVE OF EVENTS

3.1 **Introduction;** All times noted in this narrative are given in the style of the standard 24 hour clock without additional annotation and as local time, which was UTC+1. Any other timing is noted in brackets. The vessel was built in Turkey and was one of the first Chemical Tankers built by the shipyard, with three similar vessels having already been delivered. The "Panam Serena" was built under the supervision of ABS, one of the premier IACS Classification Societies with considerable experience in the construction and classification of this type of vessel. The weather at the time of the incident was good and the vessel was nearing the end of a routine discharge operation at Porto Torres in Sardinia, Italy, when the incident occurred.

3.2 **The voyage to Porto Torres;** The vessel loaded its cargo of Benzene (2,091 tonnes) and C6 (6,300 tonnes) at Rotterdam and Dunkirk, without incident, as per the cargo plan on page 6, for a full discharge at Porto Torres. The vessel had undergone a satisfactory Bahamas Flag State inspection while loading at Rotterdam, nil deficiencies had been noted. All cargo tanks were utilized for loading the cargoes except No.4 Centre tank. This tank was not required for the quantity of cargo which was being carried and some repairs were required to the tank coating. These repairs were completed during the sea passage from northern Europe to the Mediterranean. The sea passage was uneventful and the vessel arrived on the morning of the 31 December 2003, being all fast at Berth No.18, Platform B in Porto Torres at 08:50.

3.3 **Arrival and discharge operation;** upon arrival the vessel berthed, was made fast by the dock workers without incident and the usual port arrival formalities were observed. The shore gangway was placed on board between the vessel and quay, port clearance was arranged via the Harbour Masters Office and the cargo surveyor attended on board. Cargo measurement and sampling were then completed. The cargo and vapour return pipelines were connected by the terminal staff in preparation for the discharge of the cargo.

3.4 **The connection of the ship / shore electrical continuity bonding cable**; connected between the quay and the vessel by the terminal personnel is a part of the usual vessel arrival routine at Porto Torres. This is a requirement of the terminal procedures, there is some doubt that the connection of the bonding cable was made or made correctly upon the vessel's arrival.

3.5 **The vessel started discharging** the C6 at about 16:00 and started discharging the Benzene at 18:00 on the 31 December 2003, the discharge operation was proceeding in a routine manner up until the time of the first and reportedly, the most violent, in a series of approximately four explosions.

3.6 **The initial incident;** the first and largest explosion happened towards the end of the discharge operation at approximately 11:55 on the 01 January 2004.

3.7 **The cargo tank status** at the time of the incident was as follows:-

Deck Slop Tanks, Port and Starboard; empty.

No.1 Centre; Benzene - fully discharged and empty.

No.2 Port; C6 - fully discharged and empty.

No.2 Starboard; C6 - fully discharged and empty.

No.3 Port; Benzene - fully discharged and empty.

No.3 Starboard; Benzene - fully discharged and empty.

No.4 Centre; Washed, cleaned and dried prior to arrival - empty.

No.5 Port; C6 - fully discharged and empty.

No.5 Starboard; C6 - fully discharged and empty.

No. 6 Port; C6 - a small quantity of cargo was still remaining on board in this tank, which was being discharged in stripping mode.

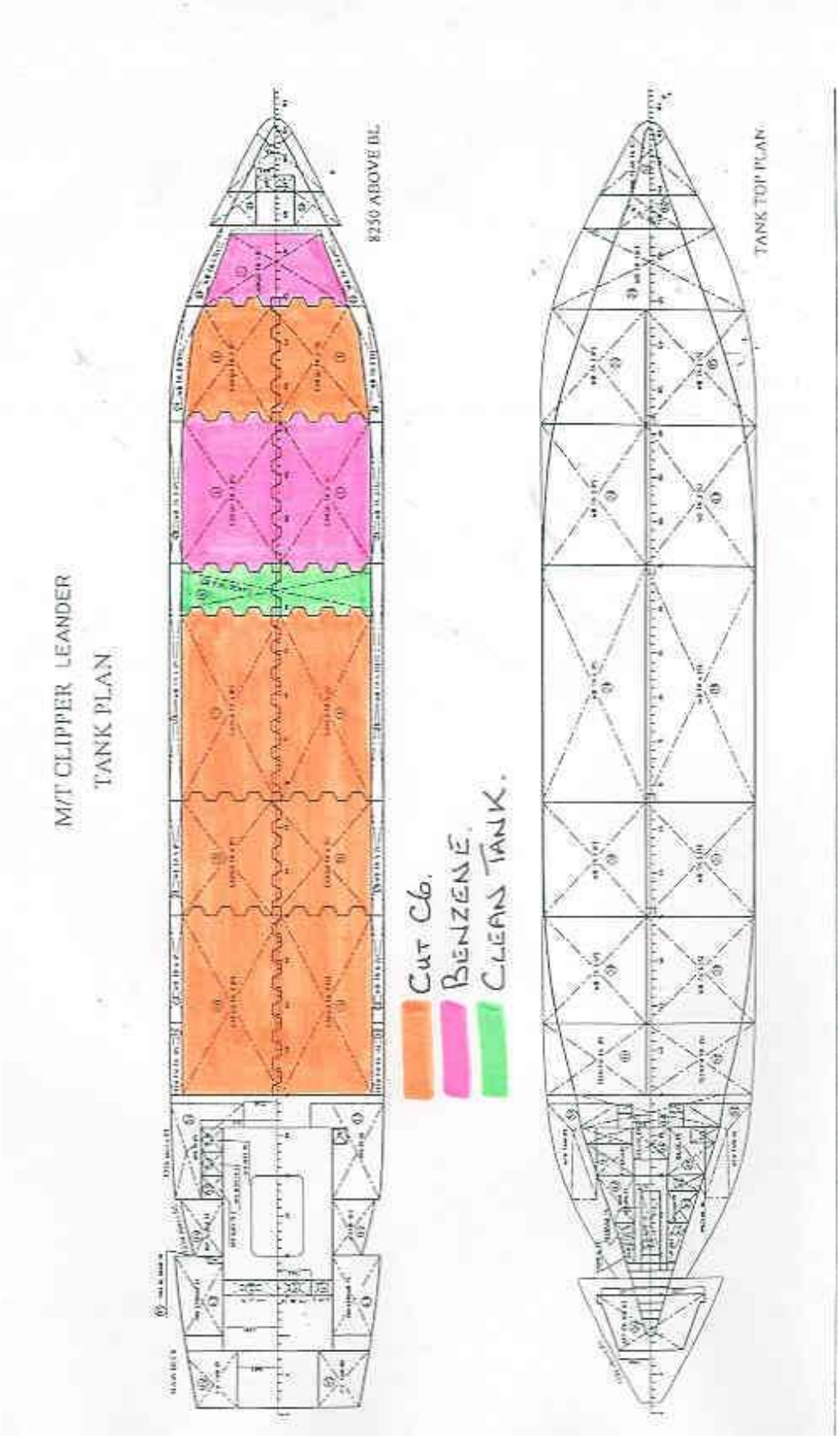
No.6 Starboard; C6 - fully discharged and empty.

No.7 Port; C6 - approximately 170 tonnes of cargo was still remaining on board in this tank, which was being discharged, in addition to No.6 Port.

No.7 Starboard; C6 - approximately 90 tonnes of cargo was still remaining on board in this tank, which was also still being discharged, in addition to No.6 Port and No.7 Port.

See cargo tank diagram over on page 6:-

3.8 Cargo Tank diagram, showing cargo distribution upon vessels arrival:-



3.9 **The Master, Officers and crew;** the master, officers and crew of were from Latvia and Russia, the two seamen who died both being from Latvia. All crew members had a good understanding of both Russian and English; there were no language or communication difficulties on board the vessel.

3.10 **The majority of the crew** had joined the vessel during October and November 2003, so were reasonably familiar with the vessel. There was a very high level of experience amongst the master, officers and crew on all types of tankers, oil, chemical and gas, with most of the crew members on board having extensive chemical tankers experience. The average age of the crew was 39. The vessel was very well manned with a fit, able, well experienced and qualified crew which complied with all statutory requirements.

3.11 **The Crew** compliment consisted of:-

Master	x 1
Chief Mate	x 1
OOW Navigation	x 2
Chief Engineer	x 1
2nd Engineer	x 1
Electrical Engineer	x 1
Total Officers	**7**
Pumpman	x 1
Motorman	x 1
Cook	x 1
Seamen	x 4
Steward	x 1
Total Ratings	**8**
Total Crew Complement	**15**

3.12 **The watch system adopted on board** the "Panam Serena" for cargo operations at Porto Torres was satisfactory, ensuring that there were sufficient crew members on duty at all times and that they were adequately rested in between duty periods, as detailed below:-

Crew Member	Duty Period	Location at time of first explosion 11:55 01/01/04
Master	0900 - 2300	On duty, having lunch.
Chief Mate	2300 - 0900	Off duty, asleep in cabin.
2nd Mate	12 - 06 (x 2)	Ready to start duty, in CCR and taking over the deck watch from the 3rd Mate.
3rd Mate	06 - 12 (x 2)	On duty, in CCR and handing over the deck watch to the 2nd Mate
Chief Engineer	06 - 12 (x 2)	On duty, having lunch.
2nd Engineer	12 - 06 (x 2)	Off duty, having lunch.
Electrical Engineer	06 - 12 (x 2)	On duty, having lunch.
Pumpman	6 hour watches as required for port cargo operations.	On duty, having lunch.
Motorman	0800 - 1800	On duty, at lunch break.
Seamen No.1 (deceased)	06 - 12 (x 2)	On duty & on main deck, handing over the deck watch to Seaman No.2.
Seamen No.2 (deceased)	12 - 06 (x 2)	On main deck & ready to start duty, taking over the deck watch from Seaman No.1.
Seamen No.3	06 - 12 (x 2)	Towards end of his duty period and in the accommodation.
Seamen No.4	12 - 06 (x 2)	Due to start duty shortly and in the accommodation.
Cook	AM - PM	On duty, briefly visiting his cabin as the midday meal was prepared and ready.
Steward	AM - PM	On duty, close to the galley.

3.13 **Activity on board prior to the explosion**; Up until the time of the first explosion the discharge operation was proceeding in a routine manner without any problems, the discharge of the three cargo tanks containing Benzene (No.1C, 3P & 3S) had been completed at 06:45 on the morning of 01 January 2004. The same morning at 09:30, the terminal staff had connected a fresh water hose from the jetty to the ship, for the purpose of providing fresh water to the vessel. The fresh water was used in order to flush out the hazardous / toxic cargo from the cargo discharge lines prior to disconnection; this was the usual terminal practice at Porto Torres.

3.14 **The vessel was also nearing the end of the discharge** of the final three cargo tanks of C6. The vessel was expected to complete the discharge of the C6 at around 12:45 and sail from Porto Torres at 15:00 in the afternoon of 01 January 2004.

3.15 **The time of the initial explosion** on board the "Panam Serena" could be placed quite accurately by all members of the crew because they have a common reference time with respect to the change of the watch at 12:00 and the mid-day meal. Members of the crew were either: preparing to end their watch; take over the watch; taking their meal break early or intending to eat their meal later. The split meal times were to ensure continuity of personnel coverage on duty and are common practice on most vessels around meal times; the arrangements are usually made by mutual consent.

3.16 **The two seamen who died** were outside the accommodation on the main deck, reportedly on the port side amidships in the vicinity of the vessels mid-ships cargo manifold, the ship / shore connection through which the cargo discharge was taking place. Their bodies were recovered from the sea a long way apart, so they may not have been standing close together at the time of the initial explosion.

3.17 **Statements by the crew** members describe the sensation of the "Panam Serena" being shaken by a sharp jolt, as if the vessel had been hit or rammed by another ship, immediately followed by a single and very loud explosion. The initial explosion was quite separate and distinct from the series of (approximately three more) explosions which followed the initial explosion; these explosions occurred in succession between, approximately one minute and a few minutes later.

3.18 **The vessel immediately listed heavily to Starboard** at this time, with many of the crew fearing the vessel would capsize and after a brief attempted by some crew members to fight the intense fire, the crew made their way towards the stern of the vessel, in accordance with the Masters orders in preparation to abandon ship. The starboard list stabilized as the series of explosions ended (see photograph of fire fighting operation, which also show the vessel listed to starboard).

3.19 **The crew members describe the main deck** area as being engulfed by thick black smoke and high flames, which are described as having originated in the vicinity of the mid-ships section of the main deck. However, the crew

found it extremely difficult to identify the *exact* location of the initial explosion.

3.20 **From the terminal's perspective** the discharge operation had proceeded quite normally until shortly before the initial explosion on board the "Panam Serena", when the terminal were experiencing some problems on another vessel which had just arrived at Porto Torres on the morning of 01 January 2004 and was berthed close by to the "Panam Serena" at berth No.13, on Platform B. The terminal personnel on duty and monitoring the discharge operation of the "Panam Serena" were summoned by their manager to assist their colleagues on the other vessel which had just arrived. Therefore, there were no terminal personnel in attendance on the berth for the "Panam Serena", at the time that the vessel exploded.

3.21 **The subsequent fire;** following the series of explosions there was an intense fire generating thick black smoke, which caused additional substantial damage to the vessel and the terminal berth. The brief attempt by some crew members to fight the fire was abandoned when the vessel listed heavily to starboard, they believed that the vessel was going to capsize and were ordered to proceed to the stern and abandon ship by the Master. The fire fighting was then taken on by the shore based emergency services, who responded to the emergency calls made by the terminal personnel.

3.22 **The damage;** caused on board the "Panam Serena" by the explosions and subsequent fire, particularly within the main deck and cargo tank area of the ship was catastrophic. The selection of photographs attached to this report demonstrates the difficulties which have hampered investigators trying to determine the initial cause and location of the first explosion.

3.23 **Drug and alcohol tests**; performed on all members of the crew by the Italian Authorities following the casualty, including the two seamen who were tragically killed, were completely negative. During the Italian Police investigation on board the vessel, no alcoholic beverages of any description were found anywhere on board, the police search included store rooms, recreational areas and crew cabins. The police findings were in line with Company policy, which prohibited drugs and alcohol on board the vessel.

3.24 **Smoking;** there was a safe smoking room provided on board the vessel, located within the vessels accommodation and situated close to the galley, this room was utilized by crew members on board the vessel who smoked. There was no indication that any crew member was smoking on board the vessel in an unauthorized area.

4 ANALYSIS

4.1 **The experience of the crew;** the majority of the crew were very well experienced in all types of tanker operations, especially chemical tanker operations and it is unlikely that the casualty was the result of crew error, misconduct and / or negligence during the course of the discharge operation. A smoking room was provided on board the vessel, in the accommodation near to the galley, which was utilized by the crew members who smoked, all drug and alcohol tests conducted by the Italian Authorities were completely negative. There was no alcohol found on board. The crew were well experienced with the regulations and requirements for the loading, carriage and discharge of extremely hazardous cargoes and the safe operation of chemical tankers.

4.2 **The location of the initial explosion;** the catastrophic damage caused to the vessel indicates that the explosions took place inside the cargo tanks. The eyewitness evidence obtained by both the Italian Police and the Bahamas Approved Inspector who attended the scene immediately following the casualty, place the location of the first explosion in the amidships area of the vessel or slightly forward of amidships. This was in the vicinity of the vessel's cargo discharge manifold, within the cargo tank section of the vessel. The witnesses clearly described the initial explosion and fire as taking place at some distance away from the vessel's accommodation. The majority of the crew were located within the accommodation and witnessed the initial explosive damage, together with the early stages of the fire. There is substantial evidence proving that further explosions took placed within other cargo tanks, some of which still contained cargo and were closer to the vessel's accommodation, as the emergency situation quickly escalated.

4.3 **Emergency stop;** the duty officer on cargo watch (3rd Mate) and relief officer (2nd Mate) taking over the cargo watch were both in the CCR at the start of the incident, which over-looked the main-deck area through a forward facing porthole. They were in the process of handing over the cargo watch when the first explosion occurred and following the initial shock, they immediately realised the severity of the situation and pressed the vessel's emergency stop button, which stops the cargo pumps and halts the discharge operation from within the CCR. The emergency stop was activated less than a minute, after the first explosion took place.

4.4 **The cargo tanks;** the majority of the cargo tanks had been discharged and were empty of cargo at the time of the first explosion, however the empty tanks were still full of potentially volatile vapour both from the small amount of residual cargo remaining within the tanks and due to the fact that vapour had been returned to the vessel via the vapour return line (VRL) from the terminal, throughout the discharge operation. A VRL is often utilized in hazardous chemical cargo loading and discharge operations, in order to retain the hazardous cargo vapour within a closed cycle, returning the vapour from the shore to the ship, as in this incident, or visa versa. There were only

three cargo tanks still being discharged with a relatively small quantity of C6 cargo remaining in each these were - 6P, 7P & 7S.

4.5 **The cargo pumps;** the cargo pumps fitted to the "Panam Serena" were Marflex deepwell pumps, i.e. each cargo tank was fitted with its own discharge pump. The Marflex pumps are designed to extract the maximum amount of product from each tank and are fitted with a main discharge line, as well as a narrower stripping line. Upon nearing completion of discharge when the bulk of the product has been discharged from a tank, the valves are set to the stripping mode, the main discharge line is purged with inert gas or air and the final quantity of product is discharged ashore via the separate and smaller stripping pipeline, minimizing the cargo residue remaining within the tank.

4.6 **The Terminal personnel;** there was some confusion surrounding the actual connection of the ship / shore electrical continuity bonding cable upon the vessels arrival amongst the terminal personnel. The requirement to attach a bonding cable between the jetty and vessels is incorporated within the terminal procedures; responsibility for making the connection lies with the terminal and is made by the terminal personnel upon the vessels arrival. In addition to making the actual physical connection / disconnection of the cable in a safe manner with the circuit open, the terminal personnel must check that the cable is functioning correctly on an indicator panel, located on the jetty and fitted with red and green indicator lights. These lights would indicate when the circuit for electrical continuity was open or closed, that the earth connection had been made safely and correctly.

4.7 **The connection of the bonding cable** is usually the first operation to be performed after the gangway has been placed on board, when the vessel has received port clearance, prior to the connection of the cargo hoses and start of the discharge operation. However, no members of the terminal personnel on duty at the time can remember who made and checked the connection or state categorically that they were the person who made the connection. Although a number of terminal personnel stated that they were sure the connection had been made, probably by someone else.

4.8 **Some members of the ships staff** stated that the connection of the bonding cable was **not** made between the terminal and the ship. It should be noted that the industry recommendations are that "Bonding Cables" ***should not*** be used between the terminal berth and the vessel.

4.9 **Electrical discontinuity between the terminal jetty and vessel;** there is sufficient evidence to demonstrate that it is possible for a large static or electrical charge to have accumulated within the structure of the "Panam Serena" during the course of the discharge operation. There is a substantial amount of safety guidance on this subject available to the industry (which is not repeated within this report) including, the "International Safety Guide for Oil Tankers and Terminals" (ISGOTT) and the International Chamber of Shipping (ICS) "Tanker Safety Guide (Chemicals)" which while taken as the industry standards are not internationally enforced. Investigators also took

into account other industry guidance, including a report published by the USCG "Static Electric Discharge Hazard On Bulk Oil Tank Vessels" which examines previous similar incidents, the circumstances surrounding them and makes reference to the National Fire Protection Associations "NFPA 77; Recommended Practice on Static Electricity". Many of the circumstances which were contributory to previous accidents are also evident in the case of the "Panam Serena", including;

i The dangers associated with the loading, carriage and discharge of refined liquid products, which tend to be "Static Accumulators". Charge generation and separation occur when the liquid moves in contact with other materials, such as piping etc. The risk is increased during the early stages of loading and when "stripping" the tanks during discharge, when the tanks are at their lowest level.

ii The dangers associated with the introduction of impurities into a liquid product, such as water. Static is generated through friction with the water droplets, producing a high voltage at the liquid interface. Water, was used to flush the lines of hazardous cargo upon completion of discharge. The water hose had been connected from the terminal to the vessel for this operation.

iii The release of air and / or inert gas into a liquid can generate a strong electrostatic charge, by bubbling action and agitation of the fluid. This was a standard practice required within the operating procedure for the deepwell pumps fitted on board. The vessel was fitted with a small supply of nitrogen in bottles, it has not been ascertained if air or nitrogen was utilized from the ship or shore supply during this operation.

iv Within the Italian Criminal Courts report on the casualty, great emphasis was placed upon the correct connection of the bonding cable by the terminal. However the ICS and ISGOTT guidance on this subject is that, a ship/shore bonding cable is **not effective as a safety device and may even be dangerous!** A ship/shore bonding cables should therefore **not** be used. ICS and ISGOTT acknowledges that although the dangers associated with ship/shore bonding cables are widely recognised, attention is drawn to the fact that some national and local regulations may still require them to be used. The terminal procedures at Porto Torres required the "Panam Serena" to be fitted with a bonding cable supplied by the terminal, to try and ensure electrical continuity between the terminal and the ship. This cable was probably not connected, or if it was connected it is possible that it was not correctly connected upon the vessels arrival.

v The terminal was utilizing a bonding cable within their procedures, attempting to achieve electrical continuity between the terminal and the vessels which berthed alongside. There was no indication within any reports that "insulation flanges" were used within the discharge hose string and in view of the terminal policy for electrical continuity, the use

of insulation flanges, would seem unlikely. Insulation flanges are generally used where the terminal policy is to insulate the vessel from the terminal, in order to create electrical discontinuity.

vi Benzene / C6 vapour is heavier than air and it is quite possible that towards the end of the discharge operation that volatile vapour had accumulated around the vessel. A VRL was in use, returning cargo vapour under pressure, to the vessel from the shore tanks. One of the seamen who had been on deck duty and was killed in the accident, had been wearing a gas-vapour mask, commonly used on chemical tankers. This may indicate the presence of gas vapour around the deck area or that an access to a cargo tank was being opened for operational reasons. Cargo tank 6P was stripping and the crew were in the process of preparing the fresh water hose for line flushing. The good weather conditions prevailing at the time would have contributed to any accumulation of gas vapour around the vessel.

vii No mention has been made within the terminal personnel statements with respect to any cathodic protection fitted to the jetty; if fitted, cathodic protection is another source of difference in electrical potential between vessel and terminal jetty.

4.10 **The analysis of the "bonding cable"**; examination of the bonding cable by investigators determined that it was partly corroded internally and not well maintained, this corrosion would have affected its electrical continuity, even if it had been connected between the terminal and the vessel correctly. The examination of the bonding cable also determined that it had suffered heat damage as a result of the fire, due to the transmission of heat along a length of the cable from the metal clamp, which was usually used to connect the cable to the vessel on the terminal berth.

4.11 **Industry guidelines;** there were differing statements from the crew with respect to the bonding cable, some believed (in accordance with the ICS and ISGOTT guidelines) that such cables were no longer required and should not be used. The terminal personnel believe it should have been used, but were unsure who (if anyone) connected the cable. This is reflective of the general confusion surrounding the use of bonding cables, particularly when the national or local regulations are not in line with the current industry guidelines. Vessels travelling between locations and countries are often subject to national or local policy, rather than international regulations, which should be in accordance with the latest recommended and current industry best practice.

4.12 **The analysis of the damage;** the series of photographs attached to the report are a selection of the many available and only indicative of the massive damage caused to the vessel following the series of violent explosions. From the damaged caused it has been determined that a series of explosions took place inside the cargo tanks. It has not been possible to determine the *exact* source of the initial explosion.

4.13 **Further investigative work** is still required to establish if there was a problem with one of the deepwell cargo pumps. There was some evidence to suggest that this may have been the case, however the overwhelming evidence within the witness statements, with respect to the location of the initial explosion and fire is not consistent with the theory that a cargo pump problem caused the initial explosion.

5 CONCLUSIONS

5.1 **Probable causes;** the most probable cause of the initial explosion was due to a static or electrical discharge of sufficient strength to create an ignition source within a volatile environment which had developed on board the vessel. Igniting an air / Benzene and / or C6 vapour mixture, which being heavier than air, had accumulated within the vicinity of the vessel. While the majority of the cargo had been discharged, the vessel's tanks were full of Benzene and C6 vapour, which had been returned to the vessel from the shore reception tanks throughout the discharge operation.

5.2 **The sequence and accumulation of factors;** the factors outlined within this report probably led to the initial explosion, taken in isolation each may not have been so catastrophic, however together they led to the tragic incident and loss of life.

5.3 **The best practice industry guidance;** the guidance issued by ICS and ISGOTT with respect to the recommended precautions concerning electrical continuity, the use of bonding cables and / or electrical insulation (including, insulation flanges) between the jetty and the vessel was disregarded by the terminal operator.

5.4 **The vessels crew did not check and confirm** with the terminal that the bonding cable was in good condition and correctly connected in order to ensure the safety of the vessel. While there was a clear terminal responsibility, with respect to the application of national and local requirements, the Master, Officers and Crew had a duty to ensure the safety of the vessel and those on board.

6 RECOMMENDATIONS

6.1 **The "Panam Serena" due to her size was not required to be fitted with a nitrogen inert gas system**, such systems are not mandatory on Chemical tankers of this tonnage. However the owners / managers, following this incident have fitted nitrogen inert gas systems to all subsequent vessels of this size and class. There is an obvious cost implication with respect to this action, which the owners have decided to accept in order to enhance safety. The responsible and expert industry bodies are expected to submit their views and proposals to IMO, on the requirements for all chemical tankers to be fitted with Nitrogen inert gas systems.

6.2 **There is a clear need for agreement on International Standards** to be adopted with respect to the precautions required to minimize the risks associated with static, electrical charge generation and discharge. The safety precautions applicable with respect to shipping as an international industry should not be subject to differing national and local regulations, with respect to such a fundamental safety matter.

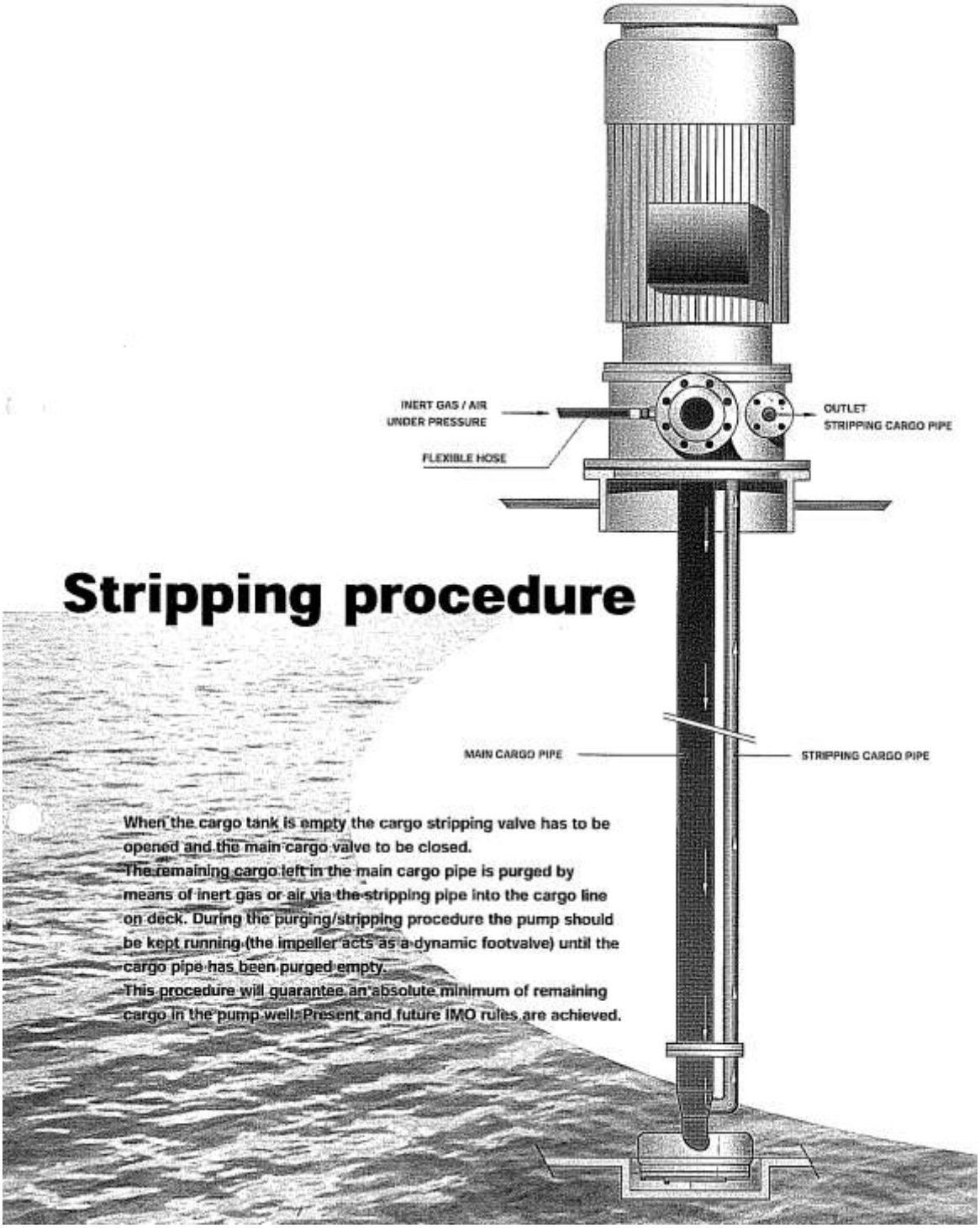
6.3 **While respecting the jurisdiction and national responsibility** of all States, there is a demonstrable need for coastal states to recognise the importance of good cooperation with, responsible Flag States in the case of a ship casualty. This will facilitate the safety investigation process, rather than hinder. Immediately entering into criminal proceedings, with resultant restrictions and legal implications can hinder the objectives of improved safety at sea.

APPENDIX I

Photographs of the "Panam Serena" on fire following the series of explosions on the 01 January 2004 and the subsequent, catastrophic damage to the vessel:-

APPENDIX II

MarFlex deep-well pump diagram:-



APPENDIX III

ISM Procedures (11.5.3) Electrical Continuity - Bonding and Earthing:-

11.5.3 ELECTRICAL CONTINUITY - BONDING AND EARTHING

1. Cargoes with low electrical conductivity may be electrostatic charged by the pipe line flow. When the charged liquid flows through non-conducting flexible ship/shore connections, a part of the charge may be picked up by intermediate metal flanges and other metal parts, which are in contact with the liquid inside the hose.

2. In order to prevent the accumulation of dangerous electrical charging, all metal flanges and other metal parts must be bonded efficiently so that there is always an adequate and continuous earthing. Generally the bonding of the metal reinforcement in the hose to the flanges provides an electrical integrity to earth via the ship manifold and hull.

3. When there is an insulating flange at the shore manifold, intermediate flanges in the ship/shore hose will still be earthed by the electrical integrity to earth via the ship manifolds and hull.

APPENDIX IV

Safety Data Sheets (copy of actual SDS) for Benzene:-

2. JAN. 2004 14:08 ARNED AGENCIES NO. 0037 P. 1

TO: COPENHAGENTANKERS DK

TELEFAX ARNED AGENCIES BV **TELEFAX**

P.O.Box 5
3130 AA Vlaardingen
Galgkade 3
3133 KN Vlaardingen
Phone : (010) 4344 799
Fax : (010) 4354 323
Telex : 21221
WWW : www.arned-agencies.nl
Email : agency@arned-agencies.nl

To Faxnumber : automatic.
Messrs : Copenhagen Tankers.
Attention : Jeanette Jensen.
Date : 02/01/04.

This message consists of 13. pages, incl. leadsheet

m.t. "Panam Serena"

Herewith MSDS as per your mail.

Brgds, Arned
Pietvld Vlis.

All our activities are carried out on the basis of the conditions applying in the relevant industry with respect to the activities concerned. The General Conditions and Rules for Dutch Shipbrokers and Agents deposited on 1 December 1992 at the Registry of the District Court in Rotterdam and the Chamber of Commerce in Rotterdam shall apply to the activities referred to in Article 1 of those conditions.

SAFETY DATA SHEET

ExxonMobil Chemical

PRODUCT NAME: BENZENE

SDS NUMBER: HDHE-G-00001
REVISION: 16 May 2003

1 IDENTIFICATION OF THE SUBSTANCE AND OF THE COMPANY

IDENTIFICATION OF THE SUBSTANCE: BENZENE

CHEMICAL FAMILY: Aromatic Hydrocarbon

The main end use of this product is: Chemical Feedstock. You may contact the local ExxonMobil affiliate for details on the end-use you are considering.

PRODUCT DESCRIPTION:
Clear colorless liquid with characteristic aromatic odor.

SUPPLIER:
ExxonMobil Chemical Holland BV
GRAAF ENGELBERTLAAN 75
4837 DS BREDA (NEDERLAND)
Telephone: +31(0) 76 5292600
Facsimile: +31(0) 76 5292700

This SDS has been printed in the English language and meets the EU Safety Data Sheet requirements for this product. No country specific information is included.

2 COMPOSITION/INFORMATION ON INGREDIENTS

EINECS NUMBER: 200-753-7 **CAS NUMBER:** 71-43-2

ExxonMobil Chemical

SAFETY DATA SHEET

PRODUCT NAME: BENZENE

SDS NUMBER: HDHE-G-00001
REVISION: 16 May 2003

3 HAZARDS IDENTIFICATION

This product is classified as dangerous, according to Directive 1999/45/EC or 67/548/EEC (see Section 15)

CLASSIFICATION/SYMBOL: TOXIC/T, CMR: C1
CLASSIFICATION/SYMBOL: HIGHLY FLAMMABLE/F
R11, R45, R68/23/24/25

HEALTH HAZARDS

May cause cancer
Toxic : danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.

PHYSICAL AND CHEMICAL HAZARDS / FIRE AND EXPLOSION HAZARDS

- Extreme hazard. Leaks of gas or spills of liquid can readily form flammable mixtures at temperatures at or above the flash point.
- Static Discharge. Product can accumulate static charges which can cause an incendiary electrical discharge.

4 FIRST AID MEASURES

INHALATION:

- Using proper respiratory protection, immediately remove the affected victim from exposure. Administer artificial respiration if breathing is stopped. Keep at rest. Call for prompt medical attention.

SKIN CONTACT:

- Flush with large amounts of water; use soap if available.
- Remove grossly contaminated clothing, including shoes, and launder before reuse.

EYE CONTACT:

- Flush eyes with large amounts of water until irritation subsides. If irritation persists, get medical attention.

INGESTION:

- If swallowed, DO NOT induce vomiting. Keep at rest. Get prompt medical attention.

5 FIRE-FIGHTING MEASURES

FIRE FIGHTING PROCEDURES:

- Use water spray to cool fire exposed surfaces and to protect personnel. Shut off "fuel" to fire. If a leak or spill has not ignited, use water spray to disperse the vapors and to protect men attempting to stop a leak.
- Either allow fire to burn under controlled conditions or extinguish with foam or dry chemical. Try to cover liquid spills with foam.

SPECIAL FIRE PRECAUTIONS:

- Because of the chemical nature of this product, complete combustion rarely occurs. In a fire, large amounts of soot and incompletely combusted material will be produced. In case of exposure to smoke or combustion products, proper breathing equipment is recommended.

HAZARDOUS COMBUSTION PRODUCTS:

No unusual

6 ACCIDENTAL RELEASE MEASURES

LAND SPILL:

- Eliminate sources of ignition. Warn occupants of downwind areas of fire and explosion hazard. Prevent liquid from entering sewers, watercourses, or low areas.
- Contain spilled liquid with sand or earth.
- Recover by pumping (use an explosion proof or hand pump) or with a suitable absorbent. If liquid is too viscous for pumping, scrape up with shovels or pails and place in suitable containers for recycle or disposal.
- Consult an expert on disposal of recovered material and ensure conformity to local disposal regulations.
- See Section 4 "FIRST AID MEASURES" as well as Section 10 "STABILITY AND REACTIVITY".

WATER SPILL:

- Eliminate sources of ignition. Warn occupants and shipping in downwind areas of fire and explosion hazard and request them to stay clear.
- Notify port or relevant authority and keep public away. Shut off source if possible to do so without hazard. Confine if possible.

SAFETY DATA SHEET **ExxonMobil Chemical**

PRODUCT NAME: BENZENE

SDS NUMBER: HDHE-G-00001
REVISION: 16 May 2003

- Remove from surface by skimming or with suitable absorbents. If allowed by local authorities and environmental agencies sinking and/or suitable dispersants may be used in non-confined waters.
- Consult an expert on disposal of any recovered material and ensure conformity to local disposal regulations.
- See also Section 4 "FIRST AID MEASURES" and Section 10 "STABILITY AND REACTIVITY".

7 HANDLING AND STORAGE

STORAGE TEMPERATURE (DegC) : Ambient
TRANSPORT TEMPERATURE (DegC) : Ambient
LOADING/UNLOADING TEMPERATURE (DegC) : Ambient
VISCOSITY (cSt) : 0.80
STORAGE/TRANSPORT PRESSURE (kPa) : Atmospheric
ELECTROSTATIC ACCUMULATION HAZARD? Yes, use proper grounding procedure

USUAL SHIPPING CONTAINERS:
Tankers, barges, tank trucks/cars, rail cars

MATERIALS AND COATINGS SUITABLE:
All types of steel
Inorganic Zinc Coatings
Epoxy Phenolics
Polypropylene
Fluorinated Silicone,
Nylon 66

MATERIALS AND COATINGS UNSUITABLE:
PVC
Epoxy resin-aluminum combinations
Natural and Synthetic Rubbers
Polyethylene

Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use.

STORAGE / HANDLING, GENERAL NOTES

- Keep container closed. Handle containers with care. Open slowly in order to control possible pressure release. Store in a cool, well-ventilated place away from incompatible materials.
- DO NOT handle, store or open near an open flame, sources of heat or

sources of ignition. Protect material from direct sunlight.
- o Material will accumulate static charges which may cause an electrical spark (ignition source). Use proper bonding and/or grounding procedures.
- o DO NOT pressurize, cut, heat, or weld containers. Empty product containers may contain product residue. DO NOT reuse empty containers without commercial cleaning or reconditioning.

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROL MEASURES / VENTILATION

The use of local exhaust ventilation is recommended to control process emissions near the source. Laboratory samples should be handled in a lab hood. Provide mechanical ventilation of confined spaces. Use explosion-proof ventilation equipment.

OCCUPATIONAL EXPOSURE LIMITS

This product consists of a single substance with the following recognised or recommended OEL value(s):

Benzene;
TWA: 0.5 ppm (1.6 mg/m3) (SKIN), ACGIH (2003).
With the Directive 97/42/EC of 27 June 1997 (OJ L 179 of 8 July 1997), the European Union has set the Occupational Exposure limit of Benzene at 1 ppm (3.25 mg/ m3) to be enforced by Member States no later than 27 June 2003. A transition period of 3 years is granted with limit value of 3 ppm (9.75 mg/m3) (skin).

Monitoring Equipment

Users may gather monitoring methods and related information by contacting the following authorities:

o ACGIH (American Conference of Governmental Industry Hygienists)

PERSONAL PROTECTION

GENERAL ADVICE

The use and choice of Personal Protection equipment is related to the hazard of the product, the workplace, and the way the product is handled. In general, we recommend as a minimum safety precaution that safety glasses with side-shields and workclothes protecting arms, legs and body be used. In addition, any person visiting an area where this product is

handled or processed should at least wear safety glasses with side-shields.

SPECIAL ADVICE

Based on and limited to ExxonMobil Chemical's experience of this product as such, the following special advice is believed to provide satisfactory protection for the industrial user or handler.

RESPIRATORY PROTECTION

Where concentrations in air may exceed the limits given in this section, it is recommended to use a half face filter mask or air supplied breathing apparatus to protect from overexposure by inhalation. Suitable filter material depends on the amount and type of chemicals being handled in the workplace, but filter material of type "A" or similar may be considered for use.

HAND PROTECTION

When handling this product, it is recommended to wear chemical resistant gauntlets. The choice of suitable protective gloves depends on work conditions and what chemicals are handled, but we have positive experience with gloves made of Viton (TM) or PVA. Note that PVA degrades when in contact with water. Gloves should be replaced immediately if sign of degradation is observed.

EYE PROTECTION

When handling this product, it is recommended to wear splash resistant goggles.

SKIN/BODY PROTECTION

When handling this product, it is recommended to wear a chemical resistant jacket

ENVIRONMENTAL EXPOSURE CONTROLS

See Section 12.

9 PHYSICAL AND CHEMICAL PROPERTIES

These are indicative values only. Please refer also to the product specification sheet.

9.1 General Information

PHYSICAL STATE: Liquid

SAFETY DATA SHEET **ExxonMobil Chemical**

PRODUCT NAME: BENZENE

SDS NUMBER: EDHE-G-00001
REVISION: 16 May 2003

FORM/COLOUR:	Clear colorless liquid.		
ODOR:	Characteristic aromatic odor.		
FREEZ./MELT/ POINT:	5.5	DegC	ASTM D852
BOILING POINT RANGE:	80	DegC	ASTM D850
VAPOR PRESSURE (50 DegC):	37	kPa	Exxon Cope
DENSITY		g/cm3	
SPECIFIC GRAVITY (15.5 / 15.5):	0.89		ASTM D4052
VAPOR DENSITY (101.3 kPa/air=1):	2.70		
VISCOSITY (40 DegC):	< 0.70	mPa.s	ASTM D445
EVAPORATION RATE (n-Bu Acetate= 1):			

9.2 Health, Safety & Environmental Information

FLASHPOINT (TCC ASTM D56):	-11	DegC
AUTOIGNITION TEMPERATURE:	561	DegC
EXPLOSIVE LIMITS (in air):	between 1.3 and 7.1	Vol%
SOLUBILITY IN WATER (25 DegC):	0.18	Wt%

9.3 Other Information

MOLECULAR WEIGHT:	78	
COEFF. OF THERMAL EXPANSION (Liq.):		DegC
IS MATERIAL HYGROSCOPIC:	No	

10 STABILITY AND REACTIVITY

HAZARDOUS POLYMERIZATION? No

CONDITIONS TO AVOID POLYMERIZATION:
Not Applicable.

STABILITY: Stable

CONDITIONS TO AVOID INSTABILITY:
Not Applicable.

MATERIALS AND CONDITIONS TO AVOID (INCOMPATIBILITY):
This product is intended for industrial use. Exposure to heat, air, oxidising agents and other chemicals not part of an industrial process should be avoided.

PRINT DATE: 16 September 2003 Cont.

SAFETY DATA SHEET **ExxonMobil Chemical**

PRODUCT NAME: BENZENE

SDS NUMBER: HDHE-G-00001
REVISION: 16 May 2003

HAZARDOUS DECOMPOSITION PRODUCTS:
None

11 TOXICOLOGICAL INFORMATION

ACUTE:

INHALATION:
Vapor concentrations above recommended exposure levels are irritating to the eyes and the respiratory tract, and may lead to central nervous system effects (drowsiness, dizziness, nausea, headaches, convulsions, paralysis and loss of consciousness).
- If the exposure is overwhelming death due to respiratory collapse can occur almost immediately or may be delayed several hours to several days.
- May cause blood and hemopoetic system disorder (e.g. cyanosis) and/or damage.

SKIN CONTACT:
- Occasional brief contact with the liquid will not result in significant skin discomfort unless evaporation is impeded.

Frequent or prolonged contact may defat and dry the skin, leading to irritation and dermatitis.
- Skin absorption of benzene can occur and damaged skin may facilitate the absorption of benzene. Exposure under these circumstances could contribute to any observed systemic toxicity produced by inhaling benzene.

EYE CONTACT:
May cause irritation with prolonged contact.

INGESTION:
- Small amounts of liquid aspirated into the respiratory system during ingestion or from vomiting may cause bronchopneumonia or pulmonary edema.
- Minimal toxicity.

CHRONIC:
Human health studies (epidemiological) indicate that prolonged and/or repeated overexposures of benzene may cause damage to the blood producing system (particularly the bone marrow) and serious blood disorders including leukemia. Animal tests indicate that benzene does not cause malformations but may be toxic to the embryo/fetus. The relationship of the results to humans has not been established.

SAFETY DATA SHEET **ExxonMobil Chemical**

The International Agency for Research on Cancer (IARC) has evaluated benzene and found it to be a human carcinogen.

The National Toxicology Program (NTP) has evaluated benzene and found it to be a human carcinogen.

In the EU, benzene is classified as a carcinogen, category 1.

Additional information is available on special request

12 ECOLOGICAL INFORMATION

ENVIRONMENTAL MOBILITY

This product is highly volatile and will rapidly evaporate to the air if released into the water.

ENVIRONMENTAL DEGRADABILITY

Based upon data for a similar component or preparation, or estimated data.
This product is expected to biodegrade rapidly and be "readily" biodegradable according to OECD guidelines.
This substance is expected to be removed in a wastewater treatment facility.
This product can degrade rapidly in air.

ECOTOXICITY AND BIOACCUMULATION

Expected to be harmful to aquatic organisms.
Long term adverse effects to aquatic organisms are not expected.
Low potential to bioaccumulate (BCF<100)

- (SELENASTRUM CAPRICORNUTUM) :
EC50 29.00 mg/l (72 HOURS) (measured) (Actual Concentration)
FLOW THROUGH

13 DISPOSAL CONSIDERATIONS

SAFETY DATA SHEET **ExxonMobil Chemical**

PRODUCT NAME: BENZENE

SDS NUMBER: HOHE-G-00001
REVISION: 16 May 2003

The waste category of this product is '07 01 XX'. The user must be aware that the conditions of use may affect the waste classification after use. Please refer to Directive 2001/118/EC for waste nomenclature.

This product is ashless and can be burned directly in appropriate equipment.
This product is suitable for recovery following appropriate recovery routes or methods.

14 TRANSPORT INFORMATION

LAND (railroad/road - RID/ADR)
CLASS: 3 PG: II UN NUMBER: 1114
CLASSIFICATION CODE: F1
HAZARD ID NUMBER: 33 LABELS: 3
TRANSPORT DOCUMENT NAME:
UN 1114, BENZENE, 3, PG II
EMERGENCY ACTION CODE: 3WE
TREMCARD PRODUCT NAME:
CEPIC TC Reference: 30S1114 ExxonMobil TC Reference: 30S1114

INLAND WATERWAYS (ADN/ADNR)
CLASS: 3 UN NUMBER: 1114
TRANSPORT DOCUMENT NAME:
UN 1114, BENZENE, 3, PG II, MP=6°C

SEA (IMDG)
CLASS: 3 PG: II UN NUMBER: 1114
MARINE POLLUTANT: NO EMS NUMBER: F-E, S-D
RISK LABEL: 3 SUBSIDIARY RISK:
TRANSPORT DOCUMENT NAME:
BENZENE, 3, UN 1114, PG II, (-11 DegC c.c.)

AIR (ICAO/IATA)
CLASS: 3 PG: II UN NUMBER: 1114

PROPER SHIPPING NAME:
BENZENE

PRINT DATE: 18 September 2003 Cont.

SAFETY DATA SHEET **ExxonMobil Chemical**

PRODUCT NAME: BENZENE

SDS NUMBER: NDHE-G-00001
REVISION: 16 May 2003

15 REGULATORY INFORMATION

CLASSIFICATION AND LABELLING ACCORDING TO EC DIRECTIVES
CLASSIFICATION/SYMBOL: TOXIC/T, CMR: C1
CLASSIFICATION/SYMBOL: HIGHLY FLAMMABLE/F
GOVERNING DIRECTIVE:
Dangerous Substances Directive 67/548/EC, as modified.

LABEL NAME:
BENZENE

NATURE OF SPECIAL RISK
R45 May cause cancer
R11 Highly flammable
R48/23/24/25
Toxic : danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.

SAFETY ADVICE
S09 Keep container in a well ventilated place
S16 Keep away from sources of ignition-No Smoking
S33 Take precautionary measures against static discharges
S43A In case of fire use sand, earth, chemical powder or foam
S45
In case of accident or if you feel unwell, seek medical advice immediately (Show the label where possible)
S53 Avoid exposure - Obtain special instructions before use

Please refer to section 16 for the text of all the "R" phrases mentioned in this document

16 OTHER INFORMATION

Library of Risk phrases listed in this document.
R11 Highly flammable
R45 May cause cancer
R48/23/24/25Toxic : danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.

PRINT DATE: 18 September 2003 Cont.

SAFETY DATA SHEET **ExxonMobil Chemical**

PRODUCT NAME: BENZENE PAGE 12
SDS NUMBER: HDHE-G-00001
REVISION: 16 May 2003

REVISION SUMMARY:

Since 8 May 2003, this SDS has been revised in Section(s):
8, 11, 13, 14, 15

In those sections, vertical bars will indicate in the margin the text that has been changed. If a section is listed, but does not show a vertical bar, it indicates that text has been removed.

This information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process. The information and recommendations contained herein are to the best of ExxonMobil's knowledge and belief accurate and reliable as of the date indicated. However, no representation, warranty or guarantee is made with regards to accuracy, reliability or completeness. Conditions of use of the material are under the control of the user; therefore, it is the user's responsibility to satisfy himself as to the suitability and completeness of such information for his own particular use.

PRINT DATE: 18 September 2003

APPENDIX V

Safety Data Sheets (copy of actual SDS provided) for C6:-

Agence de Dunkerque Date : 2/01/2003
Route des Salines, Appontement charbonnier
GRANDE SYNTHE
Postal address : B.P. 1033 - 59375 DUNKERQUE Cedex 1
PHONE: + 33 3 28 26 79 00 FAX : + 33 3 28 63 33 19 TLX : 132047 F
E MAIL : trampdkk@sea-invest-France.com

A : COPENHAGEN TANKERS **ATT. JEANETTE JENSEN**

M/T PANAM SERENA – C6 DUNKERQUE / PUERTO TORRES

please find attached SDS for C6

best regards
J-Louis Malésieux
Direct line + 33 3 28 26 79 10
Mobile + 33 6 80 57 06 84

SAFETY DATA SHEET.

Product: COUPE C6

Page: 1 / 8

Date : 20 / 09 / 1995

Product Code :01262

Version:4

01 - IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

PRODUCT NAME	COUPE C6
PRODUCT CODE	01262
SUPPLIER	

Emergency telephone number

02 - COMPOSITION / INFORMATION ON INGREDIENTS

CHEMICAL NAME OF THE SUBSTANCE	C6 cut - Benzene : 70 % (approximately) - Alkanes + Cycloalkanes : 30 % (approximately)
GENERIC NAME	Hydrocarbons
CAS	68955-29-3
EINECS	273-266-0

03 - HAZARDS IDENTIFICATION

MOST IMPORTANT HAZARDS	SAFETY INFORMATION : PLEASE READ THIS SHEET CAREFULLY
HEALTH EFFECTS	May cause cancer. Harmful if swallowed.
PHYSICAL AND CHEMICAL HAZARDS	Flammable liquid. Thermal decomposition gives : Organic derivatives
SPECIFIC HAZARDS / EEC	HIGHLY FLAMMABLE TOXIC May cause cancer. Harmful if swallowed.

04 - FIRST AID MEASURES

GENERAL ADVICE	Take off immediately all contaminated clothing.
INHALATION	Move to fresh air. Oxygen or artificial respiration if needed. Hospitalize immediately.
SKIN CONTACT	Wash immediately and abundantly with soap and water. If significant contact : Hospitalize immediately.

SAFETY DATA SHEET

Product: COUPE C6 — Page: 2 / 8

Product Code :01262 — Version:4. — Date : 20 / 09 / 1995

EYE CONTACT	Wash immediately abundantly and thoroughly with water. If irritation persists, consult an ophthalmologist.
INGESTION	Do not induce vomiting. Hospitalize immediately.
PROTECTION OF FIRST-AIDERS	In case of insufficient ventilation, wear suitable respiratory equipment.

05 - FIRE-FIGHTING MEASURES

SUITABLE EXTINGUISHING MEDIA	Foam Carbon dioxide (CO2) Water spray
EXTINGUISHING MEDIA WHICH ARE NOT SUITABLE	High volume water jet
SPECIFIC HAZARDS	Flammable liquid. Thermal decomposition gives : Organic derivatives Possible re-ignition of vapours from a distance.
SPECIFIC METHODS	Cool containers / tanks with water spray. Use antispark tools. Prohibit all sources of sparks and ignition - Do not smoke.
SPECIAL PROTECTIVE EQUIPMENT FOR FIREFIGHTERS	Wear self-contained breathing apparatus and protective suit.

06 - ACCIDENTAL RELEASE MEASURES

PERSONAL PROTECTION	Evacuate non-essential staff and those not equipped with individual protection apparatus. Prohibit all sources of sparks and ignition - Do not smoke. Prohibit contact with skin and eyes and inhalation of vapours. (Repeated exposure and/or Prolonged exposure)
ENVIRONMENTAL PROTECTION	Do not released into the environment. Do not let product enter into drains. Contain by damming.
METHODS FOR CLEANING UP Recovery	Pump into an inert labelled emergency container. Absorb the remainder with an inert absorbent material. (Sand, Loam. Do not use sawdust) Keep waste impregnated with product in tightly closed and waterproof containers.
Disposal	Destroy the product by incineration.

07 - HANDLING AND STORAGE

HANDLING Technical measures/Precautions	Storage and handling precautions applicable to products : TOXIC, FLAMMABLE, WITH VAPOURS EXPLOSIVE IN AIR Provide appropriate exhaust and ventilation at machinery. Provide showers, eye-baths. Provide self-contained breathing apparatus nearby. (For emergency useless)

SAFETY DATA SHEET

Product: COUPE C6

Product Code :01262

Version:4.

Date : 20 / 09 / 1995

Safe handling advice	Keep well away from naked flames. Use product only in a closed system. Do not use air for transfer and circulation of the liquid. Use a slow speed of circulation (static electricity risk).
STORAGE	-
Technical measures/Storage conditions	Keep containers tightly closed in a cool, well-ventilated place. Store in well insulated area. Store protected from moisture and heat. Keep at temperatures below 25°C. Keep away from sources of ignition. Provide a catch-tank on a bunded area. Provide electrical earthing of equipment and electrical equipment usable in explosive atmospheres.
Incompatible products	Diborane - Bromine pentafluoride - Permanganic acid - Iodine pentafluoride Silver perchlorate - Oxygen (liquid) Oxidizing agents Halogens Strong acids
PACKAGING MATERIALS	-
Recommended	Ordinary steel

08 - EXPOSURE CONTROLS / PERSONAL PROTECTION

PROTECTIVE PROVISIONS	Provide sufficient air exchange and/or exhaust in work areas.
CONTROL PARAMETERS	-
Exposure limits	Benzene : FRANCE 1993 : VME= 5 ml/m³ = 12 mg/m³ USA-ACGIH 1994 : TLV-TWA = 10 ml/m³ n-Hexane : FRANCE 1993 : VME = 50 ml/m³ = 176 mg/m³ USA-ACGIH 1994 : TLV-TWA = 50 ml/m³ = 176 mg/m³
PERSONAL PROTECTION EQUIPMENT	-
Respiratory protection	Wear self-contained breathing apparatus
Hand protection	Gloves
Eye protection	Safety glasses
Specific hygiene measures	Prohibit contact with skin and eyes and inhalation of vapours. (Repeated exposure and/or Prolonged exposure)

09 - PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE (20°C)	liquid
COLOUR	colourless
ODOUR	aromatic
BOILING POINT/RANGE	65 °C (approximately)
FLASH POINT	Closed cup : -20 °C. Standard : NF M 07011

SAFETY DATA SHEET

Product: COUPE C6 — Page: 4 / 8

Product Code :01262 — Version:4. — Date : 20 / 09 / 1995

AUTOIGNITION TEMPERATURE	580 °C Standard : ASTM D 2155
EXPLOSIVE LIMITS	
Lower	1,4% in volume.
Higher	8% in volume.
VAPOUR PRESSURE	(20 °C) : 120 hPa (estimated) (37,8 °C) : 300 hPa 150 °C) : 530 hPa (estimated)
DENSITY	(20°C) : 640 kg/m³
SOLUBILITY	
Water	Insoluble 820 mg/kg (20 °C)
Solvents	Miscible with most organic solvents. Miscible with : Oils, Fats, Waxes
PARTITION COEFFICIENT (n-octanol/water)	Benzene : log Pow = 2,13
OTHER DATA	Crystallization : around -5°C. Relative vapour density/air 2,7 (approximately) Henry's constant (Benzene) : 537 Pa.m³/mol

10 - STABILITY AND REACTIVITY

CONDITIONS TO AVOID	Store protected from moisture and heat. Keep at temperatures below 25°C.
MATERIALS TO AVOID	Diboranc - Bromine pentafluoride - Permanganic acid - Iodine pentafluoride Silver perchlorate - Oxygen (liquid) : Explosive reaction Oxidizing agents : chromium oxide, Perchlorates, Sulphuric acid + Permanganates. Sodium oxide, Iodine heptafluoride : Violent reaction Halogens, Strong acids
HAZARDOUS DECOMPOSITION PRODUCTS	Thermal decomposition gives : Organic derivatives
FURTHER INFORMATION	The product is stable at ambient temperature

11 - TOXICOLOGICAL INFORMATION

ACUTE TOXICITY	
Inhalation	Risk of : Headache, sleepiness nausea In case of inhalation at high concentrations : Neurological disorders. Possible loss of consciousness , Coma Benzene : Reported in animals Slightly harmful by inhalation. LC50/inhalation/4h/rat = (45 - 52) mg/l.

SAFETY DATA SHEET

Product: COUPE C6

Product Code :01262

Version:4.

Date : 20 / 09 / 1995

Ingestion

In man :
Risk of : Gastro-intestinal problems. Nervous problems
Benzene : Experimental effects on animals :
Slightly harmful by ingestion.
LD50/oral/rat = (5.8 - 4.7) g/kg

Skin-contact

If significant contact :
Skin penetration with possible toxic effects on :
Central nervous system. Digestive system

LOCAL EFFECTS

Inhalation

According to its composition :
At high vapour/fog concentrations :
Possible irritation of respiratory system

Skin-contact

Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product.
Benzene : Reported in animals :
Irritating to skin. (rabbit).

Eye-contact

Direct contact with liquid :
Transitory irritation.
Benzene : Reported in animals :
Slightly irritating to eyes. (rabbit).

CHRONIC TOXICITY

Target organs at high doses :
Central nervous system. Digestive system. Haematological system. Peripheral nervous system.

SPECIFIC EFFECTS

GENOTOXICITY :
Benzene :
Several in vivo and in vitro tests indicate potential genotoxicity
CARCINOGENICITY :
Benzene :
Proven carcinogen in man
(Benzene-induced leukaemia)
Carcinogenic effects shown experimentally in animals
REPRODUCTIVE TOXICITY :
Fertility :
Benzene :
According to limited information available in animals :
Absence of toxic effects on fertility
Foetal development :
Benzene :
Experimental effects on animals :
Absence of congenital malformations and embryotoxic effects in rodents at non-toxic doses for the mothers.

SAFETY DATA SHEET

Product: COUPE C6 Date : 20 / 09 / 1995

Product Code :01262 Version:4.

12 - ECOLOGICAL INFORMATION

- SUBSTANCE CONCERNED	Benzene
MOBILITY	Rapid evaporation : halflife time t1/2 = 2.7 h (estimated) halflife time t½ (in aqueous natural environment) : 6 d (measured)
PERSISTENCE/DEGRADABILITY	-
In water	Biological degradability : : (39 - 41) % after 14 d Degradation by OH radicals : halflife time (1/2 = (2.4 - 24) h
In air	Slight adsorption : log Koc = 1.92
In soils and sediments	Slightly bioaccumulable : log Pow = 2.13
BIOACCUMULATION	-
ECOTOXICITY	-
AQUATIC TOXICITY	Fish : LC50, 96 h > 5.9 mg/l < 100 mg/l Harmful to daphnia : EC50, 24h = 10 mg/l Harmful to algae : IC50, 72 h (Selenastrum capricornutum) = 29 mg/l Bacteria : EC50, 24 h (Nitrosomonas) = 13 mg/l
Acute toxicity	-
TERRESTRIAL TOXICITY	Earthworm : contact test, LC50, 48 h (Eisenia fetida) = 98 µg/cm²
Acute toxicity	

13 - DISPOSAL CONSIDERATIONS

DISPOSAL OF PRODUCT	Keep waste impregnated with product in tightly closed and waterproof containers. Destroy the product by incineration.

14 - TRANSPORT INFORMATION

Consult ELF ATOCHEM's safety department for any further information

UN Number	3295
ADR/RID	Class : 3 Item (letter) : 3°b Labels : 3
Prescriptions	H.I. Nr/ID Nr : 33/3295
IMDG	Class : 3.1 Packaging group : I UN Nr (IMDG) : 3295
Prescriptions	Labels : FLAMMABLE LIQUID/3
IATA	Class : 3 Packaging group : I UN Nr (IATA) or ID Nr : 3295
Prescriptions	Labels : FLAMMABLE LIQUID/3

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Product Code :01262 Version:4. Date : 20 / 09 / 1995

15 - REGULATORY INFORMATION

EEC DIRECTIVE	D. 91/155/EEC amended by D.93/112/EEC : Dangerous substances and preparations
SAFETY DATA SHEETS	
EEC CLASSIFICATION / LABELLING	D. 67/548/EEC amended by D. 94/69/EEC (21st ATP)
HAZARDOUS SUBSTANCES	F _ HIGHLY FLAMMABLE T _ TOXIC R11 _ Highly flammable. R45 _ May cause cancer. R22 _ Harmful if swallowed. S16 _ Keep away from sources of ignition - No smoking. S33 _ Take precautionary measures against static discharges. S53 _ Avoid exposure - obtain special instructions before use. S45 _ In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
Nr in ANNEX I	649-355-00-5
EEC Nr (EINECS)	273-266-0
INVENTORIES	TSCA : listed NDSL : listed KOREA : 9212-2149

16 - OTHER INFORMATION

RECOMMENDED USES	Solvent Organic synthesis
BIBLIOGRAPHY REFERENCES	Fiche toxicologique INRS : N° 49 : BENZENE BG-CHEMIE . M025 BENZOL
FURTHER INFORMATION	THIS PRODUCT MUST BE HANDLED ONLY BY PERSONNEL WELL INFORMED OF SAFETY CONDITIONS WHEN USED IN FORMULATIONS, CONTACT US FOR LABELLING.

This information applies to the PRODUCT AS SUCH and conforming to specifications of ELF ATOCHEM.
In case of formulations or mixtures, it is necessary to ascertain that a new danger will not appear.
The information contained is based on our knowledge of the product, at the date of publishing and it is given quite sincerely. However the revision of some data is in progress.
Users advised of possible additional hazards when the product is used in applications for which it was not intended. This sheet shall only be used and reproduced for prevention and security purposes.
The references to legislative, regulatory and codes of practice documents cannot be considered as exhaustive.
It is the responsibility of the person receiving the product to refer to the totality of the official documents concerning the use, the possession and the handling of the product for which he alone is responsible.
It is also the responsibility of the handlers of the product to pass on to any subsequent persons who will come into contact with the product

SAFETY DATA SHEET

(usage, storage, cleaning of containers, various interventions) the totality of the information contained within this safety data sheet and necessary to safety at work, the protection of health and the protection of environment.

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