ATSB
Australian Transport Safety Bureau

AUSTRALIAN TRANSPORT SAFETY BUREAU

MARINE SAFETY INVESTIGATION
REPORT 183

Independent investigation into the fire in the hold of
the Netherlands flag general cargo vessel

Marion Green

off the coast of Western Australia
on 28 July 2002

AUSTRALIAN GOVERNMENT – DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

Department of Transport and Regional Services
Australian Transport Safety Bureau

Navigation Act 1912
Navigation (Marine Casualty) Regulations
investigation into the fire in the hold of the Netherlands flag general cargo vessel *Marion Green* off the coast of Western Australia on 28 July 2002

Report No 183
November 2003

ISSN 1447-087X
ISBN 1 877071 42 0

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***Marion Green* at Albany, 30 July 2002**

Summary

On 28 July 2002, the Netherlands flag general-purpose cargo vessel *Marion Green*, of 11 894 gross tonnes, carrying 6 000 tonnes of cocoa beans, was off the coast of Western Australia on passage from Fremantle to Adelaide.

At 1130 that morning a fire alarm was activated by the smoke detection system in No. 2 cargo hold. After a brief inspection through the open hold access by the mate and second mate, during which they saw some flames on top of the cargo, all openings were closed and the discharge of CO_2 from the fixed firefighting installation was started. By 1715 that afternoon, 86 bottles of CO_2 had been released into the hold.

At 0700 on the following day, a slight increase in hatch cover temperature was recorded. The master was advised by the vessel's managers to discharge the remaining 11 bottles of hold CO_2 and to divert to Albany as a port of refuge.

Marion Green berthed in Albany at 1615 on 29 July. Additional bulk CO_2 was delivered to the ship from Perth and this, too, was discharged into the hold over the next few days. On the morning of 31 July, the after panels of No. 2 hatch were opened for an inspection. Flames were seen on the top layers of cargo and these were doused by the fire brigade after which the hatches were again closed and more CO_2 discharged into the hold. At 1400 the following day, 1 August, the hatch covers were once more opened and, after further flare-ups had been doused by the fire brigade, stevedores began discharging the cargo into sand bungs on the wharf. By 10 August all the cocoa bean cargo had been discharged and *Marion Green* sailed for Adelaide.

The report concludes that the investigation was unable to determine, exactly, the cause of the fire, but four distinct possibilities were examined. These were:

- Self-heating of the cargo due to fungal growth
- Ignition caused by the flammable characteristics of the phosphine used for fumigating the cargo
- Cigarette ends discarded in the hold during loading of the cargo in Makassar
- A cargo light that had been left in the hold on sailing from Makassar

It also concludes that:

- the vessel's 'no smoking' policy was not properly enforced during cargo loading
- insufficient CO_2 was released into the hold in the early stages of the fire
- inadequate information on the hazards of shipping cocoa beans was provided to the ship's staff and
- the response to the fire, once the vessel was alongside, lacked co-ordination and a clear understanding of who had the responsibility and authority for dealing with it.

The report recommends that:

- the shipowners enforce a strict 'no smoking' policy in the vicinity of cargo operations
- the shipowners ensure that ship's masters are provided with all relevant information on the hazards of carrying organic cargoes and their fumigation
- shippers, stevedores and ship's officers ensure that adequate ventilation channels are provided when stowing such cargoes and
- deck watchkeeping officers log the isolation and stowage of all electrical equipment from the holds on completion of cargo operations.

Sources of information

Master and Chief Officer of *Marion Green*

The Harbourmaster, Albany Port

Fire & Emergency Services Authority of Western Australia

Australian Quarantine and Inspection Service (AQIS)

United States Department of Agriculture

Transport Information Service, German Insurance Association

IPCS Inchem – Chemical Safety Information from Intergovernmental Organisations

UK P&I Club

References:

Thomas' Stowage

'Fire Aboard' by Frank Rushbrook CBE, 3rd Edition 1998, Brown, Son & Ferguson

Marion Green

Marion Green, is a Netherlands flag, multi-purpose, tweendeck, general cargo vessel, registered in Rotterdam, Holland. At the time of the incident it was owned and operated by Genchart BV of Rotterdam, (since changed to Beluga Genchart BV) owners of the 'Green Fleet'. The 'Green Fleet' consists of some eight (and, at the time of the incident, two more building) identical 'box-shaped' vessels which are employed in worldwide tramping.

Marion Green, was built in 1999 at the shipyard of Schelde Scheepsnieuwbouw BV, at Vlissingen in Holland. The vessel has since then been maintained in class with Lloyd's Register as ✠100 A1,✠LMC, UMS, NAV 1, Ice Class 1A.

It is a vessel of 142.81 m length overall (132.0 m between perpendiculars), with a moulded depth of 13.3 m and a maximum beam of 21.5 m. It has a gross tonnage of 11 894 tonnes and a summer deadweight of 17 050 tonnes at a summer draught of 9.689 m.

All accommodation and machinery spaces are aft of the forward engine room bulkhead which is located at frame 39. Forward of the engine room bulkhead are two fully box-shaped cargo holds, the forward of which, No. 1 hold, (between frames 107 and 151) has a cubic capacity of 7561 m^3 and the aft hold, No. 2, (between frames 39 and 103) a capacity of 12 292 m^3. The vessel can be configured with a fully flush tweendeck, consisting of loose steel, 'pontoons' each of 17.75 x 6.52 x 0.90 m, which can be positioned individually at three different heights in the holds. These pontoons can also be used to form vertical bulkheads at intervals of six metres. The ship can be readily converted from either a tween or even tripledecker, to a full container vessel, or fitted with any combination of tweendecks and bulkheads, thus making it extremely versatile.

The vessel, which has a total container capacity of 962 TEUs[1] (215 on deck and 446 underdeck), is fitted with three deck cranes each of 60 tonne lift at 16 m radius.

Marion Green is powered by a single 8-cylinder, four-stroke, Wärtsilä 8L46B diesel engine developing 7 800 kW (10 460 shp) and driving a single shaft with a variable-pitch propeller, giving the ship a maximum speed of 16 knots. The ship is also fitted with a 750 kW bow-thruster unit.

At the time of the incident, the ship had a complement of 13. This consisted of the master, mate, second and third mates, chief engineer, second engineer, bosun, cook, four able seamen and a wiper. The master, mate, second mate and chief engineer were Dutch nationals, the third mate was Belgian, and the second engineer was British. All the ratings were Filipinos. All of the ship's complement were appropriately qualified in accordance with the requirements of the STCW95 (Standards of Training, Certification and Watchkeeping, 1995) convention.

The master had first gone to sea in 1966 after completing his training at a pre-sea training college. He had served on Shell tankers, Nedlloyd container ships and general cargo vessels from the 1970s to the 1990s before joining Green Fleet in 1999. For most of the time since joining Green Fleet he had sailed as master.

The mate had been at sea for 12 years since starting as an apprentice. He had served in the offshore industry, on reefers, small coasters, general cargo vessels and heavy lift ships before joining the Green Fleet in 1999. It was his sixth voyage on this type of vessel. Neither the master nor the mate had any previous experience in the carriage of cocoa, or other bean, cargoes.

At the time of the incident, all ship's certificates required under international shipping conventions were valid. In addition, the vessel had been issued with a 'Document of

[1] Twenty-foot Equivalent Units.

Compliance with special requirements for ships carrying dangerous goods' by the Netherlands Shipping Inspectorate in June 1999. From July 2002 *Marion Green*, as a general cargo vessel, was required to hold an International Safety Management Certificate. Such a certificate was issued to the vessel on 12 February 2002 by the Netherlands Shipping Inspectorate.

Fixed firefighting installation

Marion Green is fitted with a Unitor fixed CO_2 firefighting installation for gas flooding either, or both, Nos. 1 & 2 holds and for the engine room. The major part of the installation is contained in a CO_2 compartment situated beneath the main deck on the port side aft of No. 2 hold (between frames 26 and 39) from where the release of the CO_2 can be controlled. An additional remote release cabinet for the bank of engine room bottles, only, is situated on the starboard side of the main deck, just off the main cross-alleyway within the accommodation. There are a total of 154 CO_2 bottles, each of 67.5 litre capacity and containing 45 kg of gas.

Of these, 57 bottles are arranged for release into the engine room, as a complete bank, in less than two minutes, by pneumatically operated valves. The other 97 are arranged for manual release and are dedicated to the holds. Release of those CO_2 bottles for the holds is done manually after selecting the appropriate number of bottles for the hold to be flooded. It is possible, by use of a changeover valve, to also release the engine-room bank into the holds.

The CO_2 is discharged into the holds through nozzles arranged on a ring-main around the top of each hold. In No. 2 hold, there are eight such nozzles, four on each side. These same nozzles, under normal circumstances, are also used to withdraw samples of air on a continuous basis for passing through the Autronica smoke detection system. This system, driven by small fans, constantly samples air from both holds drawing the samples through a photo-electric cell which, if it detects obscuration due to smoke, will sound an alarm on the fire detection panel situated on the after bulkhead in the wheelhouse.

FIGURE 2:
CO_2 room, showing banks of gas bottles for CO_2 flooding of cargo holds

Narrative

Cargo loading

On 17 July 2002, *Marion Green* arrived at the Indonesian port of Makassar at the beginning of voyage 6 of 2002, to load a cargo of 6 096 tonnes of Sulawesi cocoa beans in burlap bags (96 156 bags of approximately 63 kg each) for the Brazilian port of Ilheus. Upon the ship's arrival alongside in Makassar, moveable steel pontoons were arranged as a vertical bulkhead in No. 2 hold at frame 79 (the aft end of No. 9 pontoon position – 19.56 m from the forward end of the hold) thus partitioning the hold. The forward section was for two items of machinery to be loaded later in Australia, while the after, major, part was for the loading of cocoa beans.

Prior to commencing loading the bagged cocoa beans, the vessel received 42 m^3 of wooden planks and pallets for use as dunnage, 800 bamboo mats for placement over the dunnage on the tanktops and 2 200 kg of Kraft paper. The paper was to be used to line the holds for absorption of any condensation which might form during the voyage, due to changes in ambient temperature, on the sides of the holds and the undersides of the hatches

On the 16th July, the day before the ship's arrival, all the dunnage, bamboo and Kraft paper had been fumigated with methyl bromide. The cargo was similarly fumigated for a period of seven days leading up to the loading and, in addition, on 17 July, the ship's empty holds (Nos.1 and 2) were sprayed throughout with a 5 per cent solution of pyrethrins.

Shortly after 0100 on 18 July, the holds were again opened. At 0230, after preparing the dunnage and other stowage materials, two gangs of stevedores started loading the cargo of bagged cocoa beans. 48 156 bags were to be loaded into No. 1 hatch and 48 000 into No. 2 hatch. The vessel's own cranes were used for loading the bags, slung in cargo nets, into the holds where the stevedores arranged their stowage. Each sling contained five tiers of five bags each.

Cargo loading continued, with either three or four gangs working from 0800 on 18 July, until 2200 on 21 July. The weather throughout was fine, with sunny and cloudy periods, but with high ambient temperatures, usually above 30°C, and high humidity.

On a number of occasions during this period, the mates on deck watch had cause to draw the attention of the stevedores to the 'NO SMOKING' signs painted on the ship's structure around the holds, as a some men had been observed smoking in the vicinity of the holds.

On 19 July, the vessel's liferafts underwent their annual checks. During this process, the drinking water in the liferafts was replaced and the removed sachets were taken by the stevedores working in the holds for some refreshment in their hot, humid working conditions.

Loading of the 6 000 tonnes of cargo was completed at 2145 on 21 July, whereupon the top layers of cocoa bags were covered by absorbent paper and the hatches closed. Following checks to ensure that all openings to both holds were able to be thoroughly sealed, both holds were then finally fumigated by the distribution of aluminium phosphide, in sachets, around the holds. The aluminium phosphide, when exposed to atmospheric moisture, generates phosphine (hydrogen phosphide) gas, a powerful insecticide. The quantity of aluminium phosphide required to provide for five days of 'in transit' fumigation of the cargo had been calculated by the fumigation contractors before it was placed in the holds. This process was completed at 0030 on 22 July and both hatches were then closed. Shortly afterwards, the pilot boarded and *Marion Green* sailed for the Western Australian port of Fremantle.

Vessel's call at Fremantle, WA

The voyage from Makassar to Fremantle was uneventful. The hatches and all other openings to both holds remained sealed throughout the voyage, while the phosphine fumigation of the cargo took effect. All the hold ventilation fans remained off.

At 0300 on 27 July, the Fremantle pilot boarded and *Marion Green* was secured alongside No. 2 berth, North Quay, at 0435. After arrival, the second and third mates, wearing gas masks, set about opening all the hold ventilation flaps. The deck was then cleared of personnel and the hold ventilation fans were started. Ventilation of the holds continued for approximately 30 minutes longer than the required six hours, until about 1300 that day, when the mate then entered the holds testing for traces of phosphine. Testing for phosphine was carried out using 'Dräeger tubes'[2] supplied by the shipper of the cargo. The tests showed that the level of phosphine had reduced to a zero reading.

The tweendeck at the forward end of No. 2 hold was then opened and the hold prepared for loading two large heat exchangers, also destined for Brazil, which were to be stowed forward of the temporary steel pontoon bulkhead across the hold at frame 79. The ship's lifting gear was prepared and, during the afternoon, stevedores, assisted by the ship's crew loaded the heat exchangers into the hold. The task took approximately 45 minutes and, on completion at approximately 1700, the heat exchangers were covered with tarpaulins and the tweendeck pontoons replaced. When the hatch had been closed, a 20-ft container containing spare parts for the heat exchangers was then loaded onto the top of the hatch as deck cargo.

That evening the ship took bunkers. Later that night the pilot boarded and, at 0145 on 28 July, *Marion Green* sailed for Adelaide. After sailing, the hold ventilation was switched off because of heavy rain showers.

FIGURE 3:
Cargo in No. 1 hold, covered with Kraft paper and showing timber dunnage and fumigation sachets of aluminium phosphide

[2] Test equipment to which can be fitted the appropriate glass tubes containing reactant chemicals designed to show up the presence of a specific gas.

The fire

At about 0930 that morning, the mate went down to the holds to measure the humidity and dew point. He also again tested for the presence of phosphine, with a negative result. While at the access to No. 2 hold he noticed that the hold was ‘soaking wet’. Moisture was running down the bulkheads and dripping from the hatch covers. He measured the relative humidity as being 93 per cent. By 1015 he had taken the required readings in No. 1 hold. The relative humidity, at 82 per cent was significantly lower than that in No. 2 hold. Having taken the necessary readings, he restarted the hold ventilation fans then made his way to the wheelhouse.

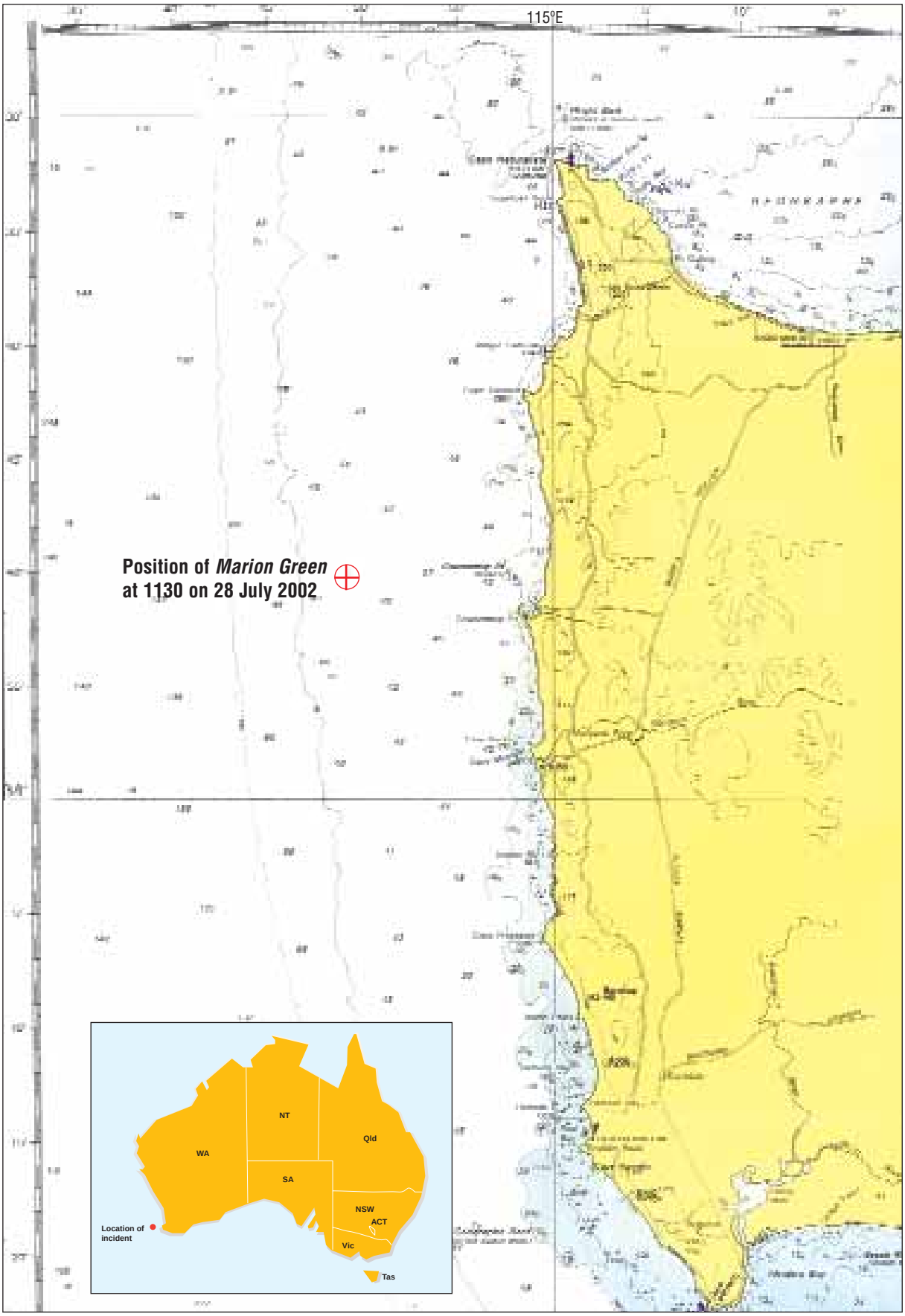
At 1130 that same morning the ship was at the approximate position 33° 50'S, 114° 49'E and making 16 knots, when a fire alarm was activated by the smoke detection system in No. 2 cargo hold. At about the same time, smoke was observed on the main deck coming from the No. 2 hold port side ventilation ducts. Hold ventilation was stopped and the mate went down to the deck with the second mate to investigate. They noticed that the access hatch was warm and there was smoke issuing from the upper hold access opening. This information was passed to the master in the wheelhouse, who re-activated the fire alarm. Two fire suits and four breathing apparatus sets were brought to the hold access from the fire locker on the main deck and from the wheelhouse.

The ship’s crew closed all ventilation openings and ran out fire hoses on deck while the chief officer and second officer donned the fire suits and breathing apparatus. They opened the starboard aft access hatch to No. 2 hold and saw flames on the top layer of bags of cocoa beans, not far from the hold access opening. A lot of smoke was coming from the hold access hatch. They played a fire hose onto the area where the flames were just visible before closing the access hatch and informing the master of the situation.

The master instructed them to make preparations to flood the hold with CO_2 from the fixed fire-fighting installation. Crewmembers started cooling the hatch covers with two fire hoses.

FIGURE 4:
Smoke issuing from No. 2 hold access hatch

FIGURE 5:
Position of *Marion Green* when the fire alarm activated at 11.30 on 28 July 2002



At 1150, the mate started to manually release the CO_2, one bottle at a time, into the hold. Initially, 25 bottles were released, after which it was decided to wait for the CO_2 lines to depressurise and to don breathing apparatus again, as there were several leaking connections in the CO_2 room. The vessel's managers in Rotterdam were advised of the situation.

At about 1210, one vent flap on the forward end of No. 2 hold was opened in order to measure the oxygen content of the issuing air/gas mixture. It was found that the oxygen content had decreased only slightly and, consequently, another 25 bottles of CO_2 were progressively discharged from about 1220. At 1245, the hold access was opened again to check the effectiveness of the CO_2 flooding. The flames appeared to have been extinguished. However a proposed entry by the mate and second mate was cancelled on account of the thick smoke and the fear of a 'backdraft'. The entrance was closed again, as was the forward vent flap.

At 1300, another 14 bottles were discharged and a fire watch was set up to monitor the temperatures of the hatch covers and coamings every 15 minutes. At 1500, a further situation report was made to the ship's managers and the Australian Search and Rescue co-ordination centre (AusSAR) was also notified.

By 1715 that day, a total of 86 bottles of CO_2 had been released into the hold and the temperatures of the hatch covers dropped steadily. During the night, the hold remained sealed and temperatures of the hatch covers were monitored, and recorded, on a regular basis. As the temperatures were dropping, the temperature observations were changed from every 15 minutes to hourly. Checks were maintained in the engine room on the forward bulkhead, being the aft bulkhead of No. 2 hold. These temperatures, however, were found to be steady.

Port of Refuge – Albany

At 0700 on the following day, an increase in hatch cover temperature of about 2°C was recorded. The mate and chief engineer opened one of the drains on the starboard side of the hatch coaming to again test the oxygen level. However, they were unable to take a reading as they were confronted by a continuous flow from the drain of a brown, mud-like, substance. At 0835, having again contacted the vessel's managers, the master was advised to discharge the remaining 11 bottles of hold CO_2 and to divert to Albany, approximately 100 nautical miles distant, as a port of refuge. Agents for the vessel, who were appointed in Albany, informed the harbourmaster of the situation and, at about 0900 that morning, the harbourmaster contacted the ship by VHF. The ship's master explained that there was a fire in No. 2 hold, that CO_2 flooding had been used and that the fire seemed to be under control. The temperatures, however, were not going down.

The vessel proceeded towards Albany and, at 1450 that same day, the harbourmaster, as pilot, boarded the ship.

At 1615 on 29 July, *Marion Green* was alongside at Albany. Shortly after berthing a meeting was held between the harbourmaster, the master, a representative from Customs and the ship's agent. As the vessel's stock of CO_2 had been severely depleted, the agent arranged for a bulk tank of 14 tonnes of CO_2 to be delivered from Perth. At 1730, representatives of the local fire brigade arrived on board to evaluate the situation. The hatch covers remained closed and temperatures were monitored throughout the night on a two-hourly basis. At 2200 that evening, more hoses were rigged and boundary cooling was again applied to the hatch covers.

This situation remained unchanged throughout the following day, Tuesday 30 July. A surveyor, appointed by the P&I Club requested, through the master, that permission be given to open the hatch, but this was refused, the harbourmaster requiring a further 24 hours of monitoring. Later that day the bulk CO_2 arrived from Perth and was placed on the main deck at the port after corner of No. 2 hold. It was connected to the ship's CO_2 flooding system through the adjacent access to the CO_2 room.

FIGURE 6:
No. 2 hold aft hatch panels partially opened

FIGURE 7:
Smoke from No. 2 hold after opening the hatches

At 0545 on the morning of 31 July, the temperatures of the hatch covers appeared to be rising again and boundary cooling was resumed. Later that morning, a decision was made to open the hold and ascertain the situation

At 0930, the access hatch was opened, followed by the two aft panels of the cargo hatch cover which were lifted into a partially open position. Much smoke issued from the hold and some flames were observed through the thick smoke on top of the cargo. The fire brigade started hosing down the top layers of bags of cocoa beans and the flames were eventually extinguished. After a short period with no more flames appearing, the hatch covers were fully opened.

As no decision had been reached at that stage on what to do with the damaged cargo, the hatches were again closed and more CO_2 was injected from the bulk tank on the main deck.

At 1500 that afternoon the vessel was required to shift ship to the next berth. On completion of the shift, steam was noticed coming from the port side coaming of No. 2 hatch. A small area of paint was scorching on the hatch cover and there was some noticeable deformation of the hatch panel. It was immediately evident that the intensity of the fire was rapidly increasing and the fire brigade was again called. At 1600, two appliances attended on the wharf and more CO_2 was injected into the hold. Substantial boundary cooling was applied to the hatch covers and coamings, by both the fire brigade and the ship's crew, throughout that night.

At approximately 1730 that evening, a tanker, *Scottish Bard*, arrived at Albany and was due to berth close to *Marion Green*. The port, however, was closed due to the fire.

On the following morning, Thursday 1 August, the temperatures of the hatch covers, being monitored by the ship's staff, appeared relatively stable. The weather had deteriorated overnight and the day became windy with rain showers and drizzle. This assisted in keeping the hatch covers cool. No attempt, however, was made to open the hold again before 1400 that afternoon, when a meeting of involved parties was convened by the harbourmaster to determine the future course of action.

Cargo discharge

In spite of various evident conflicts of interest (see p25), it was eventually agreed that there was no real option but for the cargo to be discharged and, at 1600 that afternoon, on 1 August, the hatches were partially opened. Several spot fires were again visible through the smoke. Both the fire brigade and ship's crew, all wearing BA sets, attacked the fires with several hoses.

Sand dams, into which the cargo would be placed for final dousing, were constructed on the wharf adjacent to the ship and arrangements were made, under the auspices of AQIS, for the damaged cargo to be trucked to the Albany tip where it would be buried as landfill.

At 1835 on 1 August, in consultation with the fire brigade, the discharge of the cargo commenced. The port remained closed.

On the following day, 2 August, the spot fires appeared to be under control. At 1120, the tanker Scottish Bard was allowed to berth at No. 2 wharf to discharge its cargo of petrol. The discharge of burning cargo from *Marion Green* was suspended while *Scottish Bard* discharged its cargo.

Over the next few days all the bags of cocoa beans in No. 2 hold were discharged by stevedores using the ship's cranes and grabs. Any spot fires or areas of smouldering cargo were doused during the discharge. On 6 August the ship's agent was informed by AQIS that it had reviewed its decision regarding burial of the cargo at the Albany tip and it could be reclaimed where appropriate. Approximately 44 per cent of the cargo from No. 2 hold, relatively undamaged, was salvaged and moved to a cargo shed on the wharf. Flare-ups in the

FIGURE 8:
Albany fire brigade tackling fire in no.2 hold

FIGURE 9:
Smouldering cargo at aft end of no.2 hold showing burned cavities and channels

FIGURE 10:
Discharging damaged cargo onto the wharf

cargo occurred frequently during the discharge, in the hold, on the wharf and in the cargo which had been moved to the shed. The fire brigade remained in attendance at the vessel, dealing with these fires, until they were finally stood down at 2020 on 7 August.

After completion of the discharge of cocoa beans and the cleaning out of residue in No. 2 hold, *Marion Green* sailed for Adelaide at 1550 on 10 August.

Comment and analysis

The investigation

A marine investigator from the ATSB arrived on board *Marion Green* on the morning of 30 July and, while conducting the investigation over the next five days, was also able to observe the subsequent events and the measures taken to deal with the fire during that period. The master and chief officer were interviewed, copies of the ship's logs and all other relevant documentation were obtained and samples of cocoa beans were taken from both Nos. 1 and 2 holds for later expert examination. Evidence concerning the response of the port authority and the local fire brigade was obtained. Details of the cargo, its loading in Makassar and its fumigation were also obtained, as was information which had been provided to the master by the shipper of the cargo.

Owing to the nature of the incident, it was inevitable that much of the physical evidence relating to the source of ignition was destroyed as the cargo, a large proportion of it burned, was soaked by water from fire hoses on several occasions before its discharge. In addition, the action of the grabs during the discharge damaged many unburnt bags and caused the cargo to finish up as an homogenous heap on the wharf. The pattern, however, in which the fire spread through the hold could be observed through the smoke on those occasions when the hatch covers were opened for fire-fighting operations.

Cocoa beans

Cocoa beans are the seeds, contained in a cucumber-like fruit, of the cacao tree, Theobroma Cocoa Linné. (Theobroma, from the Greek, literally means 'food of the gods') It is a member of the Sterculiaceae family. The cocoa bean (there are usually about 30–40 seeds in each pod) consists of the seed coat which encloses the cocoa kernel. The cocoa kernel is the principal component for the production of cocoa products.

The history of cocoa and chocolate dates back to the time of the Incas, Mayas and Aztecs of Central and South America. It was at one time the currency used by those peoples. It was introduced to Europe in 1527. During the 16th and 17th centuries, the Spaniards established cacao tree plantations in their colonies in Central and South America. The Dutch later took trees to other countries including their colony of Indonesia. Indonesia is not one of the largest of cocoa producing countries, unlike Brazil, the destination for the cargo aboard *Marion Green*. At the time of the incident, a worldwide shortage of cocoa existed and companies in Brazil were having to import cocoa beans in order to be able to fulfil their contracts.

Cacao seeds are the source of commercial chocolate, cocoa, and cocoa butter. Cocoa is made by removing most of the fat from the beans, then roasting and grinding them. The fat that is removed is called cocoa butter. Cocoa butter is used in confections and in the manufacture of pharmaceuticals, soap, and cosmetics. Cocoa butter has been described as the world's most expensive fat and cacao beans contain a great deal of this fat, some 40–50 per cent, in addition to small amounts of mildly stimulating alkaloids, including caffeine. Consequently, cocoa beans are a very high value cargo. The value of the cargo aboard *Marion Green* on 28 July 2002 was approximately US$10.5 million.

Shipping cocoa beans

Cocoa beans are usually shipped in burlap (made from jute or sisal) bags, each bag weighing from 60–65 kg. Owing to the value of the cargo, new, high quality bags are usually used. Cocoa beans require particular temperature, humidity and ventilation conditions. Due to its high fat content, the cargo is very apt to self-heat and there may be a risk

of cargo fire on contact with flammable substances.[3] The cargo requires to be stowed in a dry place, normally below decks. The cargo loses value, however, if allowed to become too dry and brittle; around 7 per cent moisture content being acceptable.

The temperature of the cargo is frequently hotter than the ambient temperature in areas through which the vessel may pass. Too little ventilation results in hold temperatures rising above the dew point with the consequence that condensation forms on the ship's shell plating, tank tops and hatches. Excess moisture content will cause mould growth and, if excessive, will rot the cargo. The beans themselves release large amounts of water vapour during extended voyages after which the moisture content of the beans may be observed to have decreased by 1 to 3 per cent. The vapour given off may contain acetic acid which can cause corrosion.[4] In addition to the moisture content, the beans contain certain enzymes that bring about post-fermentation which is prevented only by good air circulation around the cargo.

To keep the bags dry should condensation form, the cargo aboard *Marion Green* was loaded on top of dunnage which had been made into wooden frames, not unlike conventional pallets. The wooden frames were then overlaid with bamboo matting which was in turn covered with a layer of Kraft[5] paper. Other wooden frames were placed up the ship's sides as the cargo was loaded and, again, covered with a layer of Kraft paper. Finally, once the loading of each hold had been completed, the cargo was completely covered with a layer of Kraft paper to protect the top bags from any condensation which could drip from the hatch covers and coamings.

Ventilation

Good ventilation is essential, shippers requiring a minimum of 20 air changes per hour. Since the beans continually release water vapour during the voyage, this vapour must be removed to reduce the risk of condensation forming in the event of cooler ambient conditions, and the risk of mould growth due to high relative humidity in the hold. No. 2 hold of *Marion Green* is ventilated by means of two supply fans, port and starboard, ducted through the after bulkhead and discharging into the hold on four levels. At the forward end of the hold the hold atmosphere is extracted by two extraction fans drawing from the four levels. The capacity of the fans is sufficient to provide 20 air changes per hour when the holds are empty; considerably more than sufficient when the holds are loaded.

To facilitate the movement of air around the cargo, the holds were loaded with ventilation channels provided both in the fore-and-aft direction and athwartships. The channels were approximately 300 mm wide and extended down the full depth of the cargo. At various levels, individual bags were arranged as 'ties' across the ventilation channels to prevent the layers of bags collapsing together and blocking the channels.

The cargo in No. 2 hold was arranged with a single ventilation channel along the centre-line of the hold and two channels in the athwartships direction, such as to divide the length of the hold into three equal sections.

During the investigation, the stowage of the cargo in No. 1 hold was assessed. It was observed that the width of the ventilation channels in many areas was considerably less than 300 mm and, indeed, in some spots had closed up completely, due either to improper stowage on loading, or to subsequent movement of the cargo. It was also noted that the Kraft paper, covering the top layer of cargo, also covered the ventilation channels, hence

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3 Transport Information Service, German Insurance Association, Berlin.

4 Thomas' *Stowage.*

5 A brown paper used extensively in the packaging and manufacturing industries. Available in numerous grades and for numerous purposes. In this instance the paper used was of a relatively heavy, absorbent grade.

restricting any vertical movement of air through these channels.

Fumigation

To both protect the cocoa bean cargo from damage by insect pests and to prevent the transport of such pests from one country to another, cargoes of cocoa beans are fumigated, both before loading and for the first few days in transit. During the fumigation period, in this case for five days, the holds must remain tightly sealed and all ventilation shut down. Only when the fumigant has had sufficient time to penetrate all of the cargo is ventilation restored and maintained for the remainder of the voyage.

One of the most common fumigants used is hydrogen phosphide, usually referred to as phosphine gas (PH_3). Phosphine is a colourless gas which is toxic to insects, humans and other forms of animal life. It is very mobile with a high vapour pressure which enables it to penetrate to all parts of the cargo. This combination, together with high molecular activity and toxicity at low doses, accounts for its wide acceptance as a fumigant.

Phosphine is generated by allowing atmospheric moisture in the surrounding air to react with aluminium phosphide in the form of either tablets, pellets or sachets. Aluminium phosphide is also referred to as the 'dry gas'. Once spent, the aluminium phosphide degenerates into a grey-white powder composed of aluminium hydroxide and some inert ingredients.

On completion of loading of the cocoa bean cargo at Makassar, sufficient aluminium phosphide, in the form of sachets, to provide for five days 'in transit' fumigation was scattered randomly across the top layer of the cargo in each hold. In No. 1 hold, some of these sachets could be observed to have fallen down into the ventilation channels provided between the stacks of bags.

Information provided by shipper

Neither the master nor the mate of *Marion Green* had any previous experience of the carriage of cocoa bean cargoes and both had to rely on information from the sub-charterers provided to the ship, in a telex from Genchart, a month before the incident.

FIGURE 11:
Narrow ventilation channel between stacks of cargo in No. 1 hold. Note that some layers are almost touching

The information related to the way the bags of cocoa beans were to be slung to avoid damage, the arrangement for dunnage on the tank-tops and at the ship's sides to avoid contact with any condensation and the requirements for ventilation, temperature and dew-point monitoring.

The information went on to discuss the problems for the cargo caused by either excessive or too little ventilation, and the effects of passing through zones of ambient temperature below, or above, that of the cargo. Examples used were generic in nature, discussing the problem of 'ship sweat' (condensation on ship's sides and hatches) for bagged rice loaded in a tropical climate, and 'cargo sweat' (condensation on the cargo) for steel coils loaded in a cold climate. No information was provided to the ship specifically on the carriage of cocoa beans, nor on the subject of the possibility of self-heating of the cargo due to the growth of fungi as a consequence of warm, moist conditions.

Information on fumigation and the use of phosphine as a fumigant was provided to the ship by the Pan Asia Superintendence Corporation at Makassar. The five-page document described in detail phosphine and its detection, the process of fumigation, the requirements for ventilation, the toxic effect that phosphine has on the human body, precautions to be taken and medical treatment should poisoning occur. The company also provided the gas masks and gas detection equipment (Dräeger tubes) to be used by the ship's officers during the voyage. However, nowhere in the information provided was the hazard of flammability of phosphine mentioned.

Further information on the carriage of fumigated cargo is contained in the IMO's 'Recommendations on the safe use of pesticides in ships'. This document, however, was not carried on board *Marion Green*.

The fire

The quantity of wooden dunnage used in the holds was 42 m^2, the number of bamboo mats was 800, and the quantity of Kraft paper used was 2 200 kgs. The total amounted to a significant quantity of dry, combustible fuel for a fire in the hold, quite apart from the burlap bags and the cargo itself with its relatively high fat content. There is no question as to the fuel load available for the fire, as these materials were observed to be burning on each occasion that the hold was opened. By the time the cargo had been discharged from No. 2 hold, the smouldering fire had spread throughout the bags of beans with frequent flare-ups of the timber, paper and burlap.

The issue facing the investigation was the source, or origin, of the fire.

During the course of the investigation, four possible sources were identified:

- Self heating of the cargo, promoted by fungal growth
- Phosphine used for fumigation
- Cigarette ends found amongst the discharged cargo
- A cargo light

In each case, the fire would have started at the time of, or shortly after, the loading of the cargo in Makassar. In Fremantle, the mate noticed that the humidity in the hold was very high. This would indicate that heat was being generated in the lower part of the hold, driving moisture from the cocoa beans. However, no sign of smoke or flame was evident at that time. It was only after air had been admitted, through hold ventilation and opening the hatch covers in Fremantle, that the fire gained a hold.

Observations when the hold was first opened in Albany indicated that the source of the fire was in the lower tiers of cargo near the starboard aft

corner of the hold. The way that the fire had burned slowly up towards the top layers of cargo, and then also spread along the bottom of the hold to the forward end would be consistent with smouldering, or slow combustion, having taken place during the five day passage between Makassar and Fremantle. It continued in this manner, albeit accelerated, after the vessel arrived at Albany.

Self-heating or spontaneous combustion

Cocoa beans are not generally regarded as an hazardous cargo and are not mentioned as such in the IMDG Code. However, under suitable ambient conditions (temperature > 25°C, high relative humidity and lack of oxygen) and due to their elevated fat content which, in conjunction with moisture, results in hydrolytic/enzymatic fat cleavage, cocoa beans have a tendency for postfermentation and self-heating. Some species of fungus, such as Aspergillus Fumigatus, participate in the self-heating process. Spontaneous combustion of broken raw cocoa beans in bulk usually takes the form of smouldering cavities or channels, such a fire developing in four distinct phases:[6]

- first phase: a general biological phase in which mesophilic micro-organisms multiply in a wet spot, raising the temperature to 37°C.
- second phase: this involves the highest level of activity from thermophilic micro-organisms at temperatures of up to approximately 70°C.
- third phase: the thermophilic decomposition phase which is characterised by exothermic chemical breakdown reactions, in particular by oxidation reactions between unsaturated fatty acids and atmospheric oxygen (the cocoa beans having a fat content of >50 per cent).
- fourth phase: the pyrophoric gas phase, in which pyrophoric carbon and gasses (eg phosphine) are formed. The resultant abrupt increase in temperature gives rise to the smouldering cavities and channels within the bulk cargo.

Observation of the progress of the fire during the period 29 July to 1 August showed clearly that the fire had spread from the starboard after corner of No. 2 hold through such channels, with cavities appearing at the top of the cargo in various places. This, however, does not in itself provide sufficient evidence that this was the source of ignition for the fire as the fire could have spread in this manner, whatever the source of ignition.

Samples of the cargo were taken from both No. 1 hold (undamaged cargo) and from the damaged cargo in No. 2 hold. The samples were submitted to the Eastern Creek Plant Quarantine Laboratory of the Australian Quarantine & Inspection Service (AQIS) near Sydney, NSW. There, the seeds were examined by a quarantine plant pathologist and placed in a humid environment in petri dishes for the culture of any fungi that may have been present.

The results of the tests showed no Aspergillus contamination could be isolated from the undamaged sample of cargo from No. 1 hold. However, the tests revealed that a mould, Aspergillus Niger, which is closely related to Aspergillus Fumigatus, was present in the sample of cargo from No. 2 hold. The tests were repeated and, again, the same results were obtained. Aspergillus Niger was present in the cargo in No. 2 hold and, in the opinion of the AQIS pathologist, this could have had the same heating effect.

If the condition of the cocoa beans in the hold was conducive to mould development, then a number of different fungi, including Aspergillus Niger, could take advantage of the favourable growing conditions of warmth and high humidity to proliferate through the stored beans. Once the mould activity is encouraged to

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6 Transport Information Service, German Insurance Association, Berlin.

develop and spread, so too will there be an increase in the heat generated by the fungal growth.

The conditions necessary to promote fungal growth are warmth and moisture.

If the moulds find favourable living conditions, i.e. when the critical water content of 8.5 per cent is exceeded at an equilibrium moisture content of approximately 88 per cent, the moulds rapidly develop within 3 - 4 days, at the end of which period thousands of spores have formed on the surface of the cocoa beans[7]. During this process, considerable heat may be generated.

The cargo aboard *Marion Green* was loaded in tropical weather conditions where the ambient air temperature was consistently above 30°C with high relative humidity. In addition, during the loading of the cargo the sachets of water in the liferafts were replaced with fresh ones. Those removed from the rafts were taken for refreshment by the stevedores working in the holds. During the discharge of the burned cargo at Albany, several of these sachets, having been discarded in the hold, were found amongst the remains of the burned cargo. Some were empty, but some still contained water. Such sachets, discarded during the cargo loading in Makassar may well have wetted small areas of some of the bags of beans and thus provided ideal levels of moisture for the fungi to flourish.

During the later discharge of the, mostly undamaged, cargo from No. 1 hold it was found that 14 bags of beans had localised areas of wet staining.

When the mate first entered No. 2 hold after the vessel's arrival in Fremantle, he noticed that No. 2 hold was 'soaking wet', with moisture dripping from hatch covers and running down bulkheads. No. 1 hold was not so wet. This would indicate that an area, or areas, of the cargo in No. 2 hold were already hot, and driving off moisture, before the vessel arrived and the hatches were opened. During the passage from Makassar to Fremantle the hold ventilation had been off, to maintain the integrity of the fumigation. In Fremantle, restoring the ventilation and opening the hatches would have allowed the ingress of air which, in turn, would have allowed the fire to develop and become evident after sailing on the morning of 28 July.

Although it cannot be confirmed with any degree of certainty, there is sufficient evidence to indicate that moisture, warmth and subsequent mould growth leading to self-heating and combustion should be considered as one possible source of the cargo fire in No. 2 hold.

Phosphine as a possible source of ignition

Phosphine is a highly flammable gas which can auto-ignite at ambient temperatures. At concentrations greater than 1.8 per cent, it forms explosive mixtures with air.[8] To reduce the risk that this poses, all commercial formulations available contain ammonium carbamate which releases ammonia gas and carbon dioxide to reduce the potential fire hazard posed by phosphine. The ammonia in the formulation also serves as a warning agent, giving out a garlic-like odour. Nevertheless, great care has to be taken in how aluminium phosphide is applied due to its inherent problem of flammability. The ammonium carbamate reduces the potential danger, but it does not eliminate it.

In February 2003, the UK P&I Club published a Bulletin (No. 289), reproduced in Seaways, the journal of the Nautical Institute, drawing the attention of the maritime industry to the danger of phosphine explosions. The bulletin noted that a number of such explosions were known to have occurred. It also noted that the process of aluminium phosphide reacting with moisture in the air sometimes produces small quantities of a

7 IBID.

8 IPCS Inchem – Chemical Safety Information from Intergovernmental Organisations.

gas known as diphosphine, which, unlike phosphine, is spontaneously flammable reacting instantly with oxygen in the air. This is likely to occur when there is an imbalance between the aluminium and phosphorus, with an excess of the latter. Such a situation may arise during production of the tablets if an excess of phosphorus is inadvertently used during the preparation.

In describing a recent incident, the bulletin then goes on to state:

> Although not definitively proven, we have been advised that it is likely that potentially explosive mixtures of air and phosphine are frequently encountered during the first 12 to 24 hours of phosphine fumigation when the phosphine concentration in the upper section of the hold reaches a peak concentration. The resulting high concentration of phosphine then disperses by diffusion, with the gas diffusing into the less accessible lower sections of the cargo. In this recent case, the explosion occurred some 12 hours or more after the fumigation had been started and the hatch covers had been closed. Although no source of ignition was identified conclusively, it is suspected that defective aluminium phosphide tablets, containing localised excesses of phosphorus, were the cause. Such tablets could be envisaged as producing localised high concentrations of diphosphine leading to a very rapid reaction with oxygen and to ignition.
>
> Aluminium phosphide tablets are routinely used in fumigation and a very large number of shipments are fumigated annually without any problems. Incidences of explosions are therefore very rare and, as far as we have been advised, fumigant explosions have only been encountered when companies have used cheaper brands of aluminium phosphide tablets produced in developing countries.

The origin and chemical composition of the aluminium phosphide used to fumigate the cocoa bean cargo aboard *Marion Green* is not known, however it cannot be eliminated as having been a factor in the fire. This is particularly so if sachets had fallen into confined spots in the lower tiers of cargo, where there was potential for the gas concentration to have risen to extreme levels.

Cigarettes

'NO SMOKING' signs are prominently displayed, painted in large letters, around the hatches of *Marion Green*. Nevertheless, during

FIGURE 12:
Cigarette ends discarded around No. 1 hold access

the loading of the bagged cocoa beans at Makassar, the deck officers on cargo watch had need, on several occasions, to reprimand certain members of the loading gangs for smoking around the hatches and hold access spaces.

During the investigation, empty Indonesian cigarette packets and numerous butt-ends of cigarettes were found in the accesses to both holds. In addition, it was later reported by the surveyor appointed by the P&I Club, that similar cigarette packets and cigarette ends had been found amongst the cargo from No. 2 hold after it had been discharged ashore.

A cigarette end or match, discarded in the hold during cargo loading, without being properly extinguished, could well have initiated some smouldering amongst the cargo and associated Kraft paper, dunnage and burlap bags. This smouldering, in the absence of sufficient air, the ventilation being shut off, may have developed into a significant slow combustion fire over the next few days, developing more rapidly once the ventilation had been restored and the hatch covers opened while the vessel was in Fremantle.

Smoking materials, discarded in No. 2 hold during the loading of the cargo in Makassar must be regarded as another possible cause of the fire.

The cargo light

When the after panels of the hatch covers were first opened up on 31 July, it could be seen that an electrical cable was hanging from the upper access at the starboard after corner of No. 2 hold, down into the cargo of bagged beans. This was close to the area where the fire had been first observed and to where it is believed to have originated. See fig. 13.

In each hold access space there were a number of halogen cargo lights, stowed with their cables, and the sockets into which these lights would be plugged during cargo operations. All the plugs in the starboard aft access had been removed from their sockets, this being in compliance with the ship's routine on completion of loading.

The cable hanging into the hold was the same type as that attached to the cargo lights and the plug on the end had also been removed from its socket. However, the other end, in the hold, was found to have been burned away. Evidence given to the investigation indicated that it had also been attached to a cargo light which, in Makassar, was hanging on one of the timber dunnage frames against the aft bulkhead adjacent to the hold access. This cargo light, however, could not be located during the investigation, neither was it found amongst the cargo either in the hold, or once discharged to the wharf.

The whereabouts of this cargo light, or the reason for its cable having been left in No. 2 hold after the loading of the cargo, could not be ascertained. Neither could the point in time be determined when its plug had been removed from the power socket.

These 1500-watt cargo lights generate considerable heat. If this light had been left, switched on, in the hold at the completion of loading and had come into contact with either the bagged beans, the Kraft paper or other combustible material, it may well have provided a source of ignition.

Although possible, however, it would seem unlikely that the holds would have been closed up with the light still switched on and without it being noticed. More likely is that it was unplugged at the time that the other lights were unplugged, but the fact that the cable still led into the hold, instead of being coiled up in the access space, went unnoticed.

The ship's staff response to the fire

The fire was first discovered at about 1130 on the morning of 28 July with a fire alarm being activated on the Autronica detection system, at the same time as smoke was seen issuing from the No. 2 hold vents. The initial response by the

FIGURE 13:
Electric cable for cargo light hanging into no.2 hold from hold access

FIGURE 14:
Burned end of cargo light cable in no.2 hold

ship's staff was correct in that all ventilation was stopped and all openings were sealed off. After a brief inspection by the mate and second mate through the opened hold access and playing a hose on the flames, the decision was taken to flood with CO_2 and the first of 25 bottles was discharged at 1150.

According to the instructions on CO_2 release, issued to the vessel by the manufacturers of the fixed firefighting installation, the number of CO_2 bottles required for flooding No. 2 hold was 77 if the hold was full, and 116 if it was half full.

No. 2 hold contained 3 048 tonnes of cocoa beans with a stowage factor of approximately 1.95 m^3 per tonne. Hence the volume of cocoa bean cargo was approximately 5 950 m^3. It also contained the two machinery modules in the forward part of the hold. Allowing an approximate volume for these two crates as 220 m^3 and taking the volume occupied by the steel pontoons, from the specifications, as 833 m^3, the total volume of cargo and pontoons in the hold was roughly 7 003 m^3. The total volume of No. 2 hold is 12 282 m^3 hence, by volume, the hold was approximately 57 per cent full.

With this volume of cargo loaded in No. 2, by simple proportion, it would have been necessary to release, as a minimum, 110 bottles of CO_2 in order to raise the concentration of gas to between 30 and 40 per cent; the level necessary to smoother the fire.

After discharging the first 25 bottles, releasing the gas was suspended for a while due to leaks on several pipe connections in the CO_2 room. At 1210, a forward ventilation flap on No. 2 hold was opened to check on the effect of the CO_2 flooding, by analysing the oxygen content of the issuing air. However, as insufficient gas had been released for even a full hold, and as CO_2 is heavier than air, it is unlikely that any significant effect on the oxygen level would have been recorded at the ventilation flap on the main deck. A large proportion of the gas would have been discharged into the virtually empty

part of the hold, forward of the pontoon bulkhead, and descended to the bottom of the hold. In doing so, it would slowly displace the air upwards towards the top of the hold.

A little more than half an hour later, at 1245, the hold access hatch was opened for an inspection. Acknowledging that the action to be taken is always a matter of judgment for the master or officer in charge, in the opinion of the Inspector, this was too short a period to allow before any hold penetrations should be opened, for whatever reason.

It was not until 1715 that afternoon that 86 bottles of CO_2 had been discharged, with the remaining 11 bottles not being discharged until the following day. It is unlikely that, at any time, there was sufficient CO_2 within the hold to effectively stifle the fire which, indeed, was still active after the vessel arrived at Albany.

A safety bulletin published by the UK P&I Club on 13 August 1996 describes at some length the measures to be taken in the case of self-heating, or fire, in a cargo. The bulletin deals specifically with bagged fishmeal cargoes, but the principles involved apply to combustion in any bagged, organic cargo. The bulletin emphasises the importance of sealing, and keeping sealed, the affected hold. It states:

> It is basically undesirable to inject less CO_2 than is recommended in the manual (provided by the manufacturers of the CO_2 system) even though this means that only a few cargo spaces can be so treated.
>
> It should be appreciated that any cargo heating results from an oxidation process. This means that the oxygen concentration in a hold is depleted and the concentration of nitrogen, an inert gas, increases. Hence in a sealed hold, cargo heating tends to be self-quenching. It is therefore of paramount importance that the Master has all necessary materials on board to allow very efficient sealing of cargo spaces in order to minimise atmospheric interchange. Very efficient sealing may be a time-consuming operation but should never be skimped. Technically, provided that hold sealing is adequate, it would be possible for a ship with cargo heating in all her holds, to sail safely across the Pacific Ocean with her CO_2 supply exhausted (assuming a sufficient reserve for the engine room). However, such action would only be recommended if sealing efficiency could be guaranteed. Under normal circumstances where there is obvious progressive heating a ship would be recommended to a port of refuge to obtain adequate CO_2 supplies. This often involves fitting a bulk tank containing several tonnes of CO_2. If considered necessary, further sealing should be performed whilst the ship remains in port.

There is often a tendency for personnel trained in firefighting to exercise an ingrained urge to get to grips with the seat of a fire with the least possible delay. In a well-respected reference book on fighting ship fires, 'Fire Aboard', the author states that there is '…much to be said for playing the waiting game'.[9] He goes on to say:

> If 95 per cent of a cargo can be saved by a certain line of attack and one which involves also minimal risk of structural damage to the vessel itself, what matters it that final extinction of the fire may take 48 hours or so? …..He would urge, rather that, wherever a fixed extinguishing system is fitted in an endangered hold, it be actuated at once and the hold in question be kept tightly battened down until temperature, smoke and other tests indicate that the fire has been beaten down or suppressed.

The port authority response

The 'waiting game' was indeed played when *Marion Green* arrived alongside in Albany on 29 July, although there was considerable surprise and consternation on the part of the ship's master and officers that the local fire brigade was not in attendance on the wharf when the vessel berthed. The brigade, having not been advised of the ship's correct arrival time by the agent, arrived to assess the situation approximately 45 minutes later. Shortly after the vessel's arrival, a meeting was held between the master, the harbourmaster, a representative from

9 'Fire Aboard' by Frank Rushbrook CBE, 3rd Edition 1998, Brown, Son & Ferguson Ltd. Glasgow.

Customs and the ship's agent. The master's initial consternation was compounded by the impression which he gained that the meeting was focussed far more on administrative procedures and paperwork than on the measures which should be taken to deal with the fire.

Albany is a small port and the unit of the Fire and Emergency Service of Western Australia, based in the town, is also numerically small and has little experience of ship fires and, indeed, little familiarity with ships. From the time of *Marion Green*'s arrival it was evident that there was a lack of co-ordination in the response to the incident. The master expected the fire brigade to take charge of the firefighting, while the fire brigade expected the master to tell them what measures he wanted taken. The fire brigade suggested that the hold should be filled with high-expansion foam but this was vetoed by the P&I Club surveyor who was concerned about further damage to the high-value cargo.

The vessel's owners in the Netherlands consulted with the Rotterdam port fire brigade to obtain advice on how to deal with a fire in a cargo of cocoa beans. It appeared, however, that there had been little experience in fighting such fires and the advice forwarded to the master was to flood the hold with more CO_2, to inspect the hold later, then flood with more CO_2, until the fire had been overcome.

On the morning of 30 July, the P&I Club surveyor requested that No. 2 hold be opened up but this request was refused by the harbour-master who, correctly, required a further 24 hours monitoring of the situation and who wanted to wait for the bulk CO_2 to arrive.

On the following morning, 31 July, the hold temperature appeared to be rising in spite of the earlier use of the bulk CO_2. There had been, however, some confusion as to whether the bulk CO_2 was actually getting into the hold, since there was uncertainty regarding the correct alignment of various valves on the tank and the accuracy of the contents gauge.

At 1400 that afternoon, a meeting of involved parties was convened by the harbourmaster, to determine the future course of action. No decision had been taken at that stage as to what could be done with the damaged cargo.

The meeting revealed several conflicting interests. The master and the vessel's owners wanted the fire extinguished as soon as possible and the cargo discharged. The Australian Quarantine and Inspection Service (AQIS) did not want the cargo, which was not destined for Australia, to be landed in Australia. This reluctance was shared by the harbourmaster, who did not want 3,000 tonnes of burned, soaked, cocoa beans landed on the wharf. The harbourmaster also wanted *Marion Green* off the berth to enable the waiting tanker, carrying fuel for the Albany area, to berth and, in addition, there were concerns from the Environmental Protection Agency about any possible environmental impact which might result from the incident.

Eventually, however, it was agreed that there was no option but to discharge the cargo.

Albany Port Authority emergency procedures

The Albany Port Authority is a corporate body constituted under the Port Authorities Act 1999 and is responsible to the Minister for Planning & Infrastructure. Under the Act, the Port Authority is required to have in place a comprehensive Marine Safety Plan which is to include an Emergency Response Plan. At the time that the incident involving *Marion Green* occurred this plan was in draft state and had not been signed off by the Minister. (However such an Emergency Response Plan was in place prior to the publication of this report.)

Albany Port Authority did have in place, at the time of the incident, emergency procedures for fire, serious injury, collapse, chemical spillage, explosion or bomb threat. The procedures, however, contained very little and were essentially directed at the wharf labour force. The only procedures relating to fire instructed Supervisors to clear the area of labour and order them to the amenities block, to call the fire

brigade, to advise the harbourmaster, to hold a roll call and liaise with the ship's master.

It is the policy of the Albany Port Authority:

> …to achieve Best Practice in the management of all risks that threaten to adversely impact the Authority, its customers, people, assets, functions, objectives, operations or members of the public. Risk Management will form part of operational and line management responsibilities and be integrated into the Business Planning Process[10].

It is to the credit of the Albany harbourmaster that he did accept *Marion Green* into the port as a port of refuge. The issue of ports of refuge, following the *Erika* and *Prestige* disasters in Europe, is one which is the cause of much concern and contention both among countries of the European Union and at the International Maritime Organisation.

In terms of safety, the operation was a success, the fire was extinguished without injury or loss of life and the ship was able to resume its voyage, undamaged, and with the cargo in No. 1 hold intact.

Authority in fighting ship fires in port

The question of who has ultimate authority (and responsibility) in the case of a fire aboard ship in port, the master, the harbourmaster or the senior fire brigade officer on the scene, is not a simple one. It is a question which has arisen a number of times in the past, (eg ATSB Report No. 142, Fire aboard the Australian flag tanker *Tasman*), and is one about which there is great uncertainty in the minds of many on those involved.

In 1999, the Inspector of Marine Accidents canvassed the senior officers of the fire and emergency services of all the Australian states and the Northern Territory on their understanding of the answer to this question. The responses varied enormously, some stating that the fire brigade had complete authority and others that the master retained complete authority.

The response from Western Australia indicated that, in the opinion of the Fire and Emergency Services Authority of Western Australia, the master or chief engineer of the vessel remains responsible for the vessel at all times. The response added, however, that in regard to the legal aspects, the Authority believed that ports are beyond the Fire District and remain under the control of the harbourmaster.

Consideration of this issue revealed a number of anomalies between the various laws of the different states and Commonwealth law. Several states have laws clearly detailing the authority of the fire brigade, whereas the authority of the master, although traditional, is less clearly defined in terms of legislation. However, sections 6 and 278 of the Navigation Act 1912 imply that ultimate responsibility does rest with the master.

To further pursue these complex legal anomalies is beyond the scope of this investigation. In the opinion of the Inspector, however, what is clear is that, whatever anomalies exist, where a trained fire brigade is involved in fighting a ship fire, the fire brigade should be regarded as the authority on firefighting procedure, yet working in close co-operation with the ship's staff and harbourmaster.

In the Port of Albany's Emergency Response Plan, promulgated since this incident but before the publication of this report, the roles of the harbourmaster, the ship's master and the emergency services in such incidents have been more clearly defined.

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10 Albany Port Authority, Internet www.albanyport.com.au/risk_management_policy

Conclusions

These conclusions identify the different factors which may have contributed to the cargo hold fire aboard *Marion Green* and should not be read as apportioning blame or liability to any particular individual or organisation.

1. It was not possible to positively identify the source of the fire in No. 2 hold, although four possibilities existed. These were:

   a) Self-heating of the cargo of cocoa beans promoted by the growth of a fungus, Aspergillus Niger. This may have been initiated at a damp patch caused by spillage of the liferaft water, taken by the loading gangs working in the holds, and exacerbated by poor ventilation in an area where the ventilation channels did not allow sufficient air flow.

   b) Combustion initiated by the decomposition of aluminium phosphide into phosphine gas used for fumigation. Combustion is known to have occurred in other instances, particularly when there is an imbalance in the phosphorus content during preparation of the chemical.

   c) Smoking materials discarded in the hold during loading of the cargo. There is considerable evidence of this in the form of empty cigarette packets, cigarette ends and matches found in the hold access spaces and amongst the cargo once it had been discharged onto the wharf at Albany.

   d) A cargo light left in the hold after the completion of cargo loading.

2. The discovery of discarded smoking materials in the discharged cargo indicates that the vessel's 'no smoking' policy around the holds was not sufficiently policed by the deck watch.

3. With the volume of cargo in No. 2 hold, and the number of CO_2 bottles discharged before the vessel arrived at Albany, it is unlikely that the concentration of gas in the hold was at any time sufficient to stifle the fire. The number of bottles released was less than indicated in the instructions provided by the manufacturer of the CO_2 system.

4. Information provided to the ship's staff on the shipping and stowage of cocoa beans, their fumigation and the associated hazards was inadequate.

5. The response to the fire, once the vessel had berthed in Albany, was lacking in co-ordination and there was no clear understanding of who had the authority and responsibility for actions to be taken in dealing with the fire.

Recommendations

MR20030037
That Beluga Genchart BV take measures to ensure that a strict ‘no smoking’ policy in the vicinity of cargo operations is enforced on board their vessels.

MR20030038
That Beluga Genchart BV ensure that ship’s masters are provided with all relevant information regarding the stowage of cocoa beans, their fumigation and any associated hazards. As a minimum, the IMO’s ‘Recommendations on the safe use of pesticides in ships’ should be available on board any ship loading a fumigated cargo.

MR20030039
That shippers, stevedores and ship’s officers should all ensure that, when bagged cocoa bean or other organic cargoes are being loaded, adequate ventilation channels are provided and that cargo is stacked with sufficient ‘cross ties’ to ensure that the channels remain clear during the voyage.

MR20030040
That Beluga Genchart BV take measures to ensure that, on completion of loading cargoes, the deck watchkeeping officer makes an entry in the deck logbook confirming that all electrical equipment in the holds has been isolated and stowed as applicable.

Submissions

Under sub-regulation 16(3) of the Navigation (Marine Casualty) Regulations, if a report, or part of a report, relates to a person's affairs to a material extent, the Inspector must, if it is reasonable to do so, give that person a copy of the report or the relevant part of the report. Sub-regulation 16(4) provides that such a person may provide written comments or information relating to the report.

The final draft of the report was sent to the following:

The Master, *Marion Green*

The Mate, *Marion Green*

Beluga Genchart BV

The Harbourmaster, Albany Port Authority

The Area Manager, Fire Services of WA

Australian Maritime Safety Authority

Submissions were received from Beluga Genchart BV and from the Harbourmaster, Albany Port Authority. The text of the report has been amended where appropriate.

Marion Green

IMO Number	9164029
Flag	Netherlands
Classification Society	Lloyd’s Register
Ship Type	Multi-purpose general cargo
Builder	Schelde Scheepsnieuwbouw B.V. - Vlissingen
Year Built	1999
Owner	C.V. *Marion Green*
Ship Manager	Beluga Genchart B.V., Rotterdam
Gross Tonnage	11 894
Net Tonnage	5 920
Summer deadweight	17 050 tonnes
Summer draught	9.689 m
Length overall	142.81 m
Breadth	21.5 m
Moulded depth	13.3 m
Engine	8 cylinder Wärtsilä 8L46B four-stroke diesel
Power	7 800 kW
Crew	13 – mostly Dutch & Filipino nationals

Independent investigation into the fire in the hold of the Netherlands flag general cargo vessel *Marion Green* off the coast of Western Australia, on 28 July 2002

ISSN 1447-087X
ISBN 1 877071 42 0

Marion Green. 11.03