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ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Marine occurrence investigation No. 250
Final

Cargo fire on board the bulk carrier *Jin Hui*

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ABSTRACT

At 1230[1] on 9 February 2008, the Chinese registered bulk carrier *Jin Hui* berthed in Geelong, Australia. The ship's master had previously informed Australian authorities that there had been a fire in the ship's number three cargo hold. As a result, the emergency services were on standby when the ship arrived in Geelong.

When the number three cargo hold was opened, it was apparent that only two small areas of the cargo (palm kernel expeller) had been affected. These small areas of cargo were still smouldering so they were sprayed with water and then discharged onto the wharf.

At 1530, the local fire authority declared the fire extinguished. The ship's normal cargo discharge was then allowed to begin.

FACTUAL INFORMATION

Jin Hui

Jin Hui (Figure 1) was built in 1994 at Xingang Shipyard, China. The ship has an overall length of 143.5 m, a moulded breadth of 22.0 m, a moulded depth of 12.2 m and a deadweight of 15 619 tonnes at its summer draught of 8.52 m.

The ship is a conventional 'handy-sized' geared bulk carrier. It has four cargo holds, each fitted with a fixed carbon dioxide fire extinguishing system, and three cargo cranes, all located forward of the accommodation superstructure.

At the time of the incident, *Jin Hui* was registered in China and classed with the China Classification Society. The ship was owned and managed by the China Shipping Development Company.

Figure 1: ***Jin Hui***

1 All times referred to in this report are in local time.

The ship's propulsive power is provided by a single MAN B&W 6L42MC single acting, direct reversing, two-stroke diesel engine. The engine develops 4413 kW at 150 rpm and drives a fixed pitch propeller. The ship has a service speed of about 12 knots[2].

At the time of the incident, *Jin Hui* had a crew of 28 Chinese nationals. The master had 15 years of seagoing experience. He had spent most of that time on bulk carriers and had previous experience carrying palm kernel expeller. He held a master's certificate of competency that was issued in China in 2005. He had been sailing as master for about two years and had previously sailed on board *Jin Hui*. On this occasion, he had been on board the ship for about ten months.

Palm kernel expeller

Palm kernel expeller (PKE) is a by-product of the crushing and extraction of oil from palm kernel. It is commonly used in compound feeds for livestock because it is high in fibre and has a good balance of residual oil, energy and protein.

Bulk cargoes, including PKE, should be carried on board ships in accordance with the requirements of the Code of Safe Practice for Solid Bulk Cargoes (BC Code). The BC Code defines PKE as a 'Seed Cake'. Depending on its oil and moisture content, PKE can be defined as any one of the three following types of seed cake.

- Seed cake (non–hazardous), which poses a low fire risk and no particular hazards. There are no special precautions required for the carriage of this group of products.
- Seed cake (United Nations Number (UN) 2217), which contains less than 1.5 per cent oil and not more than 11 per cent moisture.
- Seed cake UN 1386, which includes mechanically expelled seeds containing more than 10 per cent oil or more than 20 per cent oil and moisture combined and solvent extracted seeds containing not more than 10 per cent oil and when the amount of moisture is higher than 10 per cent, not more than 20 per cent of oil and moisture combined.

In reference to the particular hazards posed by, and precautions required for, the carriage of seed cake UN 1386 and UN 2217, the BC Code states:

> May self-heat slowly and, if wet or containing an excessive proportion of un-oxidised oil, ignite spontaneously. They are liable to oxidise, causing subsequent reduction of oxygen in the cargo space. Carbon dioxide may also be produced.
>
> Regular temperature readings should be taken at varying depths of the cargo spaces and recorded. If the temperature of the material reaches 55˚C and continues to increase, ventilation to the cargo space should be restricted. If self heating continues, then carbon dioxide or inert gas should be introduced. In the case of solvent-extracted seed cakes, the use of carbon dioxide or inert gas should be withheld until fire is apparent, to avoid the possibility of ignition of solvent vapours by the generation of static electricity.

Both seed cake UN 1386 and UN 2217 are defined in the International Maritime Dangerous Goods (IMDG) Code as Class 4.2[3] dangerous goods

Cargoes such as PKE are routinely fumigated with phosphine gas en route to their destination port to ensure that any insects or animals that may have been loaded on board the ship with the cargo are killed.

The fumigant used on board *Jin Hui*, aluminium phosphide, works by generating phosphine gas when it reacts with the moisture in the cargo hold atmosphere. Phosphine gas kills the insects and animals by depressing their central nervous system and respiratory function.

The incident

On 16 January 2008, while *Jin Hui*'s crew were taking on fuel bunkers in Singapore, the master received notification from the ship's charterer that at completion of bunkers, the ship would be proceeding to Padang, Indonesia, to load 13 000 tonnes of PKE. The master checked the requirements in the BC Code for the carriage of PKE and noted the precautions regarding the possible self-heating of the cargo. He also

2 One knot, or one nautical mile per hour equals 1.852 kilometres per hour.

3 Goods liable to spontaneous combustion.

determined that the cargo could be carried on board *Jin Hui* because the ship's cargo holds were fitted with a fixed fire extinguishing system.

On 19 January, while the ship was en route to Padang, the master received, via email, the declaration documentation for the PKE cargo. The documentation included an analysis report which stated that the PKE had a moisture content of 7.93 per cent and an oil content of 8.89 per cent. Once again, the master checked the BC Code. He determined that the cargo was non-hazardous seed cake and therefore could be carried on board the ship.

At 1430 on 20 January, *Jin Hui* berthed in Padang and, at 1745, cargo loading began. The cargo operations continued over the next few days. The only delays were as a result of a couple of rain showers, during which the ship's cargo hold hatch covers were closed.

On 23 January, the shipper supplied the master with a Material Safety Data Sheet (MSDS) for the PKE and provided him with written notification that the cargo was 'non-hazardous seed cake'.

At 0900 on 24 January, cargo loading was completed. According to the draught survey, 12 335 tonnes of PKE had been loaded into the ship's four cargo holds.

Figure 2: Fumigant buried in the cargo with only the top part of the sock exposed.

Before the cargo hold hatch covers were closed, a fumigation contractor added fumigant to each cargo hold at a rate of two grams of phosphine per cubic metre of cargo. The plan was to place socks containing aluminium phosphide tablets on the surface of each cargo hold. However, it was raining so the socks were buried in the cargo in an attempt to protect the fumigant from the rain (Figure 2). The cargo hold hatch covers and ventilators were then closed. The ventilators were also wrapped in plastic and taped to ensure that the fumigant did not escape.

At 1200 on 24 January, *Jin Hui* departed Padang, bound for Geelong, Australia.

At about 1415 on 25 January, the crew observed black smoke coming from number three cargo hold, between the hatch coaming and the hatch cover.

The master was informed and he instructed the crew to seal number three cargo hold hatch covers with duct tape. He also reported the suspected cargo fire to the ship's manager and charterer.

The ship's manager and the master discussed contingency plans that included diverting the ship to Jakarta, Indonesia. The manager also contracted the services of a forensic fire consultant (consultant) to provide advice to the master.

The consultant told the master to record the cargo temperatures at varying depths in each cargo hold and to measure the concentration of carbon monoxide and oxygen in each hold. He also told the master to continue to record these details hourly and to forward them to himself, the ship's manager and the charterer.

The crew measured the cargo surface temperature and gas concentrations in each hold through the hatch cover inspection ports. They then measured the temperatures in the cargo holds via the cargo hold sounding pipes. The temperatures at the bottom of each cargo hold along with those at depths of 3.5 m and 7.5 m were recorded. The maximum cargo temperature measured at this point in time was 44˚C at a depth of 7.5 m in number three cargo hold.

The crew continued to measure the gas concentrations and cargo temperatures over the next 24 hours. As the temperatures were not increasing significantly, the consultant advised the master that it was safe for the ship to continue its voyage to Geelong. He also advised the master to continue monitoring the cargo at six hourly intervals.

During the voyage, the crew continued to monitor the cargo temperatures and gas readings. The master also continued to forward the details to

the ship manager, the charterer and the consultant.

On 5 February, the master notified the ship's Geelong agent that he suspected there had been a fire in the ship's number three cargo hold. The agent forwarded this information to the Australian Maritime Safety Authority (AMSA) and the Geelong Port Authority. The master later provided information to AMSA relating to the cargo, the fire and the shipboard response to the incident.

On 7 and 8 February, meetings were held in the Geelong Port Authority's offices to prepare for the ship's arrival on 9 February. The attendees included the ship's agent, the consultant and representatives from the port authority, the stevedores, AMSA, the Victorian Country Fire Authority (CFA), Port Phillip Sea Pilots, *Jin Hui*'s charterer and the owner of the cargo.

At 0600 on 9 February, a Port Phillip pilot, the consultant and two CFA fire fighters boarded *Jin Hui* for the passage from sea to Geelong. The pilot met with the master and discussed the pilotage plan while the consultant and the fire fighters went with the chief mate to check the cargo temperatures and cargo hold gas readings.

The pilot took the conduct of the ship and *Jin Hui* entered Port Phillip, passing Point Lonsdale lighthouse at 0635.

The consultant's measurements confirmed that the information the master had been forwarding was correct and that there appeared to be no change in the situation. The maximum measured temperature was 54˚C and the oxygen content in the cargo hold atmosphere was 13 per cent. This information was forwarded to the CFA control centre that had been set up at Lascelles Wharf, Geelong.

The CFA established an exclusion zone on the wharf in preparation for *Jin Hui*'s arrival and, by 1230, the ship was all fast alongside number three berth.

The CFA fire fighters boarded the ship and, in consultation with the master and the consultant, rigged fires hoses in preparation for opening the number three cargo hold hatch covers.

At about 1400, the hatch covers were opened and after a small amount of white smoke cleared the seat of the fire could be clearly identified. Only two small areas of the cargo's surface, each less than two metres in diameter, were smouldering (Figure 3).

Figure 3: The fire affected areas of cargo

A small amount of water was sprayed onto each of the smouldering areas of cargo and the hold was thoroughly inspected to make sure there were no other hot spots.

At about 1500, the two areas of smouldering cargo were removed from the hold with a grab and placed on the wharf. The cargo was then spread out and hosed down to ensure that the smouldering material was extinguished (Figure 4).

Figure 4: The cargo on the wharf being hosed

The consultant continued to check the temperature of the PKE in each cargo hold and, while it was warm (maximum temperature of 54˚C), he determined that it was safe to discharge the cargo.

At 1530, the fire was declared extinguished. The CFA's equipment was then removed from the wharf and discharge of the remaining cargo began.

ANALYSIS

The fire

Both fire affected areas had burnt in a circular pattern that was centred on the location of a fumigation sock (Figure 5). However, the fires had not grown in size over the ensuing days because as they developed they had consumed the available oxygen in the cargo hold. It is likely that the amount of oxygen in the cargo hold atmosphere fell to a level that would not support flame (below 15 per cent) fairly quickly. The fires then slowly smouldered until the cargo hold hatch covers were opened and they were extinguished with water.

Figure 5: Circular pattern of burnt cargo

Figure 6: Burnt fumigant sock

Only two areas of cargo showed any sign of fire. However, when the fumigation socks were removed from each of the other cargo holds, it appeared that many of them had been burnt (Figure 6).

Ignition source

The fumigant tablets (aluminium phosphide) react with moisture in the atmosphere to release phosphine gas. Heat and diphosphine gas are also generated as a result of the reaction. As the temperature and humidity in the atmosphere increases, the rate at which the gases are released also increases with the reaction producing further heat.

Localised high concentrations of phosphine and diphosphine gases are likely if the reaction occurs too quickly, if too much fumigant is placed in the packaging or if the packaging does not allow the gases to escape quickly enough.

Furthermore, there will be a localised increase in temperature if the heat produced as a result of the reaction is slow to dissipate.

Pure phosphine gas has an auto-ignition[4] temperature greater than 100˚C. However, diphosphine gas has an auto-ignition temperature of about 90 to 100˚C.

The socks containing the fumigant on board *Jin Hui* were buried in the cargo. The surrounding cargo would have slowed the dissipation of heat from the reacting fumigant tablets. As a result, it is likely that the local temperature rose to a level above the auto-ignition temperature of the diphosphine gas and that the gas subsequently ignited.

Furthermore, it is possible that the local concentrations of the gases built up quickly as a result of the hot and humid conditions inside the cargo hold and that there may have also been too much fumigant placed in each sock.

The fumigation

The contractor who carried out the fumigation of the cargo on board *Jin Hui* provided the master with documentation that named the fumigant, defined the dosage rate, outlined the fumigation plan and the safety precautions to be followed during the voyage and when the cargo holds were to be ventilated.

4 The lowest temperature at which a material will ignite due to heat, without the introduction of a flame.

However, the contractor did not supply the master with information regarding all of the hazards associated with the use of the fumigant, or instructions outlining the correct method for its application.

It is fair for a ship's master to expect that a fumigation contractor is an expert in the field and, therefore, should carry out the task correctly and supply the ship with sufficient information to allow the crew to effectively supervise the process. However, the master and the ship's crew should also heed the contractor's advice.

In this instance, the contractor advised the master that the fumigant should not be placed in the cargo holds while it was raining. He outlined how the moisture from the rain could cause the fumigant to react more quickly, possibly causing it to ignite. However, the master instructed the contractor to carryout the task immediately so that the ship's departure was not delayed. As a result, the contractor buried the fumigant in the cargo in an attempt to protect it from the rain.

While it appears that the contractor considered the risks associated with the fumigant becoming wet, he did not adequately consider the risks associated with burying it in the cargo.

FINDINGS

Contributing Safety Factors

- It was raining when the fumigant was placed in *Jin Hui*'s cargo holds so the contractor buried the socks containing the fumigant in the cargo in an attempt to protect them from the rain.
- The fumigation contractor did not adequately consider the risks associated with burying the aluminium phosphide fumigant in the cargo. *[Safety issue]*
- It is likely that the fumigant socks were insulated by the surrounding cargo, thus preventing the heat that built up as a result of the release of the phosphine and diphosphine from dissipating. As a result, the localised temperature rose to a level above the auto-ignition temperature of diphosphine and it ignited.
- It is possible that the local concentrations of phosphine and diphosphine built up quickly as a result of the hot and humid conditions inside the cargo hold and that there may have also been too much fumigant placed in each sock.
- *Jin Hui*'s master was not supplied with sufficient information to enable the ship's crew to effectively supervise the application of the aluminium phosphide fumigant. *[Safety issue]*
- The fires continued to burn, consuming oxygen from the air inside the cargo hold, until the oxygen content in the cargo hold atmosphere was below 15 per cent, at which time there was insufficient oxygen to support a flame. The fires then continued to slowly smoulder.

SAFETY ACTION

The safety issues identified during this investigation are listed in the findings and safety actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

ATSB safety advisory notices

MS20080019

The fumigation contractor did not adequately consider the risks associated with burying the aluminium phosphide fumigant in the cargo.

The Australian Transport Safety Bureau advises that ship owners, operators, masters and fumigation contractors should consider the safety implications of this safety issue and to take action where it is considered appropriate.

MS20080020

Jin Hui's master was not supplied with sufficient information to enable the ship's crew to effectively supervise the application of the aluminium phosphide fumigant.

The Australian Transport Safety Bureau advises that ship owners, operators, masters and fumigation contractors should consider the safety implications of this safety issue and to take action where it is considered appropriate.

SUBMISSIONS

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Executive Director may provide a draft report, on a confidential basis, to any person whom the Executive Director considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the Executive Director about the draft report.

A draft of this report was provided to the master and the owners of *Jin Hui*, the Australian Maritime Safety Authority, Minton Treharne & Davies, Touton Australia, SGS Australia and Sucofindo.

Submissions were received from the Australian Maritime Safety Authority, Minton Treharne & Davies, Touton Australia, SGS Australia and Sucofindo. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.