M/V Hanjin Pennsylvania: Explosions at Sea

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Final Report

The M/V HANJIN PENNSYLVANIA was built by Hanjin Heavy Industries in Korea as a general cargo container ship. It was completed in February 2002 and christened in Hamburg April of 2002 for its owners Reederei F. Laeisz, a well known German ship company with a long maritime history.

The 930 foot vessel has a TEU capacity of 4,389, a net weight of 27,530 metric tons and a gross weight of 50,242 metric tons. The ship has a total of eight cargo holds with holds one through six in front of the accommodation and holds seven and eight aft of the accommodation. Each hold is watertight and is covered with deck hatches are held in place by a series of large, heavy pins that seal the interior of the hold. Additional containers are carried above each hold on the deck hatches.

The M/V HANJIN PENNSYLVANIA was chartered by Hanjin Shipping and registered in Liberia. It had a crew of 21 and was assigned an Asia - Europe route. On the westward voyage, it called on the ports Xingang, Qingdao, Shanghai and Chiwan in China and then Singapore before heading directly to Hamburg, Rotterdam and Felixstowe in Europe.

In November 2002, the ship was on its 5th voyage west after calling on the scheduled ports in China. On November 8th it departed Singapore heading for Europe via the Suez Canal.

The Explosions

On November 11th the M/V HANJIN PENNSYLVANIA was sailing west in the Indian Ocean about 88 miles south Dondra Head, Sri Lanka when at approximately 6:00 AM local time, two explosions occurred above hold four on the port side. One crewmember died shortly after from heavy burn injuries, and another was missing and later declared dead.

The owners of the vessel reported they did not know the cause of the initial explosions, however they did not believe they were terrorist related. No reports that can be confirmed to date indicate the cause or the materials involved in these initial explosions.

There have been no reliable reports what the two crewmembers that were killed were doing prior to the two explosions, however they were near hold four at the time and may have been attempting to fight the initial fire.

The surviving crew fought the fires with CO_2 and water, but were unable to control the blaze. Containers above the port side of hold four were heavily damaged and/or ejected overboard by the fires and explosions.

Digital pictures reportedly taken by the ship's master are available on the Laeisz Internet site and other sites. These pictures show heavy fires from the containers above hold four. The fires spread and burned violently into the night, with smaller explosions periodically occurring and driving the crew back.

The remaining 19 crewmembers were rescued by the container vessel M/V WEHR ALTONA and the fires on board continued unabated. Other digital pictures show fires above hold four with black and some dark grey smoke plumes typically seen with fires of carbon based fuels. There are no signs of fireworks explosions or the light grey smoke plumes typical of powdered metal fuel fires in these pictures.

Salvage vessels with additional fire fighting equipment arrived on the scene and began to fight the fires on board. Large volumes of water were pumped onto the containers above holds one, two and three where an estimated 60 containers of fireworks were stowed, as well as holds five and six.

The fires burned for the next 3-days with intermittent explosions, spreading the fires to more containers and driving the crews back again and again. At some point during this time, the fires reached the containers above hold six in front of the accommodation and burned uncontrolled, On November 15th a powerful explosion occurred in hold six just in front of the accommodation and bridge. This explosion sent deck hatches and 40-foot containers overboard, destroying the containers in hold six and severely damaged the accommodation, bridge and engine room.

A digital still picture of this explosion taken from another vessel shows a large fire ball perhaps, 2-300 meters above the ship, with a large black plume of smoke and some dark and light grey smoke going up above and out of the picture. There are silver effects rising with the fireball and smoke then falling back to the sea, similar to but not exactly the same as a single, large aerial fireworks shell burst.

The salvage crews eventually managed to contain the remaining fires enough to be able to board the ship and fight the fires. The ship was finally secured well enough by December 13th to be towed back to Singapore. All of the fires were reportedly secured 3 days later, however some cargo and containers continued to smolder.

General average was declared by the owners and surveying operations commenced after the ship arrived in Singapore on January 3rd.

Digital pictures of the M/V HANJIN PENNSYLVANIA after the fires were controlled show her riding low in the water from the large amounts of water poured into her to fight the fires. The pictures show extensive fire and moderate explosion damage to the containers that remain above hold four, some moderate to heavy fire damage to containers above holds three and five, and extensive fire and explosion damage to the few containers that remain above hold six and the accommodation.

The pictures also show the deck hatches for hold six are no longer pinned to the deck. At least two deck hatches are missing and one is twisted and lying at an odd angle in the port side forward container rack. The remnants of some containers that were stowed on the starboard and port side deck hatches forward of the accommodation are hanging over their respective sides and bent back towards the aft.

Pictures of hold six from the accommodation show clear signs of a violent explosion in the hold, missing deck hatches and the twisted metal of the destroyed containers. The pictures of the accommodation and bridge also show signs of a powerful blast and fire. The fires and explosions reportedly reached the engine compartment was also extensively damaged.

The salvors retained a number of experts to assess the damaged ship and to assist in determining the cause; however no independent experts or others have been permitted aboard. This author was able to survey the exterior of the ship from a launch, however no permission to board the vessel was granted so no attempt to board the vessel was made.

The author was able to obtain two sound container lists of the containers that survived the explosions and fires and that had been removed from the ship for survey by the General Average. He also took part in a brief survey of about 40 undamaged containers of general cargo revealed little water damage and no smoke damage to the containers and contents. This survey consisted of the General Average calling out the container number and the interests, a yard worker breaking open the seal and opening the container doors, and the surveyors inspecting the cargo nearest the doors.

Published reports and other sources indicate there were no declared hazardous materials stowed in or above holds four, five or six; however the complete manifest and stowage diagram has yet to be made public. Even with a complete manifest and stowage diagram, this may not provide answers to what commodities or hazardous materials were aboard, especially if any were undeclared or misdeclared.

Potential Causes

Some early reports speculated the explosion may have been caused by containers of UN 1748, CALCIUM HYPOCHLORITE, DRY 5.1 (an oxidizer), however there has been no confirmation there was any declared calcium hypochlorite aboard; or that if there was any declared aboard, that any was stowed above hold four.

Calcium hypochlorite is a pool chemical that has been involved in other explosions while aboard ships in transit. It requires special care when packaged and packed into the container. It is required to be stowed above deck, and out of direct sunlight and away from heat.

There were a few containers of CHEMICALS 5.1 that survived the fires and explosions and were listed on the sound container lists, however the exact type of chemical in these containers or their position on the ship have not yet been made public.

Container vessels routinely transport refrigerated containers with foods and other temperature sensitive commodities. The refrigeration units have diesel engines and fuel to power the compressors and fans when the containers are in transit by crane or truck, as well as electrical power for use when stationary at warehouses and while on board ship.

The M/V HANJIN PENNSYLVANIA carried a large number of refrigerated containers, many declared to be carrying frozen foods. These containers were not on the sound container lists as their contents spoiled quickly in the tropical sun when power was lost as a result of the fires and explosions.

Refrigerated commodities, especially frozen foods, need to be monitored routinely to ensure the required temperatures are maintained. The ship's crew checks the refrigeration containers to ensure they are working properly and log the temperatures at regular intervals.

Refrigeration units on containers need to be in good working order, with proper levels of refrigerant and lubrication. Poorly serviced or maintained compressors can fail in short order, especially when working almost non-stop in the tropical sun. Electrical motors, systems and connections also must be properly maintained and serviced too.

Unfortunately this is a chronic problem in the shipping industry, especially for reefer containers coming from developing countries to developed countries. Refrigeration units are serviced and prepared for the voyage by poorly trained service people who do not have the proper experience or tools. Gray market spare parts and temporary fixes using methods and spare parts that are not rated for the demands also are common.

The result is refrigeration units have problems while at sea and sometimes fail. Temperatures can't be held to keep the commodities at optimum temperature, especially frozen foods when being transported long distance through equatorial temperatures. Crew members have limited abilities and resources to make repairs to refrigeration units while at sea, yet are frequently called on to attempt repairs in order to save the cargo.

Container operations also can damage the electrical cables and connections on the ship and the reefer containers. Damaged cables and connections should result in either no electrical function or circuits being tripped, however if the system has not been serviced or maintained properly or non rated parts used, it is possible that an electrical problem could lead to a fire. Usually a fire like this is localized and can be suppressed with existing fire fighting CO_2 and/or water equipment by the crew.

There was one report attributed to a member of the crew that the initial cause of the fire was an electrical fire near or on one of the refrigerated containers above deck of hold four. The photos taken by the master on the 11th and later show a number of 20-foot and 40-foot refrigerated containers above deck of hold four where the first two explosions occurred.

The Casualty Report from Lloyds indicated on December 4th, almost 3 weeks after the initial explosions that the estimated 60 containers of fireworks "had not caught fully alight". This indicates that at least some containers with fireworks did burn, but little more.

The Lloyds Casualty Report does not specify that any of the explosions, including the initial explosions above hold four on November 11th that killed the two crew members, or the powerful explosion in hold six on the 15th, involved or were caused by fireworks.

One expert who was aboard the M/V HANJIN PENNSYLVANIA and communicated directly with the author stated that according to his review of the manifest, there were no declared fireworks in or above holds four, five, six, seven or eight. He reports that all of the declared fireworks containers were listed on the manifest as 1.4G, and stowed above holds one, two and three. This is also what Hanjin and other shipping officials who had interests told the author.

The author observed whole and damaged containers at one survey that had 1.4G placards, however a review of the pictures available of the M/V HANJIN PENNSYLVANIA that were taken by the master do not show any containers with 1.4G or other hazardous materials placards. The containers with fireworks and other hazardous materials were apparently stowed in interior berths.

The expert opined that the explosion in hold six was the result of a combustible atmosphere inside the watertight hold. He believes the radiant heat from fires in the containers above hold six caused the commodity(s) in a container(s) in hold six to decompose and smolder, creating smoke, heat and pressure. The scenario requires some time for the heat, smoke and pressure to build in the confined space of the hold. It then reaches a point where the suspended fuels in the air flashover, creating a powerful explosion in much the same way as a dust explosion in grain elevator.

He does not know the actual cause of the explosions in hold six or above hold four, and his conclusion assumes the manifest is 100% accurate and there were no undeclared hazardous materials in or on hold six.

He also opined the silver effects seen in a picture of this explosion were due to "magnesium cargo which was loaded in one or more containers inside hold six, according to the cargo-manifest". He does not know or reveal the form of the magnesium, however, it is possible a non-pyrotechnic explosion with magnesium or a magnesium alloy could create this rising and falling silvery effect, especially if the metal had melted.

It is important to note that this digital picture is not a time-lapse photo. Most digital cameras are used to take snapshots and have automatic settings. They can be set manually but given the available daylight and the features of most digital cameras, it appears the lens aperture for this picture was open for less than a quarter of a second.

The author believes this may be significant because videos and still pictures of other explosions involving large quantities of aerial shells and reports, most notably those in Enschede, The Netherlands, do not show this single, large rising and falling fireworks type effect. Rather they show multiple effects from a variety of sizes, types and styles of fireworks that spread up and out from the rising fireball and smoke column.

The author however notes the fireworks explosions at Enschede did not occur in a watertight hold under pressure with other commodities. It remains possible that these effects in this picture may have been fireworks that were undeclared and stowed in hold six, and these may have been some of the fuel and the initiating explosion for the powerful explosion on November 15th.

Published reports available at this time indicate approximately 50% of the containers on board were destroyed by the fires and explosions, including all of the containers stowed in and above holds four, five and six and about half of those in hold three. Damage estimates for ship and cargo will be at least $50-100 million. All of the containers have been removed from the vessel, which is still in Singapore awaiting final disposition.

The Fireworks

The fireworks aboard the M/V HANJIN PENNSYLVANIA were declared UN 0336 FIREWORKS 1.4G or UN 0337 FIREWORKS 1.4S. All were made in China and bound for Western Europe. The declared containers of fireworks were stowed above holds one, two and three and most of these containers apparently survived the fires and explosions.

Some Chinese fireworks, notably aerial star shells and even aerial salutes, destined for the European market are often classified as UN 0336 FIREWORKS 1.4G, even though the exact same fireworks destined for the United States and other markets are classified as UN 0335 FIREWORKS 1.3G or even UN 0334 FIREWORKS 1.2G.

The disparity in classifications is due to complex economic, legal, political and other considerations. Basically Chinese manufacturers follow the instructions of their overseas customers regarding virtually all aspects of the fireworks manufacture, labeling, packaging, packing, classification, and shipping processes. The buyers in turn declare to their national "competent authorities" these are the classifications determined by the Chinese "competent authorities".

The Chinese "competent authorities" do not classify hazardous materials, including fireworks, in the same manner as many other countries. Their transportation regulations and enforcement are improving, but their system relies on provincial authorities who have limited resources and overwhelming workloads. Commodities are classified according to a complex, partially UN based system that relies on the commodity, the buyer's demands, the method of packaging, the methods of transit, the destination and many other factors.

The author offered to assist the General Average Adjuster and others with the survey of the containers of fireworks, but was not permitted to do so in spite of every effort. The author was able to discern that some containers of fireworks declared as 1.4G were destroyed by fire, but none that were seen on the salvage barges showed any signs of an explosion indicative of having aerial star shells and/or reports that would be classified as either 1.2G or 1.3G.

Preliminary reports and the little the author was able to see of the surviving containers of fireworks indicate the surviving containers sustained mostly water and/or smoke damage, with some external fire damage to the containers. Other containers of fireworks had the contents completely destroyed with heavy damage to the containers. Interestingly the orange placards were still visible, although the paint had come off.

Sources that did survey only small portions of a few of the surviving fireworks containers told this author they contained fountains, small rockets, black powder firecrackers and other fireworks for the typical New Year's Eve consumer markets in European countries. Many of these containers of fireworks were reportedly waterlogged, even after weeks of exposure to the tropical sun. Their contents were a total loss.

Preliminary Conclusions

It is the conclusion of this author with the information available to date that:

- Fireworks were most likely <u>not</u> the cause of the initial explosions above hold four, or of the catastrophic explosion in hold six.
- A fire of unknown cause or origin occurred above hold four.
- The crew reacted to this fire and attempted to control it with water and CO_2.
- This fire spread to a container(s) that most likely had undeclared or misdeclared hazardous materials that resulted in the two explosions above hold four that killed the two crew members and spread the fire to other nearby containers.
- The powerful explosion in hold six was most likely due to a fuel-air explosion in the confined hold which then burned the magnesium or a magnesium alloys stowed in hold six creating fireworks like effects.

- Some fireworks were involved as fuel in the same manner as other commodities that were caught in the chain of events the resulted from the initial fire and explosions.
- The fireworks that were declared as 1.4G or 1.4S and were classified and stowed properly behaved as expected for that classification.
- The large volumes of water worked effectively with the 1.4G or 1.4S fireworks that were burning and successfully impeded the spread of fire to non-involved containers of 1.4G or 1.4S fireworks.
- There most likely were some containers and/or cartons of aerial star shells and report shells in containers declared as containing 1.4G that would be 1.3G or 1.2G if they were classified properly.
- If there were any misdeclared or undeclared containers of fireworks, these may have caused some of the secondary fires and explosions that spread the fire from above hold four to other parts of the ship and hampered fire-fighting efforts.
- If there were any undeclared fireworks that were stowed above or in hold six, these may have been part of the fuel and/or what initiated the powerful explosion of November 15th.

The investigation and other research reveal there are significant problems with Chinese fireworks manufacture, labeling, packaging, packing, classification, and shipping that must be addressed by the industry. It also showed the problems with European government regulations regarding fireworks classifications and industry practices that came to light after the tragedies in Enschede remain, and that the harmonization of UN classifications is still far from complete.

Most of these problems can be addressed through improved communications and education by the fireworks industry, combined with improvements to existing government regulations and existing shipping and insurance industry policies.

Existing and additional reactive regulations or restrictions are not likely to make the needed improvements and in fact are usually counterproductive. Port authorities, warehouse, shipping and insurance companies that have expensive and burdensome procedures and policies that do not address real public safety concerns involving 1.2, 1.2 or 1.3 explosives or fireworks encourage misdeclarations and improper classifications.

The investigation and other research also revealed significant problems with the handling, stowage and transportation of all cargo, especially hazardous materials via modern inter-modal container system. The majority of these problems are a result of poor management, training and communications.

The fireworks industry can assist in educating the manufacturing, warehousing and shipping operations regarding fireworks, as well as the “competent authorities” regarding the proper classifications of fireworks, but can do little to address the overall problems within the inter-modal container industry.

Finally, the author would like to thank all of those who assisted in this investigation. There were many people who went out of their way to help, however there were some who did almost everything possible to hinder and even block efforts to obtain information.

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