National Transportation Safety Board

Marine Accident Brief

Fire aboard Vehicle Carrier *Alliance St. Louis*

Accident no.	DCA17FM005
Vessel name	*Alliance St. Louis*
Accident type	Fire
Location	Gulf of Mexico, about 190 miles south of New Orleans, Louisiana 26° 35’ N, 089° 23.9’ W
Date	January 16, 2017
Time	About 0252 central standard time (coordinated universal time – 6 hours)
Injuries	None reported
Property damage	>$3,750,000 est.
Environmental damage	None reported
Weather	Partly cloudy, visibility 8 miles; winds southeast at 4 knots, air temperature 65°F; calm seas
Waterway information	Open waters of the Gulf of Mexico along the outer continental shelf, water depth about 7,000 ft.

On January 16, 2017, at 0252, the vehicle carrier *Alliance St. Louis* was under way from Port Arthur, Texas, to Jacksonville, Florida, when a pipe plug on the fuel pump for the main engine’s no. 6 cylinder came loose, resulting in fuel spray onto the engine’s hot exhaust gas pipe manifold. The atomized fuel quickly ignited. The fire was contained to the main engine room and extinguished by the CO_2 fixed fire-suppression system. No injuries were reported; property damage exceeded $3,750,000.

Alliance St. Louis **pierside in Port Arthur, Texas, undergoing repair after the fire.**

* Unless otherwise noted, all miles in this report are nautical miles (1.15 statute miles).

Background

The *Alliance St. Louis*, a US-flag roll-on/roll-off vehicle carrier, was built in 2005 by Daewoo Shipbuilding & Marine Engineering Co. Ltd in Geoje, South Korea. Originally named the *Haul Paris*, flagged in Norway and classified by Det Norske Veritas, the vessel was purchased by Farrell Lines, a subsidiary of Maersk Line, and reflagged in the United States in February 2008. At the time of the accident, the *Alliance St. Louis* provided services to the US government and commercial customers; the vessel also participated in the Maritime Security Program and the Voluntary Intermodal Sealift Agreement.

Accident Events

On January 15, 2017, the day before the accident, the partially loaded *Alliance St. Louis* departed Port Arthur at 0442, bound for Jacksonville. About 1500, the second assistant engineer on duty set the engine room to unmanned mode, as was typically done at the end of each work day. The second assistant engineer conducted a routine round of the engine room at 2200 and again at 2300 before going to bed. This was the last time the crew entered the engine room that night. The second assistant engineer told investigators that he did not see or hear anything unusual in the main engine, and no alarms were recorded that evening in the alarm history log in the control room.

Accident location of *Alliance St. Louis*, marked by a red triangle, about 190 miles south of New Orleans. (Background by Google Earth)

Early in the morning on January 16, the *Alliance St. Louis* was making 15.7 knots on a course of 114 degrees. At 0252, the main engine's low fuel oil inlet pressure alarm sounded; shortly thereafter, the engine room all call/general alarm activated on the bridge and in the engineering officers' staterooms. Shortly thereafter, the vessel's fire-detection system activated, alerting the bridge crew to a fire in the incinerator space and main engine room. Seconds later, the ship lost main electrical services, including power to the main propulsion and steering systems. The emergency diesel generator automatically started and came online as designed, providing power to essential equipment and the steering system. Vessel traffic in the area was minimal; the closest vessel was about 20 miles away, and the closest oil gas platform was 31 miles away.

The bridge crew activated the general alarm on the bridge and crewmembers reported to their emergency stations. The chief mate and the chief engineer went to investigate the spaces in question, while two fire teams prepared the firefighting gear. The chief mate reported thick black smoke exiting from the ventilation louvres located on the back side of the ship's funnel and the incinerator room filling with smoke. In accordance with the emergency plan and station bill assignments, the crewmembers closed the engine room ventilation dampers and control stops to prevent the spread of smoke and reduce the supply of oxygen. They also shut the fuel and lube oil quick-closing valves to cut off potential fuel sources to the fire. The master notified the Coast Guard and the ship operating company.

The chief engineer tried to activate the hyper-mist fixed fire-suppression system in the area of the fire (there was a nozzle located above the no. 3 generator), but the control panel on deck A did not have power. The chief engineer then made his way aft to the steering gear room (where the hyper-mist high-pressure pump and actuating valves were located) to try to start the system locally, but the system was also without power.

The chief engineer and the first assistant engineer decided to enter the space to determine the location of the fire and try to restore power to the main bus to energize the hyper-mist system, which was the vessel's first line of fire-extinguishing capability and protection for the engine room and machinery spaces. Fire team no. 1 donned firefighting suits and self-contained breathing apparatuses (SCBAs), and stood by with a charged fire hose. About 0311, the chief engineer and the first assistant engineer tried to enter the after part of the engine room through the door from the steering gear room. However, thick, black, bellowing smoke limited the visibility and prevented entry. The chief engineer and the first assistant engineer then decided to enter the engine room through deck no. 4's portside entrance. They successfully entered the space and were able to make their way forward past the main engine to the engine control room. There, they checked the engine control room for fire, found several of the main bus breakers tripped, and left. On their way out, they saw that the overhead crane and main shipboard power electrical cables were on fire. The chief engineer and the first assistant engineer tried to extinguish the cable fire with a portable extinguisher, but they were unsuccessful.

At 0325, the first assistant engineer's SCBA was running low on air, so he and the chief engineer exited the engine room where they had entered. The chief engineer then re-entered the engine room by himself. This time he did what he called a "feel-over" of the main engine to see if it was hotter than usual. Satisfied that the main engine was not on fire, the chief engineer exited the engine room.

The master, in discussion with the chief mate and the chief engineer, decided to extinguish the fire using the engine room's CO_2 fixed fire-suppression system. The chief mate fully accounted for the crew outside of the emergency gear locker and, at 0335, the master authorized releasing CO_2 into the engine room for 2 minutes. The master and the chief engineer monitored the engine room's ambient air temperatures on a computer in the ship's office and saw the temperatures decrease initially, then rise again.

At 0424 and again at 0444, the crew released CO_2 into the engine room, each time accounting for all persons ahead of time. After the third release, the engine room temperatures decreased and then stabilized. The crew continued to monitor the fire boundaries, taking bulkhead and deck temperatures with a non-contact infrared gun-style thermometer, and had hoses prepared if needed. About 8,000 pounds of the 40,000-pound-capacity CO_2 fixed fire-suppression system was released into the main engine room.

The machinery space dampers, vents, and hatches remained closed for more than 26 hours. During this time, the emergency generator provided limited power to the vessel; no potable water, sewage, or HVAC was available. About 1030 the following day, January 17, a salvage master and fire team with Ardent Marine arrived via the salvage tugboat *Crosby Endeavor*. At 1300, the fire team's chief, lead firefighter, and the *Alliance St. Louis* chief engineer entered the engine room with SCBAs and a thermal-imaging camera. The fire team determined there were no hot areas or concerns of a re-flash, and they reported the fire to be extinguished.

The engineering crew discovered that the fire damaged the main shipboard power cables (between the electrical generators and the main switchboard) that ran overhead along the port side of the engine room, resulting in the vessel losing the capability of all three diesel generators to provide power to the main bus. About noon on January 18, the chief engineer, in collaboration with his engineering staff, was able to restore electrical power to vital house services, including the potable-water and sewage-treatment plant, by using temporary cables.

Under the salvage master's supervision, the *Crosby Endeavor* towed the *Alliance St. Louis* back to Port Arthur, where the vessel underwent repairs. No pollution or injuries were reported.

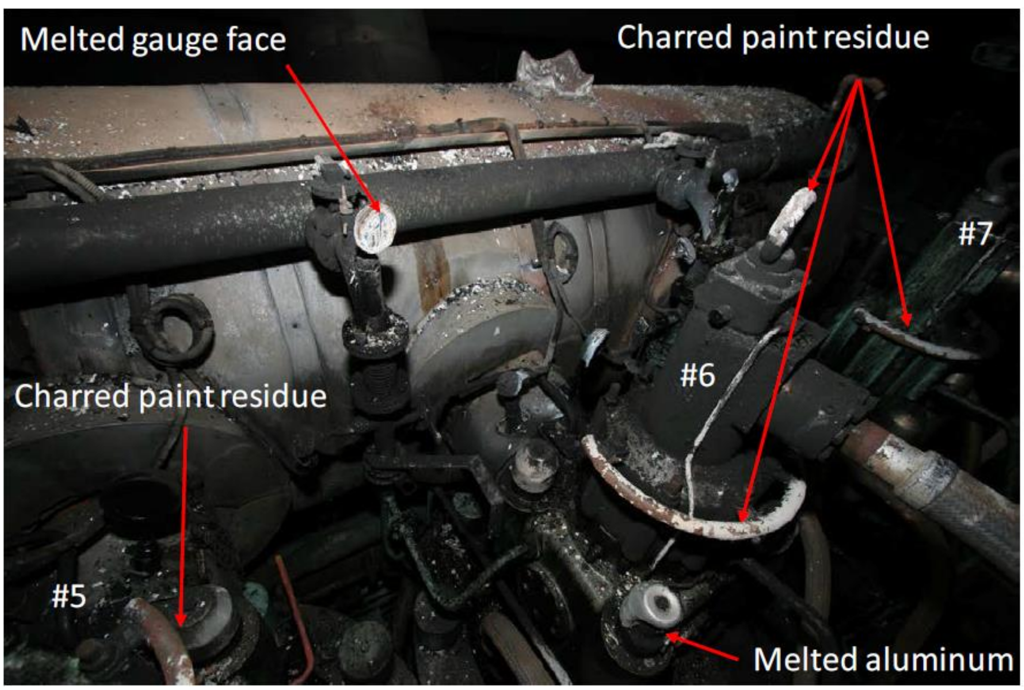
The *Alliance St. Louis* master conducted drug tests on the entire crew within the required 32-hour time frame; all results were negative. Regarding the 2-hour-window testing requirement for alcohol, the master told investigators that the crew was still engaged in firefighting activities 2 hours after the fire started; however, alcohol breath testing on most of the crew was conducted within 8 hours. All results were negative.

Investigators—together with manufacturer technicians, crewmembers, and operating company representatives—conducted a postaccident inspection of the machinery spaces, fire control station, CO_2 room, and cargo bays aboard the *Alliance St. Louis*. The areas appeared to be well-maintained and in good order, and systems operated as designed. Investigators also reviewed available documentation, certificates, and records pertaining to the main engine, CO_2 system, and other involved systems.

In addition, investigators examined the DOOSAN–MAN B&W 2-stroke, slow-speed diesel engine, type 7S60MC. The main focus was on the no. 6 cylinder's head/injector area, which was suspected as the fuel source for the fire. Examination of this area revealed that an aft pipe plug from the cylinder's fuel pump top cover was missing.

The photograph below shows the concentrated thermal damage (highlighted by the red dotted line) near the no. 6 cylinder. Thermal damage extended forward to cylinder no. 5 and aft to cylinder no. 7. Most of the fire damage was located on the engine room's 1st platform level and along the overhead and included charred paint, melted gauge faces, and melted aluminum components. On the engine room floor level, a stain from a liquid spill was found. This general area was also heavily covered in soot and coated with an oily residue (see NTSB's fire factual report for a detailed description of the fire damage).[1]

View of the entire cylinder head bank, showing concentrated thermal damage and staining centered around the no. 6 cylinder.



Thermal damage, including charred paint, melted gauge faces, and melted aluminum components.

The main engine had seven in-line cylinders that used both heavy fuel oil and ultra-low-sulfur fuel oil, also called marine gas oil (MGO). Use of ultra-low-sulfur fuel oil is required in the North American Emission Control Area. The *Alliance St. Louis* was operating on

[1] NTSB Office of Research and Engineering, Fire Investigation Factual Report No. 17-057, July 12, 2017.

MGO for more than 22 hours when the first fire-detection alarm sounded on the bridge. The auto-ignition temperature for MGO is 495 degrees F (257 degrees C). When MGO contacts a heated surface that is significantly above 495 degrees F, ignition can be instantaneous.

The engine was arranged and designed so that both the heavy fuel oil and the MGO could be used with the one fuel pump per cylinder. Each fuel pump consisted of a cast-iron pump housing with a top cover. Fuel to all cylinder fuel pumps was supplied from a lower-pressure fuel oil-circulating pump to a flanged connection on the front of each fuel pump housing. Inside the pump housing was a pump barrel that delivered fuel at high pressure to the fuel valve at 300–380 bars (4,350–5,510 psi).

The fuel pump top cover and centrally placed barrel and plunger assembly were attached to the top of the pump housings by eight threaded studs and fixing nuts. A puncture valve was located inside the top cover. The pump was activated by the engine's fuel cam.

The puncture valve was a device that, when activated, stopped fuel injection and returns excess fuel through passages back to the pump housing. There were four passages running vertically through the top covers and into the pump housing. Two of the passages were for inserting a special tool to the top of the barrel for measuring fuel pump timing and were ruled out as a factor in this accident. The other two passages returned fuel oil back to the fuel pump housing when the puncture valve was activated. Pressures inside these two passages were 7–8 bars (101–116 psi) during pump operation. The passages were designed to be closed by 10-mm pipe plugs.

During the postaccident examination, the chief engineer discovered the fuel pump's displaced aft pipe plug in the engine's catch-all area (an area around the base of the no. 6 cylinder). Investigators compared the aft pipe plug to an unused pipe plug and found them to be identical. None of the threads on the aft pipe plug were found to be damaged, nor was the plug itself deformed.

A review of maintenance records indicated that the crew last removed cylinder no. 6's top cover from its pump housing on June 23, 2016, for technicians ashore to overhaul valves. The individual who performed the task was not on board; however, several engineering crewmembers described to investigators how they normally inspected and cleaned the top covers in connection with the valve overhauls.

Several engineering crewmembers stated that, as part of the overhaul performed in June and as a standard practice on board, they removed the two pipe plugs to clean and inspect the oil passages. When reinstalling the pipe plugs the crew would usually apply a threadlock adhesive around the threads and tighten the pipe plugs by "feel" into the top cover with a metric hex key. The first assistant engineer stated that the crew followed the manufacturer's procedures for the top cover overhaul and showed investigators copies of the procedures in the workshop.[2]

The procedures did not specifically mention the pipe plugs or depict the fuel oil passages in a diagram of the top cover. However, the instruction manual did list, in the general tool section,

[2] Instruction Book for DOOSAN–MAN B&W 2-stroke, slow-speed diesel engine, type 7S60MC, section 900-1, *Checking and Maintenance Schedules*, and section 909-3.3, *Overhaul of Top Cover Complete*.

standards for tightening torques. Per the manual, the aft pipe plug on the no. 6 cylinder fuel pump top cover should have been torqued to 50–60 newton meters.[3]

Analysis

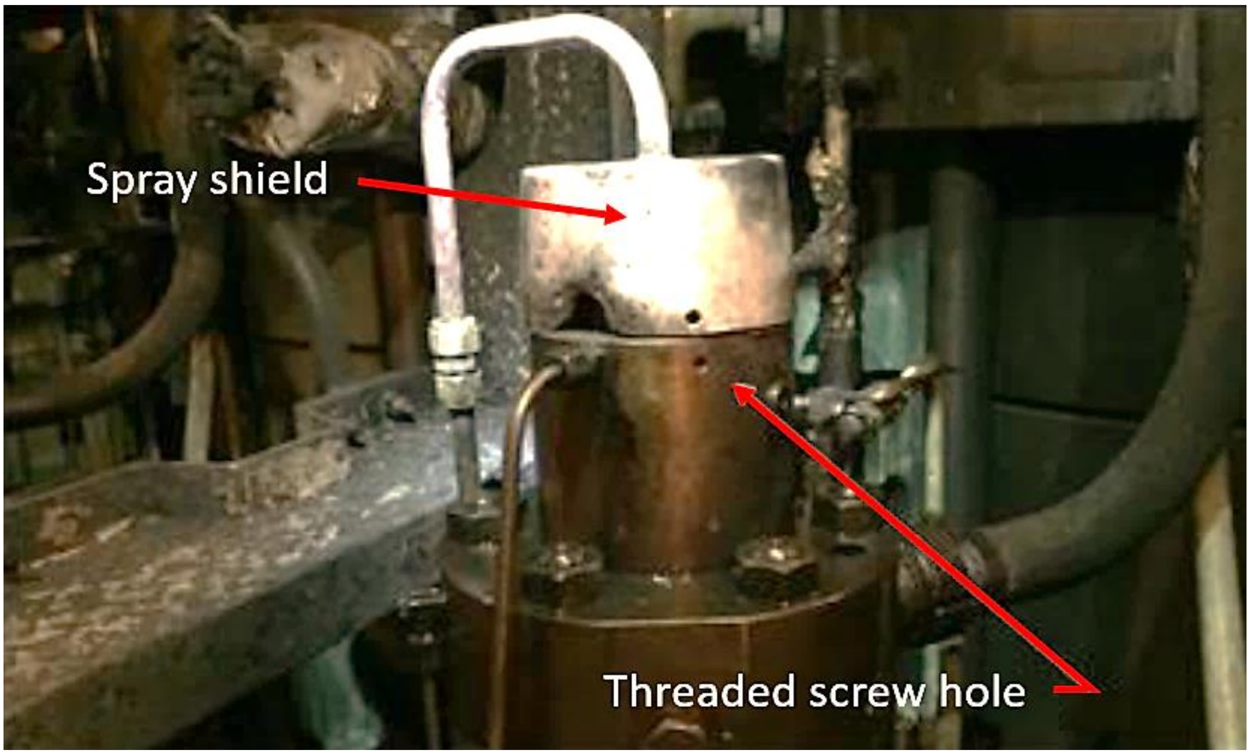
The pipe plug was likely not sufficiently torqued into the top cover during the last inspection because the crew did not recognize this as a crucial step in maintaining the reliability of the fuel oil system. The instruction book's section *Overhaul of Top Cover Complete* contributed to the crew's lack of awareness about this hazardous situation because it did not depict the fuel oil return passages or describe the purpose of the pipe plugs.

The engineers on board the *Alliance St. Louis* had never previously experienced a situation where a pipe plug vibrated out of a pump's top cover. The aft pipe plug on the no. 6 cylinder fuel pump top cover likely loosened over time due to normal main engine vibration, fuel oil pressure acting on the plug, and switching of fuels. The missing pipe plug would have provided a path for MGO to spray out of the top cover at an approximate pressure of 7–8 bars (101–116 psi). Several engineering crewmembers stated in their interviews that they had experienced an increased number of fuel oil system leaks and seepages from gaskets, flanges, seals, o-rings, and other fittings due to thermal expansion or contraction of the components and material when changing from heated heavy fuel oil to ambient and sometimes cooled MGO.

Fuel pump housing and top cover for the no. 6 cylinder, with missing pipe plug. The lower-right image shows the dislodged pipe plug (left) next to a new unused plug.

[3] Instruction Book for DOOSAN–MAN B&W 2-stroke, slow-speed diesel engine, type 7S60MC, section 913-4, *Standard Tightening Torques*.

Spray shields are used to prevent fuel sprays and leaks from contacting hot surfaces and other sources of ignition. The last step of the top cover overhaul procedures stated, “mount the protective cap (spray shield) over the puncture valve, three drain oil pipes, return oil pipe, air pipe and safety system on the top cover.” There were openings for screwing spray shields to the top covers. However, none of the ship’s spray shields were screwed to their top cover. The spray shield on the no. 6 cylinder’s top cover was found hanging off the air pipe next to the pump housing during the postaccident inspection. It was likely knocked off the top cover by the pipe plug and spraying MGO because it was not properly secured with two screws. A properly secured spray shield (per the manufacturer’s instruction manual) would have kept the MGO from spraying directly into the air and contacting the no. 6 cylinder exhaust gas pipe/receiver. Instead, the MGO would have sprayed into the shield and run down the fuel pump housing to the decks below where there were fewer, if any, potential sources of ignition.



Inboard view of the no. 6 cylinder fuel pump and top cover postaccident, with the spray shield slightly elevated to illustrate alignment of fastener holes.

From the cylinder head exhaust valves, combustion gas is led through pipes to the manifold where varying pressures and temperatures are equalized before going to the turbocharger. An exhaust gas pipe from each cylinder connects to the exhaust gas manifold, which is wrapped with insulation and covered by galvanized steel plating. Investigators found gaps in the lagging (insulation) and steel plating at every cylinder’s exhaust gas pipe/manifold interface. At the no. 6 exhaust gas manifold, the gap was approximately half an inch around most of the exhaust pipe where it joined to the manifold.

As part of their daily rounds, the engineering crew recorded exhaust gas temperatures at noon. On January 15, 2017, the exhaust gas temperature at the no. 6 cylinder was recorded as 579 degrees F, approximately 85 degrees F above the auto-ignition temperature for MGO. The range of low to high exhaust gas temperatures at the seven exhaust gas pipes was 559 to 619 degrees F. The main engine was performing as expected for the 85-percent load at which it was running on January 15, 2017; there was nothing unusual about the exhaust temperatures recorded.

The distance from the exhaust gas pipe/manifold interface to the overhead was about 6 feet. It is likely that a sudden and intense fire ensued when MGO contacted this unprotected surface. Based on fire damage, flames and intense heat burned the overhead above the no. 6 cylinder. From there, flames, smoke, and hot gas spread horizontally in all directions toward the bulkheads.

The crew's timely and effective use of the CO_2 fixed fire-suppression system likely prevented the spread of the fire and minimized the extent of damage to the engine space.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the engine room fire aboard the *Alliance St. Louis* was improper tightening of a pipe plug on the top cover of the no. 6 cylinder fuel pump housing, which resulted in a high-pressure release of marine gas oil. Contributing to the fire was the improper attachment of a fuel spray shield to the top cover, which allowed fuel to spray directly onto the cylinder's hot exhaust pipe and ignite.

Vessel Particulars

Vessel	*Alliance St. Louis*
Owner/operator	Wilmington Trust Company/Farrell Lines, a subsidiary of Maersk Line, Ltd
Port of registry	Norfolk
Flag	United States
Type	Roll-on/roll-off vehicle carrier
Year built	2005
Official/IMO number	9285500
Classification society	Lloyd's Register of Shipping
Construction	Steel
Length	635.8 ft (193.8 m)
Draft	29.8 ft (9.1 m)
Beam/width	105.6 ft (32.2 m)
Gross tonnage	57,280
Engine power; manufacturer	19,460 BHP (14,511 kW) Doosan-MAN B&W 7S60MC marine diesel engine
Persons on board	20 crew

NTSB investigators worked closely with our counterparts from Coast Guard Marine Safety Unit Port Arthur Investigations Division throughout this investigation.

For more details about this accident, visit www.ntsb.gov and search for NTSB accident ID DCA17FM005.

Issued: March 29, 2018