March 14, 2018

Chairman Robert L. Sumwalt
National Transportation Safety Board
Washington, D.C. 20594

RE: CARIBBEAN FANTASY
DCA 16FM052
PARTY SUBMISSION

Dear Chairman Sumwalt:

This is in response to the opportunity provided by 49 C.F.R. § 831.14 to a party to an investigation to submit proposed findings, a proposed probable cause, and a proposed safety recommendation(s) designed to prevent future accidents. The notice of proposed submissions was provided by the letter of January 23, 2018 of Mr. Adam Tucker, Investigator-in-Charge.

Baja Ferries, S.A. de C.V., would submit the following:

Findings

1. The vessel *Caribbean Fantasy* is a roll-on/roll-off (ro-ro) passenger and cargo vessel. The vessel particulars are fully set out in the record and in previous draft reports. Commencing in 2011, the vessel became engaged in the Caribbean trade in the transport of passengers and cargo between the Dominican Republic and Puerto Rico.
2. In early 2016 arrangements were made for a comprehensive dry dock for work in machinery and deck spaces and safety equipment. The dry dock operations were carried out at the CMR Tunisia Ship Repairs facility at Bizerte, Tunisia. The *Caribbean Fantasy* entered the dry dock on March 26, 2016. The vessel stayed 100 days at the shipyard. Extensive repairs were performed on the Mitsubishi MAN B&W 8L58/64 main engines: the exhaust gas turbochargers were overhauled, the gear coolers were inspected, portside engine alignments were performed, renew of Vulkan portside coupling, deflection of the crankshafts,

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disassembly and alignments of the port reduction gear, injector refurbishments, cylinder head overhauls including removal of the exhaust and intake valves. No work was required or was carried out with the vessel engine fuel system. The *Caribbean Fantasy* departed the Tunisia Ship Repairs facility on July 3, 2016.

3. The dry dock service in Tunisia represented approximately five million dollars investment by Baja Ferries to keep the *Caribbean Fantasy* in optimum working condition for the passenger/cargo service between Puerto Rico and the Dominican Republic.
4. Among the measures taken by Baja Ferries to improve the engine department was to contract a reputable third-party crewing agency, Midocean (IOM) Ltd., (Dohle (IOM) Ltd.) to recruit and supply officers for the Engine Department.
5. On August 9, 2016, prior to returning to the Caribbean service the USCG performed a Port State Control inspection at San Juan, Puerto Rico. The USCG Port State Control inspection reviewed the machinery spaces and procedures, the crew, deck department, fire and lifesaving drill exercise and equipment. This included launching, operation and recovery of one of the life boats. The MISLE Activity Report listed seven deficiencies, four of which were rectified immediately and three which were to be rectified in fourteen days. None were related to fuel line condition or operation. The vessel was approved to return to its Caribbean service.
6. On August 9, 2016 the vessel was also attended by the representatives of the vessel Classification Society, Registro Italiano Navale (RINA); and, by the vessel's Designated Person Ashore.
7. On August 16, 2016, the *Caribbean Fantasy* left the Dominican Republic on the third voyage to Puerto Rico upon the return to service after the dry docking. Early on the morning of August 17, 2016, as the vessel was preparing to enter San Juan Harbor, a fire incident occurred. The sequence of events as these developed is best summarized by way of the excerpts of the bridge activity, which are included as an attachment to this submission.

8. The sequence of events on August 17, 2016 commence with the Chief Engineer (CE) proceeding to the Engine Room shortly before 07:00 hours to prepare for maneuvering. He went to the stabilizer room and retracted the stabilizers before returning to the Engine Control Room (ECR).

9. In the ECR, the motorman came and told him there was a fuel leak dripping in the fuel supply system to the port main engine. The CE went to the railing between the ECR and the port main engine where he observed a dripping leak on the upper fuel rail which is part of the fuel supply system and fed from the fuel pump.

10. A wiper was standing on the lower platform between the two engines with the motorman where they observed the dripping leak from the fuel supply line behind the port main engine. From his vantage point, the wiper could not see the source of the leak.

11. After seeing the initial leak, the CE returned to the ECR and telephoned the Captain, telling him of the leak and that they must shut down the engine in order to make repairs. After reducing the propeller pitch, the CE brought a flash light from the ECR to the lower platform along the port main engine to investigate exactly where the leak originated. By this time, the leak had developed into a large spray projecting upwards and impacting the turbocharger. The spray erupted in flame and he returned to the ECR to notify the Captain. The third engineer shut down the engines and secured the pumps while the CE started the Hi-mist system from the panel in the ECR. He depressed the buttons for the zones for both the port and starboard main engines and observed that the lights illuminated, indicating that the system pumps were running.

12. At the time of the fire, the vessel was approaching the entrance to the harbor entrance, turning toward the pilot station and slowing from 15 to 10 knots. The Captain steered to port to head north, in order to clear the channel, and reduced propeller pitch to zero to help stop the vessel.

13. The vessel's fire team reported heavy smoke and could not enter the engine room space. Between 07:32 and 07:36 hours, the Captain decided to utilize the CO2 fixed firefighting system and asked for verification that the space was clear. He also secured the ventilation fans from the bridge. The Captain further ordered that the CE and the Staff Captain to close the dampers.

14. The CE, third engineer and the motorman evacuated the engine room to garage C. En route, the CE activated the quick closing valves for the fuel system and the mechanism to close the engine room dampers. At garage C he met the fire team who confirmed that CO2 was to be used. The Staff Captain and first engineer also started the drencher system for garages A and B.

15. The Captain stated that after the CO2 was released, the smoke color changed to white. About five minutes thereafter it returned to black. With the engines stopped the vessel was adrift, so the Captain ordered drop the anchor deployed with four shackles of chain. The anchor slowed the drift but did not stop the vessel. The wind gently grounded it off Punta Salinas. Due to the close proximity to shore, the Captain felt the safest course of action for the passengers was to abandon ship. This was subsequently carried out.

16. A visual examination of the engine room space revealed fire patterns consistent with a fire originating in the general vicinity of the aft end of the port side fuel rail, where the blind flange leak occurred. Close inspection of the fuel rails at the aft end of the fuel supply system for this engine revealed that both terminated with blind flanges.

17. No disruption of the gasket was visible in either flange nor was any damage to the pipe, flanges or bolts evident. Both fuel rails and the associated jumper lines connecting them to the injector pumps were lagged. However, no disruption of the lagging was apparent and no fuel wash patterns fire damage patterns were present that would suggest a leak had occurred at the injector pumps or the fuel rail piping forward of the blind flanges.

18. The fire patterns observed suggest the area of origin for the fire to be at the aft end of the port main engine in the general vicinity of the blind flange assembly of the upper fuel rail of the fuel supply system. This is based upon a local low point of fire attack as well as an inverted conical damage pattern extending upward to include the deck head above. The various investigation interviews indicate that the fire was first observed in this area such as to establish that the area of origin for the fire is the vicinity of the upper fuel rail blind flange assembly.

19. The statements of the CE, and to a lesser degree the wiper, are quite compelling that a fuel oil leak originated in the blind flange assembly of the upper fuel rail of the fuel supply system for the port main engine in the minutes prior to the fire. These men further stated that the rate of leakage increased until it became a spray and subsequently burst into flame. Thus, it must be accepted that the initial source of fuel for the fire was the diesel fuel leaking from this flange assembly.

20. The witness statements of both the CE and the wiper make it quite clear that the fuel leak impinged upon the turbocharger of the port main engine. While the exhaust and turbocharger were shielded, there are always small gaps in the shielding that permit ingress of atomized fuel. Once inside, the shielding retains the vapors, increasing the time available for pyrolysis to take place and greatly increasing the probability of ignition from the hot surfaces. Thus, it is accepted that the turbocharger or adjacent exhaust piping is the most probable source of ignition for the fire.

21. The flange and gasket were removed from the ship by the NTSB and the USCG for detailed testing and examination. Laboratory Reports 17-008; 17-053. Although these reports do not directly address the root cause of the leak, there are indications that the gasket had become rigid and broke off in several parts when the fuel pipe flange was disassembled. These suggest that the failure at the gasket was a deterioration over time, becoming hardened and brittle, most likely as a result of thermal degradation.

22. A brittle gasket, by itself, should not result in leakage unless it was also subjected to cyclic stresses or stress other than the clamping force of the flange assembly. The coincidental failure of the same flange assembly on the fuel system for the starboard main engine approximately one week earlier suggests that the same root cause may have been responsible for both failures and also that it developed during the recent operational history of the vessel.

23. Two potential sources of such stresses are a fault in the fuel pressure regulation or significant changes in fuel temperature. Pressure pulsing or simply excessive static pressure could reasonably lead to the rupture of these gaskets. Degradation or miss adjustment of the fuel circulating pumps could lead to excessive

pressure pulsing or excessive operating pressure. However, there were no reports of problems with the fuel pumps and no excessive operating pressure was revealed during interviews of the crew members.

24. Differential thermal growth due to rapid and dramatic changes in fuel temperature could create a shearing stress on the gasket as the pipe quickly transmits the new fuel temperature to the flange welded to it, but the blind flange relies on heat that is conducted through the static fuel in the dead leg. The resulting differential temperature causes one flange to temporarily expand, or shrink, relative to the other. This mechanism has been known to cause gaskets to fail over time.
25. On January 1, 2014, the U.S. Caribbean Sea Emission Control Area (ECA) went into effect under the requirements of MARPOL Annex VI. At that time, all vessels operating within the ECA were required to utilize fuel with a sulfur content of 1% or less. The sulfur limit was reduced to 0.1% on January 1, 2015. This effectively required all vessels operating within the ECA run their engines on ultra low sulphur diesel fuel.
26. The viscosity of diesel fuel is much lower than the viscosity of heavy fuel oil which vessels typically use when outside the ECA. In order for the engines to function correctly, the fuel viscosity must remain within the design operating range. This requires that the temperature of the fuel be greatly reduced when switching from heavy fuel oil to diesel fuel and vice versa. Every time a vessel crosses an ECA boundary, it will now experience this dramatic change in fuel temperature.
27. None of the vessel documents, crew interviews or NTSB draft reports indicate that the vessel lacked equipment, parts or machinery to make any ordinary maintenance repairs as to the fuel supply system.
28. The *Caribbean Fantasy* traded between Puerto Rico and the Dominican Republic, meaning it crossed the ECA boundary on each voyage. While the latest sulfur limits came into effect on January 1, 2015, the vessel was in dry dock from March to July, 2016, and underwent additional repairs afterward, along with a round trip voyage to the Mediterranean. This means that the vessel was operating in its Caribbean trade route for approximately 15 months. Assuming it made one passage per day, it would have accumulated about 375 thermal cycles over this period. This is a reasonable value to cause the gasket to fail.

Accordingly, differential thermal growth due to fuel changeover is considered the most probable credible root cause of this fire.

Proposed Probable Cause

1. The fire aboard the *Caribbean Fantasy* was caused by the failure of the gasket in the blind flange assembly of the upper fuel rail of the supply system for the port main engine.
2. The fuel supply system, and the blind flange sections, in particular the gasket sections, are exposed to differential thermal growth as a result of repeated frequent fuel changeover required by the implementation of the emissions controlled areas (U.S. Caribbean) of the International Maritime Organization, International Convention for the Prevention of Pollution of Ships. (MARPOL).
3. The repeated short interval changeover from heavy fuel oil to ultra low sulphur marine gas oil on vessels in service in the US Caribbean ECA, impose constant and frequent stress on entry and departure on those parts of the fuel supply system close to heat sources such that

   the full ramifications and consequences of this required operation are only now being developed.[1]

Proposed Safety Recommendations

When repeatedly changing fuels to meet ECA compliance, the boundary integrity of the entire fuel system should be analyzed to ensure it meets the new operating parameters. This analysis should include determining what these new parameters are, and the material compatibility with the new fuel as well as the operating temperature. In addition, the effects of thermal shock generated by the fuel changeover should be calculated to establish the ability of the generally used common components of the fuel system to handle the resulting stresses.

To: U.S. Coast Guard:

[1] The USCG and other entities early recognized that certain operational and safety implications would flow from the compliance with ECA requirements on use of 0.10 percent fuel sulphur limits. USCG Safety Alert 2-15, March 3, 2015. The implementation of practices and protocols to protect against these risks, however, have been in the nature of general advise and alertness notices with no further specific development on specific protocols.

Review the necessity of sponsoring governmental and private party research to identify the full spectrum of stresses caused by constant changeover operations. This may result in regulatory amendment.

To: All Classification Societies:

Review the necessity of amending inspection protocols for greater specificity in addressing fuel line appurtenances in proximity to heat sources on vessels whose trade engagement exposes them to constant changeover environment.

To: Owner/Operators:

In this new operational situation, where there is little historical data involving vessels in constant changeover trades, review the ECA implications on specific fuel system components in close proximity to heat sources, and put in place operation directions that are not presently found in regulatory, class or manufacturer protocols.

General Closing Comments

The action of the *Caribbean Fantasy* crew, the USCG response, the Federal and local Emergency Response agencies, and numerous good samaritan responders successfully evacuated 511 passengers and crew from the vessel in open sea conditions without loss of life. This should be recognized and commended.

Baja Ferries would reiterate and incorporate by reference in this submission all of the comments and information previously submitted by Baja Ferries in response to the various preliminary and interim draft factual/technical reports, and with respect to laboratory examinations.

The probable root cause of the fire could not have been avoided or detected under the regulatory or operational requirements and guidelines existing, in place and known at the time of the incident.

[redacted]

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ADDENDUM TO SUBMISSION

LOCAL TIME	BRIDGE ACTIVITY VDR EXCERPTS
07:24:13	Capt: "What is the problem?... leakage of what?... on which engine? ... do you want to stop the engines?"
07:24:57	"Reduce speed"
07:25:41	"Fire in Engine Room"
07:25:49	"Call the Pilot"
07:25:58	Bridge calls San Juan Harbor Pilot.
07:26:50	"Stop Engines"
07:27:00	"Mr. Skylight, Mr. Skylight, Mr. Skylight, Staging Area Garage A"
07:27:40	"Hard to Port"
07:29:04	Tel Call from ECR
07:29:16	"Evacuation of everything"
07:29:37	"Evacuate the engine room. Evacuate...yeah, well, start the high fog and evacuate..."
07:30:04	Bridge calls Pilot.
07:30:17	"...Yes, pilot, Caribbean Fantasy, we are just north of the canal... we need your support, we have a fire in the engine...we may need to get out passengers..."
07:30:39	"I call you back and keep you informed... I need...support for evacuation...I am just preparing, but I'm not sure we'll need, but I'm just preparing".
07:31:00	"We need to get everybody out of the engine machinery space, everybody, account everybody who was working on the engine room, we need to account them when they're out, we need to be sure nobody remained inside in this space"
07:31:20	"Fire Dampers Stop"
07:32:32	"Everybody...CO2...everybody out?... evacuation of whole engine".
07:32:50	"...we need to be sure everybody is outside of machinery spaces before we release CO2.... when we are ready, release immediately the CO2".
07:33:34	"... as soon as they give you the readiness, go ahead for CO2".
07:33:50	"We need to make sure to close all dampers, all fire dampers to be closed".
07:34:26	"No Staff [Captain], we are waiting readiness from Chief Engineer."
07:34:40	"... have we closed all doors, all the watertight doors?"
07:34:42	Tel Call to Hotel Reception.
07:34:49	"Reception... we have a fire in the engine room, please stop to gather all the passengers in the muster stations... but stop to make the passengers evacuation... I will send maybe an announcement... but be prepared..."

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07:35:40	"Waiting readiness from Chief Engineer."
07:36:46	"Go to CO2".
07:36:50	"Staff Captain proceed with the CO2, if everybody is out, proceed..."
07:37:19	"CO2 released".
07:37:31	"Chief Engineer...is the Hi-Fog working? Is the Hi-Fog working? Can you read me, yes or no?"
07:37:54	"...Garage B...going smoke..."
07:40:30	"(Safety Officer), start boundary cooling, above, above... and forward of control room, from Garage A and on top from Garage B..."
07:41:19	"...The smoke is too much in Garage B and C."
07:42:00	"Do you think we have to start the drenchers [in the garages]?"
07:44:29	"Proceed with the drencher under Garage B..."
07:44:43	"Prepare...for evacuation."
07:44:54	"United States Coast Guard, this is Caribbean Fantasy, we will make announcement for evacuation, we need immediately assistance..."
07:46:18	General Evacuation Announcement (English)
07:46:39	General Evacuation Announcement (Spanish)