National Transportation Safety Board

Marine Accident Brief

Explosion aboard Barge *IB1940*

Accident type	Fire/Explosion	**No.** DCA20FM002
Vessel name	*IB1940*	
Location	Chicago Sanitary and Ship Canal, Illinois Marine Towing facility, Lemont, Illinois 41°40.99' N, 87°59.37' W	
Date	November 4, 2019	
Time	0929 central standard time (coordinated universal time – 5 hours)	
Injuries	None	
Property damage	$1,750,000	
Environmental damage	None	
Weather	Visibility 10 miles, overcast, winds light at 10 mph from the west southwest, air temperature 38°F	
Waterway information	The Chicago Sanitary and Ship Canal is a waterway linking the south branch of the Chicago River with the Des Planes River at Lockport, Illinois. The canal is 30 miles long and has a minimum width of 160 feet, a minimum depth of 9 feet, and 2 locks.	

About 0930 on November 4, 2019, an explosion occurred aboard the moored tank barge *IB1940* at the Illinois Marine Towing Heritage Slip on the Chicago Sanitary and Ship Canal in Lemont, Illinois, about 25 miles from Chicago. The *IB1940*'s cargo of acetone had been unloaded, and the barge was being prepared for cleaning at the time of the explosion. No injuries or pollution were reported. The barge was declared a total constructive loss, valued at $1,750,000.

Similar barge *IB1945*. (Source: Ingram Barge Company)

Background

The barge *IB1940*, a double-hulled steel tank barge designed for the carriage of bulk liquid products, built in 2013, had a cargo capacity of 11,558 barrels (1 barrel is equal to 42 gallons). The barge was authorized by the US Coast Guard to carry various hazardous cargos. It was configured with a square bow, a square stern, and three raised, externally framed cargo tanks along the centerline with corrugated bulkheads separating each of the cargo tanks. Each cargo tank had a main tank access hatch and a four-dog, tank-cleaning access hatch located on the centerline of the vessel. The barge was equipped with a cargo pump, driven by a diesel engine serving all three cargo tanks.

Area where the explosion on the barge *IB1940* occurred, as indicated by the red triangle. (Background source: Google Maps)

Accident Events

The Illinois Marine Towing (IMT) Heritage Slip in Lemont, Illinois, received tank barges and engaged in the gas-freeing, stripping, and cleaning of cargo tanks, as well as the transferring of cargo residues and cleaning waste from cargo tanks into a vacuum truck. These operations were required to be completed in accordance with a Facility Operations Manual approved by the Coast Guard. IMT's Facility Operations Manual included attachments, which provided safety guidelines for tank-vessel-cleaning facilities and volatile-emission monitoring.

Prior to arriving at the IMT facility, the barge *IB1940* had previously carried in all three cargo tanks a cargo of acetone, which had been discharged on October 22–23. On November 1, the barge was shifted via towing vessel to the IMT Heritage Slip tank-barge-cleaning facility at mile 301 on the Chicago Sanitary and Ship Canal. Acetone is a colorless liquid used in the manufacture of plastics and other household and industrial products, including cosmetics, and its most frequent application is in the formulation of nail polish removers. Acetone is highly flammable as both a liquid and a vapor.

IMT had been contracted to remove any residual acetone from the *IB1940*'s cargo tanks, ventilate the tanks, and wipe down any wet spots inside the tanks in preparation for the next load of cargo, which was scheduled to be crude ethanol. This procedure was referred to as a "strip-and-blow cleaning." The stripping process was to be performed using a vacuum truck connected to stripping lines (pipes) aboard the barge to extract residual liquids from the barge's cargo tanks. The blowing process was to be performed using venturi-type air movers, powered by compressed air, to force fresh air into the cargo tanks and expel any residual vapors.[1] These air movers had no moving parts and were typically used for ventilating hazardous areas. At the IMT facility, filtered and dried compressed air was provided to a manifold that ran down the length of the dock, with valve connections for flexible compressed air hoses at various locations on the dock.

Afterward, the atmosphere in the cargo tanks was to be tested with a photoionization detector.[2] Once safe for entry, workers would enter the tanks and wipe up any remaining wet spots with rags. IMT had a three-page standard operating procedure (SOP) that provided guidance for this type of cleaning. The topics addressed included completing all safety checks and paperwork; grounding the barge to the pier; opening and inspecting the cargo tanks for residual product; stripping any residual product with a vacuum truck; and installing inward-facing air movers to force outside air into the cargo tanks. According to the IMT liquid barge manager, acetone had been cleaned from various barges at IMT approximately 100 times.

About 0700 on November 4, the liquid barge manager, who was a credentialed tankerman (qualified to assist or supervise the transfer of liquid cargo), assigned two liquid barge technicians (hereinafter referred to as the first and second technicians) and a new temporary worker to the *IB1940* cleaning project. The workers reviewed and signed a "Table Topper-Every Day Reminder" checklist, which included items such as checking every void tank for water and odors, putting in all scupper plugs, and ensuring two fire extinguishers were available and the emergency shower/eye-wash station and both the ground and winch wires were in place. The safety data sheet for acetone, which highlighted the dangers of the product, was also reviewed, particularly by the temporary worker, since it was his first day on the job. According to the manager, the first and second technicians did not review the SOP because they were "seasoned guys" and they had done "a lot of stripping boats," and the new temporary worker did not review the SOP because he was only to be serving in a support role (retrieving rags and tools) for the technicians and would receive introductory instructions about the barge.

After the morning meeting, the first technician went aboard the *IB1940* and inspected the cargo tanks for acetone by opening the cargo tank hatches and looking inside. He estimated that cargo tank 1 had approximately 300 gallons of residual acetone in it, and cargo tanks 2 and 3 each had approximately 50 gallons in their sumps. He stated that these findings were not recorded in writing and he believed that he reported the quantities verbally to the shipyard superintendent. He then went to work aboard other barges at the facility. The first technician recalled that he told the second technician and the temporary worker to get the air movers in place, but not to connect them

[1] For venting of residual vapors, air movers powered by compressed air with cast-aluminum base housings and galvanized-steel diffusers were used at IMT. The air movers operated on the Venturi effect using compressed air ejected through nozzle jets machined into the castings. The compressed air created a low-pressure zone that induced large volumes of atmospheric air through the base and discharged at a high velocity out the air diffuser (horn) of the air mover.

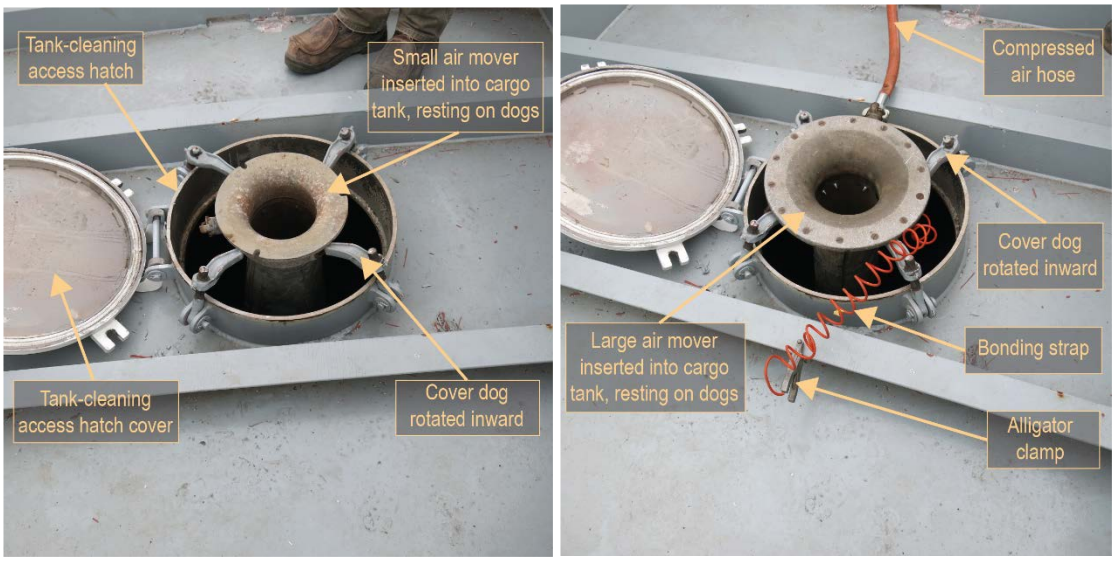
[2] A *photoionization detector* is a handheld portable instrument used to measure atmospheric conditions and is able to detect low concentrations of volatile organic compunds and other gases.

or turn them on. However, the liquid barge manager recalled that he was told that there "was no product on the barge to strip" and the technicians were going to start blowing air into the cargo tanks.

The second technician and the temporary worker began cleaning the holding tank of the vacuum truck in preparation to remove the residual acetone from the *IB1940*. About 0900, while the tank of the truck was being blown out, the second technician and the temporary worker took from the shoreside shop three air movers, recently purchased by IMT. The air movers were previously used but had not yet been put in service by IMT, and this was the first time they were being used at the IMT facility. The technician did not inspect the air movers before use and could not recall if they had bonding straps attached to their frames before use. A bonding strap, when properly connected, is a physical connection between metal parts to ensure electrical continuity and eliminates the risk of electrical discharges that can create safety hazards such as arcing, fire, and explosion.

Types of air movers from IMT's shop used aboard the barge *IB1940* on the morning of the explosion. (Photo taken after the explosion and after new bonding straps were attached to air movers.)

The second technician placed a 6-inch-diameter air mover in the 18-inch tank-cleaning access hatch of cargo tank 3 by inserting the discharge horn into the tank and resting the cast aluminum bell flange on the inward-rotated dogs used to secure the tank. He attached the compressed air connection to the fitting on the side of the air mover.



Demonstration of air-mover-installation methods reconstructed after the accident. Left: Smaller (6-inch diameter) air mover without compressed air hose and bonding wire. Right: Larger (11-inch-diameter) air mover connected with compressed air hose and bonding wire with clamp.

On the pier, the temporary worker opened the valve on the manifold to provide compressed air to the air mover. The technician aboard the barge then placed another 6-inch-diameter air mover

in the hatch of cargo tank 2, and compressed air was turned on; he then placed an 11-inch air mover in cargo tank 1, and compressed air was turned on to that unit. The technician aboard the barge also opened up each of the tank hatches to allow the air from the tanks to vent out. He could not recall if he attached the bonding straps to the barge but did recall that he did not secure the air movers in place with line during installation to avoid movement. After the three air movers were running, both workers went to the forward part of the barge to check the flanges and gaskets on the stripping pipe.

At 0929, as the workers were stepping off the barge *IB1940*, they felt a vibration as the explosion occurred within minutes of the compressed air supply to the air movers being applied. Security video footage from a nearby facility captured the explosion aboard the barge *IB1940* and showed the explosion was located approximately at the center of the barge in the vicinity of cargo tank 2. The workers ran to the IMT facility muster point and were directed to turn off the boiler, which was enclosed in a trailer about 60 feet from the stern of the barge. After hearing the explosion from the office, a shoreside worker called 911 and took a head count of the employees at the muster station. The local fire department arrived on scene and met with the manager. Together, they boarded the barge, which had a small fire at the base of each of the cargo tanks. Using two handheld dry chemical fire extinguishers through the holes created by the explosion, they extinguished the fires in each of the three cargo tanks.

View from nearby facility of the barge *IB1940* on the morning of the explosion. (Source: Illinois and Michigan Oil Company)

A postaccident survey found that the barge *IB1940* sustained extensive damage. The normally rectangular cross-section configuration of the raised cargo tank above the main deck had been bowed out in all directions. There was upward distortion of the tank-top of about five feet over the barge's entire length with numerous transverse tank top stiffeners torn. Several holes were torn in the tank-top plating.

Aerial view of top side of the *IB1940* after the explosion (Source: NBC News Chicago, annotated by NTSB)

The forward bulkhead originally separating cargo tanks 1 and 2 had mostly separated from the tank-top and was displaced forward. The aft bulkhead separating cargo tanks 2 and 3 was mostly detached and was displaced aft into the space of cargo tank 3. Both sides of the barge's hull were buckled in the midship area (cargo tank 2). A diver repaired several holes in the bottom plating to prevent the barge from taking on water and possibly sinking. The barge *IB1940* was determined to be a constructive total loss.

Damage of the *IB1940* after the explosion. Left: Cargo tank 2 showing distorted overhead and bowed forward bulkhead. Right: Exterior view of distorted portside tank bulkhead and raised tank-top.

Additional Information

After the accident, Coast Guard investigators found the air movers in various locations on the barge of the damaged *IB1940*. The two smaller air movers were found on top of cargo tanks 2 and 3. The larger air mover was found on the port side of the barge outboard of cargo tank 1. The two smaller air movers did not have bonding straps attached to their frames, and the spring-loaded bonding (alligator) clamp of the larger air mover was engaged on the securing rope. It is unknown if the smaller air movers had been previously equipped with bonding straps.

Air movers used aboard the *IB1940* and removed after the explosion for inspection. Left: Alligator clip of bonding strap engaged in line of large blower. Center and Right: Small air mover with missing bonding strap.

In the days after the accident, the air movers in IMT's shop were overhauled and outfitted with grounding wires. In a postaccident interview, the second technician (who placed the air movers in the hatches of the *IB1940*) stated that he had never competed a pre-inspection of the air movers and believed he had received some in-house training on establishing a proper ground by digging the ground clamp into the paint, but did not recall any formal training.

Air Mover Procedures. IMT used a variety of models from different manufacturers of air movers at their facility. Both the Facility Operations Manual and manufacturers of the air movers provided safety precautions advising operators to use bonding straps when operating in hazardous locations to prevent static electricity discharges. Also, air movers were required to be secured prior to admitting compressed air to prevent damage or injury from high-reaction force.

At the time of the accident, IMT had written guidance to the workers for tasks related to barge cleaning operations, but these documents did not include all procedures that were identified in the Facility Operations Manual, specifically guidance for bonding air movers to the barge. About two weeks after the accident, IMT updated the SOP for liquid barge strip-and-blow cleanings to a 13-page document, which included instructions for stripping tanks, verifying that that all residual product had been removed from the tanks, inspecting air movers prior to leaving the shop, and ensuring that the bonding strap was attached and tested for electrical continuity between the air mover horn and the bonding clamp. The updated SOP included instructions for the installation of the air movers so that they were secured with line and instructions for ensuring that the air movers were properly bonded to the barge by penetrating the paint and making good contact with the steel. The updated document also required that the compressed air system be blown down to remove moisture and particulates from the system.

In January 2020, the Coast Guard issued Safety Alert 01-20, advising of the dangers of static electricity generated by air moving equipment, which could discharge as an electric arc and ignite a flammable vapor/air mixture. The Coast Guard strongly encouraged that air movers should be properly electrically bonded to vessels, personnel should be trained on properly securing air movers in place to prevent movement, policies should be implemented for proper maintenance of air movers, and supervisors should inspect the installation, bonding, and securement of air movers before operation.

Fire and Explosion Investigation. After the explosion, a fire and explosion investigator conducted an inspection of the barge *IB1940*, air movers, and the facility. During his inspection, he sampled the barge's 3-layered paint, and measured the thickness at .023 inches. Electrical tests were conducted to determine the electrical continuity across the paint sample as well as a painted dog from the tank-cleaning access hatch; neither sample result detected any continuity. The report stated that in order to provide an adequate bond, a cable (or strap) attached to the metal frame of the air mover would need to have a positive connection to bare metal of the barge. If a spring-loaded alligator clip was used, it would need to completely penetrate the paint layer and make contact with the bare metal of the barge.

When inspecting the interior of the compressed air manifold at the facility, the fire investigator found a thin film of water and rust particles and indicated that "the flow of compressed air containing liquid droplets and rust particles would likely generate an electrical charge." The fire investigation report further stated that this electrical charge could accumulate on the air mover if it was not adequately bonded to the barge. A spark of sufficient energy to ignite acetone/air mixtures could then be generated by discharge of the electrical charge stored on the air mover to the steelwork of the barge.

The report determined that it was unlikely that the air mover in cargo tank 2 created a spark by shifting (on the tank-cleaning access hatch dogs) due to motion created by the thrust of the discharge air since the threads of the dogs were found in good condition. Due to the location of the explosion within the tank, it was also unlikely that the air mover fell into the tank. The fire investigator also determined that it would be unlikely that particles ejected from an operational gas-fired boiler located about 100 feet upwind of the opening of the barge's cargo tank 2 would remain sufficiently hot over that distance to cause ignition of the acetone vapors in the cargo tank.

The fire investigator's report concluded that an initial explosion occurred in cargo tank 2, and subsequently propagated fore and aft into cargo tanks 1 and 3. The report identified the likely fuel for the explosion as residual acetone remaining in the cargo tanks, and the likely source of ignition as a static electrical discharge from the air mover that had been placed in the tank-cleaning access hatch of cargo tank 2.

Analysis

Based on a nearby facility's video showing the explosion near the center of the barge in the vicinity of cargo tank 2 and the most severe damage to the barge found in that area, cargo tank 2 was the likely location of the initial explosion. The source of ignition was most likely a static electrical discharge from the air mover that was resting on the painted dogs of the tank-cleaning access hatch of cargo tank 2. The technician who installed the air movers could not recall if they had been bonded to the barge (ensuring that the air mover was properly bonded to bare metal on the barge) but did recall that they had not been tied off to prevent movement. Postaccident testing indicated that resting the cast aluminum bell of the air mover on the four painted dogs of the tank-cleaning access hatch without proper bonding did not provide good electrical bonding between the air mover housing and the barge. An inadequately bonded air mover would allow the accumulation of electrostatic charge generated by the flow of the compressed air stream with water droplets and rust particles. Without a proper bonding connection, a static electrical charge would likely not safely dissipate to the grounded barge, but could instead accumulate, causing a potential spark hazard.

The explosion occurred soon after the air movers were started and before the residual acetone was completely removed from the cargo tanks. When the first technician found acetone in the cargo tanks, he did not record his findings in writing but instead reported them to the shipyard superintendent verbally; the liquid barge manager stated that he was told there was no acetone left on the barge to strip. The quantity of residual acetone remaining in the cargo tanks was not properly communicated amongst the workers, and the air movers should not have been started before the tanks were verified to be completely empty.

The air movers used aboard the barge *IB1940* on the day of the explosion had been recently acquired by IMT, had not yet been put in service, and were not inspected before use on the day of the explosion. Proper inspection of the air movers could have identified operational issues with the air movers such as loose connections and/or issues with the bonding straps. The procedures that were being used by IMT at the time of the accident and were identified in attachments of the Facility Operations Manual did not include the warnings about properly bonding the air movers. Even if there had been adequate procedures, the workers assigned to cleaning the *IB1940* did not review the SOP prior to commencing cleaning operations. If the air movers had been properly bonded to the barge, the risk of a static electrical discharge would have been significantly reduced. After the accident, IMT updated their SOP to include equipment inspection, bonding procedures, and verification.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the explosion aboard the barge *IB1940* was the company's incomplete procedures that did not incorporate the safety instructions included in the Facility Operations Manual regarding the electrical bonding of air movers to barges, resulting in an unbonded air mover being operated in a cargo tank with residual acetone, thereby causing a static electrical discharge, which ignited flammable vapors in the tank.

Bonding of Equipment to Avoid Static Electricity Discharge

Hazardous cargos with flammable vapors are subject to the risk of explosion. Shipboard and shoreside personnel working aboard vessels and barges carrying such cargos should establish and follow procedures for the bonding of all air-moving equipment when venting tanks.

Vessel Particulars

Vessel	*IB1940*
Owner/operator	J O Equipment, LLC
Port of registry	St. Louis, Missouri
Flag	United States
Type	Barge/Bulk Liquid
Year built	2013
Official number (US)	1247565
IMO number	N/A
Classification society	N/A
Construction	Steel
Length	200 ft (61 m)
Beam/width	35 ft (10.7 m)
Draft	N/A
Tonnage	705 GRT
Engine power; manufacturer	N/A
Persons on board	0

NTSB investigators worked closely with our counterparts from Coast Guard Marine Safety Unit Chicago, Illinois, throughout this investigation.

For more details about this accident, visit www.ntsb.gov and search for NTSB accident ID DCA20FM002.

Issued: September 29, 2020