Log# M-32-7C

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 15, 1987

In reply refer to: M-87-27

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President
American Petroleum Institute
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On July 31, 1986, the U.S. tank barge TTT 103 exploded and sank while loading gasoline at the Chevron Oil Refinery in Pascagoula, Mississippi. The tank barge, partially loaded with diesel fuel, burned and spilled the fuel into Bayou Casotte. The fuel ignited and fire spread under the refinery's pier rupturing pipelines and engulfing the shore end of the pier in flames.

A tankerman aboard the TTT 103 at the time of the explosion was thrown into the water. He suffered numerous burns to his face, arms, and back, but managed to make his way to shore and was subsequently taken to a hospital for treatment.

Immediately after the explosion, the Chevron operator on the pier actuated the emergency shut-down system, stopped the flow of products to the pier, and notified refinery officials. He then activated the water and foam fire monitors on the pier and directed them toward the barge. Within 5 to 6 minutes, the refinery's firefighting team was on scene and started to fight the fire.

The TTT 103 sank alongside the pier and was declared a constructive total loss. It was valued at $500,000. Damage to the terminal facilities was estimated to be $4,500,000. 1/

The National Transportation Safety Board investigators could not determine the ignition source from any possible external sources. The tankerman who was on the barge controlling the loading process had an explosion-proof flashlight in his hand and a radio in his back pocket. However, he did not use the radio before the explosion. Furthermore, the tankerman had turned and walked away from the tank before the explosion occurred which suggests that his actions at that specific time did not initiate the explosion. Of the two operators that were on the wharf, one of whom was assisting with the loading of the unleaded gasoline, no one was smoking including two fishermen in a small boat tied to Chevron's mooring dolphin. Adverse weather phenomena, such as thunderstorms and lightning was not a causal factor in the accident. Therefore, the activities in the area just before the explosion provided no evidence of ignition from an external source. Moreover, the circumstances and sequence of events suggest with a high degree of probability that the ignition source was related to the loading process and involved an electrostatic charge.

1/ For more detailed information, read Marine Accident Report--"Explosion Aboard the U.S. Tank Barge TTT 103, Pascagoula, Mississippi, July 31, 1986" (NTSB/MAR-87/06).

Since the explosion occurred moments after the maximum loading or flow rate was started, there is an indication that the explosion was related to the flow process. Additionally, since high and turbulent flow rates can generate static electricity in some products, an electrostatic charge probably accumulated in the tank which was dissipated by an arc.

For an electrostatic charge to have been a source of ignition in the tank, three conditions must have existed:

1. the generation of an electrostatic charge;

2. an accumulation of an electrostatic charge capable of producing an incendiary spark; and

3. a method of discharging the accumulated charge in the form of an electrical arc.

The API Recommended Practice 2003 addresses the known factors that contribute to electrostatic charge generation. These factors include: turbulent flow, splash loading, trace impurities, water, and high velocity flow. Trace quantities of water in a petroleum product are an ideal static generator; however, the evidence indicates that the gasoline contained no water. The tankerman reported that there was vigorous turbulence in the bottom of the tank when the flow was increased to the maximum flow rate. Furthermore, the bellmouth in the tank was not submerged in the gasoline during the initial loading process before the flow rate was increased which contributed to the splashing and turbulence.

API Recommended Practice 2003 states that products (materials) with a conductivity below 50 pS/m are likely to accumulate an electrostatic charge. In such materials, the rate of generation of charge is greater than the rate of dissipation of the charge due to the low conductivity of the material. The electrical conductivity of gasoline is about 25 pS/m. Diesel fuel has a lower conductivity than gasoline and, in this case, was about 5 pS/m. Based on this information, both of these products are classified as static electrical charge accumulators, although API Recommended Practice 2003 does not require initial loading rate restrictions on such highly volatile flammable liquids.

The diesel fuel was reported to have been stripped from the cargo pipelines on the barge before the gasoline was loaded, although the excessive trim of the barge may not have allowed the diesel fuel to be removed completely from the lower longitudinal header. An undetermined amount of diesel fuel may have remained in the pipeline between the stripping line and the drop line from the athwartship deck header. Therefore, as the gasoline began to flow, the diesel fuel would have mixed with gasoline and air in the pipeline. The mixture, most likely would have entered the No. 2 port and starboard tanks first. Consequently, during the turbulent flow related to initial loading operations the diesel fuel, if present, would have contributed to an accumulation of an electrical charge due to its low conductivity. Since the diesel fuel would have been followed by air, gasoline, and perhaps mixtures of air and gasoline in turbulent flow, the electrical charge would not have had an opportunity to dissipate. Furthermore, since unleaded gasoline 2/ also has a conductivity low enough to be classified as a charge accumulator,

2/ Unleaded gasoline is a static electrical charge accumulator, but leaded gasoline is not because of its high conductivity.

the accumulation of a static charge in the gasoline would have continued. Although the presence of diesel fuel in the loading line was not required for electrostatic charge generation, the presence of diesel fuel cannot be eliminated as a contributing factor.

Another condition needed to produce ignition by an electrostatic charge, spark gap, would have been provided by the internal structures in the tanks. These structures would have been at ground potential since the barge was grounded in salt water. When the electrostatically charged fuel of a different potential approached a beam or frame at ground potential, a spark gap would have been created. If the difference in potential between the surfaces of the two elements is sufficiently high, the electrostatic field in the gap between the surfaces is ionized and a rapid discharge (arc) occurs.

The ignition of a hydrocarbon vapor requires an arc of electrical current containing a minimum of about 0.25 millijoules of energy. To obtain this amount of energy from an electrostatic charge, the charge must be dissipated rapidly to create the needed current density. This can most easily be effected by the presence of an electrical conductor to which the electrostatic charge is transferred and collected; the charge is then dissipated in the form of an arc to some other material at a different potential. Although, any evidence was destroyed in the explosion, there may have been a foreign metal object (electrical conductor) in the tank that was not detected on the preloading inspection. Such an object would have absorbed the electrostatic charge from the fuel and would have provided the concentrated source of potential needed to create a spark. Without such a conductor it is more difficult to dissipate the charge rapidly enough to provide sufficient energy in the arc for ignition of flammable vapors.

In summary, the explosion and fire occurred shortly after the flow rate for loading unleaded gasoline was increased to the maximum rate of about 4,500 barrels per hour. Additionally, turbulent flow around the bellmouth in the tanks was present just before the explosion. Consequently, the Safety Board concludes that the following factors contributed to the explosion and fire: (1) a premature high rate of flow from the loading line of gasoline which resulted in a highly turbulent condition in the tank; (2) the generation of an electrostatic charge in the gasoline due to its low electrical conductivity and the highly turbulent flow from the loading line; (3) the presence of a flammable mixture of gasoline/diesel vapor and air due to the unloading process in which gasoline was replaced with air, the hatch covers that were open for a period of time, and the pumping of air into the tanks during the loading operation; and (4) the probability that diesel fuel was added to the tanks during the initial loading. The possible contribution of electrical conducting foreign object(s) in the tank, although not established, could not be overlooked.

The accumulation of an electrostatic charge in volatile products is generally prevented by eliminating static generation factors and adding static dissipation factors. The control of generation factors is accomplished by reducing the inlet flow rate and velocity, by reducing agitation and turbulence in the product, by bottom loading which eliminates free falling or dropping liquids, and by avoiding product contamination. Antistatic additives can be used to increase static dissipation.

Based on recent information from the petroleum industry and Chevron, the Safety Board has determined that loading restrictions at various terminals are being implemented for highly volatile, flammable, low conductivity petroleum products such as gasoline. In fact, Chevron has decided to follow the safety guidelines (ISGOTT) for loading its products rather than the API Recommended Practice 2003. The reason for this change is to improve safety because of two uncertainties that may exist in a loading operation:

(1) deficient equipment such as foreign material in a tank; and (2) unknown operating deficiencies such as a mixed fuel. Furthermore, the Safety Board understands that the API Recommended Practice 2003 probably will be revised based on the explosion and fire that occurred on the TTT 103.

Therefore, as a result of its investigation, the National Transportation Safety Board recommended that the American Petroleum Institute:

> Amend the guidelines found in API Recommended Practice 2003, Fourth Edition, March 1982 for loading of highly volatile flammable liquids to include initial loading rate restrictions. While the amendments to the guidelines are being developed, issue an interim procedure to restrict the initial loading rates of highly volatile flammable liquids. (Class II, Priority Action) (M-87-27)

Also as a result of its investigation, the Safety Board issued Safety Recommendation M-87-21 and -22 to the U.S. Coast Guard, M-87-23 through -25 to Chevron, U.S.A., and M-87-26 to the Petroleum Services Corporation,

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility ". . . to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any actions taken as a result of its safety recommendations and would appreciate a response from you regarding action taken or contemplated with respect to the recommendation in this letter. Please refer to Safety Recommendation M-87-27.

BURNETT, Chairman, GOLDMAN, Vice Chairman, and LAUBER, NALL, and KOLSTAD, Members, concurred in this recommendation.

By: Jim Burnett
Chairman