

A study was conducted at 20 gasoline bulk marketing terminals to determine benzene exposure levels to both Gulf and outside carrier personnel operating at these facilities. Emphasis was placed on breathing zone samples of short duration during loading of trucks at the rack. Racks utilizing various methods of product transfer were surveyed. From the results of the study, it can be seen that the largest employee exposure to benzene occurs at facilities utilizing top loading without vapor recovery. Exposures during loading can exceed 5.0 ppm for short periods but are below 0.5 ppm for an eight-hour time-weighted average.

Benzene exposures during gasoline loading at bulk marketing terminals

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introduction

A study has been conducted at bulk marketing terminals in the east, southeast, and southwestern United States to determine benzene exposure levels for both Gulf and outside carrier personnel operating at these facilities. The overall study was conducted to make an assessment of benzene exposures during loading rack operations.

In an effort to obtain representative personnel exposure data from various methods of loading and control systems, a total of 20 terminals were visited from August 1977 through December 1977. The majority of sampling was done at racks utilizing one of the following three loading methods: top loading without vapor recovery, bottom loading with vapor recovery, and bottom loading without vapor recovery. Since only one rack utilizing top loading with vapor recovery was tested, an inconclusive amount of data was obtained.

benzene in gasoline

Gasoline is a complex mixture of relatively volatile hydrocarbons. The concentration of the various hydrocarbons in finished gasoline depends on the characteristics of the crude oil from which it was refined and on the processing techniques used. Benzene is a volatile aromatic

hydrocarbon present in gasoline that contributes to the antiknock rating of gasoline. However, most domestic refiners find benzene more valuable as a petrochemical feedstock. Therefore, it is separated from gasoline streams, in varying degrees, for other uses.⁽¹⁾ Current data indicate that commercial gasoline in the United States generally contains less than 2.0 lv% (liquid volume percent) benzene.⁽²⁾ Results from this study indicate that the gasoline from locations surveyed contained an average of 1.25 lv% of benzene. At these locations the benzene content ranged from 0.50 to 2.4 lv%.

Exposures to benzene during loading rack operations occur as a result of several actions. A major source of exposure is a result of the gasoline flow into the empty tanker, displacing hydrocarbon vapors. Leaking fill lines and draining of tanks also result in exposures from evaporation of the gasoline.

methods

The study was conducted at various types of loading racks. Emphasis was placed on taking samples at the rack during loading operations because this is the single procedure which offered the highest potential for exposure. A limited number of random samples were taken during unloading operations without regard to



Figure 1 - Top loading operation with no vapor recovery.

the type of facility (service station or bulk plant) where the product was being delivered.

Personnel sampling was performed with the use of Dupont P-200 low flow air sampling pumps. The pumps were calibrated at periodic intervals to assure constant flow. An average sampling rate of 190 ± 10 cc/minute was obtained during the study. The pump was attached directly to the individual being monitored and vapors were drawn through a 100 mg charcoal tube with a 50 mg backup section placed as close to the individual's breathing zone as possible.

analysis

All sample analysis was done by the Gulf Industrial Hygiene Laboratory, an AIHA accredited laboratory. Charcoal tubes were analyzed by NIOSH Method No.: P & CAM 127¹⁴ for organic solvents in air. The basic procedure for this method is adsorption of vapors on charcoal, desorption with carbon disulfide and analysis with a gas chromatograph.

A Hewlett-Packard 3354 laboratory automation system with automatic sample injectors was used to analyze the samples. Teflon[®] sealed valves were used in the sample vials to prevent any atmospheric contamination. A recalibration standard was run on each chromatograph after every 10 injections. Gasoline samples were analyzed for liquid

volume percent benzene utilizing gas chromatography with a highly polar stationary phase column.

operations

At bulk marketing terminals various grades of gasoline (regular, unleaded, and premium) are brought to the facility via pipeline, ship or barge, pumped into storage tanks and subsequently to the loading rack. They are then transferred to tank trucks at a rate of 1135.6 to 2271.2 Lpm (300 to 600 gpm). The initial transfer method is dependent on the location of the facility (inland or coastal) and the method of transfer to the truck is controlled by the type of loading rack. Truck loads ranged from 29,526 to 32,555 L (7800 to 8600 gal). The variation in load volumes is a reflection of the load restrictions set by the individual states.

Regardless of the type of loading rack the initial step taken by the driver is to connect a static line to the trailer in order to complete a positive ground. Without this connection, static build-up could cause an explosion.

At top loading facilities, driver/salesmen use overhead arms with telescoping tubes to fill each compartment with product. The manually operated pump activation lever is located at the rack end of the telescoping tube so the driver/salesman does not have to stand over the compartment port on the truck while loading



Figure 2 - Typical bottom loading facility



Figure 3 - Operator shacks at bottom-loading facility

(Figure 1). A metering system is also located on the rack itself to indicate the volume of product loaded. The lack of an automatic loading system at these facilities allows only one compartment to be loaded at a time. During loading, gasoline vapors are vented through the open compartment hatches.

The bottom loading facilities (with and without vapor recovery) have loading arms with flexible tubes which connect to self sealing valves on the side of the tank truck. Each of the filling tubes have an automatic metering system which is set by the driver-salesman to prevent spillover. A backup sensor is in each truck compartment to

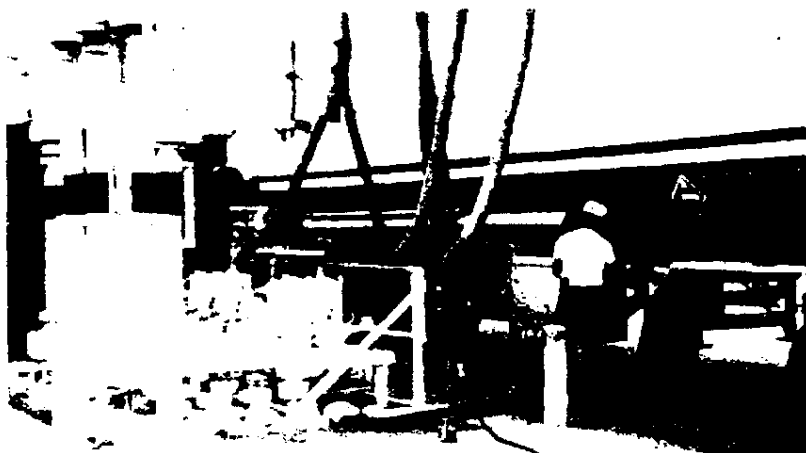


Figure 4 - Driver attaching vapor recovery line.

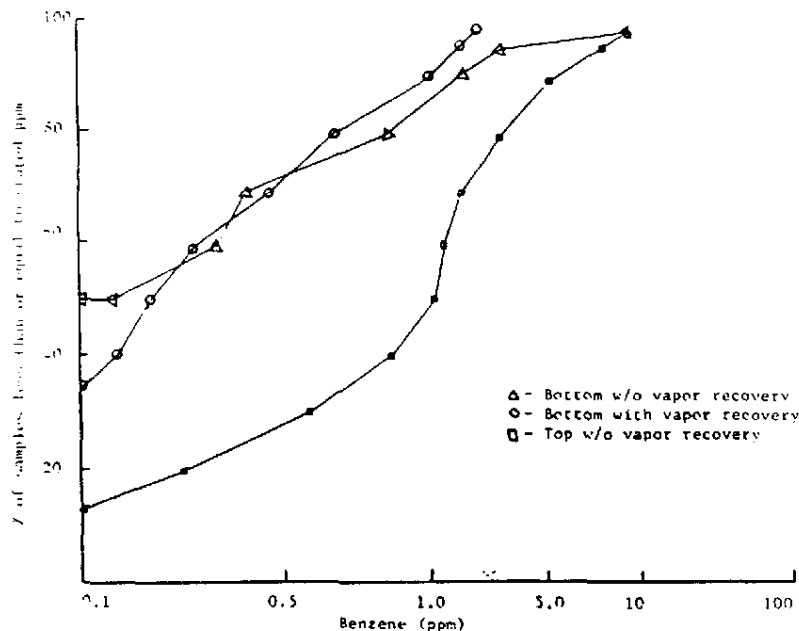


Figure 5 — Cumulative frequency plot of benzene exposures during loading at marketing terminals.

reduce further the possibility of spillover and allow as many as five compartments to be loaded simultaneously (Figure 2). The system is activated by a dead-man button located in an operator shack adjacent to the filling tubes (Figure 3). At the bottom loading facilities, gasoline vapors are dispelled through vents on the top of the truck or through a vapor recovery system attached to a vent on the side of the truck (Figure 4).

Driver/salesmen load product from two to six times a shift depending on their delivery assignments, but three to four loads is most common.

At all of the facilities, regardless of the loading configuration, there are a variety of inherent factors that are capable of producing significant variability in the sample results. These factors include:

- 1) Method of loading
- 2) Position of the pump activation lever or dead-man button
- 3) The existence and position of an operator shack
- 4) Wind speed and direction
- 5) Temperature and humidity

- 6) Type and position of roof overhang
- 7) Individual driver idiosyncracies

results

Emphasis was placed on samples of short duration, 15 to 45 minutes, during loading of the trucks at the rack because this is the operation which presents the largest potential for exposure to the driver/salesman. Through observations and measurements it was determined that during offloading at delivery points and while driving there is little potential for benzene exposure.

Exposure data from the 20 terminals surveyed was grouped according to the method of loading used and plotted on a cumulative frequency diagram (Figure 5). From the results of the study it can be seen that the largest potential for employee exposure to benzene occurs at facilities utilizing top loading without vapor recovery. Operations at bottom loading racks, with and without vapor recovery, result in significantly lower benzene exposures.

At top loading facilities without vapor recovery, 95 percent of the benzene exposures during loading were below 8.5 ppm. At bottom loading facilities without vapor recovery, 95

TABLE I
Summary of Benzene Exposures During Loading at Bulk Marketing Terminals

Terminal Type	Mean Benzene Exposure During Loading (ppm)	Standard Error of Mean	Median	Average Loading Time	Calculated 8-Hour TWA	
					3 Trips	4 Trips
Top Loading Without Vapor Recovery	2.29	0.25	1.1	20 minutes	0.29	0.38
Bottom Loading Without Vapor Recovery	1.04	0.27	0.14	18 minutes	0.11	0.15
Bottom Loading With Vapor Recovery	0.57	0.13	0.22	15 minutes	0.05	0.07

percent of the exposures were below 3.5 ppm, and at bottom loading facilities with vapor recovery 95 percent of the exposures during loading were below 1.8 ppm.

As a result of the study the average exposure during loading at each type of rack is known. With this data, knowing the average loading time for each type of facility and the number of times a driver/salesman is at the rack each day, an eight-hour time-weighted average exposure can be calculated. Table I shows the results of this calculation for three and four loading operations daily. In making these calculations zero exposure was assumed for operations away from the rack.

Driver-salesmen do experience nominal exposure to benzene during off-loading at delivery points. Although a small amount of data was collected during these procedures, the results indicate that the exposure potential is minimal. These measurements were made without regard to the type of facility where the product was being delivered. The overall average for these measurements was 0.35 ppm.

discussion

The higher benzene exposures at top loading racks appear to be mainly attributable to driver position during loading. Drivers at both types of bottom loading facilities use self-sealing valve hook-ups and must engage a dead-man button away from the truck to load. Drivers at the top loading facilities without vapor recovery must stand on top or adjacent to their transports and are exposed to gasoline vapors being vented during the entire loading period.

In some cases, higher than normal exposures at bottom loading facilities were found to be the result of loading tankers equipped with vapor recovery hardware while no vapor recovery system was installed at the rack. In these cases, the vapors were exhausted from the dome lids, carried through pipe to the rear of the transport where they were released through the vent to which the vapor recovery system would have been connected. This venting leads to increased vapor concentrations in the rack area where drivers must remain for the loading operation, resulting in higher than normal benzene exposures.

conclusions

Based on the results of this study, the following conclusions are made:

- a) Operations at facilities utilizing top loading without vapor recovery result in the highest benzene exposures.
- b) Operations at bottom loading facilities, with or without vapor recovery systems result in similar benzene exposures.
- c) In all cases, regardless of type of facility, the calculated 8-hour TWA exposures were well below 0.5 ppm. This was true even when using the upper 95% confidence limit numbers in the calculations.

acknowledgements

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