APPENDIX I

Comparison of Spill Frequencies and Amounts at Vapor Recovery and Conventional Service Stations In California

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Comparison of Spill Frequencies and Amounts at Vapor Recovery and Conventional Service Stations in California

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Based on a survey conducted in 1989 and 1990 at 21 conventional nozzle and 33 vapor recovery nozzle equipped service stations in California, the California Air Resources Board staff conclude that conventional nozzles in California produce a greater number of quantifiable spills (≥ 1 ml) and a greater average volume per spill than do vapor recovery equipped nozzles. This conclusion is based on survey results showing conventional nozzles having spills 30.3 percent of the time at four fueling intervals vs 22.3 percent for vapor recovery nozzles, and having an average spill volume of 13.3 ml vs 10.6 ml for vapor recovery nozzles. However, if spillage noted from a conventional nozzle during a very large spill event is subtracted from the total quantified spill volume, the average volume per quantifiable spill for a conventional nozzle would drop to 11.0 ml. This value is very close to the 10.6 ml average volume per quantifiable spill with a vapor recovery nozzle. In addition, conventional nozzles in California produce about 14 percent more drop (<1 ml) spillage than do vapor recovery nozzles. Drop spillage has not been quantified as to the volume of gasoline it represents.

Starting in 1976, air pollution control districts (APCDs) in California with major metropolitan areas began adopting rules to control the release of gasoline vapors (a precursor to the formation of ozone) during the filling of vehicle gasoline tanks at retail service stations in the districts. APCDs requiring such equipment typically had not attained the California or federal ambient air quality standard for ozone. Equipment controlling the release of gasoline vapors during the fueling of vehicles is referred to as "Phase II vapor recovery equipment." Most vapor recovery nozzles can be distinguished from conventional nozzles by a rubber-type boot around the nozzle spout that is used to capture gasoline vapors escaping from a vehicle fuel tank. By 1986, 90 percent of the gasoline sold in California was dispensed through retail service stations equipped with Phase II controls.

In 1988 the California Air Resources Board (CARB) required *all* APCDs in the state to adopt rules that required the installation of Phase II vapor recovery equipment at new retail service stations and at existing retail stations with an annual gasoline throughput of greater than 480,000 gallons. Such equipment was required in order to control the release of emissions of benzene, which had previously been identified by the CARB as a toxic and cancer-causing pollutant. Thus, those districts in California that had not previously required installation of Phase II equipment were now required to do so. Compliance with this requirement by affected existing stations was to be accomplished within two years after adoption of an appropriate rule by a district. As noted above, many of California's districts were already complying with the new requirements.

What the new requirements mean is that by the beginning of 1991, a very large majority of retail service stations in California will not have conventional nozzles but will have vapor recovery nozzles. This trend will increase as the years go by.

Since the first installation and use of Phase II vapor recovery nozzles in California, the CARB initially received a considerable number of complaints about the difficulty in using these nozzles and about possible excess spillage with their use. Consequently, suppliers of the Phase II equipment have been in a continual process of refining the design of this equipment in order to increase its ease of use and to decrease spillage.

Because in the near future only a relatively small number of retail service stations in California will be equipped with conventional nozzles, CARB management decided it was time to conduct a comparison study on the spillage potential of conventional and vapor recovery nozzles in California. The purpose of the study was to determine the spillage frequency and amounts associated with the two types of nozzles.

Implications

In deciding whether to pursue vapor recovery nozzles at service stations or on-board vapor control in vehicles as a means to reduce hydrocarbon emissions during vehicle refueling, policy makers need to consider, among other things, gasoline spillage associated with conventional vs vapor recovery nozzles. Such information is also useful in explaining to the general public the possible advantages of vapor recovery nozzles. In addition, Table 4.4–7 of AP-42 does not differentiate between spillage losses from vapor recovery nozzles and conventional nozzles. A study was conducted by California Air Resources Board staff at conventional and vapor recovery nozzle equipped service stations in California. Vapor recovery nozzles were found to produce fewer spills and spillage amounts, and spillage losses per 1000 gallons of station throughput were calculated for each type of nozzle.

Subsequently, from July 1989 to February 1990, staff of the Compliance Division of CARB, after receiving proper training, were dispatched to numerous service stations in California in order to observe and document fuelings at these stations and any related spills. The methodology and results of this study are documented in this paper, along with subsequent conclusions.

Methodology

Pre-Survey Experimentation

Defining a Gasoline Spill. In theory, a gasoline spill at a service station can be defined in many ways:

- As the point in the refueling process where the spillage occurs (pre-fuel, fueling, shutoff, post-fuel), and each point constitutes a separate spill.
- As spilled gasoline on the side of a vehicle.
- As small drops the sizes of dimes, quarters, and half dollars which have fallen onto the concrete surface of the station.
- As a certain measurable area of spilled gasoline on the concrete surface that can be easily, accurately, and consistently related back to a specific volume of spilled gasoline.
- As spillage of any kind at any point during the fueling process that is agglomerated and constitutes one spill.

In order to help define a spill, staff of the California Air Resources Board's (CARB) Compliance Division conducted experiments at service stations in the Sacramento area of California, where various volumes of gasoline were spilled from a graduated cylinder, from a set height (30 in.), onto the concrete surface. Staff discovered that the smallest, best continuous measurable spill (in square inches) that was quantifiable (in milliliters) was 1 ml. Below that volume, the gasoline tended to stick to the walls of the graduated cylinder, and the amount that did spill tended to disperse into scattered spots on the concrete surface. It was also noted that spills of 1 ml or greater produced a temporary stain that could be measured after the person finished refueling her or his vehicle. Consequently, staff decided to define a spill, in part, as that volume of spilled gasoline that produced a stained area (sometimes with gasoline on it) on the concrete surface that was equivalent to 1 ml or greater of gasoline.

Staff was also very concerned about *when* in the fueling cycle a spill occurred; so staff decided to define a spill in terms of when it occurred:

- Pre-fuel, which includes removing the nozzle from the dispenser and inserting it into the vehicle fill pipe.
- Fueling, which includes the dispensing process from start to the nozzle shut-off phase.
- Shut-off, which includes any spills which occur at nozzle shut-off either by automatic or customer controlled shut-off.
- Post-fuel, which includes any spillage occurring during removal of the nozzle from the vehicle to hanging the nozzle up on the dispenser.

Furthermore, staff also decided that spillage at any one of these intervals would be counted as a separate spill.

Another phenomenon observed during experimentation of measuring spills was gasoline that spilled on the side of a vehicle during the refueling process but never fell to the drive surface. Experimentation was conducted on vehicles to see if gasoline spilled on the vehicle from the fill pipe opening to the bottom of the body of the vehicle could be measured and quantified. It was discovered that such variables as the fill pipe height, shape of the vehicle's body, amount of roll-under of the vehicle (the point where the body of the vehicle slopes inward), condition of the vehicle's paint, and how much dirt was on the vehicle influenced the retention of any gasoline spilled on the vehicle downward from the fill pipe opening. It was not possible, however, to obtain a constant measurable amount that spilled on the vehicle surface.

Nevertheless, it was determined from the experimentation that the spills varied from one to three milliliters before they would drip off onto the drive surface as drips or measurable spills. Therefore, to account for spills on the vehicle, staff decided to use a symbol "V" on the survey form to indicate a vehicle spill of from one to three milliliters. In quantifying the volume associated with "V" spills, Compliance Division management decided that an average of two milliliters per spill would be used.

Although drops of gasoline (less than 1 ml) that fall from the nozzle or possibly from the side of a vehicle constitute spillage, our pre-survey experimentation indicated it was difficult to relate drop-area size to a known volume of spilled gasoline. In addition, spilled drops on the surface evaporated quickly. To address in some way the phenomenon of drops spilled, staff decided to simply count them during the survey and enter, on the survey form, the number of drops that occurred at each of the fueling intervals.

Variables Affecting or Not Affecting Spill Surface Area. The variable that had the greatest effect on the area of any gasoline spilled was the drive surface surrounding the gasoline dispenser islands where the vehicles parked while being refueled. This was due to the porosity and surface condition which affected the absorbency of the drive surface. This was always concrete. We found that there was no constant regarding the concrete conditions; therefore, we decided to do a measured spill at each service station prior to conducting the survey.

The other variable that influenced the spill surface area was the height at which the measured gasoline was poured onto the concrete drive surface. Accordingly, we decided to use a constant measured spill height of 30 inches. This height takes into account the various heights of vehicle fill pipes and the various locations of the fill pipes on different vehicles.

It was also determined during experimentation that temperature and wind did not play an effective variable in the spill process, but did effect the speed in the evaporation of the spilled gasoline. Therefore, staff decided not to collect temperature and wind data as part of the data collected for the survey.

Gasoline Service Station Selection

The process of selecting service stations having either vapor recovery or conventional nozzles was made as economically as possible by choosing stations as close to the ARB Compliance Division office as possible. This office is located in Sacramento, California. By driving around, the project leader for the survey developed a list of vapor recovery stations for the City of Sacramento (a large metropolitan area) and a list of conventional nozzle stations located in smaller cities and communities in the Sacramento Valley from Arbuckle to Redding, California (Redding was the largest). The only selection criteria used was that the service station be close to a major road or freeway to help ensure that the station would be busy and that a cross-section of the types of people in California would be using the pumps at the stations. Service stations in Sacramento have been required to use vapor recovery nozzles and related equipment since 1980. So people in this city have been exposed to using the equipment for a considerable length of time.

Training of Observers

The training included classroom and field training at service stations for all the members of the survey team (nine people). The training was conducted solely by the project leader in order to minimize any variables in the data collection. Team members were instructed on how to fill out the two types of forms to be used in the survey: the "Service Station Surface Spill Survey Form" and the "Vehicle Fuel Spill Survey Form." The service station form contained entry spaces for such information as inspector name, date, station name, type of surface at the station, and results of spill testing of various volumes of gasoline. The spill survey form contained entry spaces for such information as station data, types of nozzles used, type of vehicle that refueled, fill pipe location, gallons dispensed, whether customer topped off, type of spillage, etc.

All members practiced spilling measured volumes of gasoline (1, 2, 3, 5, 10, 20, and 50 ml) and measuring the surface area of the ensuing spill. These benchmark surface areas and related volumes, when done at the station, would serve as guides for judging the area and volume of any spill. Team members were also told to document the following on the spill survey form: (1) all spills of 1 ml or greater; (2) the number of drops that were spilled at each phase of the fueling process; and (3) gasoline spilled on the side of a vehicle with a "V" symbol.

The project leader informed the team that he would monitor each member's methodology during the first time at a service station in order to ensure that all members conducted the benchmark spill tests and that they measured and recorded any spills according to the established procedure. Periodically, the project leader expected to monitor the performance of the survey members in order to ensure consistency in the methodology.

One important final point: Compliance Division management had decided that it wished to obtain "real world" data at a station, i.e., with the station in the "as is" condition. Consequently, team members were instructed not to give station operators advance notice of the survey. This no-notice criterion is based on prior experience that advance notice can cause excessive maintenance to be performed on the equipment prior to a survey. In addition, the service station operators were to be told that an inspection of the use of the refueling equipment was being conducted rather than a gasoline spill survey. This statement was to be made in order to reduce the chance of bias results of any full-serve refueling operation.

Field Observations

During the period of July 25, 1989 through January 11, 1990, teams of one, two, and three persons were sent by the spill project team leader to 33 vapor recovery stations in the Sacramento, California area to observe spillages of gasoline and to record their findings. Thirty-seven separate visits were made at these stations because some stations were visited more than once. All of the vapor-recovery nozzle equipment that was observed for spills was in good working order. Ninety-seven percent of the observed fuelings were at self service pumps.

The vapor recovery nozzle equipped service stations were predominately balance-type systems. Of the 33 vapor recovery equipped service stations, 31 were of the balance type, one Hirt vacuum assist type, and one Healy assist type. Of the 31 balance-equipped service stations, seven were equipped or partially equipped with OPW balance equipment while the remainder used Emco Wheaton balance equipment.

During the period of September 19, 1989 through November 17, 1989, one and two person teams were sent to 21 conventional nozzle stations along the Interstate 5 freeway in the Sacramento Valley to observe for spillages of gasoline and to record their findings. One station was visited in Arbuckle, three in Williams, one in Orland, 13 in Redding, and three in Red Bluff, California. All of the conventional nozzle equipment that was observed for spills was in good working order. Ninety-seven percent of the observed fuelings were at self service pumps.

The conventional nozzle equipped service stations used equipment manufactured by Emco Wheaton, OPW, Husky, Catlow, Carder, Viking and other equipment which could not be identified. It was also observed that in conventional nozzle equipped stations, a mix of nozzle manufacturers' equipment was used as a normal practice, whereas in vapor recovery nozzle equipped service stations, one manufacturer's equipment was usually used.

All the members of the survey team were equipped with safety equipment, proper forms, and measuring devices for conducting spills and measuring spills during refueling of vehicles. The members were also equipped with clean-up equipment for the gasoline that was spilled in order to determine spill size. In observing the fueling operation, staff placed themselves as close to the vehicle as possible without interfering with the fueling process. When a spill judged to be greater than or equal to one milliliter was observed, staff measured its dimensions with a tape measure, calculated the surface area, and then compared that area with the benchmark surface areas established for 1, 2, 3, 5, 10, 20, and 50 milliliter spills when the staff first arrived at the station. This comparison was done to arrive at the closest approximation of the volume of the spill. "V" spills and number of drops observed were also documented on the survey form.

Results

Spill Frequencies and Amounts of Spills

Spills One Milliliter or Greater (Measurable Spills). Table I presents the number and percentage of fuelings with measurable spills at the four fueling intervals for vapor recovery and conventional nozzle systems.

Table I. Number and percentage of fuelings with measurable spills.

Service station type	Number of fuelings	Number of measurable spills at four fueling intervals	Percent of fuelings with measurable spills
Vapor recovery	1515	232	15.3
Conventional	1496	249	16.6

As Table I indicates, a greater percentage of conventional nozzles had measurable spills associated with them at the four fueling intervals than did vapor recovery equipped nozzles.

Table II presents the total volume of the measurable spills that occurred during the four fueling intervals and the volume of an average measurable spill for both conventional and vapor recovery nozzle systems.

Table II. Total volume of measurable spills and average volume per spill.

Type of fueling	Number of measurable spills at four fueling intervals	Total volume of measurable spills	Average volume per spill
Vapor recovery	232	3373 ml	14.5 ml
Conventional	249	5618 ml	22.6 ml

As Table II indicates, conventional nozzles had a greater volume of measurable spillage associated with them than did vapor-recovery equipped nozzles.

A very large spillage event occurred while observing conventional fuelings. This event produced two large spills (one during fueling, one during shutoff at a single fueling) that accounted for approximately 19 percent of the total amount of measurable gasoline spilled by conventional nozzles. However, even had this event not occurred, the total measurable amount spilled would be 4575 milliliters, and an average measurable spill would be 18.4 milliliters, which is still greater than the measurable spillage from vapor recovery nozzles.

A description of this event follows: During the fueling process the customer had control of the nozzle, but the nozzle kept slipping out of the vehicle fill pipe, allowing a large amount of gasoline to be spilled on the concrete. Subsequently, after the customer got the nozzle to stay inserted, he put the fillpipe cap under the trigger of the nozzle to keep it operating by itself. When the nozzle was supposed to shut off because the tank was full of gasoline, the nozzle did not shut off, and gasoline kept spilling on the concrete surface until the customer took action to stop the flow from the nozzle.

Vapor recovery nozzles have latching devices which keep the nozzle inserted in the vehicle fillpipe. In addition, vapor recovery nozzles have a secondary shutoff system in case the primary fails. Also, vapor recovery balance nozzles have an interlock system which prevents gasoline from being dispensed unless the boot is compressed, such as occurs when the nozzle is inserted into a vehicle fill pipe. These design features of vapor recovery nozzles help reduce spillage.

"V" Spills. In addition to the measurable spillage on the concrete that occurred, there was also spillage that occurred on the vehicle itself during some of the refuelings. As noted earlier, these spills were called "V" spills. Table III, as follows, presents the number and percentage of "V" spills that occurred during the four types of fueling intervals.

Table III. Number and percentage of fuelings with "V" spills.

Service station type	Number of fuelings	Number of "V" spills at four fueling intervals	Fuelings with "V" spills (%)	Total volume of "V" spills
Vapor recovery	1515	106	7.0	212 ml
Conventional	1496	205	13.7	410 ml

Measurable and "V" Spills Combined (Quantifiable Spills). Combining the measurable spills that reach the concrete of the service station surface with the "V" spills that occur on the side of the vehicle gives one the total percentage and volume of spills, greater than one milliliter, that staff observed during the survey. This combination is referred to as quantifiable spills. Table IV, as follows, presents the number, percent, and average volume of quantifiable spills observed during the four fueling intervals of the survey.

Table IV. Number, percent, and average volume of quantifiable spills observed during the survey.

Type of fueling	Number & percent of fueling intervals with quantifiable spills	Total amount of quantified spill	Average volume per spill
Vapor recovery	338 (22.3%)	3585 ml	10.6 ml
Conventional	454 (30.3%)	6028 ml	13.3 ml

As can be seen in Table IV, conventional nozzles produce a greater number of quantifiable spills and a greater average volume per spill than do vapor recovery equipped nozzles. However, if the large-event spillage from a conventional nozzle discussed in Table II above is subtracted from the total quantified spill volume of Table IV (6028 ml − 1043 ml = 4985 ml), the average volume per quantifiable spill for conventional nozzles would drop to 11.0 ml. This value is very close to the average volume per quantifiable spill with a vapor recovery nozzle.

Drops of Fuel. One of the observations made by the staff during the survey was to document the number of drops of gasoline that splattered on the concrete surface of the service station during the survey. The majority of these drops were the size of a dime to a quarter but some were larger. All were judged to have a surface area equivalent, usually, to much less than one milliliter, which was the spill size counted by the staff. However, drops were very numerous, as is depicted in Table V that follows.

Table V. Instances and number of drops of gasoline observed during the survey.

Type of fueling	Number of fuelings	Instances of drops during the four fueling intervals	Total number of drops occurring during the four fueling intervals
Vapor Recovery	1515	512 (34%)*	2498 (43%)**
Conventional	1496	688 (46%)*	3352 (57%)**

* Calculated as a percentage of total fuelings.
** Calculated as a percentage of total drops that occurred with both conventional and vapor recovery nozzles.

As Table V indicates, the instances of drops occurring during the four fueling intervals and the total number of drops that occurred during these intervals happened more often with conventional nozzles than with the vapor recovery nozzles.

Number and Volume of Spills, and Number of Drops During Fueling Intervals. As noted earlier in the methodology section, staff observed spills at the four different fueling intervals: pre-fuel, fueling, shutoff, and post-fuel. At each interval, staff documented whether a "V" spill occurred, a one milliliter or greater spill occurred, and whether drops occurred. The following table, Table VI, presents the number of instances that spills and drops occurred in each fueling interval. The notations "V" and "M" (for milliliter) are used for spills, and "D" is used for drops. Subsequently, Table VII presents similar information for the total volume of spills and the total number of drops that occurred at each of the fueling intervals.

As revealed by Tables VI and VII, conventional nozzles in California are most likely, first, to produce measurable spills and "V" spills during the shutoff interval, and second, during the post-fuel interval. Vapor recovery nozzles are most likely, first, to produce measurable spills and "V" spills during the post-fuel interval, and second, to produce measurable spills during the fueling interval and "V" spills during the shutoff interval. We believe the higher percentage of spills produced by conventional nozzles in the shutoff interval may be due (1) to a higher gasoline dispensing rate observed with these nozzles during the survey than observed with vapor recovery nozzles (8.3 gal/min vs 6.9 gal/min), and (2) to the fact that CARB certified vapor-recovery nozzles are required to meet more stringent shutoff criteria than conventional nozzles.

These tables also indicate that a significantly large number of drops produced by both vapor recovery and conventional nozzles occur during the post-fuel interval of fueling.

Table VI. Number of instances of spills and drops in each fueling interval.

Type of fueling	Number of instances of spills or drops											
	Pre-fuel			Fueling			Shutoff			Post-fuel		
	V	M	D	V	M	D	V	M	D	V	M	D
Vapor recovery	6	35	30	19	35	2	21	25	5	60	137	475
Conventional	6	11	47	19	38	4	105	138	23	75	62	614

Table VII. Total spill volume and number of drops in each fueling interval.

Type of fueling	Total spill volume (in ml) and Total number of drops											
	Pre-fuel			Fueling			Shutoff			Post-fuel		
	V	M	D	V	M	D	V	M	D	V	M	D
Vapor recovery	12	432	124	38	1121	3	42	839	14	120	981	2357
Conventional	12	65	173	38	1662	35	210	3563	92	150	328	3052

Spill Frequency and Average Volume When All Measurable and "V" Spills (One or Several) Occurring During the Fueling Process Are Defined as One Spill Only. For the spill survey discussed in this paper, the method chosen and used for counting the number of spills was to count each measurable or "V" spill observed at one of the four fueling intervals as a separate spill. After conducting the survey, we discovered that the American Petroleum Institute (API) had conducted a spill survey slightly earlier than ours in the Washington, D.C. and Baltimore, Maryland areas. However, API counted all kinds of spills on the concrete surface—from a single small-drop splash to a spill of many milliliters to a combination of spills at various fueling intervals—as one spill only per fueling. API did not count "V" spills on the side of a vehicle as being spills, however.

We were curious how using such a methodology would affect the frequency and average volume of spills we found with the two types of nozzle systems studied (vapor recovery and conventional). So we reviewed our survey data and recounted all measurable "M" and "V" spills that occurred during the fueling process as one spill only per fueling (i.e., a "V" spill and a one milliliter spill at each of the four fueling intervals would equal only one spill during the fueling process). As we did with our original counting procedure, we added up all volumes associated with individual "M" and "V" spills during the fueling process. Our results using the new definition for a spill are presented in Table VIII as follows. Because API did a statistical analysis of the spill data it developed, we also did a standard statistical analysis of the two spill frequency percentages (16.6 percent vs 20.7 percent) that we found using the API definition of a spill.

Table VIII. Number, percent, and average volume of spill using concept of one spill only per fueling.

Fueling type	Number of fuelings	Number and percent of fuelings with one spill only per fueling	Total spill volume	Average volume per spill
Vapor recovery	1515	251 (16.6%)	3585 ml	14.3 ml
Conventional	1496	310 (20.7%)	6028 ml	19.4 ml

As shown in Table VIII, our using the concept of one spill only per fueling produces data that indicates that conventional nozzles engender a greater percentage of spills and a greater average volume per spill than do vapor recovery nozzles. This is the same conclusion that we reached using our survey's original definition of a spill. The difference in the percentage of spills between conventional and vapor recovery nozzles is also statistically significant. If the large-event spillage from a conventional nozzle discussed in Tables II and IV is subtracted from the total spill volume for conventional nozzles presented in Table VIII, the average volume per quantifiable spill for conventional nozzles would drop to 16.1 ml. This value is fairly close to the average volume per spill with a vapor recovery nozzle (14.3 ml). This conclusion is approximately the same one that we reached with our survey's original definition of a spill.

Spillage Loss Per 1000 Gallons of Throughput

AP-42, the Environmental Protection Agency document containing air pollutant emission factors (Supplement C, September 1990), lists spillage of gasoline from gasoline service stations as 0.7 lb per 1000 gallons of throughput (Table 4.4–7). This spillage loss does not differentiate between losses from vapor recovery nozzle stations and conventional nozzle stations.

Based on the spillage amounts documented by our survey, we calculated the spillage losses per 1000 gallons of throughput for both vapor recovery and conventional nozzle stations. Our calculations are as follows:

Vapor Recovery Nozzle Stations.

Given:

3585 ml gasoline spilled per 14,043 gal gasoline dispensed during survey observations

1 gal of gasoline = 3785.30 ml of gasoline

1 gal of gasoline weighs 6.20 lb

Thus:

$$\frac{3585}{14{,}043} \times \frac{1}{3785.30} \times \frac{6.20}{1} = 0.00042 \text{ lb spillage/gal disp.}$$

$$0.00042 \times 1000 \text{ gal}$$

$$= 0.42 \text{ lb spillage/1000 gal throughput}$$

Conventional Nozzle Stations.

Given:

6028 ml gasoline spilled per 16,200 gal dispensed during survey observations

1 gal of gasoline = 3785.30 ml of gasoline

1 gal of gasoline weighs 6.20 lb

Thus:

$$\frac{6028}{16{,}200} \times \frac{1}{3785.30} \times \frac{6.20}{1} = 0.00061 \text{ lb spillage/gal disp.}$$

$$0.00061 \times 1000 \text{ gal}$$

$$= 0.61 \text{ lb spillage/1000 gal throughput}$$

Conclusions

Based on California survey data, conventional nozzles in California produce a greater number of quantifiable spills (≥ 1 ml) and a greater average volume per spill than do vapor recovery equipped nozzles. However, if spillage noted from a conventional nozzle during a very large spill event (producing approximately 19 percent of measurable spillage with conventional nozzles) is subtracted from the total quantified spill volume, the average volume per quantifiable spill for a conventional nozzle would drop to 11.0 ml, which is very close to the 10.6 ml average volume per quantifiable spill with a vapor recovery nozzle. In addition, conventional nozzles in California produce about 14 percent more drop (<1 ml) spillage than do vapor recovery nozzles. Drop spillage has not been quantified as to the volume of gasoline it represents.

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