REPORT OF THE
DEPARTMENT OF AIR POLLUTION CONTROL

Study of the Use of State II Vapor Recovery Systems: Analysis of Costs and Benefits

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

HOUSE DOCUMENT NO. 50

COMMONWEALTH OF VIRGINIA
RICHMOND
1992

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WALLACE N. DAVIS
EXECUTIVE DIRECTOR

February 3, 1992

TO: The Honorable L. Douglas Wilder, Governor of Virginia, and Members of the General Assembly

Pursuant to House Joint Resolution 415, the attached report on the use of Stage II vapor recovery systems has been prepared. This resolution directed the Department of Air Pollution Control to study the use of Stage II vapor recovery systems for controlling gasoline vapors released during the fueling of motor vehicles at service stations. Specifically, HJR 415 requested that the study include an analysis of the costs and benefits of such a program to the environment, public health, and industry.

We are pleased to submit this report entitled "Study of The Use of Stage II Vapor Recovery Systems: Analysis of Costs and Benefits."

Sincerely,

Wallace N. Davis

Wallace N. Davis
Executive Director

VIRGINIA DEPARTMENT OF AIR POLLUTION CONTROL

STUDY OF THE USE OF

STAGE II VAPOR RECOVERY SYSTEMS:

ANALYSIS OF COSTS AND BENEFITS

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February 3, 1992

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EXECUTIVE SUMMARY

In 1990, the Virginia General Assembly adopted House Joint Resolution 415. This resolution directed the Virginia Department of Air Pollution Control (DAPC) to study the use of Stage II vapor recovery systems for controlling gasoline vapors released during the fueling of motor vehicles at service stations. Specifically, HJR 415 requested that the study include an analysis of the costs and benefits of such a program to the environment, public health, and industry.

Gasoline vapors are emitted into the air in substantial amounts during the transfer of gasoline from one container to another. Two types of control systems (Stage I and Stage II) are available to prevent vapors from being emitted during the transfer of gasoline products to and from above-ground storage tanks, transfer trucks, underground storage tanks, and motor vehicle tanks. Stage I vapor control systems prevent the emission of gasoline vapors during the transfer of product from the above-ground tanks at bulk terminals to transfer trucks and then into the smaller underground tanks at service stations. Stage II vapor control systems then prevent the emission of vapors during the transfer of gasoline product from service station tanks to vehicle fuel tanks. It is this last type of system, Stage II, which is the subject of this study.

System Technology

Stage II control systems consist of a special gasoline nozzle and vapor recovery hose connected to the pipes leading to the underground storage tank. The special nozzle and hose allows gasoline to flow from the underground storage tank into the vehicle tank while the gasoline vapors, collected at the vehicle fillpipe/nozzle interface, flow back to the underground storage tank. This process prevents gasoline vapors from being emitted into the air and returns them to the underground storage tanks. Stage II systems, which were originally bulky and difficult to operate, have greatly improved over the years because of technological advances in nozzle and hose components. As far as ease of handling is concerned, the size and weight of Stage II nozzles and hoses are now comparable to conventional hoses and nozzles.

Benefits

Gasoline vapors combine with other air pollutants to form ozone. High ozone levels are a serious threat to the old and infirm and impair the ability of healthy people to exercise. Excessive ozone also causes appreciable damage to forests, crops, buildings, and textiles. Furthermore, the chemical compounds in gasoline (especially benzene) have been found to be carcinogenic to humans. Stage II vapor recovery systems prevent the escape of gasoline vapors during the fueling of motor vehicles, thereby lessening the public's exposure to unpleasant gasoline fumes and their associated health effects.

Along with the health benefits, Stage II control systems can save substantial amounts of gasoline which would otherwise be lost to the air. For instance, a medium-sized station that pumps 50,000 gallons per month (600,000 gallons per year) will recover approximately 1,200 gallons of gasoline that would otherwise be released into the air in the form of gasoline vapors. This reduction in gasoline vapors and subsequent gasoline savings assumes the implementation of a Stage II program that meets EPA inspection and control requirement criteria for a Stage II program allowing an exemption for stations selling less than 10,000 gallons of gasoline per month. Most programs allow exemptions for service stations pumping 10,000 gallons or less per month.

Virginia's Gasoline Dispensing Facilities

Gasoline dispensing facilities in Virginia consist of approximately an equal number of public (retail) and private facilities, the latter owned and operated by government agencies, school systems, and companies of all sizes. The total number of private and public gasoline dispensing facilities is roughly 12,000, and in 1990 these facilities sold slightly more than three billion gallons of gasoline. Of Virginia's public facilities, it is estimated that approximately 34% are owned by independent small-business marketers of gasoline.

Costs

The costs of Stage II systems are most easily compared by looking at above-ground and underground components separately. The reason for this is that the cost of installing above-ground equipment is governed by the type of system installed, while the cost of installing underground equipment is governed by the layout of the station and whether other necessary underground work can be accomplished at the same time.

The capital cost for Stage II above-ground equipment and installation for a typical station with nine dispenser nozzles and average monthly sales of 50,000 gallons is approximately $16,810. The annual cost of Stage II equipment (primarily for the repair and replacement of hoses and nozzles) is about $3,138.

The cost of installing underground pipes is harder to estimate due to the many types of station layouts (orientation of islands and tanks). The cost of pipe installation for a nine-nozzle station with monthly sales of 50,000 gallons ranges from $7,000 to $8,000, depending on which Stage II system is used. Substantial savings can be realized, however, if pipes are installed when other work is being done on underground tanks, such as that needed to comply with the federal Underground Storage Tank program. EPA estimates a savings of 5% to 20% in total Stage II costs if piping is installed concurrently with other underground work.

The cost of Stage II control systems will probably be recovered through an increase in the sale price of the gasoline which is usually passed onto the consumer, and which most sources estimate to be one- to two-cent per gallon. With this price increase, a Stage II system installed at a medium-sized station (selling 50,000 gallons per month) could conceivably pay for itself in about six years, with larger stations (selling more than 100,000 gallons per month) recouping their costs in less time.

The cost-effectiveness of implementing a Stage II program in Virginia's three major urban areas (Northern Virginia, Richmond, and Hampton Roads) is estimated to range from $800 to $1200 per ton of reduced vapor emissions. This rate is very favorable in comparison with other existing technologies for control of the same pollutants. These other technologies have cost-effectiveness rates ranging between $2,000 and $6,000 per ton of reduced emissions. The cost-effectiveness of current controls to smaller businesses (due to mandates from the 1990 Clean Air Act amendments) is estimated to reach $15,000 per ton of reduced emissions.

Clean Air Act Statutory Requirements and Ongoing Programs

A "nonattainment area" is a geographical region which has failed to achieve the air quality standards set by the U.S. Environmental Protection Agency for the maximum allowable concentrations of certain air pollutants. In Virginia, as in most other states, the most problematic air pollutant is ozone. The 1990 Clean Air Act classifies ozone nonattainment areas according to five levels of severity (marginal, moderate, serious, severe, and extreme) and requires progressively more stringent control measures for each level. Virginia's three major urban areas all have air quality that does not meet the federal standard for ozone: the Northern Virginia nonattainment area is classified as serious; the Richmond nonattainment area is classified as moderate; and the Hampton Roads nonattainment area is classified as marginal. Stage II controls are now federally mandated, as a result of the 1990 Clean Air Act, for the Northern Virginia and Richmond nonattainment areas in an effort to attain the ozone standard.

The Act requires that all gasoline stations selling more than 10,000 gallons per month in moderate or worse ozone nonattainment areas install Stage II vapor recovery systems to prevent gasoline vapors from escaping to the atmosphere during motor vehicle fueling. An additional exemption is granted for stations selling less than 50,000 gallons per month which are owned by independent small business marketers. Gasoline stations required to install Stage II controls must do so within two years after the effective date of the state's Stage II regulation.

A number of states, counties, and cities are currently implementing Stage II control programs: California, New York, New Jersey, Massachusetts, the District of Columbia, St. Louis, Philadelphia, and Florida's Dade County. In addition to the District of Columbia and the nonattainment areas in the Northern Virginia and Richmond areas, the Clean Air Act amendments of 1990 have mandated statewide Stage II controls in the eleven northeastern states from Maine to Maryland as part of a comprehensive plan to reduce ozone pollution throughout the region.

I: INTRODUCTION

In 1990, the Virginia General Assembly adopted House Joint Resolution 415, which directed the Virginia Department of Air Pollution Control (DAPC) to study the use of Stage II vapor recovery systems for controlling gasoline vapors released during the fueling of motor vehicles at gasoline service stations. Specifically, HJR 415 requested that the study include an analysis of the costs and benefits of such a program to the environment, public health and industry.

A substantial amount of gasoline vapors are emitted to the ambient air each year during the storage and transfer of gasoline. To reduce the vapors emitted to the atmosphere during the storage of gasoline in large aboveground tanks, internal floating roofs can be installed on fixed roof tanks, and external floating roofs with continuous secondary seals can be installed on floating roof tanks. Two types of control systems (Stage I and Stage II) are available to prevent gasoline vapors from being emitted to the ambient air during the transfer of gasoline between aboveground storage tanks, transfer trucks, underground storage tanks, and motor vehicle tanks.

Stage I vapor control systems prevent the emission of vapors during the transfer of gasoline from aboveground tanks (usually at gasoline bulk terminals or bulk plants) to transfer trucks and then into smaller underground tanks (usually at service stations). When gasoline is transferred into a tank, whether it be a large aboveground tank or an underground tank, the vapors in the tank being filled are forced out of the tank by the incoming liquid. A system of hoses and piping between the container being emptied and the container being filled allows for the transfer of the excess vapors into the container being emptied. These excess vapors are then returned to a bulk terminal where they are either recondensed to gasoline or disposed of through incineration.

Stage II vapor control systems prevent the emission of vapors during the transfer of gasoline from gasoline dispensing facilities to vehicle fuel tanks. Stage II vapor recovery systems consist of a special gasoline dispensing nozzle and vapor recovery hose connected to aboveground and underground pipes leading to the underground storage tank. The vapors being pushed out of the vehicle tank at the vehicle fillpipe are collected by the special nozzle and routed through the hose to the aboveground and underground pipes and then into the underground storage tank. The net result of preventing vapor loss during vehicle fueling is realized in the savings of gasoline normally lost to the atmosphere in the absence of Stage II controls and the health benefit to the public of less exposure to harmful gasoline fumes.

Information used to calculate the costs of Stage II control equipment; to estimate benefits, such as emissions reductions and gasoline savings from the use of Stage II controls; and to characterize Virginia's gasoline marketing industry has been obtained from the Virginia Department of Transportation, Department of Motor Vehicles, the Weights and Measures Division of the Department of Agriculture and Consumer Services (DACS), various reports from the gasoline marketing industry and their affiliates, and from various the United States Environmental Protection Agency (U.S. EPA) documents concerning Stage II controls. Stage II equipment cost estimates from U.S. EPA reports, which were based on the national petroleum marketing industry, have been applied to data which characterizes Virginia's gasoline market in order to estimate the costs of installing Stage II equipment in the three major urban areas in Virginia (Northern Virginia, Richmond, and Hampton Roads) and throughout the state. Detailed information on the costs and benefits of Stage II controls is also presented.

II: System Technology

A. General Mechanics of Stage II Vapor Recovery

When gasoline is pumped into a vehicle's tank, the liquid gasoline forces an equal volume of gasoline vapor out of the tank and into the atmosphere through the vehicle's fillpipe. Stage II control systems prevent the gasoline vapors from escaping to the atmosphere by capturing them and routing the vapors from the fillpipe back to the service station's underground storage tank (UST). Stage II vapor control systems consist of a special nozzle attached to a coaxial hose (a hose within a hose), and a series of piping, both aboveground and underground, which leads to the underground storage tank. The coaxial hose allows gasoline to flow through the center of the hose into the vehicle tank while the gasoline vapors flow back through the outer portion of the hose, through the piping and back to the underground storage tank. In most Stage II systems, the nozzle is equipped with a accordion-like rubber sleeve (bellows) that fits over the vehicle's fillpipe when the nozzle is inserted into the vehicle's fillpipe during fueling. The nozzle and bellows create a tight fit that captures the vapors being pushed out of the vehicle's fuel tank and returns them to the underground storage tank via the coaxial hose which links with the piping leading back to the storage tank.

B. Basic Types of Stage II Vapor Recovery Systems

The basic concept of Stage II vapor recovery is quite simple: as gasoline is being transferred into the vehicle fuel tank, the displaced gasoline vapors are transferred back into the station's UST. The technology to achieve this, however, is not so simple. Three years ago, three basic types of Stage II systems were in use in the United States: the vapor balance system, the vacuum assist system, and the aspirator assist (or hybrid) system. Within the last two years, a fourth type of system, the bellowless nozzle system, has been developed. The first three systems have been certified as at least 95% efficient by the California Air Resources Board (CARB); however, the bellowless nozzle system (developed by the Amoco Oil Company) is still being tested. Industry and U.S. EPA sources state that in the United States, 98% of all Stage II systems installed prior to 1991 have been vapor balance systems.

Vapor Balance Systems

Vapor balance systems (Figure 1) were the first Stage II systems developed. They operate on the principle of positive displacement, whereby the pressure created in the vehicle fuel tank by the incoming liquid gasoline forces the vapors through the combination fuel dispensing/vapor collection nozzle, through a coaxial hose connected to aboveground and underground piping, and into the service station's UST. A bellows, fitted over the spout of the nozzle, cups around the vehicle's fillpipe to ensure all escaping vapors are routed into the vapor recovery system. For the system to work, there must be a tight seal between the bellows and the fillpipe. Early versions of the nozzle weighed more than six pounds and required much more pressure be exerted between the nozzle and the fillpipe before gasoline transfer would occur (due to automatic cutoff mechanisms designed to guarantee a tight seal). Later versions have greatly reduced these problems such that nozzles now weigh only three to four pounds (the approximate weight of a traditional nozzle), and require much less pressure to be exerted on the fillpipe (Figure 2).

Vacuum Assist Systems

These systems were initially developed as a means of avoiding the need for a tight seal between the nozzle/fillpipe interface which was accomplished through exerting pressure on the nozzle when placed in the fillpipe; the substantial amount of pressure that had to be exerted on the nozzle in the early generation vapor balance systems lead to considerable consumer dissatisfaction. Vacuum assist systems (Figures 3 and 4) also have a bellows on the nozzle and a coaxial hose, but use a vacuum-generating device to draw vapors from the fillpipe area into the UST; therefore, vapors are recovered effectively without a tight seal at the nozzle/fillpipe interface. The suction is produced from either an in-line vacuum pump or from the gasoline facility compressed air unit, and as a result, these systems pump more vapor and air back into the UST than the volume of gasoline being removed. Consequently, the system requires a processing unit such as an incinerator for combustion and elimination of excess vapors.

Aspirator Assist (or Hybrid) Systems

The aspirator assist system (Figure 5) borrows from the concepts of both the vapor balance and vacuum assist systems. It was designed to enhance vapor recovery at the nozzle/fillpipe interface by creating a vacuum, while keeping the vacuum low enough so that a minimum level of excess vapor/air is returned to the UST. In this system a small amount of liquid gasoline is pumped from the storage tank and is routed to a restricting nozzle called an aspirator. As the gasoline travels through this restricting nozzle, a small vacuum is generated, which is used to draw vapors into the rubber bellows at the nozzle/fillpipe interface with only a small volume of air being drawn through the nozzle into the hose and UST. A tight seal between the bellows and the fillpipe is not required, nor is an incinerator or other secondary processor.

Bellowless Nozzle Systems

The bellowless nozzle system (Figure 6) is another type of vacuum system. Vapors are drawn, by a vacuum, into spout openings in a bellowless nozzle (Figure 7) which looks very similar to a conventional nozzle. Suction is created by a dual chamber gasoline-driven vacuum pump (located in the bottom of the UST) where the flow of gasoline itself is used to drive the hydraulic pump and create the vacuum. The vacuum is regulated by the flow of fuel, and the ratio of gasoline dispensed to vapors collected is approximately one-to-one; therefore, excess vapors are not generated and incineration or other secondary processors are not needed. The bellowless nozzle system was developed by the Amoco Oil Company several years ago and has been installed at various Amoco Oil Company service stations throughout the United States. The Amoco Oil Company has not indicated whether it will sell the nozzles or design specifications to other sectors of the gasoline marketing industry.

C. Advances in Stage II Equipment Technology and Convenience

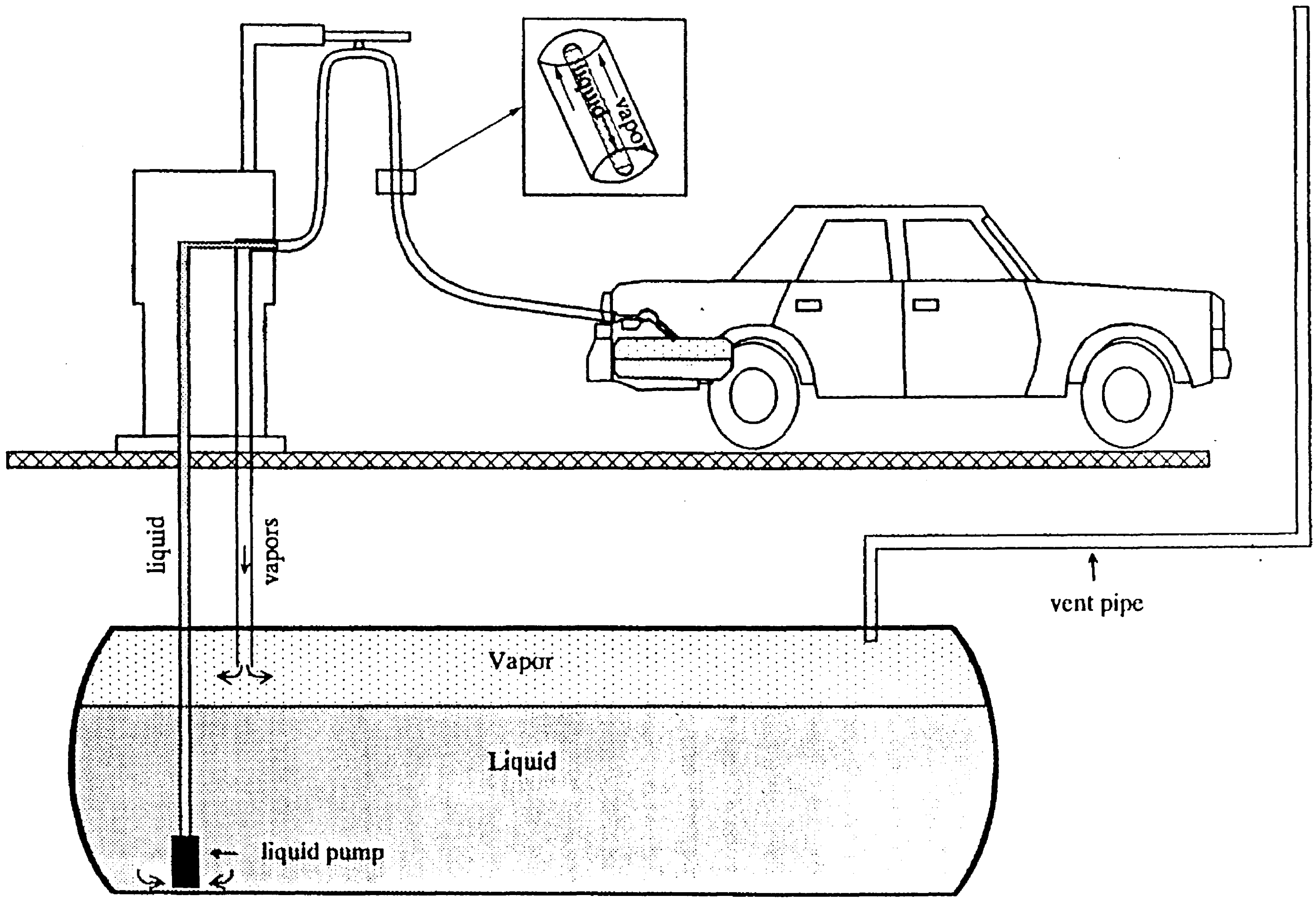
Assertions that Stage II equipment is bulky and difficult to use have been based on experience with earlier generations of the technology. In some areas that implemented Stage II controls in the early 1980s, such as the District of Columbia, many stations still have the older equipment in use. This older equipment would not be used, however, in any area that now proceeds with Stage II controls.

Many past problems with Stage II equipment have been associated with the vapor recovery nozzle. Stage II nozzles are far more reliable and user friendly today. New nozzles are shorter, narrower, and lighter than their predecessors. Originally weighing over six pounds, newer nozzle designs have reduced the weight by two to three pounds, rendering new Stage II nozzles only slightly heavier than conventional ones. Another contributing factor to complaints about Stage II equipment was the pressure required to compress the bellows on the nozzle into the fillpipe which was necessary to deactivate the insertion interlock, allowing the gasoline to flow into the vehicle tank. The earlier generation nozzles required a pressure of up to 24 pounds to deactivate the interlock. This, combined with the weight of the nozzle and the tension of the springs in the bellows, made nozzle operation difficult for some customers. The improvements in the weight of the nozzle and the amount of pressure exerted on the nozzle have greatly reduced operational difficulties. In fact, the pressure required to deactivate insertion interlocks has been decreased to as low as five pounds on some nozzles.

Historically, hoses have been another source of problems, specifically with regard to their weight, durability, and propensity to kink. This was particularly true with the original dual hose system, which has now been replaced with the coaxial hose. First generation coaxial hoses were hardwalled and heavy, however, new corrugated thermoplastic coaxial hoses have been introduced within the last two years that weigh less than half (approximately five pounds) what the older hardwalled hoses weighed.

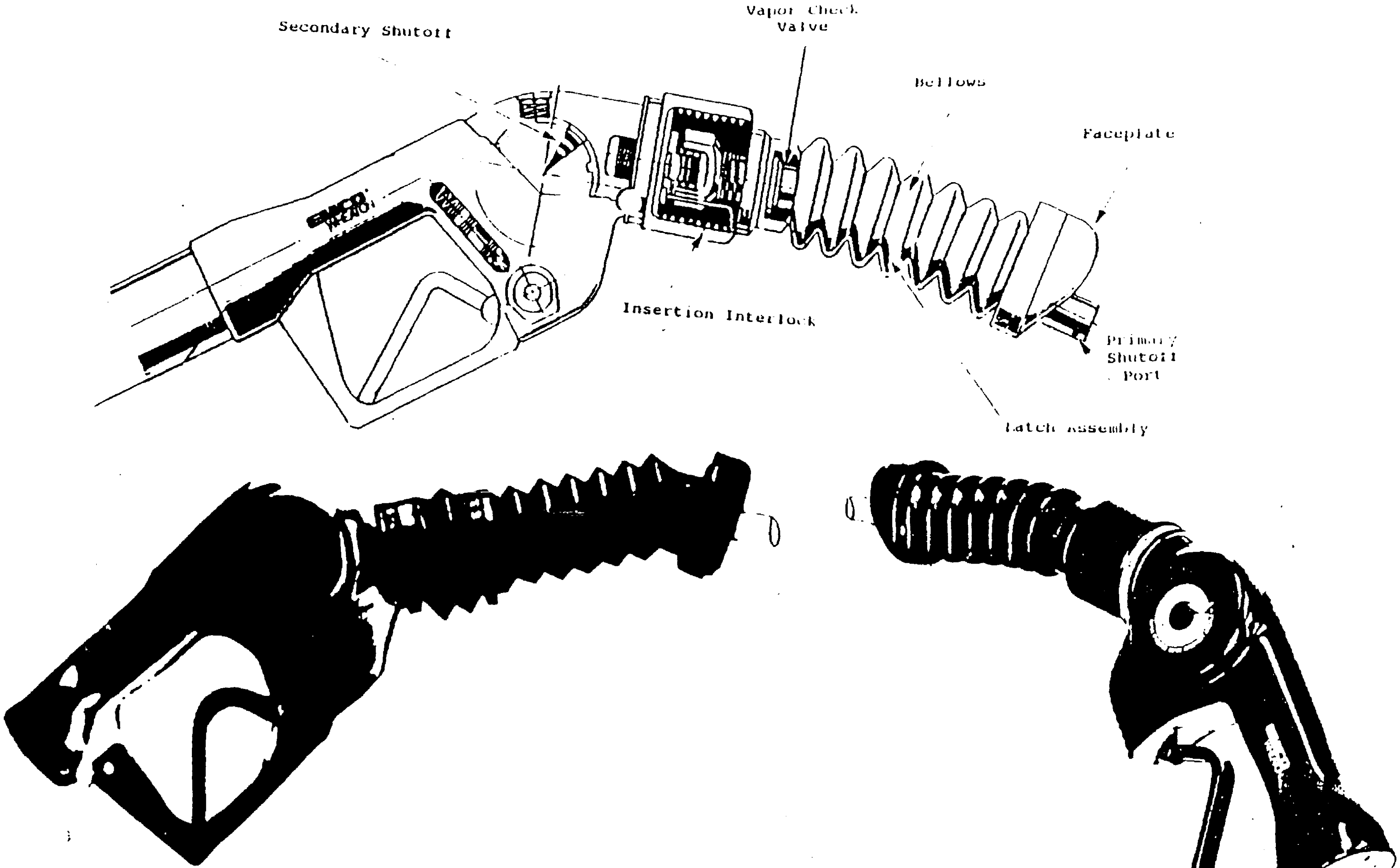
Recent improvements in Stage II hardware have been prompted by expansion of the market resulting from implementation of the program in New York, New Jersey, and Philadelphia. With Massachusetts soon to begin implementation, and Pennsylvania and other areas considering requiring statewide Stage II controls, competition for the expanding market will stimulate further technological improvement and cost reductions.

Occasionally, questions arise as to whether Stage II nozzles are compatible with the fillpipes of all vehicles. In the 1970s it was found that the fillpipes of some vehicles did not allow the nozzles to lock-on to the fillpipe, thereby deactivating the interlocks and allowing gasoline to flow into the vehicle tank. The State of California quickly recognized this problem and passed legislation that required the standardization of all vehicle fillpipes. Automakers responded by standardizing vehicle fillpipes for vehicles sold throughout the country beginning with 1980 model year vehicles.



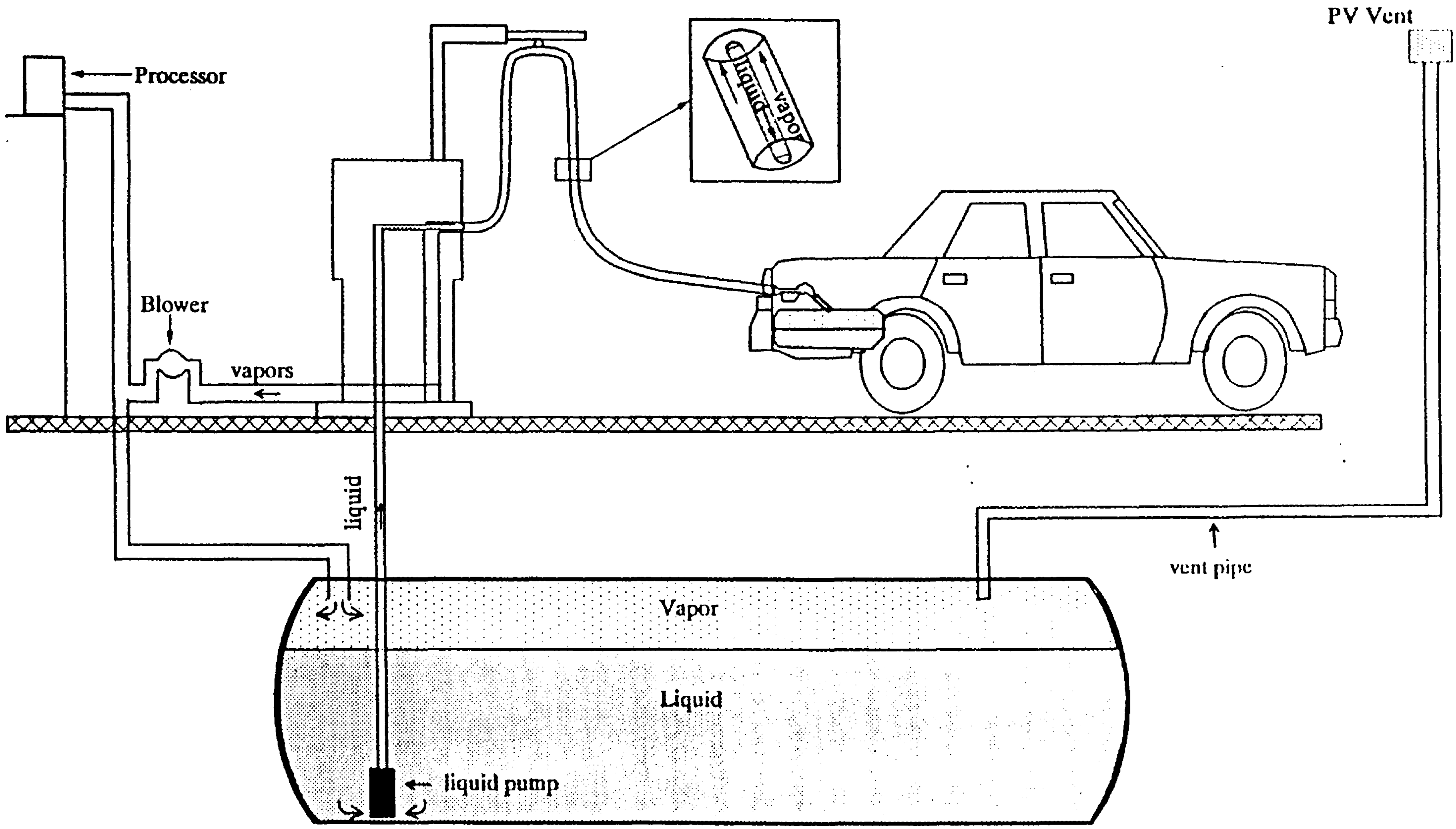
Source: U.S. EPA

Figure 1. Vapor Balance System



Photos Courtesy of Dover Corporation/OPW Division Cincinnati, OH
and Emco Wheaton, Inc. Research Triangle Park, NC

Figure 2. Example Balance Nozzles



Source: U.S. EPA

Figure 3. Vacuum Assist System

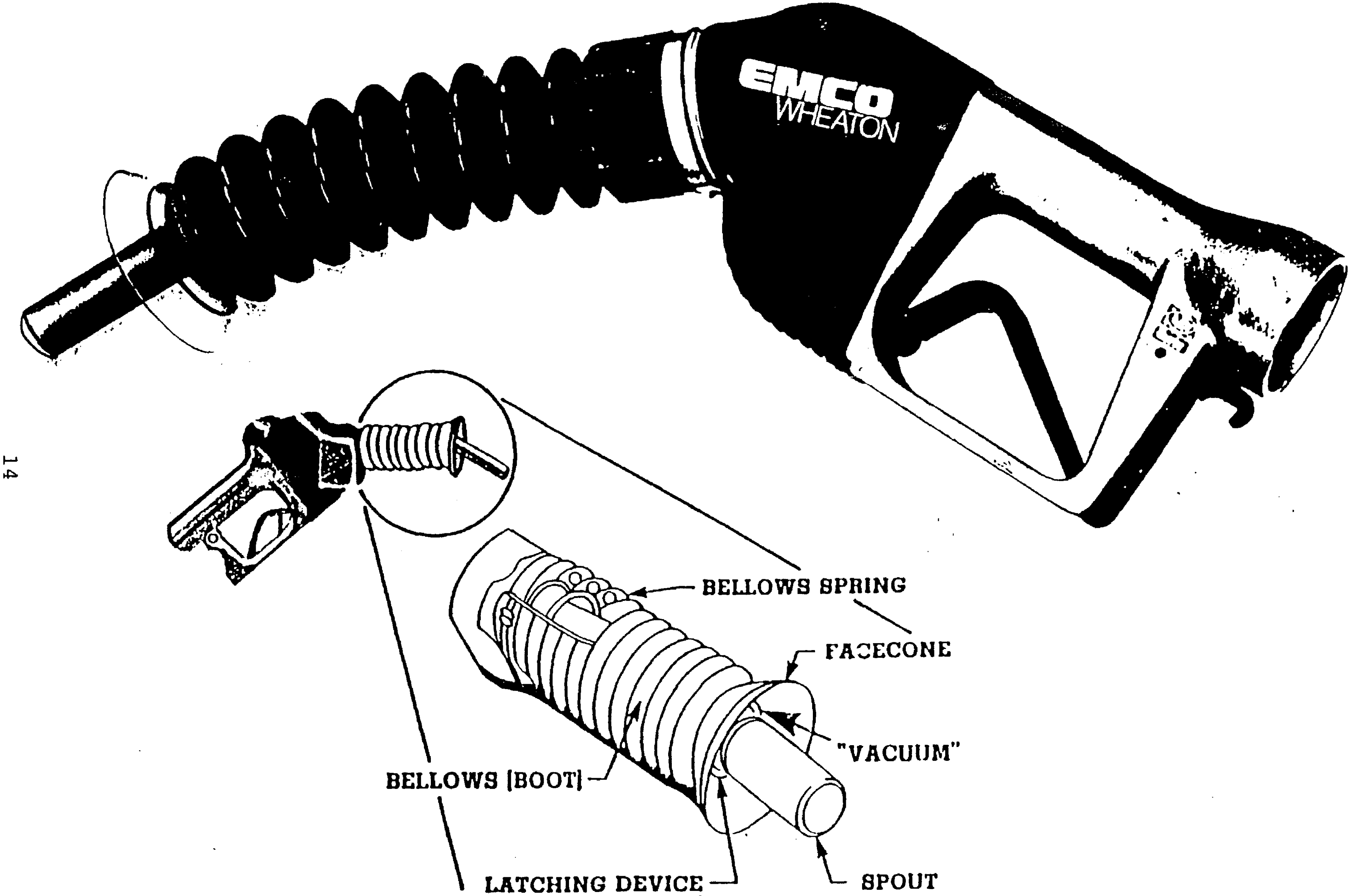
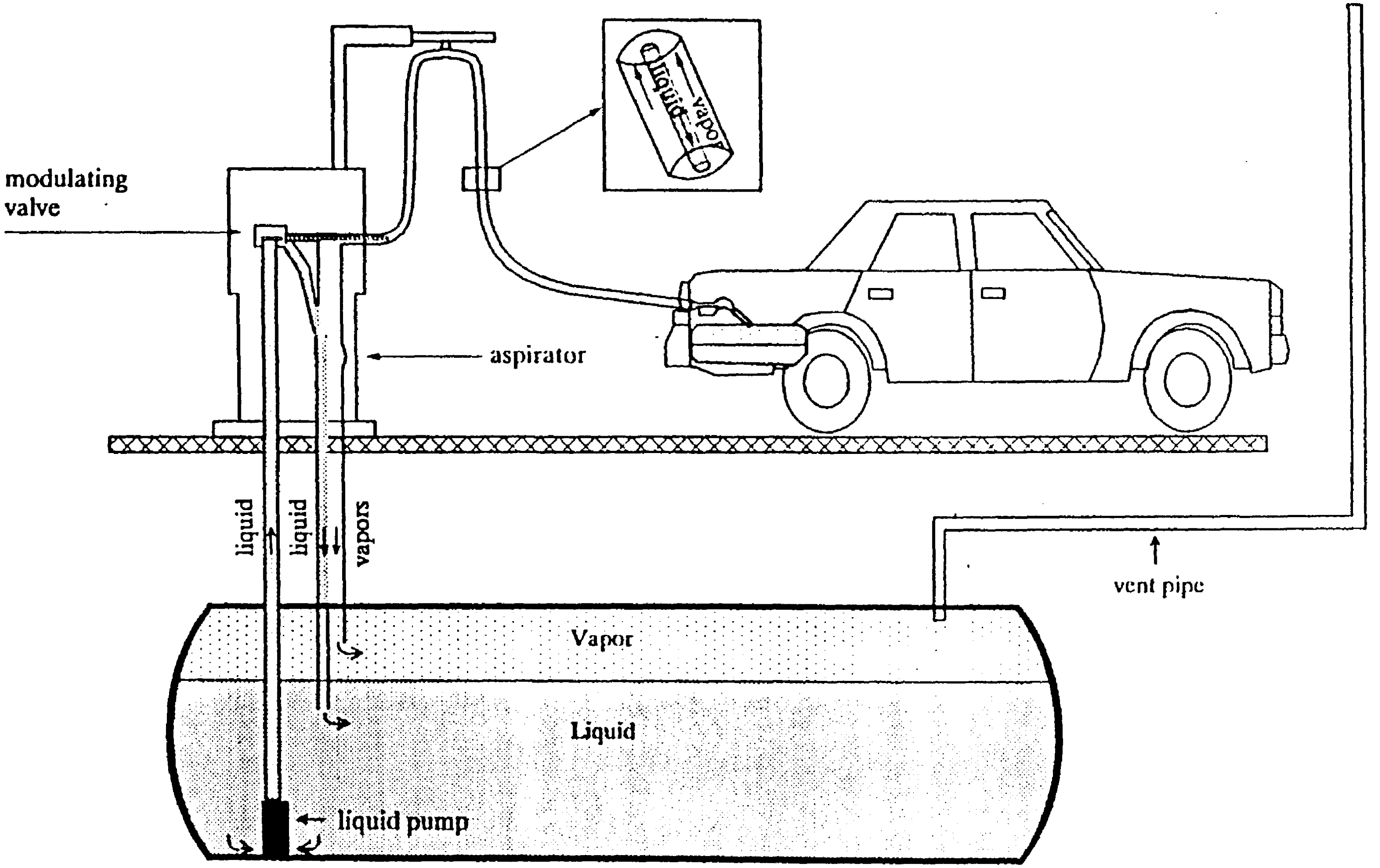


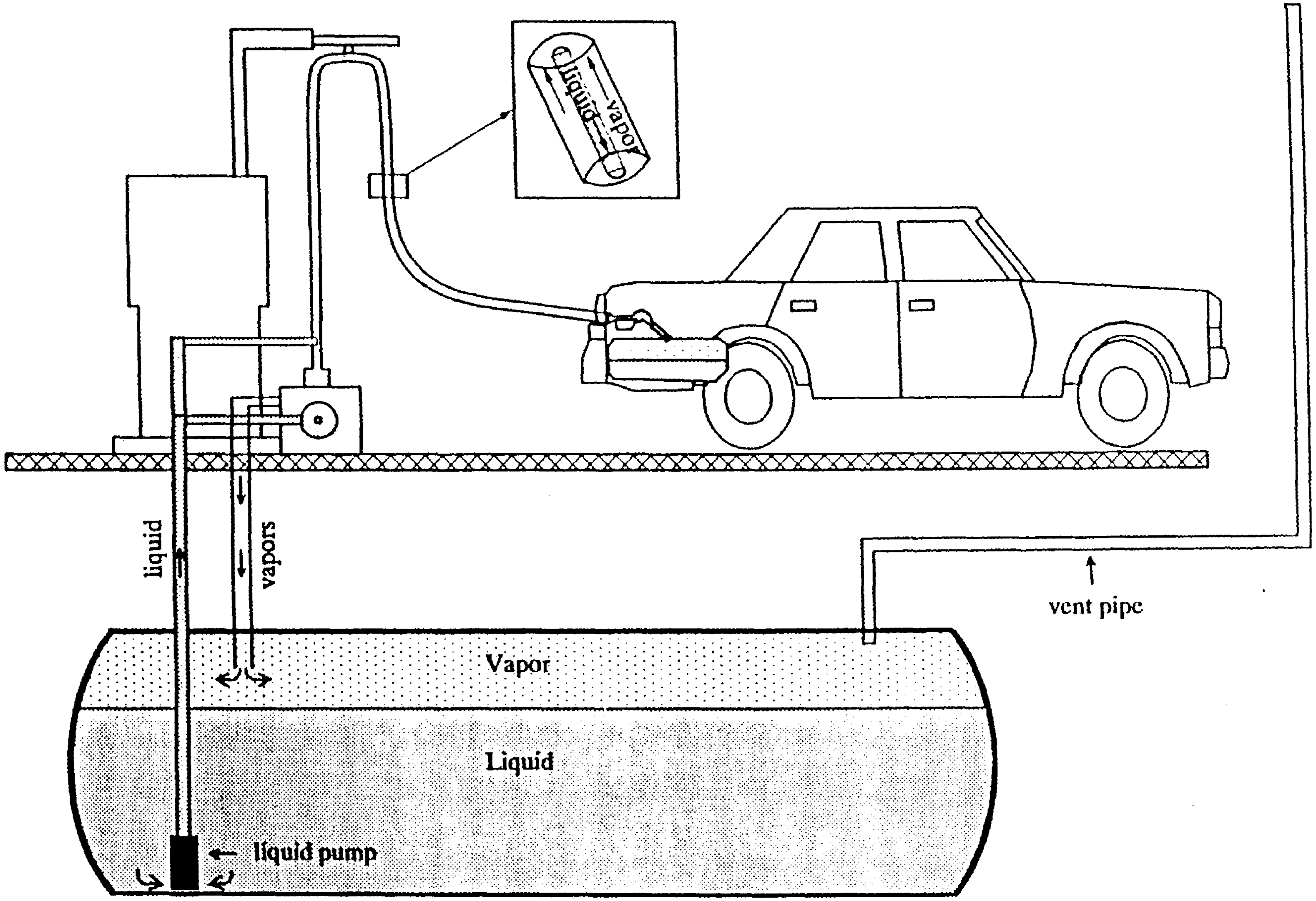
Photo Courtesy of Emco Wheaton, Inc. Research Triangle Park, NC

Figure 4. Example Assist Nozzle



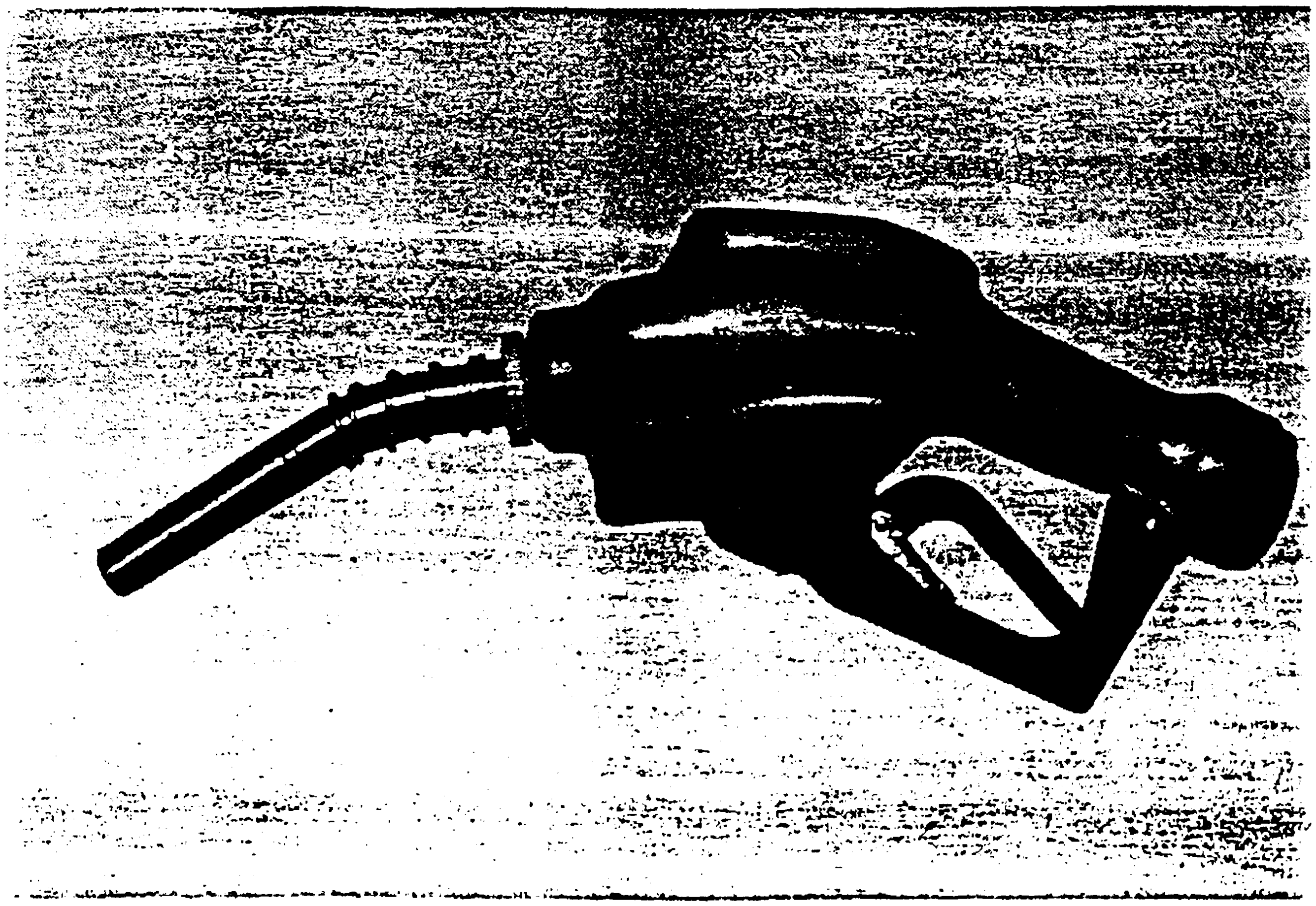
Source: U.S. EPA

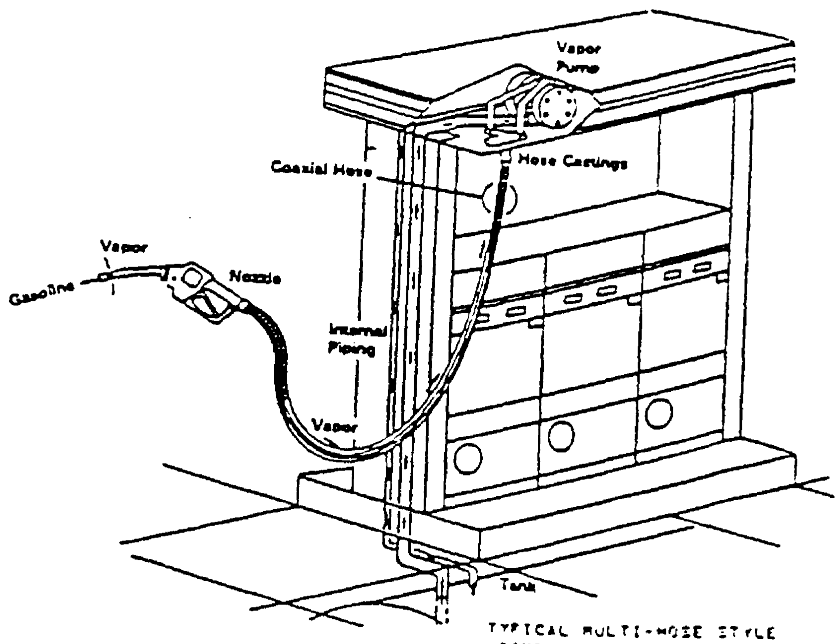
Figure 5. Aspirator Assist System



Source: U.S. EPA

Figure 6. Bellowless Nozzle System





Source: U.S. EPA

Figure 7. Example Bellowless Nozzle

III: Benefits

A. Health and Environmental Impacts of Fueling Emissions

Gasoline and its vapors consist of a complex mixture of volatile organic compounds (VOCs), which in the presence of sunlight, combine with other pollutants to form ozone. In 1990, slightly more than 3 billion gallons of gasoline were pumped into motor vehicle tanks in Virginia. In the absence of Stage II controls on gasoline pumps, the fueling of motor vehicles in 1990 resulted in approximately 15,500 tons of VOCs being emitted to the atmosphere.

The National Ambient Air Quality Standard (NAAQS) for ozone is 0.12 parts per million (ppm). The 0.12 ppm standard was established by the U. S. Environmental Protection Agency (U.S. EPA) and is designed to protect the health of the general public with an adequate margin of safety. Numerous counties and cities within the Northern Virginia, Richmond, and Hampton Roads areas have been identified as ozone nonattainment areas pursuant to new provisions of the 1990 Clean Air Act (Table 1); therefore, over 3.5 million Virginia citizens are being exposed to air quality that does not meet the federal health standard for ozone. Of the 3.5 million citizens in Virginia's nonattainment areas, over 1.8 million were reported in 1987 to have chronic lung diseases (asthma, emphysema and chronic bronchitis) or incidence of acute respiratory conditions (pneumonia, influenza and acute bronchitis).

A growing body of scientific data indicates that health and welfare effects associated with ozone are more serious than envisioned in the late 1970s. Some scientists believe that existing air quality standards may provide little or no margin of safety. Perhaps the most significant new finding is that ozone not only affects people with impaired respiratory systems, such as asthmatics, but also many people with healthy lungs, both children and adults. It can cause shortness of breath and coughing when healthy adults are exercising, and more serious effects in the young, old, and infirm. Recent U.S. EPA estimates suggest there are 20 to 30 million ozone-sensitive people in those major urban areas where levels are 25 percent (0.15 ppm) or more above the current health standard. The Northern Virginia Nonattainment Area is one of those major urban areas with ozone levels of up to 0.165 ppm. Equally high levels of ozone are often recorded in rural sectors downwind from these metropolitan areas.

Evidence from scientific studies of vegetation indicates that ozone can reduce plant yield in tomato, bean, soybean, snap bean, peanut, and corn crops. The potential agricultural losses nationwide are estimated to be two to three billion dollars per year. Ozone also has an impact on forests, causing premature leaf-drop and lower growth rates. Materials damage attributed to ozone includes cracking of rubber products, weakening of textiles, changes in dyes, and premature cracking of paint.

Health risks associated with exposure to gasoline vapors from fueling emissions are not limited to just those associated with ozone exposure. Many of the VOCs which make up gasoline are also known as hazardous air pollutants. Although benzene is the most well known toxic constituent of gasoline and its vapors, the many toxic vapors emanating from gasoline have collectively been found to cause cancer. Consequently, U.S. EPA has concluded that gasoline vapors are a probable human carcinogen.

A substantial amount VOC and toxic vapors are emitted to the ambient air each year during the storage and transfer of petroleum liquids. The use of currently available Stage II vapor recovery systems can substantially reduce the amount of these vapors emitted to the ambient air, thereby reducing the formation of ozone, lowering ozone concentrations in the ambient air, and reducing the exposure of the public to toxic gasoline vapors.

B. Emissions Reductions as a Result of Stage II Controls

Table 2 presents the reduction of VOC emissions (from gasoline vapors) that would occur if Stage II controls where implemented in various geographic areas. Those areas are (see Table 1 for specific localities): (1) the Northern Virginia ozone nonattainment area (all localities within the Washington, D.C. MSA) and the Richmond ozone nonattainment area (seven localities within the Richmond/Petersburg MSA); (2) the Northern Virginia nonattainment area and all localities within the Richmond/Petersburg MSA; (3) both areas listed in options (1) and (2) and all localities in the Norfolk/Virginia Beach/Newport News MSA (eleven out of twelve of these localities comprise the Hampton Roads nonattainment area); (4) all areas in Virginia other than the three major MSAs; and (5) the entire state of Virginia. Emissions reductions have been calculated assuming implementation of a Stage II program requiring annual service station inspections and allowing exemptions for stations pumping 10,000 gallons of gasoline or less per month. This type of program yields a Stage II program effectiveness of 84%.

Implementation of this type of Stage II program in all localities within the Washington, D.C. and Richmond/Petersburg MSAs, for instance, would result in a 4,430 tons per year reduction in VOCs, annual savings of 1,772,166 gallons of gasoline, and annual savings to gasoline marketers of $2,126,599. Allowing for a <50,000 gallon per month exemption for service stations owned by independent small business marketers (in addition to the 10,000 gallon per month exemption for non-independent stations) substantially lowers the Stage II program effectiveness to 77%. Reduction of the program effectiveness also substantially lowers the amount of emissions reduced and the number of gallons of gasoline saved. Conversely, a Stage II program with annual service station inspections and no exemptions yields a program efficiency of 86%, thereby increasing emissions reductions and gasoline savings.

TABLE 1

AREAS IN VIRGINIA DESIGNATED AS
NONATTAINMENT FOR THE OZONE
NATIONAL AMBIENT AIR QUALITY STANDARD

Washington, D.C. Metropolitan Statistical Area (MSA)

*Arlington County
*Fairfax County
*Loudoun County
*Prince William County
*Stafford County
*Alexandria City
*Fairfax City
*Falls Church City
*Manassas City
*Manassas Park City

Richmond - Petersburg MSA

*Charles City County
*Chesterfield County
Dinwiddie County
Goochland County
*Hanover County
*Henrico County
New Kent County
Powhatan County
Prince George County
*Colonial Heights City
*Hopewell City
Petersburg City
*Richmond City

Norfolk - Virginia Beach - Newport News MSA

Gloucester County
*James City County
*York County
*Chesapeake City
*Hampton City
*Newport News City
*Norfolk City
*Poquoson City
*Portsmouth City
*Suffolk City
*Virginia Beach City
*Williamsburg City

White Top Mountain (non-MSA)

The portion above 4500 feet elevation in Smyth County (located within the Jefferson National Forest).

* Areas designated nonattainment pursuant to 1990 Clean Air Act. Stage II controls are mandated for moderate and serious nonattainment areas (i.e., all localities in the Washington, D.C. MSA and the nonattainment localities within the Richmond/Petersburg MSA).

TABLE 2

EMISSIONS REDUCTIONS AND GASOLINE SAVED AS A RESULT OF STAGE II CONTROLS AT GASOLINE DISPENSING FACILITIES
FOR A STAGE II PROGRAM* WITH VARYING GEOGRAPHIC COVERAGE

COUNTY/CITY	1990 THROUGHPUT (gal/year)	VOC EMISSIONS FROM FUELING (tons/year)	EMISSIONS REDUCTION (tons/year)	GALLONS OF GASOLINE SAVED ANNUALLY	DOLLARS SAVED ANNUALLY ($1.20/gal)
Areas Mandated by 1990 CAA (Washington, D.C. MSA and Richmond Nonattainment Areas)	937,952,172	4,830	4,058	1,623,032	$1,947,639
Washington, D.C. MSA and Richmond/Petersburg MSA	1,024,136,388	5,274	4,430	1,772,166	$2,126,599
Washington, D.C. MSA, Richmond/Petersburg MSA and Norfolk/Newport News/ Virginia Beach MSA	1,449,800,076	7,466	6,272	2,508,734	$3,010,481
All areas in Virginia other than the three major MSAs	1,566,846,009	8,069	6,778	2,711,270	$3,253,524
Statewide	3,016,646,085	15,536	13,050	5,220,004	$6,264,005

* Components of the Stage II program: annual station inspections, a <10,000 gallon/month exemption, and 84% program efficiency.

IV: Characterization of Virginia's Gasoline Dispensing Facilities

Gasoline dispensing facilities or service stations are sites where gasoline is dispensed to motor vehicle tanks from stationary (usually underground) storage tanks. There are basically two categories of service stations, public (retail) and private facilities. Public stations are facilities which sell gasoline to the public and include facilities such as marinas, parking garages, convenience stores, mass merchandisers or "pumpers", and traditional gasoline service stations. A subcategory of public gasoline dispensing facilities are facilities owned by independent small business marketers of gasoline (independents). An independent is an owner of a retail service station that derives 50% or more of its income from gasoline sales, and is not directly or indirectly affiliated with a refiner, controlled by a refiner or is not a refiner with a total refinery capacity of more than 65,000 barrels per day. The term "controlled by" means ownership by the refiner of more than 50% of the stock belonging to the company that owns the service station. Private facilities are those where gasoline is not sold, but dispensed into vehicles owned by the company that owns the gasoline dispensing facility. Private facilities include government agencies, companies such as car rental, utility, taxi, bus, trucking and local service companies, and school systems, and farming operations.

The National Petroleum News (NPN), which gathers data on the national gasoline marketing industry on an annual basis and publishes its annual NPN Factbook, estimates there are 6,000 public retail stations in Virginia. The Weights and Measures Division of the Virginia Department of Agriculture and Consumer Services (DACS) reported there were approximately 6,350 retail stations in Virginia during 1990. However, no station-by-station retail or private facility listing complete with monthly gasoline throughput data could be obtained from the DACS, the State Water Control Board, or the Division of Motor Vehicles.

In the absence of data from Virginia's regulatory agencies and the resources for the Department of Air Pollution Control (DAPC) to develop its own database, national service station characteristics were used in conjunction with state statistics for the number of public stations and gasoline throughput on a county/city basis to estimate the number of retail and private stations in various size (throughput) categories in each of Virginia's three major MSAs (Washington, D.C., Richmond/Petersburg, and Norfolk/Virginia Beach/Newport News) and in the remaining localities throughout the state (Table 3). The number of retail stations that are owned by independents was also estimated by applying nationwide statistics to the number of retail stations in various areas of Virginia. The result is the number of independent-owned stations in each throughput category as seen in Table 3. It appears that approximately 34% of Virginia's public stations are owned by independents.

According to national 1990 statistics, the number of private service stations is slightly greater than the number of public stations; nationwide, there are approximately 210,330 private stations and 210,210 public stations. If there are at least as many private stations as retail stations in Virginia, the total estimated number of public and private stations is slightly greater than 12,000 (6,000 public and slightly more than 6,000 private stations). In 1990, Virginia's public and private service stations sold slightly more than three billion gallons of gasoline.

TABLE 3

PUBLIC GASOLINE DISPENSING FACILITIES AND INDEPENDENT SMALL BUSINESS GASOLINE MARKETERS IN VIRGINIA

NUMBER OF FACILITIES IN EACH GASOLINE THROUGHPUT CATEGORY

GEOGRAPHIC AREA	0-9,999 gal/mo.		10,000-24,999 gal/mo.		25,000-49,999 gal/mo.		50,000-99,999 gal/mo.		<100,000 gal/mo.		TOTAL # STATIONS	
	PUBLIC	INDEPENDENT	PUBLIC	INDEPENDENT	PUBLIC	INDEPENDENT	PUBLIC	INDEPENDENT	PUBLIC	INDEPENDENT	PUBLIC	INDEPENDENT
Washington, D.C. MSA	63	14	93	41	115	94	175	112	111	72	557	333
Richmond/Petersburg MSA	41	9	59	27	74	61	113	73	73	46	361	215
Norfolk/Newport New/Va. Beach MSA	43	9	64	28	78	65	120	77	77	49	382	228
All areas in VA other than the three major MSAs	1020	184	1177	365	1040	468	549	214	137	54	2640	1284
Statewide	1167	216	1393	461	1307	688	957	476	398	221	3940	2060

V: Costs

A. Cost to Gasoline Marketers of Stage II Vapor Recovery Systems

The costs of Stage II systems are divided into aboveground and underground components. Aboveground equipment consists of all the nozzles, hoses, swivels, check valves, and other related components needed at the dispensers to capture the vapors displaced during the fueling of vehicles. The costs presented here are limited only to equipment that has been certified by California Air Resources Board (CARB) and is currently being marketed for Stage II systems. The underground equipment consists of the piping needed to route the vapors back from the hose to the underground storage tank (UST). Aboveground costs at a facility depend on the number of nozzles present at the service station, while underground costs are driven by the physical layout of the facility.

The aboveground and underground costs presented here are U.S. EPA estimates, which fall in between those reported by the American Petroleum Institute (API) and Multinational Business Services, Inc. (MBS). API and MBS conducted cost analyses of Stage II equipment installed in St. Louis, Missouri in the late 1980s and attempted a comparison with the U.S. EPA's cost analysis in the 1987 Draft Regulatory Impact Analysis (RIA) that estimated the costs for various sizes of service stations. Pacific Environmental Services, Inc. (PES), under U.S. EPA contract, also conducted an independent analysis of Stage II installation costs in St. Louis. Capital cost data submitted by API suggested that U.S. EPA had, on average, understated costs by about 40 percent. Capital costs submitted by MBS suggested U.S. EPA had, on average, overstated costs by about 20 percent. In addition, the St. Louis cost analysis done by PES also fell between the API and MBS cost estimates. The PES cost analysis compared favorably (within 5 percent) with U.S. EPA's cost analysis. Therefore, U.S. EPA cost analyses for Stage II system components are presented here and are later used to estimate the cost of Stage II controls in Virginia.

1. The Aboveground Portion of Stage II Systems

<u>Nozzles</u> (Table 4)

New nozzles for the vapor balance, vacuum assist, and aspirator assist systems are reportedly comparable, at approximately $240 per nozzle. In addition, rebuilt nozzles are available for an average cost of about $190, and old cores can be turned in for credits of about $50. No estimates are given for how frequently nozzles must be replaced, but given the fact that they have more internal working parts than conventional nozzles, it is likely that replacement would be required more frequently than for conventional nozzles. Of the three major types of systems, the balance system has the fewest number of internal working parts.

The parts of the nozzles likely to require replacement most often are the bellows and the faceplate. The cost of replacement for bellows ranges from $30 to $50 and about $15 for the faceplate. On average, nozzle parts will have to be replaced about three times a year for balance systems. The bellows employed in the vacuum assist system must be replaced twice per year on average.

Hoses (Table 5)

The original two hose system used in the first Stage II systems has been replaced with a coaxial hose (hose within a hose), which has proven to be more durable, lightweight, and flexible, but more costly. Coaxial hoses range in cost from about $140 to $230 per typical 10-foot hose, and have an average lifetime of approximately one year when equipped with high hang hose retractors or high hang dispensers.

Hose life has been extended greatly because of new, more durable hose materials, and because of the requirement for high hang retractors (Figure 8) and dispensers which force the hoses up off the ground, thereby minimizing or eliminating hose problems such as collapsed hoses from being run over, hose tears, or wearing from being constantly dragged on the ground. An added advantage of this equipment is the reduced amount of "musclepower" that must be exerted by the self-service customer. The approximate cost of a high hang hose assembly is $100, and slightly higher for a high hang dispenser (Table 6).

The high hang hose assembly also minimizes vapor path blockage in the vapor hose caused by "spitback" of liquid during fueling operations or simply as a result of condensation of the vapors in the line. As a result, the secondary cutoff mechanism prevents the pumping of fuel when the vapor line is blocked. A liquid venturi trap (Figure 9) can be installed in the hose to prevent vapor blockage at a cost of approximately $200. Liquid removal traps can also be purchased already installed in the hose at a cost of between $240 for a typical 10-foot section of hose (Table 5).

Dispensers

Product dispensers at existing service station must be converted to allow the installation of vapor return piping. There is typically enough room in conventional dispensers to allow these modifications, however, newer dispensers, such as multi-product dispensers, may have to be converted to allow the installation of the vapor piping through the dispenser housing and back into the underground piping. Typical costs to convert an existing dispenser are about $50 to $60.

Other Aboveground Components

Other components that must be purchased with the aboveground equipment could include hose breakaway fittings, vapor check valves, swivels, flow limiters, and hose splitters. Table 6 illustrates the typical costs associated with these components. These pieces of equipment are not expected to wear or fail at the same rate as nozzles, bellows, faceplates, or hoses.

Installation of the Aboveground Portion of Stage II System

Installation costs, like equipment costs, vary based both on size of station (i.e., per nozzle) and type of system selected. Per nozzle installation costs are cheapest for vacuum assist systems (about $50) and most expensive for hybrid systems (about $100) with balance systems in between (about $80). However, for vacuum assist systems, there is an additional $1,300 or more per station cost for installation of the collection and processing unit.

Other Maintenance Costs

Beyond replacement of nozzles, bellows, faceplates, and hoses, there should be few to no additional maintenance costs for the aboveground portion of most systems. The only significant exception: the vapor pumps and vapor processors used on vacuum assist systems require annual maintenance totaling as much as $400 to $600.

Total Aboveground Costs

Total aboveground equipment and installation costs for vapor balance systems at five different "model stations" ranging from a single island with two single-product dispensers to a four island station with multi-product dispensers and 30 nozzles are presented in Tables 7 and 8. The capital cost for aboveground equipment and installation of a Stage II vapor balance system at a typical station with nine dispenser nozzles and average monthly sales of 50,000 gallons is approximately $16,810. The annual cost of this Stage II equipment (primarily for the repair and replacement of hoses and nozzles) is about $3,138.

Aboveground cost comparisons between the various Stage II systems were not supplied by U.S. EPA, however, New Jersey's experience with Stage II systems shows the cost for equipment and installation of a vacuum assist system is typically higher than that required for a vapor balance system. New Jersey's approximate 1986 costs for equipment and installation of a vacuum assist system ranges from $17,000 to $28,200 for stations with a monthly throughput of 10,000 to 200,000 gallons, respectively. By contrast, the approximate capital cost for equipment and installation of a vapor balance system ranges from $7,000 to $24,000 for the same size stations.

2. The Underground Portion of Stage II Systems

The underground portion of Stage II systems can be more expensive to install than the aboveground portion, as the majority of the costs are associated with digging trenches and laying piping. Galvanized pipe is typically used for vapor risers, while fiberglass piping is used for vapor return lines. Proper installation of the underground piping is critical in proper functioning of the entire Stage II system.

It is impossible to pinpoint a cost for the underground piping portion of the system, either on a per-station, per-nozzle, or per-island basis. However, Multinational Business Services, Inc. reports that the work for installation of the underground piping comprises between 33% and 42% of total installation cost of a Stage II system. Much depends on the configuration of the station, particularly the distances between islands, location of tanks in relation to islands, and whether other necessary underground work can be accomplished at the same time. U.S. EPA estimates that the cost of installing underground piping for a "typical" nine-nozzle station with a monthly throughput of 50,000 gallons ranges between $7,000 and $8,000, depending on which Stage II system is used (Table 9). National Petroleum News states that St. Louis retailers reported the average cost per nozzle for installing underground Stage II piping is roughly $1,100.

Substantial savings can be achieved by installing the piping at the same time the concrete is already broken for work on underground storage tanks, especially in conjunction with work that may have to be done to comply with the December 22, 1998 deadline for UST upgrades with a capacity of greater than 110 gallons under the federal Underground Storage Tank regulation. The National Petroleum News reports that petroleum marketers can install the vapor recovery lines at the time of installation for their UST equipment upgrades at an additional cost of $4,000 for 500 to 600 feet of piping for an average of three to four dispensers. However, if marketers wait to tear up their concrete a second time, they could be looking a capital outlays between $25,000 and $30,000. U.S. EPA estimates a savings of 5% to 20% in total Stage II capital costs if piping is installed concurrently with other repair or replacement work. In many urban areas, regulators have found that many service stations have already installed Stage II underground piping during UST work in view of the likelihood of eventually have to install Stage II controls.

B. Cost of Stage II Equipment Installation and Maintenance in Virginia

U.S. EPA has estimated the capital and annual cost of Stage II equipment installation and maintenance (Tables 7 and 8) for public service stations according to facility size (monthly gasoline throughput). These national cost figures were applied to the estimated number of retail stations for each county/city within Virginia's three major MSAs, and for the remaining counties/cities throughout Virginia. Both capital and annual costs for single and multi-product dispensers are presented in Table 10 for each of the three MSAs, for all areas in Virginia other than the three MSAs, and for the entire state. Costs are further broken down for Stage II programs without a throughput exemption and with a <10,000 gallon per month exemption which is characteristic of most Stage II programs currently operating in the United States. Costs for a Stage II program allowing a <50,000 gallon per month exemption for retail stations owned by independents were not calculated.

The cost of Stage II equipment installation and maintenance for affected gasoline dispensing facilities in various groupings of areas is presented in Table 10. Those areas are (see Table 1 for specific localities): (1) the Northern Virginia ozone nonattainment area (all localities within the Washington, D.C. MSA) and the Richmond ozone nonattainment area (seven localities within the Richmond/Petersburg MSA); (2) the Northern Virginia nonattainment area and all localities within the Richmond/Petersburg MSA; (3) both areas listed in options (1) and (2) and all localities in the Norfolk/Virginia Beach/Newport News MSA (eleven out of twelve of these localities comprise the Hampton Roads nonattainment area); (4) all areas in Virginia other than the three major MSAs; and (5) the entire state of Virginia.

Table 11 presents capital and annual costs of Stage II equipment for public retail stations in various possible control areas. Private stations would sustain the same costs per facility (Tables 7 and 8), resulting in total costs by county or MSA which are approximately the same as that of public stations, but only if the Stage II program did not allow a throughput exemption. Ninety percent of private stations, however, have a monthly gasoline throughput of <10,000 gallons; therefore, 90% of the private stations in Virginia would be exempt from Stage II controls under a Stage II program with a <10,000 gallon per month exemption.

Stage II controls conserve gasoline through the capture of vapors at the nozzle/fillpipe interface which are then routed back to the storage tank. U.S. EPA and MBS have estimated this conservation effect at roughly 2/10 of one percent of the gasoline that is dispensed, or about two gallons out of every thousand pumped. Thus, a medium-sized station that pumps 50,000 gallons per month (600,000 gallons in a year) would conserve approximately 1,200 gallons. Gasoline savings have been calculated (Table 2) for the four geographic areas where a Stage II regulation could be implemented (as discussed above) assuming implementation of a Stage II program with a <10,000 gallon/month exemption.

The cost of the Stage II control system is eventually recovered through an increase in the sale price of the gasoline. Most sources estimate a one- to two-cent per gallon increase in the cost of gasoline as a result of Stage II controls. A Stage II system installed at a service station pumping approximately 50,000 gallons per month could conceivably pay for itself in about six years, figuring that the station increased gasoline prices by one cent per gallon and incurred a capital cost of approximately $17,000 and annual costs of roughly $3,000. Larger stations selling more than 100,000 gallons of gasoline per month could recoup their costs in four to five years.

C. Cost To Consumers of Stage II Vapor Recovery Systems

Costs of Stage II equipment installation and maintenance will undoubtedly be passed on to the customers as an increase in the price per gallon of gasoline. U.S. EPA, the state of New Jersey, and Multinational Business Services, Inc. (MBS) state that the increase in price of gasoline will amount to less than one cent per gallon, regardless of the monthly gasoline throughput of the station. MBS states, however, that efforts to recover costs at the rate loans must be repaid could increase the cost to as much as two cents per gallon for smaller stations during the first five years of the program.

D. Cost Effectiveness of Stage II Systems

In defining levels of control, pollution cannot totally be eliminated in most situations. Therefore, the issue becomes defining the appropriate level of control. With this in mind, a tool called "cost effectiveness" is used in the process of determining the appropriate level of control and selecting the appropriate control strategy or system. It is useful for comparing various control systems among themselves. The cost effectiveness of a pollution control system is a simple ratio of the projected cost of the control system to the amount of emissions that would be controlled. The resulting cost effectiveness can then be compared to that of other related controls to provide a measure of how "reasonable" the system is relative to the others. Thus, the cost effectiveness value for a particular control system is usually expressed in terms of dollars per ton of pollutant removed by the control system. The cost effectiveness value is obtained by adding the capital costs for the control equipment to the operating and maintenance costs and amortizing that sum over an appropriate period of time. The result is called the annualized cost. Dividing this value by the tons of pollutant removed gives the cost effectiveness value.

The cost effectiveness of vapor balance Stage II control systems in various areas of program coverage is presented in Table 12. Cost effectiveness values are presented for both single product and multi-product dispensers for a Stage II program with no throughput exemptions and for one with a <10,000 gallon per month exemption. Cost effectiveness was calculated by dividing the annualized cost of controls (Table 11) for the area in question by the emissions reduction (Table 2) that would result from Stage II program in that particular area. The cost effectiveness of Stage II program implementation in the first three areas of program coverage (Washington, D.C. MSA and only the Richmond nonattainment localities; the Washington, D.C. MSA and the entire Richmond/Petersburg MSA; and all three major MSAs) is approximately the same. The cost effectiveness increases substantially, however, when implementing a Stage II program in all areas in Virginia other than the three major MSAs.

The cost effectiveness of Stage II controls in Virginia's nonattainment areas compare favorably with cost effectiveness of many existing VOC controls and those currently in development. The United States Congress, Office of Technology Assessment (OTA) presents cost effectiveness figures (in 1994 dollars) for reasonably available control technologies (RACT) at existing stationary sources of VOC in nonattainment areas throughout the United States. These sources include petroleum refining, certain types of chemical manufacturing, paper surface coating, automobile surface coating, gasoline terminals, service stations (Stage I controls), and dry cleaning operations. RACT level controls are required by regulation throughout the United States for each of these source categories. The 1994 cost effectiveness of RACT on nonattainment area existing VOC stationary sources ranges between $2,200 to $6,600 per ton of VOC removed. OTA also estimates the cost effectiveness for Stage II Controls in nonattainment areas to be roughly $1,000 per ton of VOC reduced. The cost effectiveness of VOC controls on stationary sources for which control technology guidelines (CTGs) will soon be developed (wood furniture coating operations, autobody refinishing operations, coke oven byproduct plants, publicly owned treatment plants, and bakeries) is estimated by OTA to range from $5,300 to $6,600 per ton of VOCs reduced. It is also estimated that the cost-effectiveness of current controls to smaller businesses (due to mandates from the 1990 Clean Air Act amendments) could be as much as $15,000 per ton of emissions reduced. A cost effectiveness of approximately $800 per ton to $1200 per ton for Stage II controls in Virginia's three major MSAs is much less than the cost effectiveness of controls on VOC sources soon to be regulated by new CTGs and well below the cost effectiveness of RACT controls on existing stationary sources.

TABLE 4. PURCHASE COSTS FOR VAPOR RECOVERY NOZZLES AND REPLACEMENT PARTS[3,4,5]
(May 1991 Dollars)

Item	Cost
Nozzle Costs	
New Nozzle	$240
Core Return Credit	$50
Rebuilt Nozzle	$190
Component Costs	
Nozzle Boot	$25
Boot Kit	$40
Face Seal Kit	$15
Clamp Kit	$5
Boot Assembly Kit	$30-50

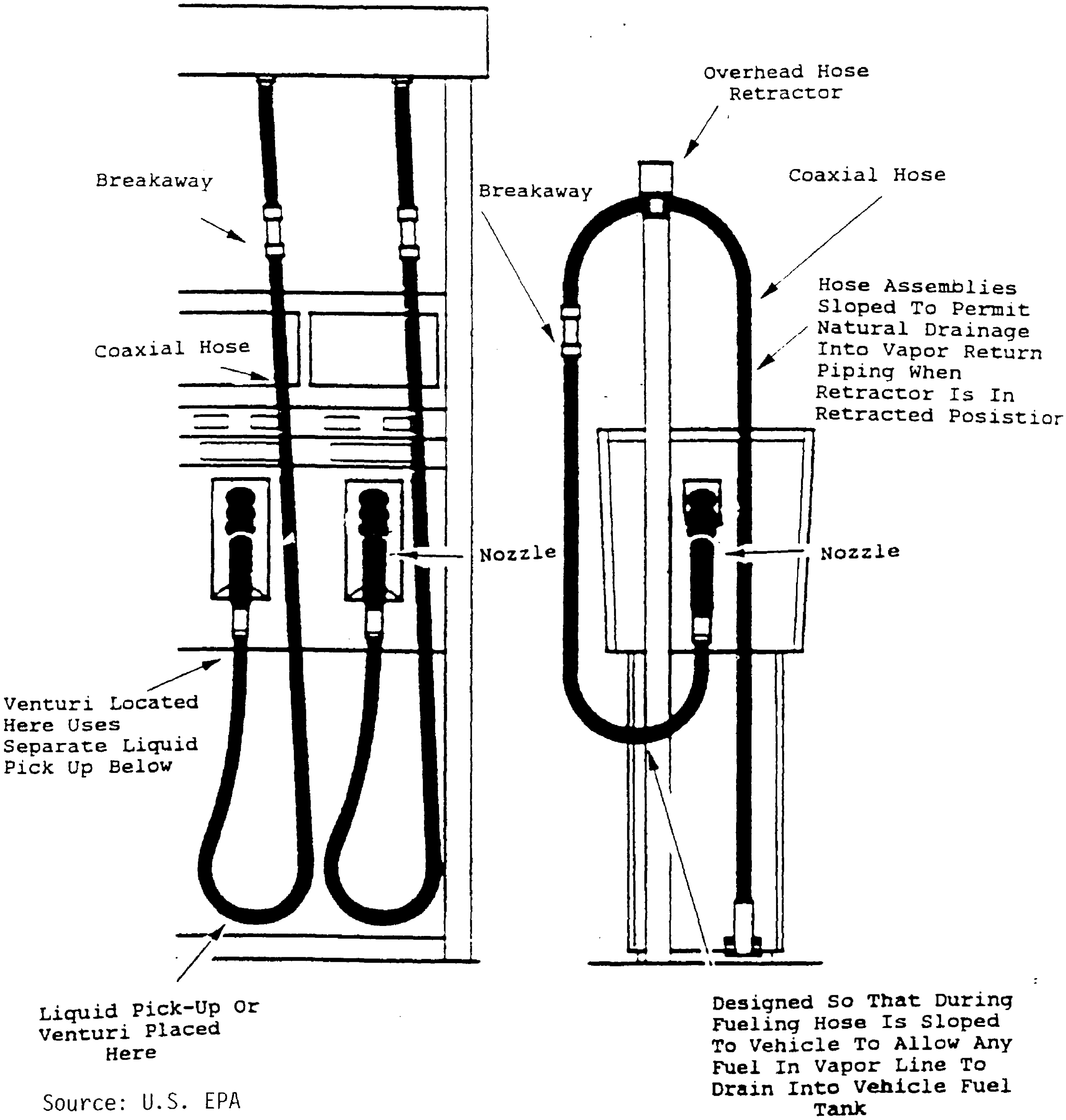
Source: U.S. EPA

TABLE 5. TYPICAL VAPOR RECOVERY HOSE COSTS[13,14,15]
(May 1991 Dollars)

Item[a]	Costs
Coaxial Hose	$140-$230
Liquid Removal Trap	$200
Coaxial Hose with Removal Trap	$240

Source: U.S. EPA

[a] Costs presented for a typical 10 foot hose system.



Source: U.S. EPA

Figure 8. High Hang Hose Configurations

TABLE 6. TYPICAL COSTS OF OTHER VAPOR RECOVERY COMPONENTS[10,12,13]
(May 1991 Dollars)

Item	Costs
High hang hose assembly	$100
Hose break away fittings	$140
Vapor check valves	$80
Swivels	
Nozzle	60
Island	60
Dispenser	60
Retractor	60
Flow limiters	
Hose splitters	60

Source: U.S. EPA

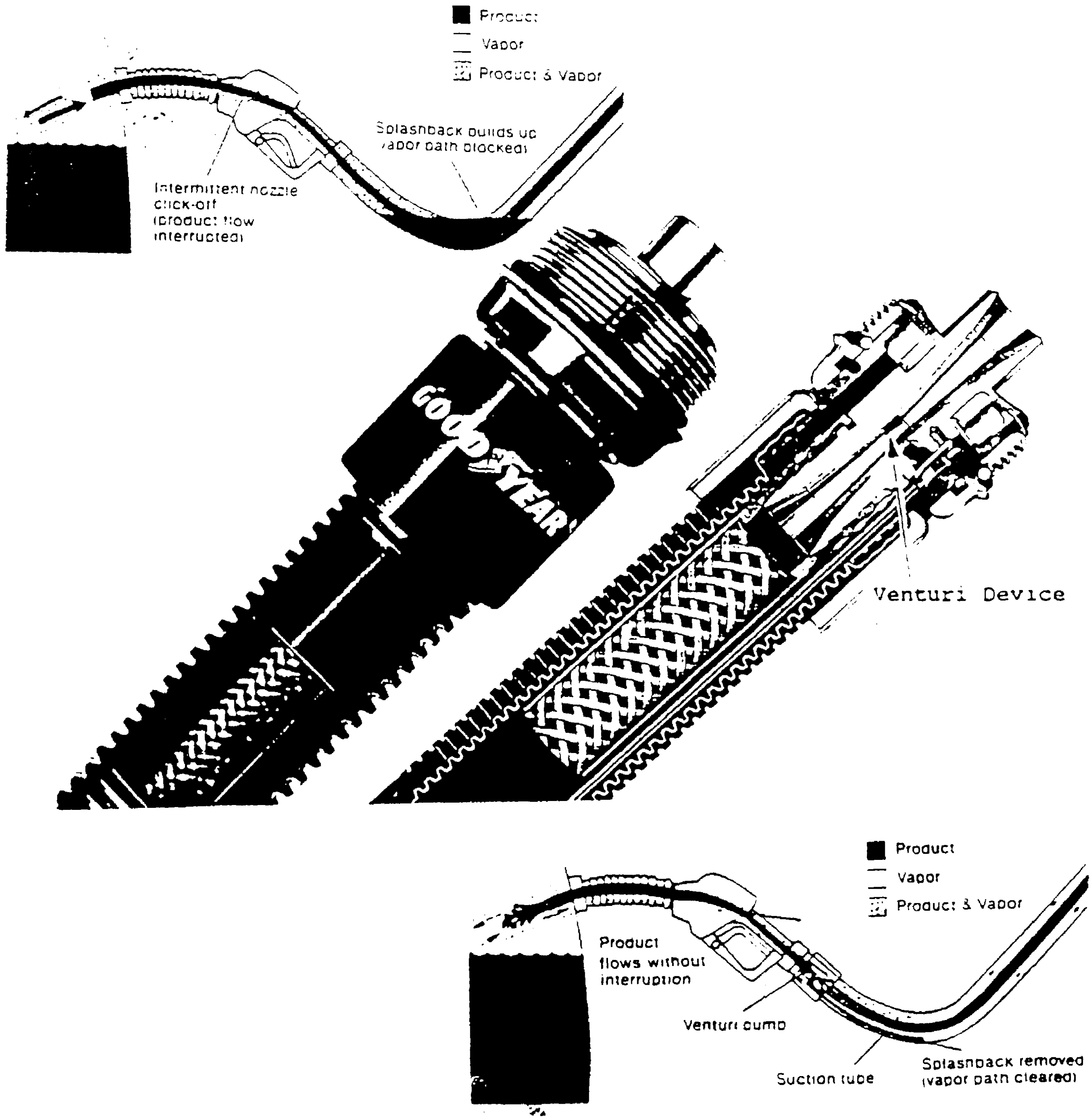


Photo Courtesy of Goodyear Tire & Rubber, Co. Akron, OH

Figure 9. Example Liquid Removal Device

TABLE 7. 1991 STAGE II BALANCE SYSTEM CAPITAL ABOVEGROUND COST

COMPONENT		COST OF COMPONENT	
	MONTHLY THROUGHPUT (GALLONS)	SINGLE DISPENSER	MULTIPRODUCT DISPENSER
MODEL PLANT 1	0 - 9,999		
Number of Nozzles		2	4
Dispenser Direct Cost		1,580	3,210
Piping Direct Cost		3,910	3,910
Total Capital Cost		5,490	7,120
MODEL PLANT 2	10,000-24,999		
Number of Nozzles		3	6
Dispenser Direct Cost		2,370	4,810
Piping Direct Cost		4.950	4,950
Total Capital Cost		7,320	9,760
MODEL PLANT 3	25,000-49,999		
Number of Nozzles		6	12
Dispenser Direct Cost		4,740	9,620
Piping Direct Cost		7,860	7,860
Total Capital Cost		12,600	17,480
MODEL PLANT 4	50,000-99,999		
Number of Nozzles		9	18
Dispenser Direct Cost		7,120	14,430
Piping Direct Cost		9,690	9,690
Total Capital Cost		16,810	24,120
MODEL PLANT 5	≥100,000		
Number of Nozzles		15	30
Dispenser Direct Cost		11,860	24,060
Piping Direct Cost		12,650	12,650
Total Capital Cost		24,510	36,710

Source: U.S. EPA

TABLE 8. 1991 STAGE II BALANCE SYSTEM ANNUAL ABOVEGROUND COST

COMPONENT		COST OF COMPONENT	
	MONTHLY THROUGHPUT (GALLONS)	SINGLE DISPENSER	MULTIPRODUCT DISPENSER
MODEL PLANT 1	0 - 9,999		
Capital Recovery Costs		701	893
Maintenance Cost		475	475
Other Indirect Costs		219	285
Recovery Credit		129	129
Total Annualized Cost		1,266	1,524
MODEL PLANT 2	10,000-24,999		
Capital Recovery Cost		939	1,555
Maintenance Cost		617	617
Other Indirect Costs		293	485
Recovery Credit		518	518
Total Annualized Cost		1,331	2,139
MODEL PLANT 3	25,000-49,999		
Capital Recovery Cost		1,668	2,313
Maintenance Cost		1,230	1,230
Other Indirect Cost		504	699
Recovery Credit		906	906
Total Annualized Cost		2,496	3,336
MODEL PLANT 4	50,000-99,999		
Capital Recovery Cost		2,297	3,298
Maintenance Cost		1,852	1,852
Other Indirect Cost		672	965
Recovery Credit		1,683	1,683
Total Capital Cost		3,138	4,432
MODEL PLANT 5	≥100,000		
Capital Recovery Cost		3,455	5,175
Maintenance Cost		3,090	3,090
Other Indirect Cost		980	1,468
Recovery Credit		4,790	4,790
Total Annualized Cost		2,735	4,943

Source: U.S. EPA

TABLE 9. TYPICAL VAPOR PIPING COSTS FOR 65,000 GALLON PER MONTH SERVICE STATION[23]

	Vapor Piping Costs
Individual Balance System	7,700
Manifolded Balance System	8,000
Hybrid System	7,700
Vacuum Assist System[a]	7,000

[a] Average of both the Hirt and Hasstech certified vacuum assist systems.

Source: U.S. EPA

TABLE 10

CAPITAL AND ANNUAL COSTS OF STAGE II CONTROLS FOR MULTI-PRODUCT AND SINGLE PRODUCT DISPENSERS AT PUBLIC STATIONS
FOR A PROGRAM WITH NO THROUGHPUT EXEMPTIONS AND ONE WITH A <10,000 GALLON/MONTH EXEMPTION

FOR AREAS OF VARYING GEOGRAPHIC PROGRAM COVERAGE

	STAGE II CAPITAL COSTS				STAGE II ANNUAL COSTS			
	STAGE II W/ NO EXEMPTIONS		STAGE II W/ <10,000 gal/mo EXEMPTION		STAGE II W/ NO EXEMPTIONS		STAGE II W/ <10,000 gal/mo EXEMPTION	
COUNTY/CITY	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS
Washington, D.C. MSA	$13,474,410	$19,218,320	$12,970,680	$18,670,080	$2,205,649	$3,288,323	$2,108,167	$3,170,975
Richmond/Petersburg MSA	$6,799,460	$9,753,790	$6,574,370	$9,461,870	$1,120,824	$1,670,462	$1,068,918	$1,607,978
Hampton/Newport News/ Virginia Beach MSA	$9,147,710	$13,120,680	$8,851,250	$12,736,200	$1,510,051	$2,248,840	$1,441,698	$2,166,544
All areas in Virginia other than the three major MSAs	$39,906,000	$55,200,270	$34,306,200	$47,937,870	$7,551,204	$10,651,882	$6,259,884	$9,097,402
Statewide	$69,327,580	$97,293,060	$62,702,500	$88,806,020	$12,387,728	$17,859,507	$10,878,667	$16,042,899

TABLE 11

CAPITAL AND ANNUAL COSTS OF STAGE II CONTROLS FOR MULTI-PRODUCT AND SINGLE PRODUCT DISPENSERS AT PUBLIC STATIONS
FOR A PROGRAM WITH NO THROUGHPUT EXEMPTIONS AND ONE WITH A <10,000 GALLON/MONTH EXEMPTION

FOR AREAS OF VARYING GEOGRAPHIC PROGRAM COVERAGE

	STAGE II CAPITAL COSTS				STAGE II ANNUAL COSTS			
	STAGE II W/ NO EXEMPTIONS		STAGE II W/ <10,000 gal/mo EXEMPTION		STAGE II W/ NO EXEMPTIONS		STAGE II W/ <10,000 gal/mo EXEMPTION	
COUNTY/CITY	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS
Areas Mandated by 1990 CAA (Washington, D.C. MSA and Richmond Ozone Non. Areas)	$20,273,870	$28,972,110	$19,545,050	$28,131,950	$3,326,473	$4,958,785	$3,177,085	$4,778,953
Washington, D.C. MSA and Richmond/Petersburg MSA	$22,094,480	$31,583,740	$21,305,270	$30,665,260	$3,626,333	$5,406,021	$3,463,019	$5,209,425
Washington, D.C. MSA, Richmond/Petersburg MSA and Hampton/Newport News/ Virginia Beach MSA	$31,242,190	$44,704,420	$30,156,520	$43,401,460	$5,136,384	$7,654,861	$4,904,717	$7,375,969
All areas in Virginia other than the three major MSAs	$39,906,000	$55,200,270	$34,306,200	$47,937,870	$7,551,204	$10,651,882	$6,259,884	$9,097,402
Statewide	$69,327,580	$97,293,060	$62,702,500	$88,806,020	$12,387,728	$17,859,507	$10,878,667	$16,042,899

TABLE 12

COST EFFECTIVENESS OF STAGE II CONTROLS FOR MULTI-PRODUCT AND SINGLE PRODUCT DISPENSERS AT PUBLIC STATIONS FOR A PROGRAM WITH NO THROUGHPUT EXEMPTIONS AND ONE WITH A <10,000 GALLON/MONTH EXEMPTION

FOR AREAS OF VARYING GEOGRAPHIC PROGRAM COVERAGE

	COST EFFECTIVENESS ($/TON)			
	STAGE II W/ NO EXEMPTIONS		STAGE II W/ <10,000 gal/mo EXEMPTION	
AREA OF PROGRAM COVERAGE	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS	SINGLE PRODUCT DISPENSERS	MULTI-PRODUCT DISPENSERS
Areas Mandated by 1990 CAA (Washington, D.C. MSA and Richmond Ozone Non. Areas)	$820	$1,222	$783	$1,178
Washington, D.C. MSA and Richmond/Petersburg MSA	$818	$1,220	$782	$1,176
Washington, D.C. MSA, Richmond/Petersburg MSA and Hampton/Newport News/ Virginia Beach MSA	$819	$1,220	$782	$1,176
All areas in Virginia other than the three major MSAs	$1,114	$1,572	$924	$1,342
Statewide	$949	$1,368	$834	$1,229

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VI: Statutory Requirements and Ongoing Stage II Programs

A. Clean Air Act Amendments of 1990

Section 182 (b)(3) of the 1990 Clean Air Act requires that all gasoline dispensing facilities in moderate or worse ozone nonattainment areas with a gasoline throughput of more than 10,000 gallons per month must install vapor recovery systems (Stage II controls) to prevent gasoline vapors from escaping to the atmosphere during motor vehicle fueling. Stage II control equipment would, therefore, be required for affected facilities in the Richmond nonattainment area (moderate) and in the Northern Virginia nonattainment area (serious).

Section 182 (b)(3) also allows for an exemption for independent small business marketers (independents) of gasoline that sell less than 50,000 gallons per month. An independent small business marketer is a person engaged in the marketing of gasoline who would be required to pay for procurement and installation of vapor recovery equipment under Section 324 of the Act; this definition does not apply if the marketer is a refiner or is affiliated with a refiner who produces more than 65,000 barrels per day. Section 324 contains additional specific provisions relating to vapor recovery for independents who market petroleum products. According to Section 324 (a), independent-owned facilities with a gasoline throughput of 50,000 gallons per month or more are allowed an extended three year phase-in period for installation of Stage II control equipment. Section 324 (a) reiterates the exemption for independent-owned facilities with a throughput of less than 50,000 gallons per month; however, Section 324 (b) states that nothing in Section 324 can prohibit any state from adopting or enforcing a Stage II regulation for independents having monthly sales of less than 50,000 gallons per month.

Section 182 (b)(3)(B) requires that the compliance date for installing Stage II controls for affected gasoline dispensing facilities built after the effective date of the state's Stage II regulation is six months after that regulation's effective date. Facilities that dispense 100,000 gallons of gasoline or more per month are required to install Stage II controls no later than one year after the effective date of the state's regulation. All other gasoline dispensing facilities must be in compliance no later than two years after the effective date of the state's Stage II regulation.

The possibility exists that the mandate for Stage II controls may be waived for Richmond and Northern Virginia nonattainment areas. Section 202 (a)(6) of the Act provides that after the regulation requiring onboard refueling vapor recovery (ORVR) systems for new vehicles is adopted by U.S. EPA, Stage II controls will no longer be required in moderate nonattainment areas

(Richmond nonattainment area), and Stage II controls may be waived for serious (Northern Virginia nonattainment area), severe, and extreme nonattainment areas when the U.S. EPA Administrator determines that onboard controls are in widespread use throughout the United States motor vehicle fleet. The U.S. EPA is required to adopt the onboard regulation by November 15, 1991 after consultation with the U.S. Department of Transportation (DOT) regarding safety issues. The DOT delegated the responsibility for assessing the safety of these systems to the National Highway Traffic Safety Administration (NHTSA). On August 5, 1991, the NHTSA reported to U.S. EPA on the safety risks associated with ORVR systems. The NHTSA continues to have concerns about the safety of ORVR systems, and recommends Stage II controls as a viable, safer alternative to ORVR systems. After U.S. EPA gave indications that the regulation would not be published in its final form prior to the November 15, 1991 deadline, East Coast Corporation of Richmond, Virginia and Sheetz, Inc. of Altoona, Pennsylvania jointly forwarded notice on September 25, 1991 to U.S. EPA promising to sue the agency for not issuing the regulations governing ORVR systems by the deadline. As of February 1, 1992, the U.S. EPA has not published a proposed onboard regulation.

B. Status of Ongoing Stage II Control Programs in Other States

Stage II vapor recovery has been a part of VOC emissions control in San Diego, California since 1974. Sixteen other districts in California contain areas which are classified nonattainment for ozone and have Stage II programs that have been in effect for over a decade. The Stage II program has become one of California's major VOC control strategies, by reducing VOC emissions by 48,000 tons annually, and saving 15 million gallons of gasoline. Other areas of the country have also established Stage II vapor recovery programs. The District of Columbia implemented a program in the early 1980s and St. Louis, Missouri adopted vehicle fueling regulations in the late 1980s. From the late 1980s to 1991, New Jersey, New York, Massachusetts, Philadelphia, and Dade County, Florida have adopted Stage II programs; these programs range from those that are currently well into the implementation and enforcement stages to those in the initial stages of the program. Statewide Stage II controls have been mandated by the 1990 Clean Air Act amendments in eleven northeastern states from Maine to Maryland (including the District of Columbia and Northern Virginia) as part of a comprehensive plan to reduce ozone pollution throughout the region.

The role that emissions reductions from Stage II programs will play in bringing Virginia's three nonattainment areas into attainment with the ozone standard cannot yet be determined. The amount of reductions needed for each nonattainment area will not be known until early 1993, after emission inventories are completed (November 1992) and analysis of air quality impact is completed. At that time, the emissions reductions that may be obtained by implementing Stage II programs in areas not currently required to have Stage II controls by the 1990 Clean Air Act may be needed (along with reductions from other new and expanded programs) to bring the area(s) into attainment. Once the nonattainment areas have been brought into attainment with the ozone standard, there must be no net increase in emissions to avoid jeopardizing the attainment status of the area. Stage II emissions reductions may also be needed to provide emissions credits which would allow for future growth in these newly designated attainment areas, without causing the area to revert to nonattainment status. The magnitude of emissions reductions needed to attain the standard and the cost effectiveness of each of the possible available control measures will be the deciding factors in determining where Stage II controls will be required in the future.

REFERENCES

American Lung Association, "Estimated Prevalence and Incidence of Respiratory Disease By Lung Association Territory," September 1989.

Multinational Business Services, Inc., "Stage II Refueling Controls for Ozone," May 1991.

National Petroleum News, "Stage II Handbook - Coping With Stage II," in National Petroleum News August 1991.

Society of Independent Gasoline Marketers of America, "An Introduction to Stage II Vapor Recovery," June 1991.

United States Congress, Office of Technology Assessment, "Catching Our Breath - Next Steps for Reducing Urban Ozone," July 1989.

United States Environmental Protection Agency, "Technical Guidance - Stage II Vapor Recovery Systems for Control of Vehicle Refueling Emissions at Gasoline Dispensing Facilities - Volume I: Chapters," EPA-450/3-91-022a, November 1991.