Public/Stakeholder Comments Received
by the
Massachusetts Department of Environmental Protection (MassDEP)
on the
Consultant's Draft Final Report on Stage I & II Programs
(Prepared by Eastern Research Group Inc. & de la Torre-Klausmeier Consulting)

October 2012

The following compilation of comments received by MassDEP includes emails, letters, presentations, white papers, analysis and other documentation submitted by the following parties, whose submissions appear in the same order:

Allan, Barbara Kwetz – Lexington, MA
Arid Technologies, Inc. – LaGrange, IL
Arnold, Anne – EPA New England, Boston, MA
Independent Oil Marketers Association of New England – North Falmouth, MA
Loscutoff, William & Gilson, Donald – CA
Vapor Systems Technologies Inc. – Springsboro, OH

From: Barbara Allan [mailto:bkallan1010@gmail.com]
Sent: Friday, August 31, 2012 1:30 PM
To: Hiney, Eileen (DEP)
Subject: Comments on Air Program Support For Stage I and Stage II Programs in Massachusetts

Dear Ms.Hiney,

I wish to offer for your consideration my comments on the Air Program Support for Stage I and Stage II Programs in Massachusetts:

I want to commend MassDEP for undertaking this study. It provides the needed technical basis for determining the future of emission controls at gas dispensing facilities (GDFs) which are ubiquitous sources of not only ozone precursors, but, equally if not more significantly, air toxics. Minimizing emissions from these facilities and thus exposure to them is important for the public's health. Massachusetts residents are directly exposed to these emissions as they fuel their vehicles. To the extent that some number of these facilities are located in or near residential areas, or even adjacent to actual residences, some portion of Massachusetts residents have an even higher exposure to hazardous and carcinogenic air pollutants inherent in gasoline and emitted at the GDFs than the average citizen.

The study makes a case that Massachusetts does meet US EPA's criteria for widespread use of vehicles equipped with ORVR systems. The study identifies July 2013 when Stage II equipment provides the same emissions reductions as ORVR, and that sometime between July 2015 and July 2016 the continued presence of Stage II may actually cause emissions to increase.

The analyses that support these conclusions are based on IEE factors, the values of which range significantly and could alter the results of the analysis. Implicit in these analyses is also the assumption that ORVR is effective throughout the life of a vehicle, which, to my knowledge, has yet to be tested and proven. This means that MassDEP needs to be cautious and conservative in pursuing Stage II decommissioning. With those caveats, since termination of the Stage II program requirement requires a SIP revision and EPA approval, use of the EPA factor is the most appropriate, and the analysis using that factor should be the basis for informing MassDEP' next steps. Since the EPA IEE factor shows that Massachusetts will continue to accrue emission reduction benefits from Stage II in combination with ORVR until 2015, MassDEP should not terminate the program until then. This has a number of benefits: maximizing continued incremental emission reductions; providing sufficient lead time to develop and process regulatory changes, which need to include requirements for the technically appropriate decommissioning of Stage II equipment (not discussed in this report, but important); and getting EPA SIP approval, which will need to show compliance with yet unspecified CAA requirements.

Given the caveats, the uncertainties in the analysis, and most importantly the continuing impact of ozone- forming and toxic emissions from GDFs, MassDEP should enhance its requirements for Stage I as part of the Stage II program decommissioning regulatory process. This would provide a "margin of safety" for the identified uncertainties, additional public health protection, and additional cost-effective emission reductions as part of the Commonwealth's ozone contingency plan, a SIP requirement, and/or ozone maintenance plan. In general, it appears that the Stage I enhancement options are most cost-effective for those GDFs with a greater than 500,000 gallon annual throughput, and two of the options actual show a net cost savings due to significant fuel savings.

With respect to requiring GDFs to implement Module 1 of CA EVR, I recommend that MassDEP make this a BACT requirement for new GDFs and all GDFs, regardless of throughput, making major modifications. This will allow for a cost-effective phase-in of what is clearly an available control technology, since components are already in-use in Massachusetts, i.e., swivel adaptors meeting CA EVR standards, and will provide incremental emission reductions.

With respect to requiring continuous vapor leak monitoring systems, I recommend that MassDEP require this as part of the Stage II decommissioning package for GDFs with a greater than 500,000 gallon annual throughput. Although there appears to be uncertainty with respect to the cause of test failures, the dollar per ton cost is low (regardless of whether EPA or industry provided inputs are used) and the emission reduction potential great. These systems also provide a net cost savings because of significant fuel savings. This requirement should also immediately be applicable to all new stations and all modifications, regardless of throughput, as BACT.

With respect to pressure management systems, I recommend that MassDEP support the further research of this technology that Connecticut and New York are considering. These systems have the potential to reduce emissions at GDFs at a relatively low cost per ton, and also save fuel, thus accruing cost savings to the GDF. The results of such research should be used to inform MassDEP of the efficacy of these systems.

Finally, I commend MassDEP for looking at the impacts of removing Stage II equipment in environmental justice areas. While the results of the analysis, relying on best available data and a number of reasonable assumptions, do not provide a definitive recommendation, other than further research (always a laudable endeavor), they do seem to show that emissions from GDFs can affect all communities, regardless of their designation. Accordingly, MassDEP should ensure that the next phase of controls from GDFs continue to minimize emissions cost-effectively statewide.

Thank you for the opportunity to comment.

Sincerely,

Barbara Kwetz Allan

Lexington, MA

ARID Technologies' Inc. Comments on the

dKC de la Torre Klausmeier Consulting

DRAFT REPORT

ANALYSIS OF FUTURE OPTIONS FOR CONNECTICUT'S GASOLINE DISPENSING FACILITY VAPOR CONTROL PROGRAM

19 January, 2012

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Sincerely,

Barbara Kwetz Allan

Lexington, MA

Introduction

ARID Technologies, Inc. was founded in 1993, and the company specializes in the design and manufacturing of vapor recovery equipment used at gasoline dispensing facilities. ARID does not manufacture Stage II vapor recovery equipment; however the company does manufacture a membrane based vapor processor called PERMEATOR. The ARID Permeator enhances existing Stage II vapor recovery technology by actively managing storage tank pressure. By selectively separating hydrocarbon vapors from air, the storage tank pressure is reduced while at the same time valuable fuel is conserved and atmospheric emissions are avoided.

ARID was not contacted by Mr. Klausmeier in preparing his dKC draft report submitted to the State of Connecticut. ARID takes this opportunity to provide our view on the report submitted by Mr. Klausmeier.

Widespread Use

The EPA Proposal to eliminate Stage II vapor recovery, if followed, will not result in the most cost effective means to reduce pollutants and will not save valuable fuel. In fact, our data show that emissions will be significantly increased above the levels possible with state-of-the-art technology; which has already been proven and is commercially robust.

Details

In general, vapor emissions at gasoline dispensing facilities (GDF) are comprised of refueling emissions and storage tank emissions. In turn, refueling emissions are generated at the nozzle/vehicle interface and at the outlet from the carbon canister used on the ORVR systems. The storage tank emissions are comprised of vent line emissions through the pressure/vacuum valve (p/v valve) and fugitive emissions through various point sources within the vapor containing hardware; where the vent & fugitive emissions are a function of storage tank pressure.

The goal for the GDF is to minimize the total emissions VOC's and HAP's (Volatile Organic Compounds and Hazardous Air Pollutants); which is the sum of the refueling and storage tank emissions. Traditionally, a practical tradeoff existed where the A/L (Air to Liquid) ratio of the Stage II system could be increased to improve vapor collection at the nozzle/vehicle interface; however, this increase in A/L results in air ingestion into the storage tank with a penalty in fuel evaporation, tank pressurization and the generation of both vent and fugitive emissions. With ORVR alone, air ingestion via Stage II is minimized, however air will still be ingested through the vent line and many non-ORVR vehicles will emit raw, uncaptured hydrocarbons directly into the vicinity of the refueling motorist; or to an adjacent motorist. To adequately optimize a solution for the GDF, both sets of emissions must be considered simultaneously.

Why give up one molecule of toxic vapor capture or containment; especially if the means to capture and contain the vapor yield a favorable economic payback?

ORVR and Stage II Emissions

In our view, the concept of ORVR "widespread use" is a flawed idea. It's primary flaw centers on the "breakeven" or "cross over point" ; where the emissions from ORVR alone are said to equal the emissions from Stage II only is not supported by the math; …. the proper math that is. What is neglected in this discussion is a proper accounting of the hydrocarbon emissions from non-ORVR vehicles; where Stage II systems are not in use. It is best to illustrate this important point by example; if the throughput of a given gasoline dispensing facility (GDF) is 150,000 gallons per month; and if one assumes an emission factor of 8.4 lbm of hydrocarbons per 1,000 gallons of fuel dispensed; the following assumptions and calculations can be carried out:

1. Assume Stage II Recovery In-Use Efficiency of 86%
2. Assume ORVR In-Use Efficiency of 95% (neglecting any subsequent drop-off as a function of time)
3. Assume ORVR penetration rate as shown in attached Table 1: "Refueling Emissions"; for year 2013, ORVR penetration is 72%

Table 1 below shows refueling emissions as a function of ORVR penetration rate under a range of scenarios. The emissions are tabulated for a sample GDF site with 150,000 gallons per month of throughput.

First, calculate the uncontrolled refueling emissions from this site:

Uncontrolled Refueling Emissions =150,000 gal/month x 8.4 lbm/1,000 gal = 1,260 lbm per month x 12 months/year = 15,120 lbm/year (This is column 1 in Table 1)

Next, calculate the refueling emission with only ORVR; assume ORVR efficiency of 95% and ORVR penetration of 72%, from year 2013

ORVR Emissions = 1,260 lbm/mo. x (.72) x (1 - .95) + 1,260 lbm/mo. x (1 - .72) = 45.36 + 352.8 = 398.16 lbm/mo. x 12 months/year = 4,777.92 lbm/year (This entry is found in column 2, for year 2013 in Table 1); please note that this figure is derived from the ORVR penetration x (1 - the ORVR efficiency): 45.36 lbm/mo. and then one has to also ***add the raw emissions*** (on the right side of the equation; 352.8 lbm/mo.) ***from non-ORVR vehicles*** to yield the sum of 398.16 lbm/mo. Please note that the raw emissions exceed the controlled emissions by a factor of 352.8/45.36, or 7.8 times.

In another context; if the ORVR efficiency is 95%; the raw emissions from a non-ORVR vehicle represent twenty times the emissions from an ORVR equipped vehicle (1/.05). In Connecticut, the population of automobiles is approximately 2 million (1,999,809, US Dept. of Transportation, Federal Highway Administration, Highway Statistics, 2006). Thus, if ORVR penetration is 72% in year 2013; then 28% or 560,000 vehicles do not have ORVR. Using the factor from above; upon refueling each "batch of 560,000 cars", the raw emissions will be equivalent to 20 x 560,000 or 11,200,000 vehicles. This far exceeds the total vehicle population by a factor of 5 times.

- In the Klausmeier report, the author cites an annual Connecticut gasoline throughput of 1,514,621,566 gallons (based on year 2010 data). If we assume these gallons are approximately evenly distributed among the 2 million vehicles in Connecticut; the annual consumption per vehicle is 757 gallons per year. Assume further a fill-up volume of 13 gallons per refueling. Then, the average number of fill-ups per car in CT is 757/13 = 58. So the average driver fills up his/her vehicle, 58 times per year. Thus, in year 2013, the equivalent emissions from non-ORVR vehicles refueling at non Stage II sites is 20 x 560,000 x 58 = 649,600,000 cars. The ORVR equipped vehicle emissions for the same period are .72 x 2,000,000 x 58 = 83,520,000 cars; where the non –ORVR vehicles contribute an additional emissions burden of 566,080,000 cars! This is simple math; and clearly this sub-optimal scenario should not be desired by the State of Connecticut. Please reference this link for video of a refueling event with a non-ORVR vehicle at a non-Stage II GDF: http://www.youtube.com/watch?v=E8Hoj-_v0W4&feature=related
- These vapor emissions include benzene, a known carcinogen and toxic component.

Further Analysis

We have first showed in very simple terms why elimination of Stage II and sole reliance on ORVR-only is not prudent, and that the notion of WSU (Widespread Use) is flawed. The cost of terminating the Stage II program and relying solely on ORVR will yield significant increases in emissions for CT in comparison to a State-of-the-Art alternative. These increases are further quantified and tabulated below.

Table 1: Refueling Emissions: Single GDF

			1	2	3
Year	**ORVR Penetration Rate**	**Gasoline Throughput**	**Refueling Emissions**	**Refueling Emissions**	**Refueling Emissions**
		gal/month	*No Stage II/ No ORVR*	*No Stage II/* ***With ORVR***	*With Stage II/ With ORVR*
			lbm/year	*lbm/year*	*lbm/year*
2011	69%	150,000	15,120	5,208.84	1,512.00
2012	71%	150,000	15,120	4,921.56	1,512.00
2013	72%	150,000	15,120	4,777.92	1,512.00
2014	74%	150,000	15,120	4,490.64	1,512.00
2015	75%	150,000	15,120	4,347.00	1,512.00
2016	77%	150,000	15,120	4,059.72	1,512.00
2017	78%	150,000	15,120	3,916.08	1,512.00
2018	79%	150,000	15,120	3,772.44	1,512.00
2019	80%	150,000	15,120	3,628.80	1,512.00
2020	81%	150,000	15,120	3,485.16	1,512.00

Column 3, ***Refueling emissions with Stage II and with ORVR*** is calculated by assuming that the recovery efficiency is increased to 90%; thus (1-.90) or 10 % of the column 1 emissions result.

Continuing on, we next consider the impact of storage tank vent and fugitive emissions (The Klausmeier report refers to these emissions as Incompatibility Excess Emissions, IEE). These emissions are important to include in the analysis since the sum of the refueling emissions and the vent and fugitive emissions represents an accurate picture of the total emissions experienced at the GDF site.

Table 2: Vent, Fugitive & Total Emissions (including IEE Emissions)

4	5	6	7	8	9	10
Storage Tank Vent & Fugitive Emissions	**Storage Tank Vent & Fugitive Emissions**	**Storage Tank Vent & Fugitive Emissions**	**Total Emissions (Refueling + Storage Tank)**	**Total Emissions (Refueling + Storage)**	**Total Emissions**	**Total Emissions**
With Stage II/ with ORVR No Processor	*No Stage II/ with or without ORVR No Processor*	*With Processor*	*No Stage II, No ORVR, No Processor*	*No Stage II, With ORVR, No Processor*	*Stage II & ORVR, no Processor*	*Stage II, ORVR with Processor*
lbm/year	*lbm/year*	*lbm/year*	*lbm/year*	*lbm/year*	*lbm/year*	*lbm/year*
6,570	2,190	45.99	17,310	7,399	8,082.00	1,557.99
6,796	2,265	47.57	17,385	7,187	8,307.95	1,559.57
6,997	2,332	48.98	17,452	7,110	8,509.21	1,560.98
7,156	2,385	50.09	17,505	6,876	8,668.23	1,562.09
7,231	2,410	50.62	17,530	6,757	8,742.87	1,562.62
7,307	2,436	51.15	17,556	6,495	8,819.02	1,563.15
7,385	2,462	51.69	17,582	6,378	8,896.68	1,563.69
7,464	2,488	52.25	17,608	6,260	8,975.90	1,564.25
7,545	2,515	52.81	17,635	6,144	9,056.70	1,564.81
7,627	2,542	53.39	17,662	6,028	9,139.11	1,565.39

In Table 2 above, column 4 is calculated by using an average of two emission factors measured by actual field tests conducted at GDF using Stage II vacuum assisted vapor recovery systems. These entries represent the emissions from the storage tank at a GDF using Stage II vacuum assisted systems in conjunction with ORVR vehicles, at the penetration rates listed in Table 1. For column 4 entries, no processor is employed to actively manage the storage tank pressure.

As seen in Appendix 1, the Draft Paper entitled, "**Stage II Vapor Recovery Systems — Options Paper",** U.S. EPA, Office of Air Quality Planning and Standards, Emissions Monitoring and Analysis Division, Emissions Factors and Policy Applications Group (C339-02), February 7, 2006, P 132-p 135; IEE = 3.48 lbm/1,000 gal. The second reference, attached as Appendix 2 of this report is entitled, "Vent Line and

Fugitive Emissions Study, National Gasoline Dispensing Facility", ARID Technologies, Inc., 30 December 2009, P 10; IEE = 3.82 lbm/1,000 gallons; derived as follows; (617.568 gal evaporated/month)/ (806,404 gal dispensed/mo.) x 1,000 x 5 lbm/gal).

Thus, the average emission factor used for year 2011 is (3.48 + 3.82)/2 = 3.65 lbm/ 1,000 gallon. (dKC notes a range of 0.42 lbm/1,000 gal to 2.5 lbm/1,000 gallons; perhaps Mr. Klausmeier overlooked our EPA reference) It should be noted that this factor was increased in subsequent years due to the increasing population of ORVR vehicles, in accordance with Table 1; as ORVR penetration increases, the IEE will increase due to leaner vapors being returned to the storage tank vapor space, which in-turn causes a reduction in hydrocarbon concentration in the vapor space and results in the evaporation of liquid phase gasoline. For simplicity, Table 2 does not list the years (2011 – 2020) on the left hand side of the table. It should also be noted that the IEE measured in the referenced field tests above represents the IEE at only a relatively small range in time; where the combination of several key variables dictates the effective, seasonally adjusted overall emission factor.

ARID has derived a proprietary Evaporative Loss Model (ELM) which considers the impact of key parameters such as fuel storage tank temperature, fuel RVP (Reid Vapor Pressure), A/L ratio of the Stage II system, ORVR penetration, and altitude of the GDF. Based on ARID's extensive field data and practical operating experience, we believe the actual emissions factors (over an annual period) to be much larger than the factors obtained during the field test periods noted above.

Column 5 in Table 2 above represents the storage tank emissions from a GDF not using Stage II, with or without ORVR, and no vapor processor. The presence or absence of ORVR does not impact the air ingestion into the storage tank; which will be via the vent line after the negative cracking pressure of the pressure/vacuum (p/v) valve is reached. Typically, the air ingestion will occur when a negative pressure of -6 to -8 inches of water column is reached. Column 5 entries are derived by dividing column 4 entries by 3. This is a representative figure from field tests on USA GDF sites.

Column 6 in Table 2 above represents the storage tank emissions from a GDF using Stage II vacuum assisted vapor recovery, ORVR vehicles and a processor to actively manage storage tank pressure. Column 6 entries are derived by applying a recovery efficiency of 99.3% to column 4 entries (The 99.3 % recovery efficiency is listed for ARID's PERMEATOR system on page 133 of the "**Stage II Vapor Recovery Systems — Options Paper"** reference noted previously.) Thus, column 6 entries = column 4 x (1-.993).

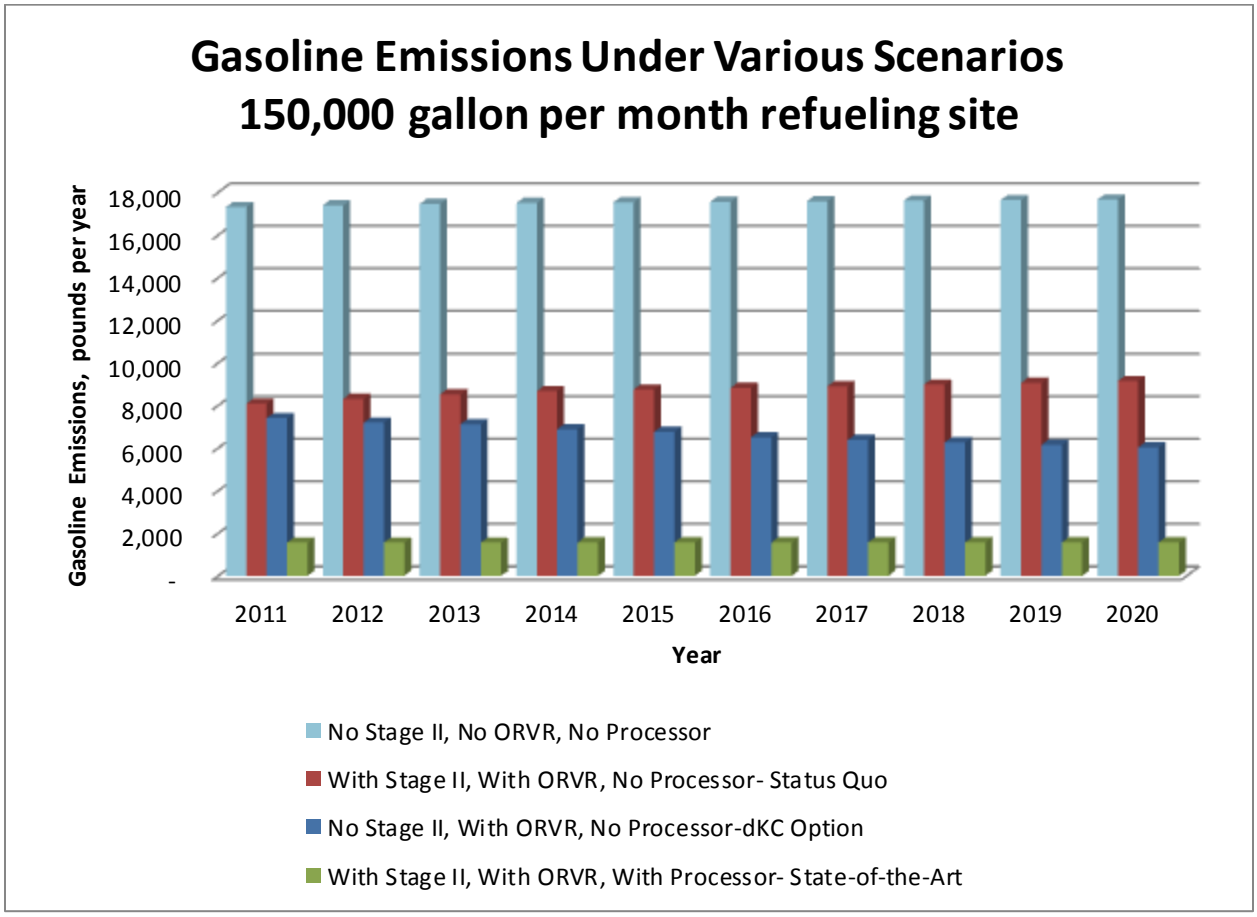
Column 7 in Table 2 represents the sum of the refueling emissions (Table 1, column 1) and the storage tank emissions (Table 2, column 5); where No Stage II, No ORVR and No Processor are used at the GDF. This is the worst case scenario, with no controls on refueling or the storage tank.

Column 8 in Table 2 represents the sum of the refueling emissions with ORVR (Table 1, column 2) and the storage tank emissions (Table 2, column 5); where No Stage II, and No Processor are used at the GDF; with sole reliance on ORVR for emissions reductions. This scenario represents the recommendation made by Mr. Klausmeier.

Column 9 in Table 2 represents the sum of the refueling emissions with Stage II and ORVR (Table 1, column 3) and the storage tank emissions without Processor (Table 2, column 4); where Stage II and ORVR are used at the GDF, but a vapor processor is not employed. This scenario represents the status quo for CT GDF not employing processors.

Column 10 in Table 2 represents the sum of the refueling emissions with Stage II and ORVR (Table 1, column 3) and the storage tank emissions with a Processor (Table 2, column 6); where Stage II, ORVR and a Processor are used at the GDF. This scenario represents the state-of-the-art solution for GDF.

Chart 1: Relative Emissions: Refueling & Storage Tank



As seen in Chart 1, clearly, the ORVR-only case is not an optimum alternative. For the period 2011 thru 2020; the total emissions under each scenario are as follows:

- Worst Case (No Controls): 175,226 lbm
- Status Quo: Stage II, With ORVR, No Processor: 87,198 lbm
- Klausmeier (dKC) Recommendation: No Stage II, ORVR, No Processor: 66, 634 lbm
- State-of-the-Art: ARID: Stage II, ORVR, with Processor: 15,625 lbm

The Klausmeier recommendation may look attractive relative to the No Processor option; however, when compared to the State-of-the-Art option using a Processor, the Klausmeier option shows an increase of 51,009 lbm of emissions, or an increase of 25 tons of hydrocarbon vapor emissions.

Table 3: Emissions Summary: Single GDF, 10 year time horizon

	Uncontrolled	*Status Quo*	*Klausmeier*	*State-of-the-Art*
	lbm	*lbm*	*lbm*	*lbm*
	175,226	87,198	66,634	15,625
% Reduction vs. Uncontrolled	0	50.2%	62.0%	91.1%
% Reduction vs. Klausmeier				76.6%

The State-of-the-Art option represents a 91.1% reduction in atmospheric emissions (in close proximity to the motorist), while at the same time saving a large volume of salable fuel and yielding a rapid payback on invested capital for the gasoline dispensing facility owner/operator. In addition to increased operating efficiency, the risk of groundwater contamination via below grade fugitive emissions is also significantly reduced. Moreover, the State-of-the-Art option using an ARID PERMEATOR represents a further 76.6% reduction in emissions in comparison to the Klausmeier proposal.

A Note about Pressure Integrity and Failure Modes

In the Klausmeier study, the author highlights the high failure rate of Stage II vacuum assisted systems in terms of vapor leakages, and he proposes a lower than 86% in-use vapor recovery efficiency factor. It should be noted that GDF equipped with Stage II vacuum assisted systems (not equipped with vapor processors) operate at a relatively high pressure for a large majority of the time. With reference to the attached "Vent Line and Fugitive Emissions Study, National Gasoline Dispensing Facility" found in Appendix 2; page 6 shows that the storage tank pressure at this site exceeded + 2 inches of water column pressure for 93.73% of the time, during the interval 9 October – 20 November 2009. The cracking pressure of the p/v valve at this site is + 3 inches of water column. Since the storage tank is exerting a nearly constant, high back pressure on the storage tank hardware and associated piping, leaks are to be expected. In fact, the likelihood for leaks forming in the p/v valves, automatic tank gauge caps, overfill drain valves and other tank fittings is increased by the prevailing tank pressure. In addition, the pressure spikes during bulk tanker deliveries (Stage I operations) are also amplified by the high baseline starting pressure. It is ARID's contention that the use of active vapor processors such as PERMEATOR will yield a significant reduction in observed vapor leakages; since the storage tank pressure will be managed to a very low level; during normal operations and also during transient periods with bulk tanker deliveries. In addition, failure modes associated with A/L ratio failures are typically due to low A/L values; where again, the high back pressure in the storage tank does not allow the vacuum pump within the dispenser to reach its rated output level. By reducing the prevailing back pressure, the A/L ratios

should revert back to their design values since the dispenser based vacuum pumps will not have to overcome a high back pressure. As such, Stage II vapor recovery efficiencies will be increased, and the incidence of vapor leakages should be decreased.

It should also be noted that the ARID Permeator is equipped with pressure sensors, a data logger, and remote data acquisition equipment to provide continuous monitoring of storage tank pressure integrity; with outgoing alarms automatically sent if measured parameters fall outside of a prescribed range. (Please note that ARID's data acquisition and storage equipment was used in the NH Study referenced in the Klausmeier report).

A Note on IEE Mitigation

The Klausmeier report mentions several options for minimizing incompatibility excess emissions. ARID would like to highlight technical details as follows:

Please note distinction between "Active processor" and "passive carbon canister"
. Active processor such as Permeator responds to all pressure excursions such as atmospheric pressure variation, bulk tanker deliveries, diurnal breathing, and evaporative losses. The Permeator has high turn-up capability for processing pressure and volume spikes associated with multiple compartment drops during bulk fuel deliveries.
. Passive canister has limited adsorption capacity and cannot be regenerated under positive pressure in the storage tanks (Stage II Vac Assist Systems); moreover, even with slight negative pressure which may develop in the storage tanks (Stage II Balance Systems); driving force for regeneration will quickly diminish as adsorbed molecules are desorbed and go back into vapor phase

- CT estimates 95% vac assist population.

- Nozzle which is designed to limit air ingestion from vacuum pump during fueling of ORVR vehicles has limited benefit
. If the motorist pumps 10 gallons of fuel to their car, and only 4 gallons of air/hydrocarbon vapor are returned to the storage tank; the storage tanks will quickly reach the negative cracking pressure of the p/v (pressure/vacuum valves); and atmospheric air will be ingested through the vent line; thus the remaining balance of 6 gallons of air will be ingested via the vent line. At the same time, raw uncaptured hydrocarbon vapors will be allowed to escape at the nozzle/vehicle fill pipe interface (with ORVR, there are still emissions at the nozzle/fillpipe interface). Moreover, when fueling rates are reduced or the GDF closes for business; due to the constant ingestion of ambient air, the storage tank vapor space will lean out, and gasoline will evaporate from liquid phase to vapor phase, pressurize the tank, and escape from the p/v vent. The nozzle itself is unable to "process" the resulting extra vapor volume.

- Balance System conversion: the conversion of vacuum assisted systems to balance systems has operational and technical challenges. From an operational standpoint, the use of bigger, bulkier nozzles represent an added challenge for the average motorist. Also, the fuel flow rates with balance systems tend to be lower due to flow on the inner, smaller diameter coaxial hose. In addition, condensation and evacuation of resulting liquid phase fuel along the vapor return path has proved to be troublesome. Moreover, it is known that the negative pressure developed in the vehicle fill pipe via a venturi flow pattern can draw vapors from the GDF storage tank to the

ORVR canister; this reverse flow pattern puts extra load on the ORVR canister and can negatively impact adjacent fueling positions.

Cost Effectiveness

As previously mentioned, ARID has developed a proprietary Evaporative Loss Model, the ELM is presented below:

ARID TECHNOLOGIES - Evaporative Loss Model for Typical Stage II Vac-Assist site

INPUTS			
Monthly Throughput (gallons)	150,000	Vapor/Liquid Ratio	1.05
Monthly Gasoline Gallons Saved Yr 2013	302	Gasoline RVP	10.00
Daily Gasoline Gallons Saved Yr 2013	10.05	Storage Tank Temperature	75.00
Gasoline Saved, Year 2013, % of throughput	0.20%	Depreciation Life (yr)	5.00
System Installed Cost	$40,000.00	Altitude (feet above sea level)	750
Discount Rate	10%	Lessee Discount Rate (After Tax)	10%
Value of Recovered Gasoline	$3.50		

BENEFIT SUMMARY		
OWNING UNIT		
After Tax IRR		23%
After Tax NPV @	10%	$20,839
Total Avoided Emissions (Tons)		98.68

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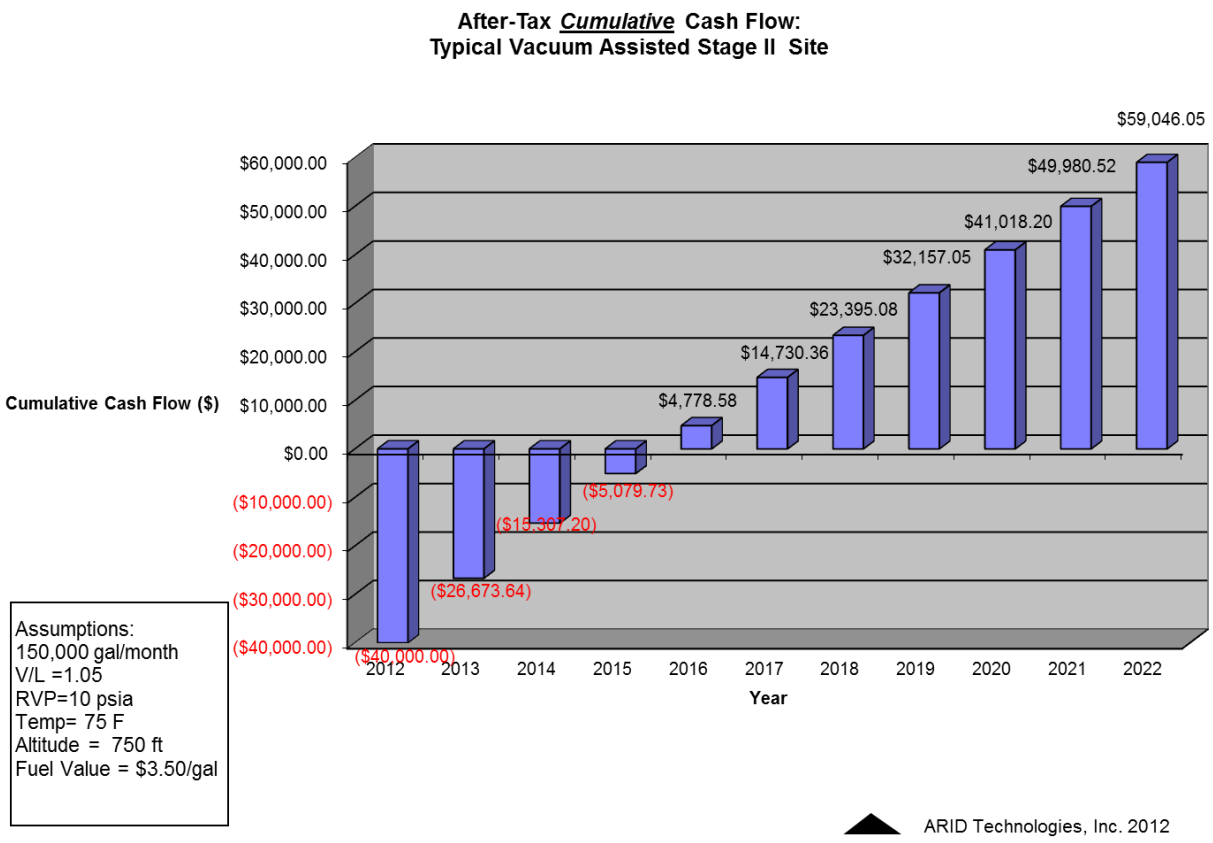
PRODUCT SAVINGS	Coefficients	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ORVR Vehicle Population			78.6%	80.2%	81.8%	83.4%	85.1%	86.8%	88.6%	90.3%	92.1%	94.0%
Evaporative Emissions, V/L =xx, Tons/Yr-Station	1.05		7.43	7.53	7.62	7.73	7.83	7.93	8.04	8.15	8.26	8.37
Recovery with Membrane (Tons of Gasoline)	99.3%		7.38	7.47	7.57	7.67	7.77	7.88	7.98	8.09	8.20	8.32
Pounds of Gas Saved (1 ton =2,000 lbs)			14,753.29	14,945.73	15,142.01	15,342.23	15,546.44	15,754.75	15,967.21	16,183.93	16,404.98	16,630.45
Gallons of gas Saved (5.2 lb = 1 gallon)			2,837.17	2,874.18	2,911.93	2,950.43	2,989.70	3,029.76	3,070.62	3,112.29	3,154.80	3,198.16

CASH FLOW FOR PURCHASED UNITS	Coefficients	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Value of Liquid Gasoline Saved	$3.50		$9,930.10	$10,059.62	$10,191.74	$10,326.50	$10,463.95	$10,604.16	$10,747.16	$10,893.03	$11,041.81	$11,193.57
Bulk Tanker Loading Savings			$2,738.08	$2,738.08	$2,738.08	$2,738.08	$2,738.08	$2,738.08	$2,738.08	$2,738.08	$2,738.08	$2,738.08
Subtotal Product Savings			$12,668.18	$12,797.70	$12,929.82	$13,064.58	$13,202.03	$13,342.23	$13,485.24	$13,631.11	$13,779.89	$13,931.65
Annual Capital, Operating & Maintenance Expenses	1.50%	($40,000.00)	($600.00)	($600.00)	($600.00)	($600.00)	($600.00)	($600.00)	($600.00)	($600.00)	($600.00)	($600.00)
Depreciation: 5 year ACRS			($16,000.00)	($9,600.00)	($5,760.00)	($4,320.00)	($4,320.00)	$0.00	$0.00	$0.00	$0.00	$0.00
Incremental Operating Income			($3,931.82)	$2,597.70	$6,569.82	$8,144.58	$8,282.03	$12,742.23	$12,885.24	$13,031.11	$13,179.89	$13,331.65
Incremental Tax Expense	32.00%		($1,258.18)	$831.26	$2,102.34	$2,606.26	$2,650.25	$4,077.51	$4,123.28	$4,169.95	$4,217.56	$4,266.13
Incremental Net Income After Tax			($2,673.64)	$1,766.44	$4,467.48	$5,538.31	$5,631.78	$8,664.72	$8,761.96	$8,861.15	$8,962.33	$9,065.52
Add Back Depreciation			$16,000.00	$9,600.00	$5,760.00	$4,320.00	$4,320.00	$0.00	$0.00	$0.00	$0.00	$0.00
After Tax Cash Flow		($40,000.00)	$13,326.36	$11,366.44	$10,227.48	$9,858.31	$9,951.78	$8,664.72	$8,761.96	$8,861.15	$8,962.33	$9,065.52
Cumulative Cash Flow		($40,000.00)	($26,673.64)	($15,307.20)	($5,079.73)	$4,778.58	$14,730.36	$23,395.08	$32,157.05	$41,018.20	$49,980.52	$59,046.05
Volume saved/month (gallons)		316.27	301.62	304.71	307.85	311.06	314.33	317.67	321.08	324.55	328.09	331.71
% Throughput Saved		0.21	0.201	0.203	0.205	0.207	0.210	0.212	0.214	0.216	0.219	0.221
gallons saved per day		10.54	10.05	10.16	10.26	10.37	10.48	10.59	10.70	10.82	10.94	11.06

The cumulative cash flow for this model is presented below:



For the inputs noted in the ELM; the fuel savings from operation of the PERMEATOR are shown to be about 2 gallons of fuel per 1,000 gallons of fuel dispensed. It should be noted that this volumetric savings rate corresponds to a mass savings rate of about 10 lbm of hydrocarbons per 1,000 gallons; a figure significantly higher than the previous figure of 3.65 lbm/1,000 gallons used in the IEE calculation for base year 2011. In practice, we note agreement within 10 to 15% between actual measured results and predicted values with the ARID ELM.

For a typical site with throughput of 150,000 gallons per month, an approximate 4 year payback is seen with an after-tax internal rate of return of 23%. For the interval 2012 – 2022, 98.68 tons of emissions are avoided while fuel savings of $132,832 are accumulated **from a single GDF**. These economics are for the capital equipment sale of ARID's PERMEATOR. An installed cost of $40,000 is used in this analysis.

ARID offers Permeator under two options: (1) Capital Equipment Purchase, or (2) Shared Savings Arrangement. With the capital purchase option, the one-off list price of the Permeator is $37,000, which includes a 3 year warranty on parts & labor. Under the shared savings arrangement, the Permeator is supplied at zero cost, and the customer makes monthly payments equal to 50% of the saved fuel value. In this manner, even GDF with relatively small throughput can take advantage of the fuel savings and emissions reduction benefits of PERMEATOR.

Summary

Using the number of CT Stage II sites referenced in the Klausmeier summary; if the two smallest throughput categories are exempt from using State-of-the-Art technology to mitigate vapor emissions (< 300,000 gal/year and 300,000-500,000 gal/year categories); the remaining 1,060 Connecticut sites are viable candidates for emissions reductions and associated fuel savings. If one subtracts the annual fuel consumption estimated from the two smallest throughput categories (approx. 270,000,000 gal/yr.) from the annual consumption figure of 1,514,621,566 gal/yr.; the remaining throughput of 1,244,621,566 gallons per year passing through 1,060 GDF sites will yield significant fuel savings and emissions reductions.

Tables 4A, 4B, 4C, 4D and 4E below present a summary of the fuel savings and emissions reductions for the State of Connecticut, along with cost data. In these Tables, the IEE emissions are based on a more realistic figure calculated via the ARID ELM, these IEE factors are listed in the Evaporative Loss Model presented on page 10 of this summary. In addition, the Status-Quo, Klausmeier recommendation and State-of-the-Art options are compared. Moreover, per the rationale above, ARID assumes that 82% of the State of Connecticut's gasoline volumes will pass through Stage II vacuum assisted GDF, numbering 1,060 sites.

Table 4A: Refueling Emissions: State of CT

			1	2	3
Year	**ORVR Penetration Rate**	**Gasoline Throughput**	**Refueling Emissions**	**Refueling Emissions**	**Refueling Emissions**
		gal/year	*No Stage II/ No ORVR*	*No Stage II/* ***With ORVR***	*With Stage II/ With ORVR*
			tons/year	*tons/year*	*tons/year*
2011	69%	1,244,621,566	5,227	1,800.84	522.74
2012	71%	1,244,621,566	5,227	1,701.52	522.74
2013	72%	1,244,621,566	5,227	1,651.86	522.74
2014	74%	1,244,621,566	5,227	1,552.54	522.74
2015	75%	1,244,621,566	5,227	1,502.88	522.74
2016	77%	1,244,621,566	5,227	1,403.56	522.74
2017	78%	1,244,621,566	5,227	1,353.90	522.74
2018	79%	1,244,621,566	5,227	1,304.24	522.74
2019	80%	1,244,621,566	5,227	1,254.58	522.74
2020	81%	1,244,621,566	5,227	1,204.92	522.74

Table 4B: Vent, Fugitive & Total Emissions (includes IEE Emissions)

Connecticut - Statewide

4	5	6	7	8 (Klausmeier)	9 (Status Quo)	10 (State of the Art)
Storage Tank Vent & Fugitive Emissions	**Storage Tank Vent & Fugitive Emissions**	**Storage Tank Vent & Fugitive Emissions**	**Total Emissions (Refueling + Storage Tank)**	**Total Emissions (Refueling + Storage)**	**Total Emissions**	**Total Emissions**
With Stage II/ with ORVR No Processor	*No Stage II/ with or without ORVR No Processor*	*With Processor*	*No Stage II, No ORVR, No Processor*	*No Stage II, With ORVR, No Processor*	*Stage II & ORVR, no Processor*	*Stage II, ORVR with Processor*
tons/year	*tons/year*	*tons/year*	*tons/year*	*tons/year*	*tons/year*	*tons/year*
6,129.76	2,043	42.91	7,271	3,844	6,652.50	565.65
6,191.99	2,064	43.34	7,291	3,766	6,714.73	566.09
6,256.78	2,086	43.80	7,313	3,737	6,779.52	566.54
6,320.75	2,107	44.25	7,334	3,659	6,843.49	566.99
6,386.00	2,129	44.70	7,356	3,632	6,908.75	567.44
6,452.56	2,151	45.17	7,378	3,554	6,975.30	567.91
6,520.45	2,173	45.64	7,401	3,527	7,043.19	568.38
6,589.69	2,197	46.13	7,424	3,501	7,112.44	568.87
6,660.33	2,220	46.62	7,448	3,475	7,183.07	569.36
6,732.37	2,244	47.13	7,472	3,449	7,255.11	569.87

Table 4C: State of the Art vs. Klausmeier & Status Quo

Connecticut - Statewide

State of CT Savings	**Emissions Reductions**	**Fuel Savings**	**Fuel Savings**	**State of CT Savings**	**Emissions Reductions**	**Fuel Savings**	**Fuel Savings**
State of the Art vs. Klausmeier				***State of the Art vs. Status Quo***			
tons/year	*%*	*gal/year*	*$/yr. @ $3.50/gal*	*tons/yr.*	*%*	*gal/yr.*	*$/yr.*
3,278	85%	1,311,379	4,589,826	6,087	91%	2,434,741	8,521,594
3,199	85%	1,279,774	4,479,208	6,149	92%	2,459,459	8,608,108
3,171	85%	1,268,367	4,439,283	6,213	92%	2,485,193	8,698,175
3,092	85%	1,236,989	4,329,461	6,277	92%	2,510,603	8,787,110
3,064	84%	1,225,642	4,289,748	6,341	92%	2,536,521	8,877,823
2,987	84%	1,194,602	4,181,106	6,407	92%	2,562,957	8,970,350
2,959	84%	1,183,599	4,142,597	6,475	92%	2,589,922	9,064,728
2,932	84%	1,172,774	4,104,709	6,544	92%	2,617,427	9,160,993
2,905	84%	1,162,129	4,067,453	6,614	92%	2,645,481	9,259,184
2,879	83%	1,151,669	4,030,843	6,685	92%	2,674,097	9,359,339
			Total $ 42,654,234				Total $ 89,307,403

Table 4D: Revenue per Ton of Emissions Reduced

CT Sites for Processor	*Cost per CT Site, Installed*	*Average Fuel Savings, Statewide*	*Average Emissions Reductions, Statewide*	*Emissions Reductions Cost or Revenue*
Number	*$*	*10 year period; $/yr. @ $3.50/gal*	*10 year period; tons/year*	*Revenue, $/ton reduced*
1,060	40,000	8,930,740	6,379	1,400

Table 4E: Revenue per Ton of Emissions Reduced

Total Cost for Processors	*Financing Cost*	*Net Cost (Net Revenue)*	*Net Revenue for Emissions Reductions*
$	*10 yr., straight line*		
	$/yr.	*$/yr.*	*$/ton*
42,400,000	4,240,000	+ 4,690,740	+ 735

The cost to equip and install 1,060 sites with Processors (under a capital equipment purchase) is approximately $40,000 x 1,060 = $42.4 million. Assume 10 year depreciation to yield annual cost of $4.24 million per year. The net cost is then + $8.93 million/yr. - $4.24 million/yr. = + $4.69 million/yr.; where the cost per ton of emissions reduced; is not a cost, but rather a revenue equal to ;

- (+ $4.69 million/yr.) / (6,379 tons/year) = + $735 in revenue generated/ ton of VOC reduced

The chart summarizes the emissions is presented below, and we obtain dramatically different figures from Table 22 and Table 27 shown in the Klausmeier report.

In conclusion, the elimination of Stage II and sole reliance on ORVR technology does not provide the State of Connecticut with optimal emissions reductions; in terms of both refueling and storage tank emissions. Overlooked in past studies and analyses on this topic are two key elements: 1.) The raw, uncontrolled emissions from non ORVR vehicles, and 2.) The impact of using active processors to manage storage tank pressure and significantly reduce storage tank emissions comprised of vent and fugitive emissions.

The brief analysis above shows that the use of an active processor such as the ARID Permeator provides the following benefits to a GDF:

- *Enhancement of Stage I; pressure spikes during bulk tanker deliveries are processed by Permeator*
- *Enhancement of Stage II; providing ORVR/Stage II Compatibility, without the use of any special nozzles or other special hardware on the "front-end" Stage II system (i.e. Conventional Stage II can remain in place)*
- *On-going and continuous pressure monitoring; we measure tank pressure every 4 seconds and store a 2 minute average; we also monitor and store ambient temperature and atmospheric pressure; where any critical variables (such as tank pressure) which fall outside of a prescribed range trigger an automatic e-mail alert sent to our central monitoring center*
- *Economical payback on invested capital; where the fuel savings rate averages 2 gallons of fuel saved per 1,000 gallons of fuel dispensed*
    - *For smaller throughput sites, the Permeator system is available under a shared savings arrangement; whereby the unit is provided for zero cost, and the GDF owner/operator makes monthly payments to ARID equal to 50% of the fuel savings*

The aggregate benefits for the State of Connecticut GDF operators include $8.9 million per year in fuel savings while at the same time reducing emissions of volatile organic compounds and air toxics by 6,379 tons per year.

Further Note

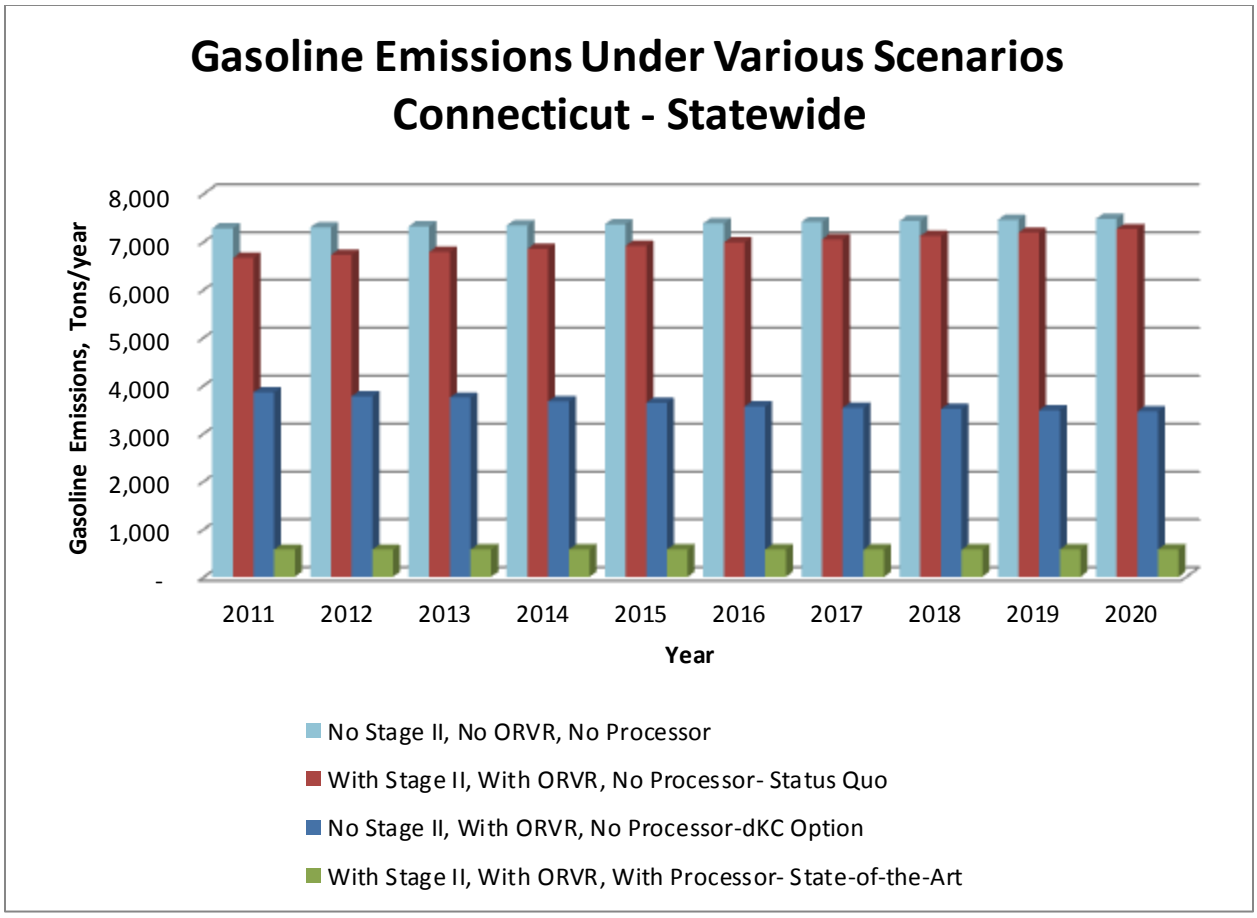
ARID does not seek a regulatory mandate or requirement for Connecticut GDF to use an active processor such as Permeator. However, we do believe that Connecticut GDF owners and operators should be made fully aware of viable options. Even if the compelling benefits of the State-of-the-Art approach using Stage II/ORVR/and Active Processors are ignored by US EPA and the State of Connecticut; ARID believes that individual GDF owners and operators should be free to continue to use Stage II, ORVR and an active processor.

We read with interest the section in the Federal Register which addresses SIP Revision; specifically the section 110 (l) requirements as well as the Clean Air Act Section 116; where States remain free to choose to implement Stage II programs in any area. Perhaps States that continue to use Stage II, in conjunction with a vapor processor will qualify for special state-of-the-art, or MACT status.

This qualification could trigger financial incentives to the GDF owner/operator such as reduced taxes on motor vehicle fuel and/or a subsidy to help cover the capital and installation expenses of installing vapor processor hardware. Moreover, the State may also qualify for various financial incentives while at the same time earning emissions reductions in their SIP. It seems reasonable to reward the proactive States and GDF owner/operators who employ a state-of-the-art approach to reduce emissions above and beyond mandated levels. On the one hand, they will earn an attractive return by paying back their capital investment with saved fuel, but on the other hand, an extra incentive can help ensure that Stage II systems are not incorrectly removed in "knee-jerk" reaction by the majority of the GDF owner/operators.

As an added benefit to regulatory agencies, the efforts expended by the GDF owner/operator will be much stronger and more focused if their "good housekeeping" practices earn them the opportunity to realize an economic benefit – in other words; why ensure leak integrity of your vapor piping system, if you know the losses are constantly occurring through the p/v valve ? However, if the GDF owner/operator installs and maintains Stage II technology along with a vapor processor; they have a strong financial incentive to make sure all systems on the forecourt are properly operating and that the associated piping system remains leak free.

We hope our technical comments and critical review of the Klausmeier report will help CT DEP and EPA to better understand the key technical issues in the interaction of Stage II and ORVR operations at GDF's. With this knowledge in-hand, we hope that regulatory agencies can craft a thoughtful, science-based approach to reduce GDF hydrocarbon emissions in the optimum manner. To that end, ARID stands ready to assist this effort in an objective way.



A Note About the Use of MOVES and Additional Data Used in dKC Analysis

We have been involved in this industry for 19 years, and the analysis presented in Appendix A on prediction of "widespread use"; pages 32-41 was extremely difficult to follow. The analysis seems overly complex, with a multitude of assumptions, models and factors to allow backing in to a "widespread use date". It appears as though Mr. Klausmeier misses the fundamental point that refueling emissions are generated at the automobile/nozzle interface and that vent & fugitive emissions (IEE) are generated within the storage tank. We feel the analysis presented by ARID in this summary more accurately and logically describes and quantifies the Stage II/ORVR dynamics.

In addition, in Appendix B, Mr. Klausmeier references CARB text which must pre-date 2006; as the ARID CARB Certification G70-209 is not mentioned for ORVR Compatibility. ARID received this Certification in October, 2006.

From: Ted Tiberi <ttiberi@ARIDtech.com>
Subject: ARID Input on MA Emissions and means to mitigate
Date: May 15, 2012 11:11:31 AM CDT
To: "Eileen (DEP) Hiney" <eileen.hiney@state.ma.us>
Cc: DELAKLAUS@aol.com

Dear Eileen & Rob,

Spreadsheet Tab Index:

1 Stage II-ORVR-Processor Chart: MA emissions under four scenarios from time frame 2013 - 2022; includes Stage II enhancement

2 Annual State of MA-ELM Data: raw data for Chart in Tab 1; assumptions listed and cell calculations are active for your review. Revenue/Ton for Stage II enhancement calculated at + $ 670 per ton

3 ARID ELM Stage II Site: ARID Evaporative Loss Model is shown for prediction of Stage II emissions (from Storage Tanks) and associated fuel savings at a typical MA site with throughput of 150,000 gallons per month. This ELM uses ORVR population data provided by Klausmeier

4 Cumulative Cash Flow Chart: Cash flow for Stage II Enhancement is presented here; this is graphical representation of data shown in Tab 3; again the throughput is 150,000 gal/mo

5 Pressure Profile Permeator OFF: Non Stage II site in PA; pressure profile with Permeator not active; 3 April - 24 April 2012

6 Press Interval- Permeator OFF: pressure intervals for Non Stage II site with Permeator not active

7 Press Interval-Permeator ON: pressure intervals for Non Stage II site with Permeator actively managing pressure; 26 April - 28 June 2011

8 Non Stage II, Raw Data: raw data for Non Stage II case for both Permeator OFF and Permeator Actively managing pressure

9 Carb Correlation Perm OFF: using pressure interval data to calculate fugitive emissions via CARB equation 9.1.1 and 9.2.1, with Permeator OFF

10 Carb Correlation Perm ON: using pressure interval data to calculate fugitive emissions via CARB equation 9.1.1 and 9.2.1, with Permeator ON

11 Non Stage II Emission Calcs: calculating the total emissions from storage tanks at Non Stage II site; the total tank emissions = fugitive emissions + vent emissions. The vent "losses" are calculated as Permeator fuel savings (as if Permeator was not operational)

12 ARID ELM Non Stage II Site: ARID Evaporative Loss Model is used to predict Non Stage II emissions from storage tanks at typical MA site (the result is compared to figure obtained by other method in the Tab 11)

13 Non Stage II Economics: the average emission factor for Non Stage II site is tabulated and used to generate State of MA emissions inventory from storage tanks (at Non Stage II sites; assuming Stage II is de-activated). Also presented is savings with the ARID processor; in this case the ARID Permeator AT-100 which is designed to process a slightly lower vapor flow rate than the standard Permeator AT-150. The Permeator AT-100 is used for Stage I enhancement and will be offered at reduced up-front cost in exchange for monthly payments from GDF owner/operators. These monthly payments represent a % of saved fuel; where the income from fuel savings funds the monthly payment, with a significant portion of the saved fuel income retained by the GDF owner/operators. The AT-100 also includes pressure monitoring, remote data acquisition and outgoing email capability.

Eileen/Rob; I'd be pleased to walk you both through the spreadsheet and address any specific questions. Perhaps I can visit with you in Boston sometime Eileen; please advise. Thank you again for the opportunity to provide our technical calculations and viewpoint on this important topic.

Best Regards, Ted

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Overview of Storage Tank Evaporation Losses and Permeator Operation

Stage II & ORVR Case and Stage I Only Case (No Stage II)

Ted Tiberi, ARID Technologies, Inc., www.ARIDtech.com, 630.681.8500

15 May 2012

Problem With Stage II and ORVR

- Fuel storage tanks ingest air while Stage II vacuum assisted systems refuel cars equipped with ORVR Canisters (On-Board Refueling Vapor Recovery)
- The air causes the liquid in the tanks to evaporate
- A small amount of liquid creates a large volume of vapors – 1 gallon of liquid gasoline expands to 520 gallons of gasoline vapor
- The increased volume of vapors causes the tanks to increase in pressure until the cracking pressure of the p/v (pressure/vacuum) valve is reached
- When the pressure vacuum valve opens at the cracking pressure, vapors escape from the vent lines – these leaks are called "vent emissions"
- Also, as the tanks are building up pressure on the way to the cracking pressure of the p/v valve, any small gaps or breaches in the hardware connected to the tank vapor space can become leaky – these leaks cause "fugitive emissions". These fugitive emissions are a strong function of storage tank pressure. Increasing pressure results in higher fugitive emissions.
- If the hardware leaks are below grade (below ground), the vapors can eventually condense and create a groundwater contamination problem
- Magnitude of the losses are on average 2 gallons of liquid fuel per 1,000 gallons of fuel dispensed – a site pumping 200,000 gallons per month will lose about 400 gallons per month to evaporation

Solution

- ARID's Permeator AT-150 uses a selectively permeable membrane to separate gasoline vapors from air, and then to exhaust clean air to the atmosphere and return rich vapors to the vapor space of the storage tanks

- Permeator turns on when the combined tank pressure reaches the Hi set point and turns off when the pressure reaches the Low set point
- By enriching the vapor space above the liquid in the tanks, the root cause of evaporation is eliminated
- Also, by reducing the pressure in the tanks below the cracking pressure of the p/v valve, vent emissions are eliminated
- Moreover, by reducing the pressure in the tanks to a much lower average level, the magnitude of fugitive emissions is significantly reduced
- Thus, Permeator reduces air emissions, saves fuel and reduces risk for groundwater contamination

Economics

- One-off list price of Permeator is $37,000 which includes a three year warranty on parts and labor
- Assume installation costs on "new build site" of $3,000 and "retrofit site" of $13,000 (depends on site-specific factors and if excavation is necessary for routing inlet and return vapor lines)
- New build all-in costs of $40,000 and retrofit all in costs of $50,000
- Assume 200,000 gallons per month of gasoline sales with loss rate of 2 gallons per 1,000 dispensed
- Monthly fuel savings = 400 gallons x $4.00/gallon = $1,600 per month = approx $20,000 per year
- Payback on new build = 40/20 = 2.0 years
- Payback on retrofit = 50/20 = 2.5 years
- Operation expense negligible: $40 per month in electrical power and annual oil change
- Other advantages: elimination of groundwater contamination risk reduces environmental cleanup exposure and liability for on-going remediation projects – perhaps this translates to lower insurance premiums
- Further advantages: use of sensors, data logger and remote data acquisition gear allows on-going monitoring of fuel savings data as well as rapid reporting of

anomalies such as faulty p/v valves, unseated overfill drain valves or other situations which cause the vapor space to go leaky.

Problem with Stage I only (No Stage II)

- Fuel storage tanks ingest air when dispensing activity causes the storage tank pressure to reach the negative pressure setting of the p/v valve
- When dispensing activity decreases or when the station shuts down, the ingested air causes the liquid in the tanks to evaporate
- A small amount of liquid creates a large volume of vapors – 1 gallon of liquid gasoline expands to 520 gallons of gasoline vapor
- The increased volume of vapors causes the tanks to increase in pressure until the cracking pressure of the p/v (pressure/vacuum) valve is reached
- When the pressure vacuum valve opens at the cracking pressure, vapors escape from the vent lines – these leaks are called "vent emissions"
- Also, as the tanks are building up pressure on the way to the cracking pressure of the p/v valve, any small gaps or breaches in the hardware connected to the tank vapor space can become leaky – these leaks cause "fugitive emissions". These fugitive emissions are a strong function of storage tank pressure. Increasing pressure results in higher fugitive emissions.
- If the hardware leaks are below grade (below ground), the vapors can eventually condense and create a groundwater contamination problem
- Magnitude of the losses are on average 0.5 to 1.5 gallons of liquid fuel per 1,000 gallons of fuel dispensed – a site pumping 200,000 gallons per month will lose on average about 200 gallons per month to evaporation

Solution

- ARID's Permeator AT-100 uses a selectively permeable membrane to separate gasoline vapors from air, and then to exhaust clean air to the atmosphere and return rich vapors to the vapor space of the storage tanks

- Permeator turns on when the combined tank pressure reaches the Hi set point and turns off when the pressure reaches the Low set point
- By enriching the vapor space above the liquid in the tanks, the root cause of evaporation is eliminated
- Also, by reducing the pressure in the tanks below the cracking pressure of the p/v valve, vent emissions are eliminated
- Moreover, by reducing the pressure in the tanks to a much lower average level, the magnitude of fugitive emissions is significantly reduced
- Thus, Permeator reduces air emissions, saves fuel and reduces risk for groundwater contamination

Economics

- The Permeator AT-100 will use the same robust and commercially proven components as the standard Permeator AT-150 product, but will be designed to process a slightly lower flow rate of vapors.
- This product will be provided at reduced up-front cost in exchange for monthly payments from GDF owner/operators. The monthly payments represent a % of saved fuel; where the income from fuel savings funds the monthly payment; with a significant portion of the saved fuel income retained by the GDF owner/operator.
- Operation expense negligible: $20 per month in electrical power and annual oil change, with ARID maintaining the unit over the monthly payment collection period
- Other advantages: elimination of groundwater contamination risk reduces environmental cleanup exposure and liability for on-going remediation projects – perhaps this translates to lower insurance premiums
- Further advantages: use of sensors, data logger and remote data acquisition gear allows on-going monitoring of fuel savings data as well as rapid reporting of anomalies such as faulty p/v valves, unseated overfill drain valves or other situations which cause the vapor space to go leaky.

ARID Technologies, Inc.
Ted Tiberi
www.ARIDtech.com
ttiberi@ARIDtech.com
15 August 2012
Comments to State of MA

Some key concepts:

1. "ORVR and Stage II are largely redundant technologies"? Why? If a vapor processor is used, the ORVR and Stage II technologies are clearly not redundant, but rather complementary technologies, yielding the optimum emissions reductions.
2. The concept of "widespread use"? Do the lines really intersect? No; with reference to Chart found in Appendix, ARID's data shows that the ORVR, Stage II with processor Case yields the maximum emissions reductions at all ORVR penetration rates.
3. "Foregone Stage II VOC emissions reductions" vs. "Increased vehicle refueling emissions" (One cannot neglect the raw VOC and HAP emissions from non-ORVR and non-Stage II refueling activities). The ERG report references the *declining emissions reductions* achievable with Stage II as ORVR population increases. This statement is true; however, the ERG report does not seem to address the *magnitude of the emissions generated from non-ORVR refueling activity*. As seen in our comments and calculations below, these emissions are significant, and we were unable to generate figures consistent with the ERG report values. ARID does not have deep understanding of the MOVES algorithm; however, we thought our simple calculation method should have shown better agreement with the MOVES generated data. We ask ERG to further explain the rationale and algorithm and to confirm if the non-ORVR emissions are in fact included in their analysis.
4. 95% ORVR control efficiency means that 20 x the emissions will result from non-ORVR refueling
5. 98% ORVR control efficiency means that 50 x the emissions will result from non-ORVR refueling. For example, 10 vehicles being refueled without ORVR will generate the same emissions as 500 cars being refueled with ORVR; assuming an ORVR vapor recovery efficiency of 98%.
6. Why was enhanced Stage II, with ORVR and vapor processors not considered by State of MA as a viable control option? If vapor processors are considered to enhance Stage I; the use of processors to enhance Stage II is clearly a viable option; especially considering the Chart in the Appendix.

The comments above and below are supplemented by the spreadsheets, reports and additional comments submitted to Ms. Eileen Hiney via email on 14 August 2012.

Specific Comments on the ERG Report, **"Air Program Support for Stage I and Stage II Programs in Massachusetts"**, 16 July 2012

Page 3-4; "Because…ARID's estimates have not been independently verified, ERG did not use their IEE factors in our analysis". The ARID IEE factors were generated by a third-party study conducted at a GDF located in Florida; with oversight from Florida DEP, the Palm Beach County Health Department, and the United States EPA, Research Triangle Park. This study is referenced in the EPA's February 7, 2006 Options Paper, entitled, "Stage II Vapor Recovery Systems – Options Paper". The specific ARID reference can be found on pages 132 thru 135.

Page 3-9; Summary

- "ORVR systems alone will result in the same reductions as Stage II systems alone around July 2013". We disagree with this statement, since we were not able to show agreement with the ERG values and the values we calculated with simple algebra. Please refer to calculations, below for year 2013:

  ORVR Penetration Rate: 77.7%; gasoline throughput for State of MA = 2,916,370,000; Emissions from ORVR only = 951,728 lb./year (95% recovery efficiency, 8.4 lb./1,000 gallons Uncontrolled emissions rate). So for ORVR emissions; 0.326 lb./1,000 gallons. For Emissions from non-ORVR vehicles = 5,462,944 lb./yr. (non ORVR % = 1-ORVR% = 22.3%); for non-ORVR vehicles, the emissions rate is 1.87 lb./1,000 gallons; where total rate is 0.326 + 1.87 = 2.20 lb./1,000 gallons. ERG reports a value of about 1.2 lb./1,000 gallons.

  Stage II only Emissions: 87% of fuel dispensed through Stage II systems, and 86% recovery efficiency yields value of 1,491.90 tons/year of emissions = 2,983,796 lb./year = 1.023 lb./1,000 gallons.

  We do not understand why the ORVR only emissions data do not show closer agreement with our simple derivation. Does the MOVES model adequately account for the raw emissions from non-ORVR vehicles? For example, in year 2013, the non-ORVR emissions are equal to 5,462,944 lb./year; which exceeds the ORVR emissions rate by a factor of 5.74 to 1.

- When the case of Stage II enhancement with a vent processor is considered; the ARID data show that the optimum option for emissions reductions is the combination of Stage II, ORVR and vent processor. ARID has measured IEE factors much higher than the ERG reported figure of 0.86 lb./1,000 gallons. The cost effectiveness of Stage II controls, when used in conjunction with

ORVR and a vapor processor are favorable through all time periods with ever increasing ORVR penetration rates.

Page 4-3; section 4.1.2 Vapor Leak Monitoring Systems. The ARIDAS (ARID Data Acquisition System) gear was used by the State of NH in their study to assess storage tank vapor leakages (This report is referenced on page 4-7 of the ERG Report). The ARID equipment was used throughout the New England winter months with no operational problems. The ERG report failed to mention the use of this equipment for the NH study. In addition, ARID has a PERMEATOR vapor processor system installed in the state of MA (Danvers, MA). This unit has been operating error free for over two years. ARID is pleased to share operating data from this unit with state of MA DEP.

Page 4-10; Section 4.2.3 Require Pressure Management System (Emissions Processors) Pressure/Vacuum or P/V valves do not reduce vent losses from gasoline storage tanks. The P/V valve will simply allow pressure to increase up to the threshold or cracking pressure of the P/V valve; as such, fugitive losses (which are a direct function of storage tank pressure) will increase.

Page 4-11; ARID Technologies Summary. The ARID data reports emissions reductions from both vent and fugitive emissions from the gasoline storage tank. Our data does not assume that GDF's do not have P/V valves; our data (and supporting studies) show clearly that the presence of the P/V valve simply increases fugitive emissions (while at the same time decreasing vent emissions); where the total emissions (Vent + Fugitive) remain essentially constant. The figure listed of 4.5 lb./1,000 gallons represents the emissions reduction from a non-Stage II site. ARID's ELM (Evaporative Loss Model) also is suited to predicting emissions reductions from Stage II sites with inputs of A/L ratio, fuel RVP, fuel temperature, gasoline throughput, ORVR penetration, and altitude of the GDF. ARID has equipment available to monitor and measure vent losses at GDF, and we volunteer our equipment and insights to State of MA, CT, NY and other States seeking to make measurements of these parameters.

We did not receive an opportunity to clarify any questions by the ERG report author on any of our inputs.

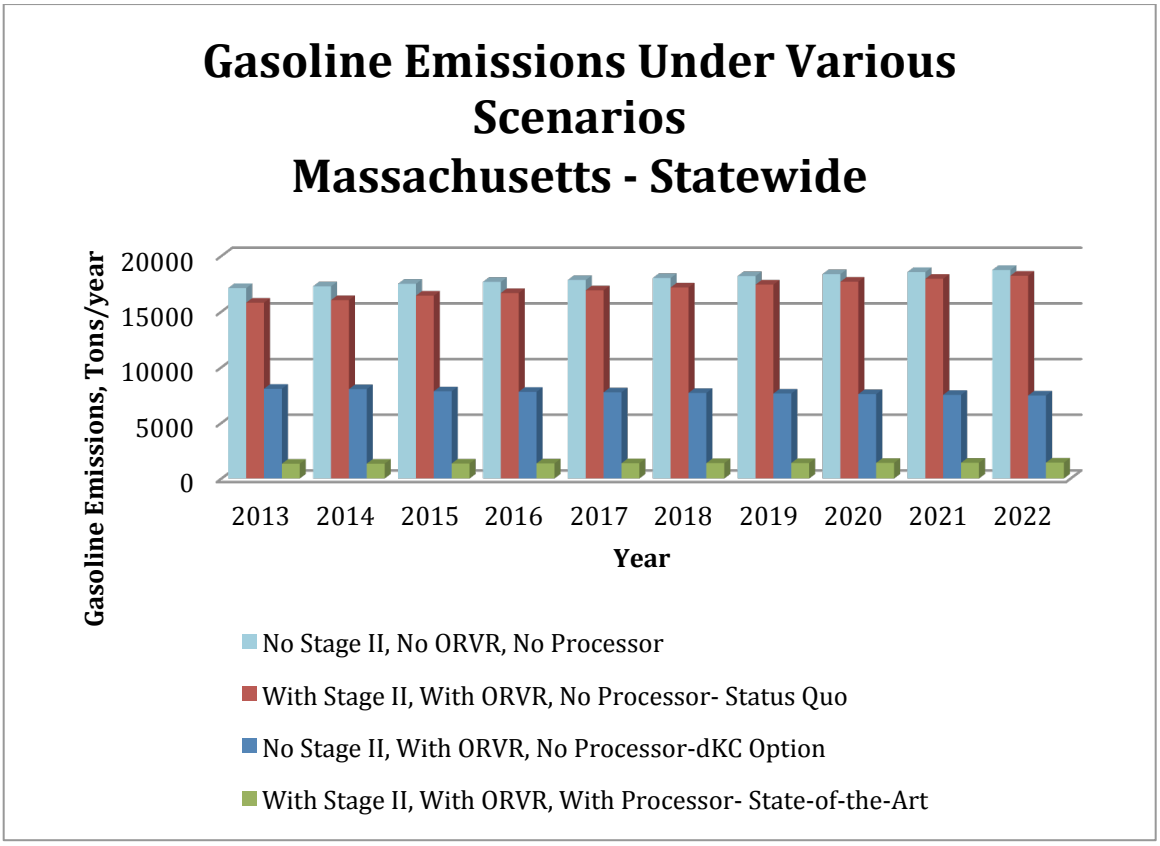
Page 4-13; Costs for Continuous Monitoring for Vapor Leaks

ARID mentioned previously the ARIDAS system. This unit has been proven in the New England environment and is robust. Fixed Cost/GDF is about $4,750. It should be noted that the PERMEATOR system (ARID's vapor processor) includes the ARIDAS gear.

Page 5-1; Environmental Justice Communities
The ORVR population data shown for EJ (73%) vs. non EJ (77%) communities does not appear very meaningful since the derivation of these figures appears very

complex and relied upon so-called Inspection Center data. Readers will need more data to fully understand the source of the ORVR data. The key point is that non Stage II and non-ORVR refueling activities will directly expose the motorist (and nearby people) to VOC's and HAP's from gasoline vapor. These vapors will be ingested and inhaled with significant adverse health effects. These adverse health effects could be avoided with the continued use of Stage II, where the adverse impacts of IEE are mitigated with the use of a vapor processor.

Appendix



28 September 2004

Mr. Thomas A Driscoll
Senior Environmental Scientist
United States EPA
Office of Air Quality Planning & Standards
Emissions Monitoring and Analysis Division
Emissions Factors and Policy Applications Group (D243-02)
109 T.W. Alexander Drive
Research Triangle Park, North Carolina 27709

Dear Mr. Driscoll,

As a follow-up to my presentation on 20 September at the Public Meeting hosted by USEPA, I am pleased to provide my written statements and supporting information concerning Stage II VRS and ORVR incompatibility.

Background

ARID Technologies, Inc. has been directly involved in gasoline vapor recovery technology and associated storage tank dynamics since the company was founded in 1993. From inception to present, ARID has installed more than 125 PERMEATOR systems worldwide, and our experience includes system installations and technical studies conducted in Japan, Europe, South Korea, Mexico and the United States. ARID has developed an Evaporative Loss Model which is used to quantify "incompatibility excess emissions" at a given refueling facility based on five primary factors: gasoline RVP, gasoline storage tank temperature, V/L ratio of the Stage II system, altitude, and ORVR vehicle population. This model has been shown to provide very accurate results between measured and modeled values throughout a diverse range of parameters compiled from refueling facilities located around the world.

Widespread Use

It appears as though stakeholders are interested in the concept of "widespread use" due to the assumption that as more and more vehicles are equipped with ORVR controls, the need for Stage II vehicle vapor recovery systems will diminish. The further assumption made in the Issue Paper is that the combination of Stage II and ORVR technologies yields lower overall emissions than the emissions generated with either technology used alone[1].

ARID respectfully challenges the latter assumption, as our measured and modeled data show a remarkable increase in the incompatibility excess emissions (IEE) generated in the storage tank system as a result of the fundamental incompatibility of Stage II vacuum assist and ORVR technologies. In Appendix 1, Figures 1-4 show the In-use Control Efficiency (IUE) and overall

[1] Stage II Vapor Recovery Systems Issues Paper, Thomas Driscoll, August 12, 2004, pages 17 and 21

130 N. LaGrange Road ▲ LaGrange, Illinois 60525 ▲ Tel: 708-354-1100 ▲ Fax: 708-354-4995 ▲ www.aridtech.com

storage tank evaporative and vehicle refueling emissions at an individual gasoline dispensing facility. The dispensing facility conditions are as follows:

- Δ Throughput: 330,000 gallons per month in 2005 (growth rate of 2.5% per year, thereafter)
- Δ V/L = 1.05 (Stage II vacuum assist system, ORVR penetration per CARB)
- Δ Altitude: 1,000 feet above sea level

Two cases are presented: Figures 1 & 2 are based on 13 RVP fuel at 72 F (Case 1), and Figures 3 & 4 are based on 9 RVP fuel at 85 F (Case 2). Case 1 represents a moderate climate USA site in the winter months, and Case 2 represents a typical moderate climate USA site in the summer months. As seen in Figure 2, with ORVR and Stage II systems employed, year 2005 storage tank and vehicle refueling emissions equal 30 tons per year for a single refueling station (0.24% of throughput = 15 lbm/1,000 gallons). As ORVR penetration and fuel consumption increase in the future years, the emissions reach a level of 40 tons per year by 2010 (0.29% of throughput = 20 lbm/1,000 gallons). The year 2005 and 2010 IEE emissions exceed the AP-42 figure of 1 lbm/1,000 gallons by a factor of 15 and 20, respectively.

In Figure 1, the In-use Control Efficiency (IUE) for the ORVR and Stage II system combination begins at about 50% in year 2005. In future years, the overall recovery efficiency for this option declines and approaches the ORVR only option. Unfortunately, the options are converging at an IUE of about 30% (The best achievable IUE by ORVR only is approximately 50%). Conversely, the ORVR and APCD option begins with an IUE of about 80% and approaches a level of about 98%.

Case 2 plots are presented in Figures 3 & 4. As seen in Figure 4, with the ORVR and Stage II systems in use, year 2005 storage tank and vehicle refueling emissions equal about 18 tons per year, and the emissions increase to a level of about 22 tons per year by 2010. In Figure 3, the In-use Control Efficiency (IUE) for the ORVR and Stage II system option begins at about 60% in year 2005. Again, the ORVR only option and the Stage II/ORVR option converge to a low IUE – in this case about 40%. The ORVR and APCD option begins with an IUE of about 76% and approaches a level of 98%.

For comparison, the measured IEE for two sites are presented in Appendix 2. One site is located in Grass Valley California and the other site is located in Lantana, Florida. As seen in the data summary, the California site IEE measure approximately 0.34% of throughput and the Florida site IEE average about 0.36% of throughput. The excess vapor generation rate is very accurately calculated, and the hydrocarbon concentration of the vapors generated was estimated. The accurate quantification of the IEE is readily accomplished by application of known test methods, and ARID strongly recommends that such testing is conducted and/or supervised by USEPA.

For yet another comparison, additional data are presented for each site in Appendix 3. The measured savings in evaporative losses (IEE) are shown to be 0.40% of throughput and 0.37% of throughput for the California and Florida sites, respectively. These data were generated with the use of ARID's remote data monitoring and acquisition technology used in conjunction with sensors installed on the PERMEATOR (Please recall the details of these calculations presented to you and USEPA Staff during our previous meeting in August 2004).

In general, ARID would like to emphasize the presence and magnitude of the incompatibility excess emissions, IEE. Instead of considering such emissions as part of ancillary issues, ARID

feels that the magnitude of these emissions are such that they must strongly influence the thought processes contemplated for the definition and supporting algorithms related to "widespread use". In addition, these emissions must be considered in the context of the administration of potential SIP credits for various aspects of vapor recovery.

Emission Factors for Fugitive Emissions

With reference to the plot presented in Appendix 4, Mr. Paul Marzilli of the California Air Resources Board (CARB), calculated fugitive emissions with PERMEATOR "OFF" and with PERMEATOR "ON" at ARID's Grass Valley Chevron test site located in Grass Valley California[2]. The results of these measurements are as follows:

	PERMEATOR "ON"	**PERMEATOR "OFF"**
UST average pressure	0.178 inches H2O	2.823 inches H2O
Fugitive emission factor	0.074 lbm/1,000 gallons	0.782 lbm/1,000 gallons

The ratio of the fugitive emission factor with PERMEATOR OFF to PERMEATOR ON is equal to .782 /.074 = 10.6: 1. In addition, the ratio of the fugitive emission factor with PERMEATOR ON to the IEE factor calculated in Case 1 (2005) is 15 /.074 = 202.7. Thus, the UST vent emissions exceed the fugitive emissions by more than 200 times.

The accounting of the emissions as either "fugitive" or "vent emissions" is largely an academic exercise. The key concept is that an excess vapor generation rate is present within the storage tank system (We use the term "vent emissions" to include emptying, breathing, and IEE emissions). This excess vapor volume created will result in an observed pressure increase within the storage tank system. A relatively "tighter system" will yield higher vent emissions and a relatively "leaky system" will yield higher fugitive emissions. In general, if an APCD device is employed to reduce the overall storage tank pressure while at the same time capturing and recovering vent emissions, the driving force for fugitive emissions is dramatically reduced, and the vent emissions themselves are significantly reduced.

When one combines the Bernoulli equation with the Continuity equation, one obtains the following expression for relating the mass of emissions through a hole in a pressurized system:

m = A x (2 x P atm/RT x (P tank – P atm)) ^1/2; where

m = mass flux
A = effective area of the "hole" or "holes" in the system
P atm = atmospheric pressure
R, T = ideal gas constants
P tank = tank pressure

Thus, the square root of a pressure differential accurately describes the variation of fugitive emissions with pressure for a given temperature and hole size.

[2] Email correspondence from Mr. Marzilli to Ted Tiberi, ARID Technologies, Inc., Wednesday, April 21, 2004, cc: Cindy Castronovo and Laura McKinney (CARB). Method used was TP-201.2F.

Another point is that the API and CARB estimated incompatibility excess emissions are on the same order of magnitude as the fugitive emissions measured with PERMEATOR OFF. More importantly though, the magnitudes of these IEE are very small in comparison to the Case 1 vent emissions reported by ARID.

	API, 2004 Study	CARB, 1999 Study	ARID, Case 1
IEE[3]	0.33 lbm/1,000 gal	0.86 lbm/1,000 gal	15 lbm/1,000 gal

The ratio of each value to that reported by ARID is 45:1 and 17:1, for the API and CARB figures, respectively.

SIP Credits

After proper quantification of IEE, decisions on providing SIP, or other market based emissions reduction credits can be properly formulated. From Figures 1 & 3 in Appendix 1, one can quickly see that the maximum recovery efficiency is provided by the integration of ORVR, Stage II and APCD control technologies. The second best option, with significantly reduced cost of ownership (and operation) is the combination of ORVR and APCD control technologies. Assuming the ultimate objective is cleaner air, USEPA and individual states can craft various innovative strategies which allow gasoline dispensing facility owners/operators to proactively take steps to significantly reduce emissions of VOC (volatile organic compounds) and HAPS (hazardous air pollutants). In addition to enjoying the economic benefits of being able to resell the same volume of fuel which they purchased, gasoline marketers will appreciate the cleaner environment in close proximity to their refueling station. As an added bonus, any SIP or emission reduction credits accruing to the state and/or gasoline marketer can accelerate adoption of APCD technologies.

The "Issue Paper" asks for comments about encouraging increased inspection and maintenance of hardware employed at gasoline dispensing facilities. ARID feels that in the past, the incentive for "good housekeeping" practices by facility owners has not been present. The two primary reasons for this are 1.) If a station owner put forth the effort to ensure leak integrity and proper operation of their vapor recovery system, they could guarantee themselves that all their lost product would escape their storage tank system through the p/v vent, and 2.) The sole reliance on centralized monitoring of tank levels and liquid line leak test results removed the involvement of the local site personnel.

These negative factors can be mitigated by the following developments: 1.) The use of an APCD now gives the station owner the proper incentive to ensure hardware is properly maintained and that the vapor carrying components remain leak-tight. Instead of losing vapors at the UST vent (or fugitive sources), the wise station owner will diligently maintain their APCD equipment with the confidence that their efforts and investment will be rewarded with saved product. 2.) The use of simple monitoring technology (such as overall storage tank pressure and APCD run times) can be coupled with local involvement of station personnel. For example, visual inspections may be helpful in identifying catastrophic liquid leaks, but visual inspections are perhaps not as insightful for identifying vapor leaks or vacuum pump degradation within sealed housings. As a solution, consider the impact of continuous monitoring of storage tank pressure from a central

[3] Table 1, page 14, Stage II Vapor Recovery Systems Issues Paper, Thomas Driscoll, August 12, 2004

location, with exceptions reporting capability. This means that if storage tank pressures (or APCD duty cycle) varied significantly from the "normal profile" expected, the system would alert site personnel to conduct further inspections. The site personnel assigned by the marketer (for the individual station, or group of stations) would then further investigate typical leak sources and would arrange for detailed hardware inspections (vacuum pump service) or a leak decay test, if necessary, to pinpoint the anomaly.

This approach re-involves the local personnel to take "ownership" of the inspection and maintenance processes. Due to the use of an APCD, their efforts are rewarded with saved product. It seems reasonable that SIP credits (or other market based credits) could be linked to the use of APCD systems, integrated monitoring and local inspection/maintenance programs to further accelerate adoption of good housekeeping practices. In addition, the designation of BACT, MACT or RACT for the use of APCD technology and/or inspection & maintenance programs could possibly trigger additional SIP credits, government subsidies, tax relief or market based emission credits.

Monitoring of Stage II

The issue paper raises an interesting point regarding the capital investment to monitor systems which are likely being phased out. ARID believes that useful monitoring information can be obtained from "macro" variables such as combined storage tank pressures and APCD run times. The use of "micro" variables (A/L ratios) generated at individual refueling points with so-called ISD systems does not seem necessary nor prudent, considering the cost of the information generated coupled with the likelihood of a short useful lifetime of such equipment. On the other hand, the need for "back-end" APCD technology will continue in perpetuity, regardless of the "front-end" mix of Stage II vacuum assist and ORVR technologies. Thus, a monitoring approach of macro variables associated with operation of APCD technology represents a simple, elegant, robust and much more long-term and cost effective option for petroleum marketers.

Conclusion

ARID strongly supports the need for field testing to accurately quantify the storage tank vent emissions (IEE, emptying and breathing and fugitive). We support further emissions factor work on items (a) – (c) listed on page 28 of the "Issues Paper". New, updated emissions factors are needed to allow relevant decisions to be made regarding widespread use and the potential administration of SIP and other market based credits. ARID also believes that a need exists for APCD technology now and in the future, regardless of the mix of Stage II and ORVR technologies used for vehicle vapor recovery. The APCD technology can be considered "Stage III" technology – storage tank vapor containment technology as opposed to vehicle vapor collection equipment.

The stakes in this discussion are high, as VOC's and HAPS are being emitted in great quantities and in close proximity to gasoline dispensing facilities. Often times, these refueling facilities are located relatively close to large population centers. In recent years, the concept of "co-branded" sites has resulted in consumers and facility employees spending much more time within the refueling station environment. This extra time spent directly correlates to increased exposure to potentially harmful emissions. As seen in Appendix 5, recent studies have quantified the increased emissions and their associated impact on human health.

Thank you for the opportunity to provide our comments and data. We are available at the convenience of USEPA Staff to discuss in-person in Research Triangle Park, via email, or by telephone any of the information presented in this correspondence. ARID looks forward to helping USEPA understand, measure and mitigate gasoline storage tank evaporative losses.

Sincerely,

Tedmund P. Tiberi

Tedmund P. Tiberi
President

Appendix 1
Storage Tank & Vehicle Refueling Emissions
In-use Control Efficiency (IUE)

Figure 1: In-use Control Efficiency (IUE)

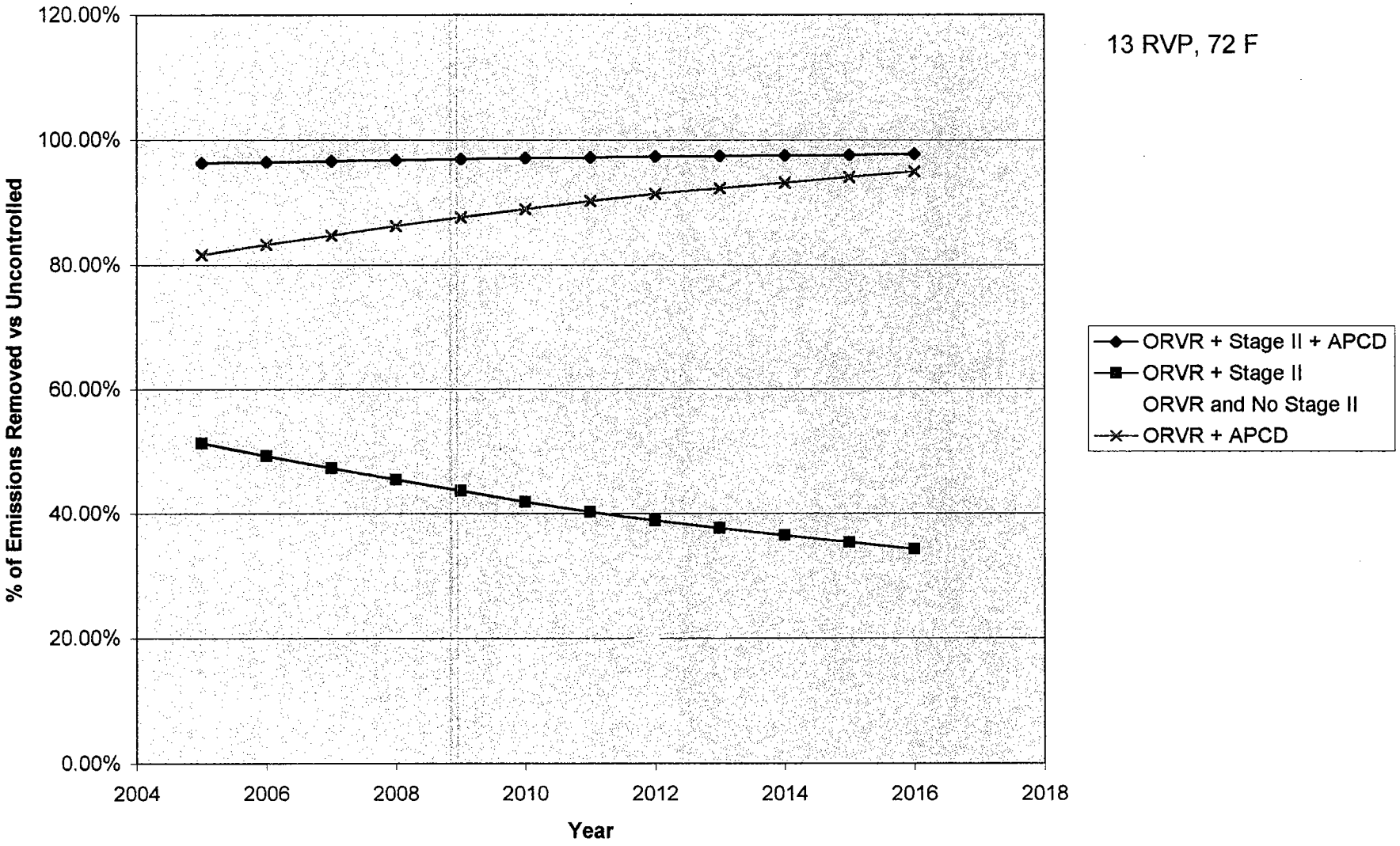


Figure 2: Storage Tank Evaporative and Vehicle Refueling Emissions at a Gasoline Dispensing Facility

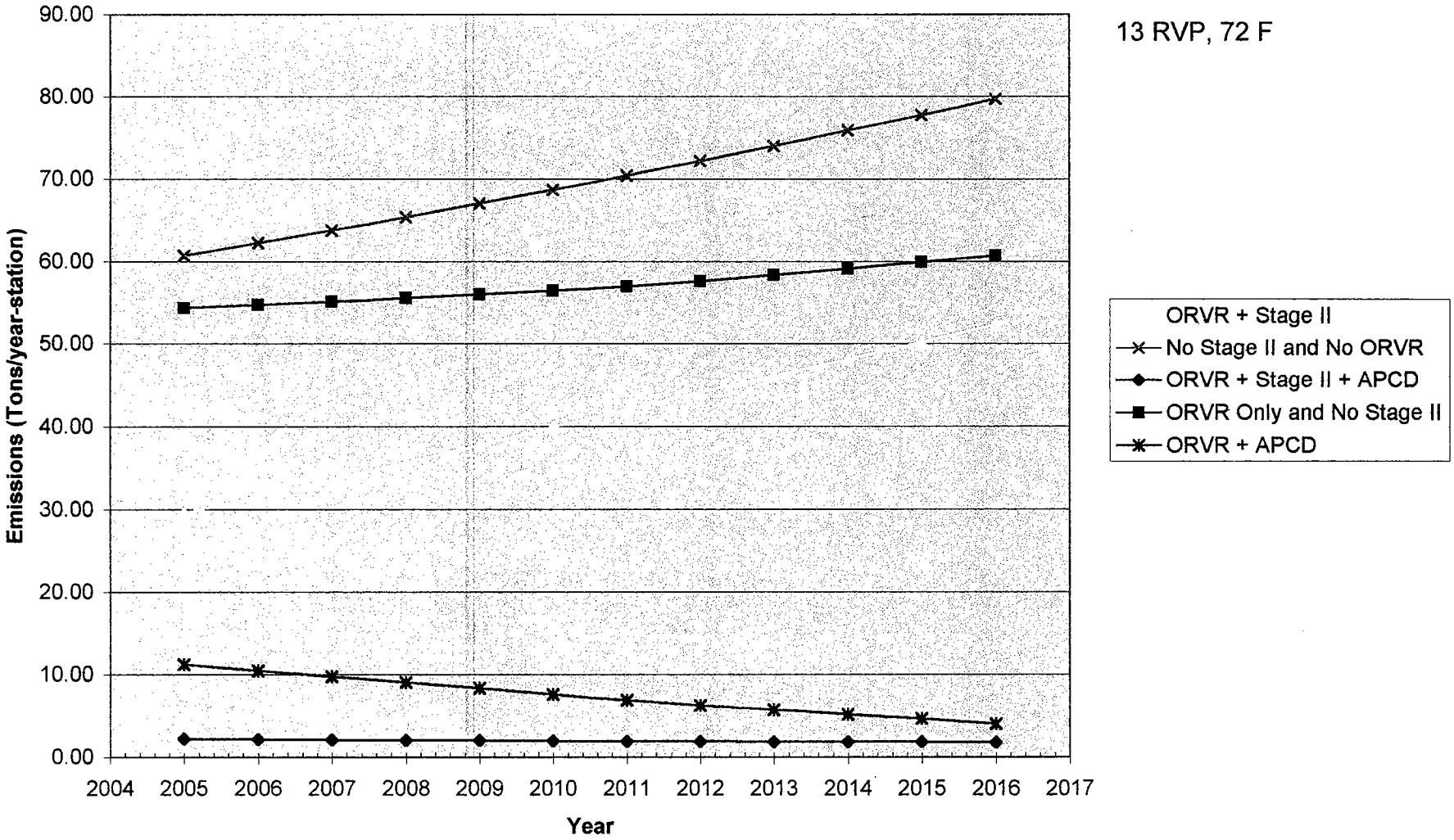


Figure 3: In-use Control Efficiency (IUE)

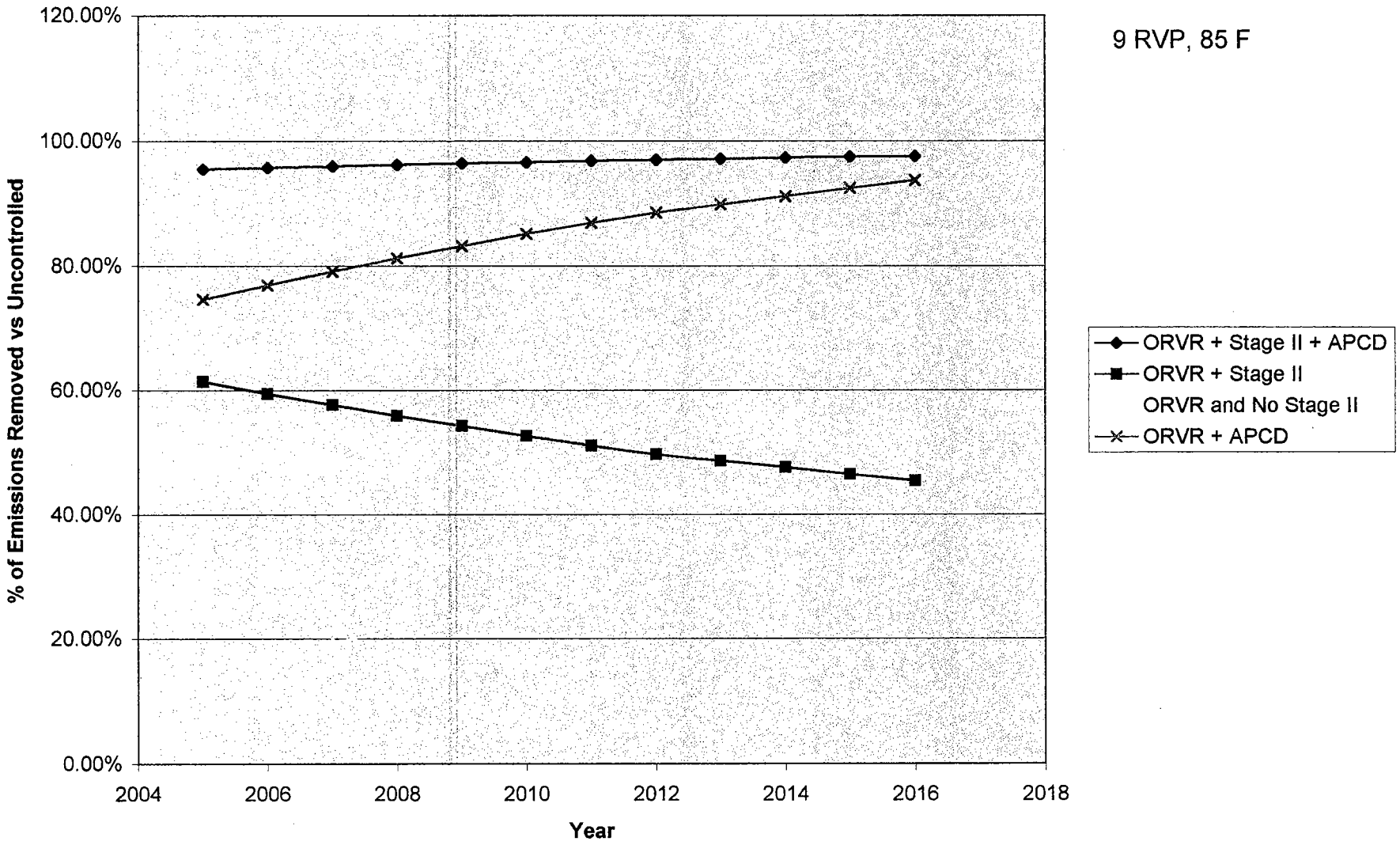
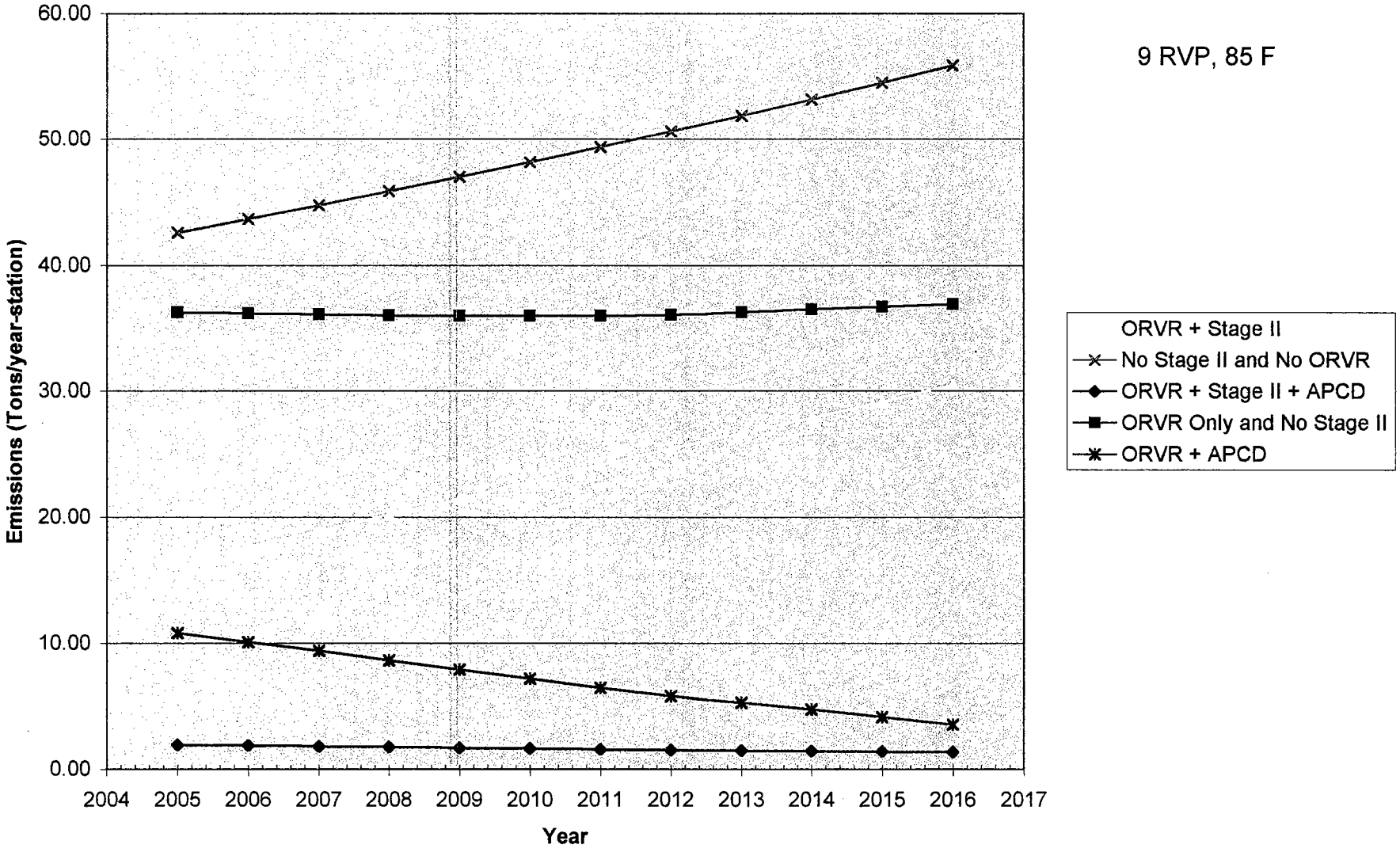
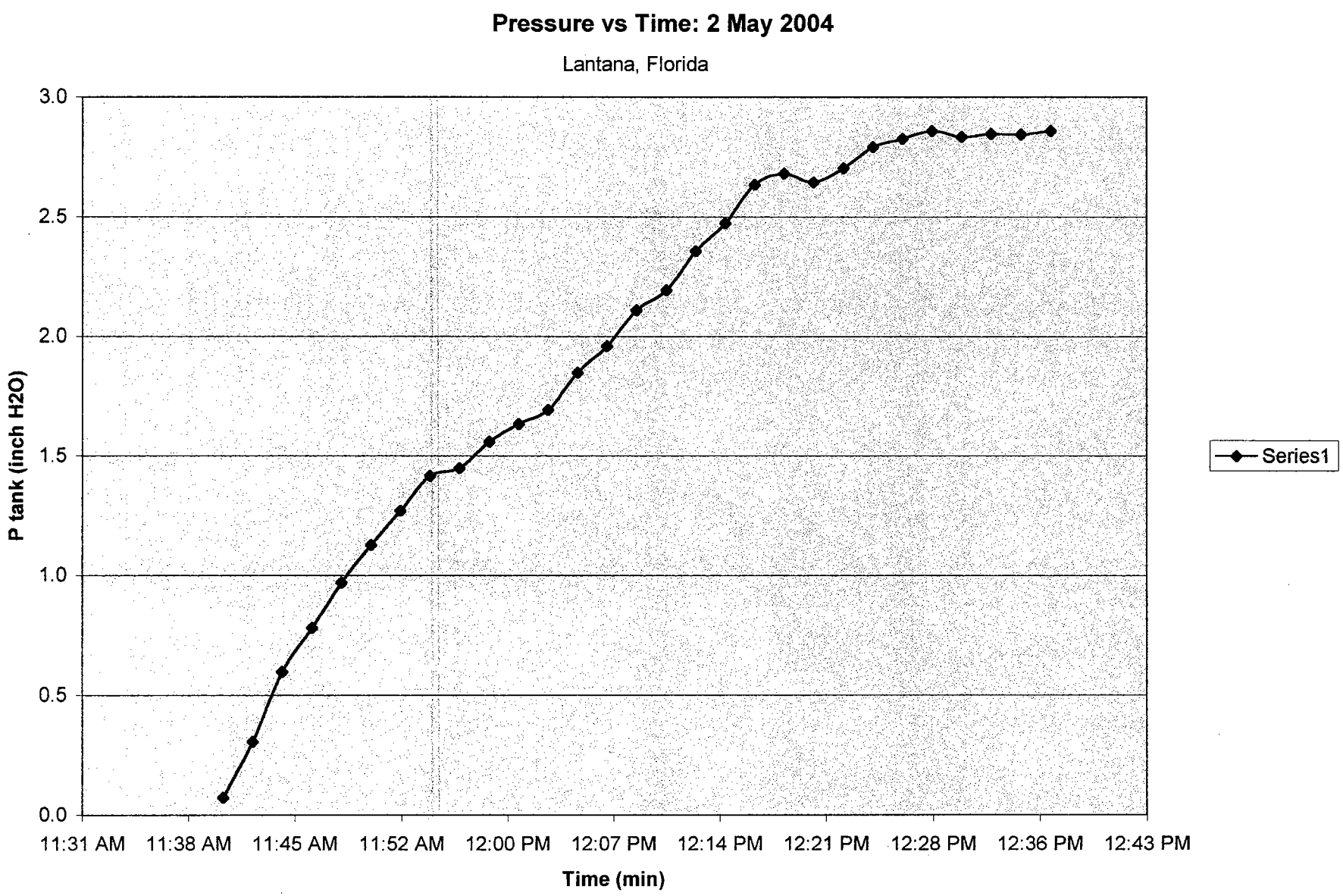


Figure 4: Storage Tank Evaporative and Vehicle Refueling Emissions at a Gasoline Dispensing Facility



Appendix 2
Measured Incompatibility Excess Emissions (IEE) – Method 1


Pressure vs Time: 2 May 2004
Lantana, Florida
P tank (inch H2O)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11:31 AM
11:38 AM
11:45 AM
11:52 AM
12:00 PM
12:07 PM
12:14 PM
12:21 PM
12:28 PM
12:36 PM
12:43 PM
Time (min)
Series1

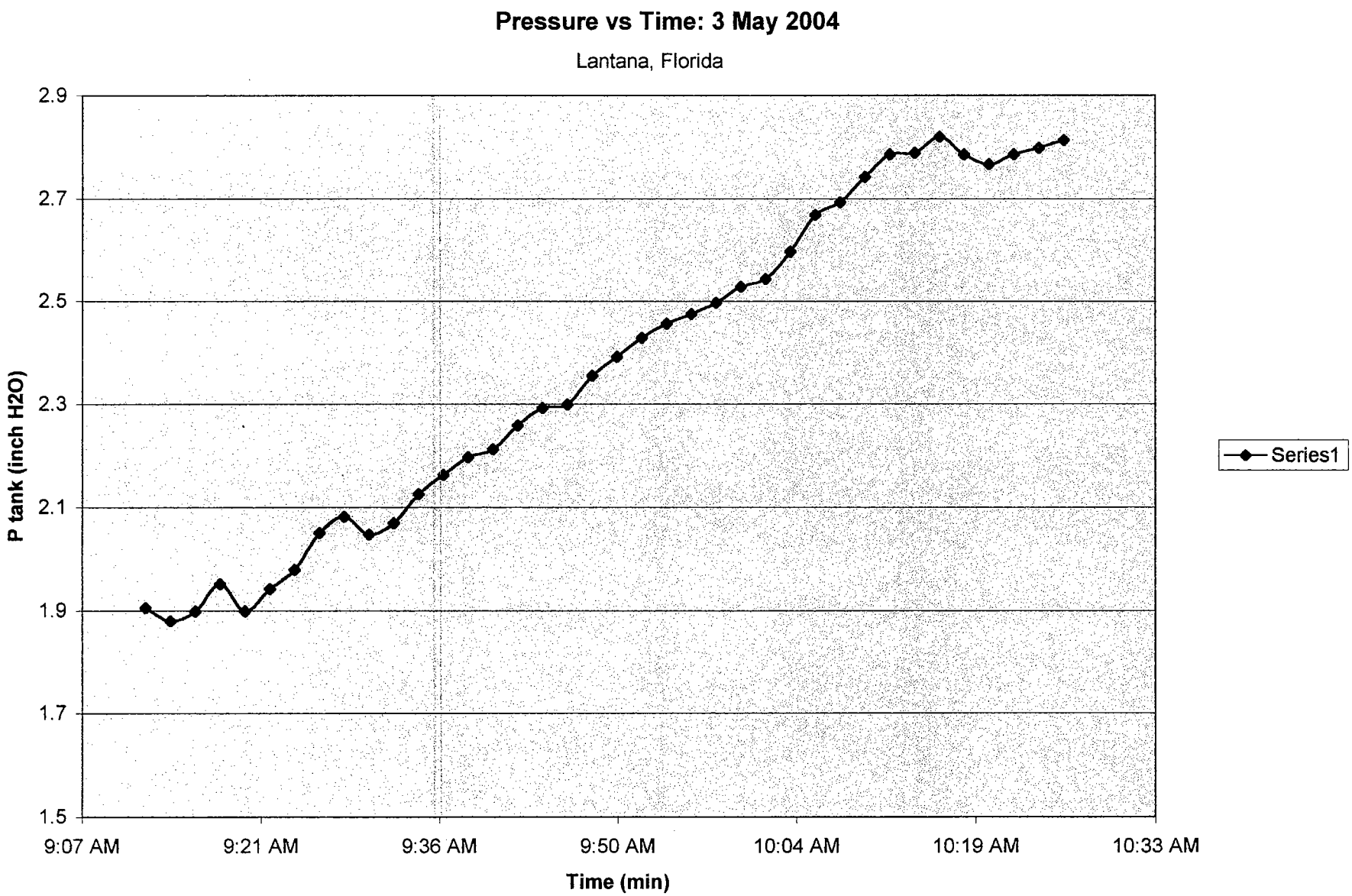
Baseline Evaporative Loss Data: Preliminary Data Set based on approximately 1 hour of data collection on 2 May 2004
SN80726

Date	P atm in H2O	P tank in H2O	**T1:Unleaded** gallons of gasoline	**T2:Unleaded** gallons of gasoline	**T3:Premium** gallons of gasoline	Total	Ullage (gal)	Ullage (ft3)	Vapor Volume Contained within Ullage (ft3)
5/2/2004 11:28	408.2752	0.741292							
5/2/2004 11:30	408.2752	0.493061							
5/2/2004 11:32	408.2752	0.790939							
5/2/2004 11:34	408.2752	0.725778							
5/2/2004 11:36	408.2752	8.97E-02							
5/2/2004 11:38	408.2153	6.18E-02	T1, T2, and T3 data taken from Veeder-Root Tank Gauge						
5/2/2004 11:40	408.2153	7.42E-02							
5/2/2004 11:42	408.2752	0.306887	14399	15748	15213	**45360**	**14640**	1957.2	1958.7
5/2/2004 11:44	408.2752	0.598559							
5/2/2004 11:46	408.2752	0.78163	14392	15707	15188	**45287**	**14713**		
5/2/2004 11:48	408.2752	0.970907							
5/2/2004 11:50	408.2752	1.126051							
5/2/2004 11:52	408.2752	1.268785							
5/2/2004 11:54	408.2752	1.414621							
5/2/2004 11:56	408.2752	1.448753	14351	15483	15078	**44912**	**15088**		
5/2/2004 11:58	408.2752	1.557354							
5/2/2004 12:00	408.2752	1.631823							
5/2/2004 12:02	408.2153	1.690778							
5/2/2004 12:04	408.2153	1.845923							
5/2/2004 12:06	408.2153	1.957628	14308	15294	14978	**44580**	**15420**		
5/2/2004 12:08	408.1554	2.109669							
5/2/2004 12:10	408.1554	2.193448							
5/2/2004 12:12	408.1554	2.354798							
5/2/2004 12:14	408.1554	2.472708							
5/2/2004 12:16	408.0955	2.634059	14195	15109	14873	**44177**	**15823**		
5/2/2004 12:18	408.0955	2.680602							
5/2/2004 12:20	408.0955	2.643368							
5/2/2004 12:22	408.0955	2.702323							
5/2/2004 12:24	408.0955	2.792307							
5/2/2004 12:26	408.0955	2.826438	14083	14923	14777	**43783**	**16217**	2168.0	2183.1
5/2/2004 12:28	408.0955	2.86057							
5/2/2004 12:30	408.0955	2.835747							
5/2/2004 12:32	408.0955	2.848159							
5/2/2004 12:34	408.0955	2.845056							
5/2/2004 12:36	408.0955	2.86057	**14093**	14753	14704	**43550**	**16450**	2199.2	2214.6

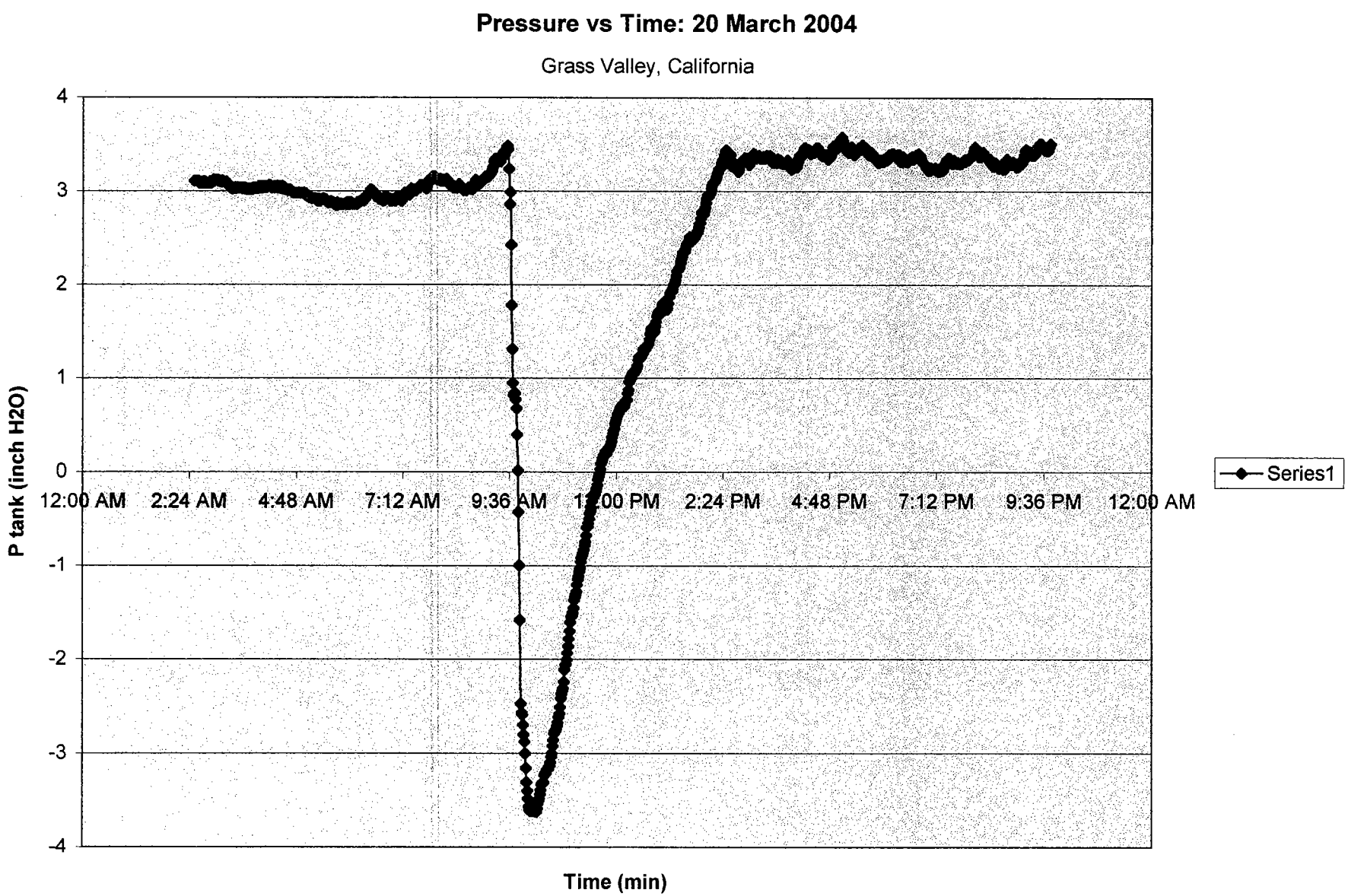
Gallons of gasoline dispensed in interval above	Average gallons/hr of gasoline dispensed in interval	Time Interval, min	Vapor volume increase in interval, ft3	CFM, ft3 per minute of vapor volume increase	lbm/min	lbm/hr	gal/hr	gal/day	gal/mo of gasoline lost to evaporation	% of Throughput Lost
1810	2011.11	54	255.92	4.74	0.24	14.59	2.81	67.32	**2019.64**	0.40%
1577	2150.45	44	224.37	5.10	0.26	15.69	3.02	72.44	**2173.09**	0.43%

Comments/Assumptions:

Molecular Weight of gasoline vapor = 66
Concentration of vapors escaping system = 30% by volume


Pressure vs Time: 3 May 2004
Lantana, Florida
P tank (inch H2O)
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
9:07 AM
9:21 AM
9:36 AM
9:50 AM
10:04 AM
10:19 AM
10:33 AM
Time (min)
Series1

Interval	Gallons	Gal/hr	Ft3	Time	Ft3/min	lbm/min	lbm/hr	gal/hr	gal/day	gal/mo	% Throughput
A-C	2015	1633.784	278.802	74	3.767595	0.19326	11.5956	2.229924	53.51817	1605.545	**0.321%**
A-B	1367	1577.308	189.662	52	3.647346	0.187092	11.22551	2.158752	51.81005	1554.302	**0.311%**


Pressure vs Time: 20 March 2004
Grass Valley, California
P tank (inch H2O)
4
3
2
1
0
-1
-2
-3
-4
12:00 AM
2:24 AM
4:48 AM
7:12 AM
9:36 AM
12:00 PM
2:24 PM
4:48 PM
7:12 PM
9:36 PM
12:00 AM
Series1
Time (min)

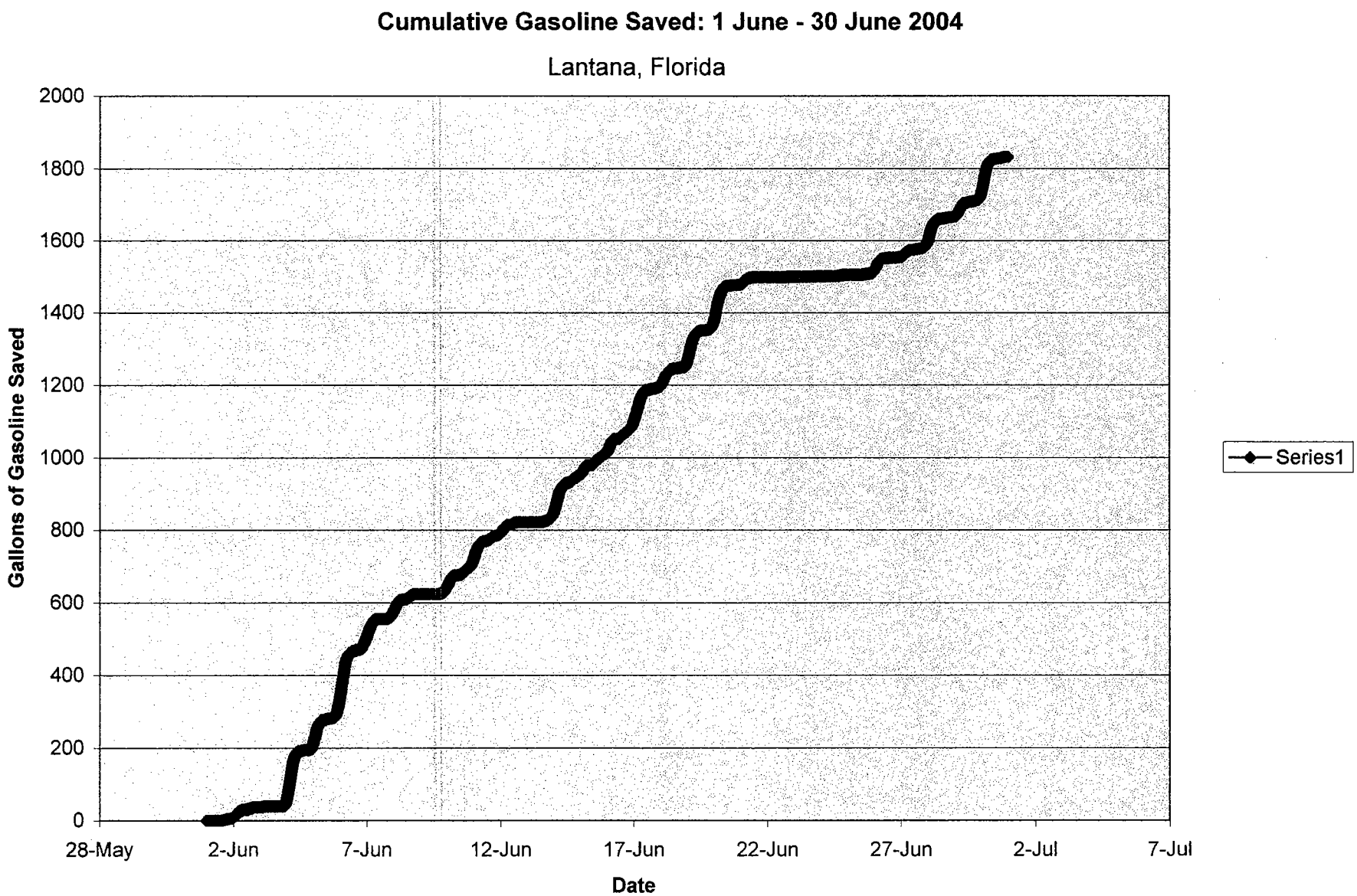
Evaporative Emission Rate
Grass Valley, CA Site

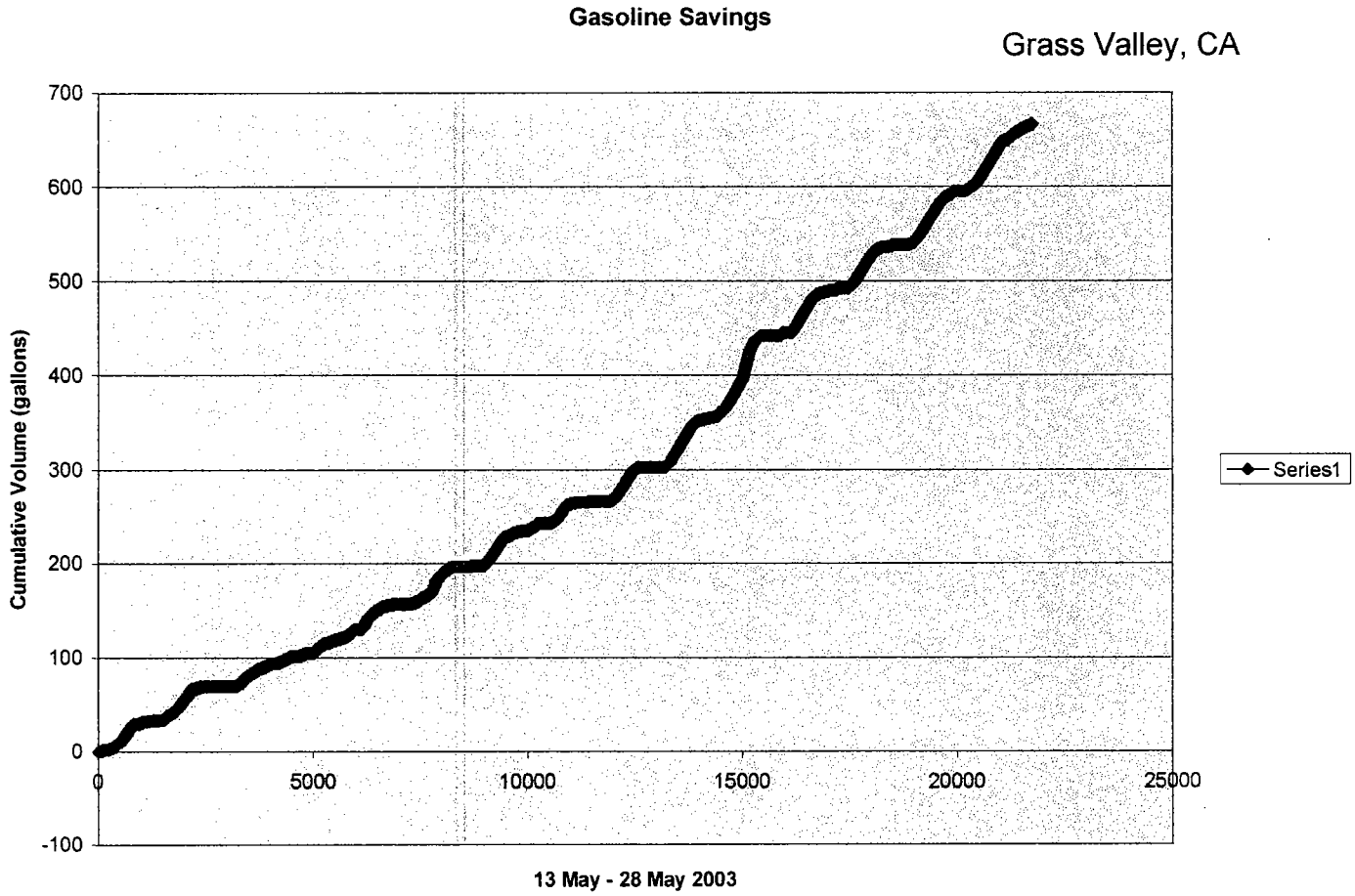
Ullage	gal Assumed ullage @ t0	P initial	P final	gal Vol @ P i	gal Vol @ P f	P atm	gal Delta V
30000	18000	-3.5246	3.0206	17830.7741	21222.9618	374.9	3392.18769
30000	15000	-3.5246	3.0206	14858.9784	18198.7905	374.9	3339.81212

Average monthly throughput: 330,000 gallons

ft3	min							
	Time	CFM	lb HC/min	lb HC/hr	lb HC/day	gal/day	gal/mo	Tons/year
453.5010282	229	1.98035383	0.12867169	7.72030169	185.28724	35.6321616	1068.96485	33.3517033
446.4989471	229	1.94977706	0.126685	7.6010998	182.426395	35.0819991	1052.45997	32.8367511

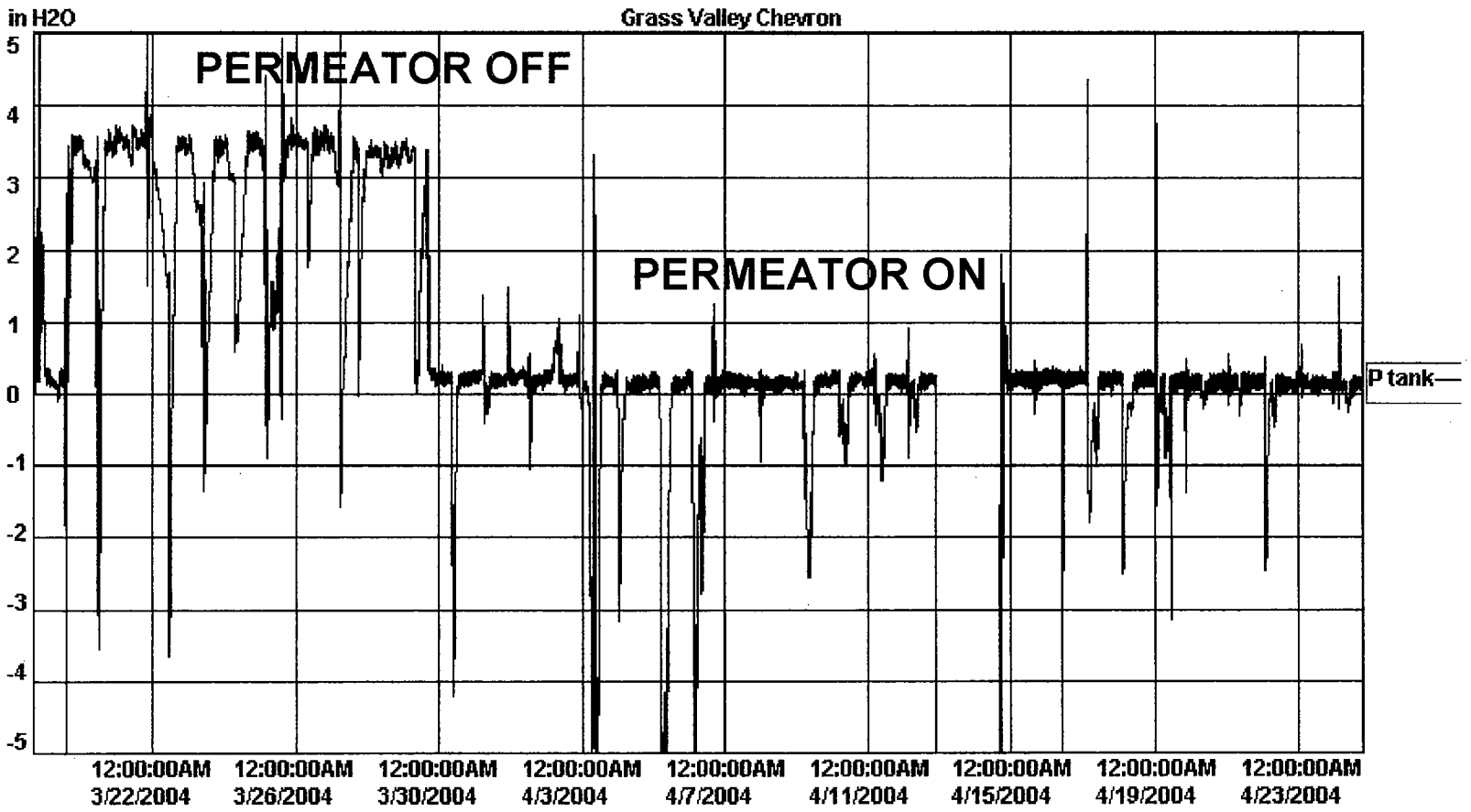
Appendix 3
Measured Incompatibility Excess Emissions (IEE) – Method 2


Cumulative Gasoline Saved: 1 June - 30 June 2004
Lantana, Florida
Gallons of Gasoline Saved
2000
1800
1600
1400
1200
1000
800
600
400
200
0
28-May
2-Jun
7-Jun
12-Jun
17-Jun
22-Jun
27-Jun
2-Jul
7-Jul
Date
Series1



Monthly Savings	**1332.89**	**gallons**
% Throughput	**0.404%**	
lbm/1,000 gallons	**21.003**	

Appendix 4
Grass Valley Chevron
Storage Tank Pressure Plot
PERMEATOR "OFF" vs. PERMEATOR "ON"


in H2O
Grass Valley Chevron
PERMEATOR OFF
PERMEATOR ON
P tank
5
4
3
2
1
0
-1
-2
-3
-4
-5
12:00:00AM 3/22/2004
12:00:00AM 3/26/2004
12:00:00AM 3/30/2004
12:00:00AM 4/3/2004
12:00:00AM 4/7/2004
12:00:00AM 4/11/2004
12:00:00AM 4/15/2004
12:00:00AM 4/19/2004
12:00:00AM 4/23/2004

Appendix 5
Increased Emissions in the Vicinity of Gasoline Dispensing Facilities
Health Impact of HAPS From Emissions

Author Keyword(s)
Vol Page
HOME HELP FEEDBACK SUBSCRIPTIONS ARCHIVE SEARCH TABLE OF CONTENTS [Advanced] Go

Occupational and Environmental Medicine 2004;**61**:773-778
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ORIGINAL ARTICLE

Acute childhood leukaemia and environmental exposure to potential sources of benzene and other hydrocarbons; a case-control study

C Steffen[1], M F Auclerc[2], A Auvrignon[3], A Baruchel[2], K Kebaili[4], A Lambilliotte[5], G Leverger[3], D Sommelet[6], E Vilmer[7], D Hémon[1] and J Clavel[1]

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Aim: To analyse the association between potential environmental exposure to hydrocarbons and the risk of acute childhood leukaemia.

Methods: A hospital based multicentre case control study, stratified on centre, age, and sex, with 280 leukaemia cases and 285 controls was carried out. Data were collected by a standardised interview of the mothers.

Results: No clear association was seen between maternal occupational exposure to hydrocarbons during pregnancy and leukaemia, or between residential traffic density and leukaemia. There was an association between dwellings neighbouring a petrol station or a repair garage during childhood and the risk of

childhood leukaemia (OR 4.0, 95% CI 1.5 to 10.3), with a duration trend. The association, which appeared particularly strong for acute non-lymphocytic leukaemia (OR 7.7, 95% CI 1.7 to 34.3), was not altered by adjustment for potential confounding factors.

Conclusions: Results showed an association between acute childhood leukaemia and dwellings neighbouring auto repair garages and petrol stations, which are benzene emitting sources. These findings could be due to chance, although the strength of the association and the duration trend are arguments for a causal association.

Abbreviations: AL, acute leukaemia; ALL, acute lymphocytic leukaemia; ANLL, acute non-lymphocytic leukaemia

Keywords: leukaemia; childhood; environment; epidemiology; hydrocarbons

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Work in brief
Dana Loomis
Occup Environ Med 2004 61: 727. [Extract] [Full Text]

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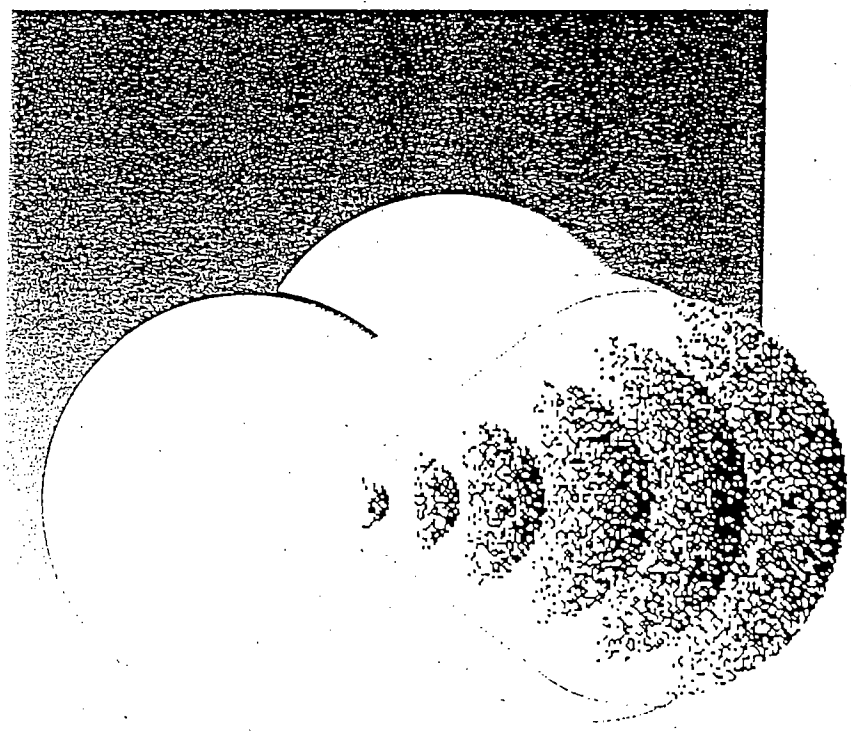
BENZENE, TOLUENE AND XYLENE MEASUREMENTS IN THE VICINITY OF PETROL STATIONS



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BENZENE, TOLUENE AND XYLENE MEASUREMENTS IN THE VICINITY OF PETROL STATIONS

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JOINT RESEARCH CENTRE

Introduction

It is estimated that 35 % of the anthropogenic volatile organic compound (VOC) emissions are due to vehicle exhaust and evaporative losses [1]. In urban areas the contribution to the VOC emissions from traffic may reach 60 - 80 % of the total emissions. VOCs play an important role in the formation of photochemical smog, and benzene in particular is known to be a cancerogenic agent. Therefore, there is no doubt that good air quality in cities depends on the control of VOC emissions. Regardless of the policies adopted by individual countries in the European Union, several EC directives have been implemented in order to control the emissions, e.g., catalytic converters have been installed to limit car emissions [2] and specifications have been formulated concerning benzene levels in petrol [3]. Recently, a new directive has been proposed setting out guidelines for the control of VOC emissions from petrol stations. This directive also concerns the installation of vapour recovery systems at the pumps, in order to prevent the dispersion of fuel vapours into the air when refilling [4].

VOC emissions from petrol storage and distribution systems represent some 500.000 tonnes per year, i.e. 5 % of total man-made VOC emissions in the European Union. Petrol stations situated in urban areas are considered critical locations from the point of view of air quality. Evaporative losses are the principle cause of contamination around petrol stations. These losses are mainly produced during tank refilling, by the vent pipes of the storage reservoirs, as well as during accidental fuel spillages while refilling.

The objective of the campaign was to determine the impact of ambient VOC concentration levels and the grade of dispersion of VOCs emitted by petrol stations in urban agglomerations.

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Selection of the contaminants

The diversity of contaminants emitted by petrol due to evaporation depends on its composition. About 95 % of the vapour emissions from petrol derive from paraffinic (80 %) and olefinic (15 %) compounds; the remaining 5 % from aromatic compounds [5]. The latter compounds have proven to be the most important because of their carcinogenic effect and their higher percentage levels in unleaded fuels. The carcinogenic effect between the monoaromatic hydrocarbons is demonstrated for benzene. Compounds such as toluene, xylenes, ethyl benzene, 1,2,4-methyl benzene cause an increase in the number of overall malignant tumours [6].

The composition of fuel vapour is directly related to its liquid composition. It is known that unleaded petrol contains a high proportion of aromatic hydrocarbons (between 30-45 %). Benzene, toluene and xylene (BTX) were selected as a tracer for VOCs emitted by petrol stations because of their toxic effect and their presence in fuels at a significant levels.

Sampling strategy

Approximately 20 sampling sites were selected for each petrol station. These sites were distributed in the precinct and in the surroundings of the petrol stations over an area of approximately 200 metres in diameter. In Figures 3 to 6, the positions of the samplers are indicated. The diffusive samplers were fixed to lamp-posts at a height of 3 metres above the ground and were protected from precipitation with a special cover.

Three consecutive sampling periods of fourteen days were established for each campaign - see Table II -. Diffusive samplers were collected at the end of each period.

In addition, daily analyses were carried out using active tubes in station A, B and C.The position of the active tubes is indicated in Figures 1 to 4 by a red cross.

Table II: Sampling periods during the campaign - 1994 -

Season / Period	Petrol station/city	From	To
Winter - 1st period	C and D - Brussels	January 22nd	February 5th
Winter - 2nd period	C and D - Brussels	February 5th	February 19th
Winter - 3rd period	C and D - Brussels	February 19th	March 5th
Autumm - 1st period	C and D - Brussels	September 19th	October 4th
Autumm - 2nd period	C and D - Brussels	October 4th	October 19th
Autumm - 3rd period	C and D - Brussels	October 19th	November 3rd
Autumm - 1st period	A and B - Murcia	September 25th	October 9th
Autumm - 2nd period	A and B - Murcia	October 9th	October 23rd
Autumm - 3rd period	A and B - Murcia	October 23rd	November 6th

Meteorological conditions during the campaigns

Table IV shows the meteorological conditions for the respective sampling periods and locations. A brief description of the table is given below:

Winter campaign in Brussels (January 22nd to March 5th)

The weather conditions were typical for the cold season in the North of Europe. In particular, overcast sky with rain and snow predominated during this period, with mean temperatures ranging from 0 to 10 ºC. Anticyclonic conditions with nocturnal inversions, low temperatures (as low as -8 ºC), and weak solar radiation prevailed from 13th to 20th February.

Autumm campaign in Brussels (September 19th to November 3th)

Temperatures ranged from 5 to 18 ºC with average temperature of 12 ºC. Mean wind speeds of about 3 m/s were measured. Humidities of about 80 % and a mean daily precipitation of 3.9 L/m^2 could be considered normal for this period in Brussels.

Autumm campaign in Murcia (September 25th to November 6th)

Meteorological data were available from the Murcia Meteorological Station (3 km from Murcia city). Temperatures ranged from 8 to 30 ºC with an average temperature of about 20 ºC. The average relative humidity was 80 %, the atmospheric pressure ranged between 1013 and 1018 mbar (sea level) and the mean wind speeds were between 1.6 and 1.9 m/s. Precipitations over 8 L/m^2 were only measured for four days during the first four weeks.

Table IV: Meteorological conditions for the period campaigns

Season /period	Location	Temperature, °C			RH %			Rainfall L/m^2	Aver. pressure mbar	Wind					
										Direction frequency, %					Average speed m/s
		Min.	Max.	Aver.	Min.	Max.	Aver.			First quarter	Second quarter	Third quarter	Fourth quarter	Calm	
Autumm/1st	Murcia	13	30	20.4	.40	100	77	21.4	1013.5	37.1	14.2	26	16.3	6.4	1.9
Autumm/2nd	Murcia	12	28	20.3	40	100	77	23	1017.8	25.8	13.3	28.5	22.8	9.6	1.7
Autumm/3rd	Murcia	7.6	25	17.7	36	100	81	4.2	1016.5	19.6	11.8	34.5	25.7	8.4	1.6
Autumm/1st	Brussels	10.6	18.3	14.2	77	91	84.3	17.2	NA	30.3	17.7	38.2	17.7	–	2.5
Autumm / 2nd	Brussels	5.6	14.8	9.7	63	89	76.3	0.7	NA	30.13	52.5	14.9	2.35	–	2.6
Autumm 3rd	Brussels	8.4	14.3	10.9	70	96	84	44.8	NA	1.3	21.7	75.5	1.4	–	4.7
Winter / 1st	Brussels	3.3	7.7	5.8	66	100	82	51.9	NA	3.9	12.9	58.2	24.9	–	4.8
Winter / 2nd	Brussels	-0.4	5.2	2.3	63	97	78	6.4	NA	20.5	42.4	23.8	13.2	–	3.5
Winter / 3rd	Brussels	8.1	14.3	11	63	99	84	36.7	NA	9.3	21.47	60.7	8.53	–	3.4

NA: Non Available

Table VI: Petrol station A (Murcia). Average concentrations during the autumm period (μg/m³)

Position	benzene	toluene	m-xylene
1	21,1	60,2	32,8
2	24,8	65,0	36,1
3	25,3	66,8	48,5
4	20,9	60,9	31,7
5	20,6	56,5	32,3
6	33,3	78,7	44,1
7	27,2	63,5	42,7
8	25,5	61,1	33,6
9	39,1	83,6	49,8
10	23,7	53,1	30,8
11	121,5	218,7	93,2
12	172,4	302,9	122,4
13	177,2	316,5	116,2
14	108,3	214,0	85,3
15	23,5	61,7	37,6
16	187,6	325,1	142,4
17	144,4	286,4	119,7
18	85,5	184,4	87,9
19	13,6	36,7	20,7
20	14,7	40,6	22,0
21	11,9	34,2	19,4

Table VII: Petrol station B (Murcia). Average concentrations during the autumm period (μg/m³)

Position	benzene	toluene	m-xylene
1	12,7	36,3	17,6
2	17,0	48,2	27,4
3	20,6	56,2	39,7
4	17,7	53,1	28,1
5	23,8	69,2	39,3
6	21,9	58,4	34,3
7	29,9	70,8	38,3
8	18,7	58,3	35,9
9	37,9	74,3	37,7
10	70,2	134,2	61,1
11	121,2	213,4	87,5
12	90,1	152,1	61,9
13	121,3	197,0	78,5
14	96,7	197,8	86,4
15	79,3	157,2	72,8
16	33,2	85,2	42,6
17	27,9	62,8	35,7
18	12,2	29,9	15,2
19	13,7	32,0	15,7
20	12,9	32,9	17,4

Table X: Petrol station C (Brussels). Average concentrations during the winter period (µg/m³)

Position	benzene	toluene	m-xylene
1	4,4	6,3	4,7
2	4,3	12,8	7,9
3	3,9	16,2	6,4
4	2,3	6,9	3,7
5	5,6	9,0	5,4
6	2,8	7,9	3,1
7	15,7	66,3	32,3
8	10,3	51,0	24,9
9	17,5	43,0	21,5
10	19,9	52,0	17,3
11	11,9	34,8	12,6
12	4,6	16,2	7,0
13	9,9	23,6	7,5
14	6,9	16,4	4,2
15	3,3	8,9	4,3
16	4,5	13,4	8,0
17	3,9	11,7	4,7
18	8,8	16,1	4,9
19	2,7	14,0	5,0

Table XI: Petrol station D (Brussels). Average concentrations during the winter period (µg/m³)

Position	benzene	toluene	m-xylene
1	4,0	10,2	2,4
2	4,1	11,2	3,0
3	4,3	12,2	3,2
4	23,4	49,8	9,7
5	4,3	12,2	3,2
6	4,0	17,7	7,9
8	13,1	33,7	9,1
9	16,3	42,1	11,3
10	17,6	42,5	11,4
11	20,3	42,2	14,2
12	6,8	31,2	12,3
13	3,4	11,1	6,1
14	4,3	13,3	7,7
15	4,4	22,5	16,9
16	3,0	13,0	7,9
18	3,8	15,8	8,3
19	–	16,4	10,1
20	4,2	17,5	9,7
21	4,2	15,6	8,1

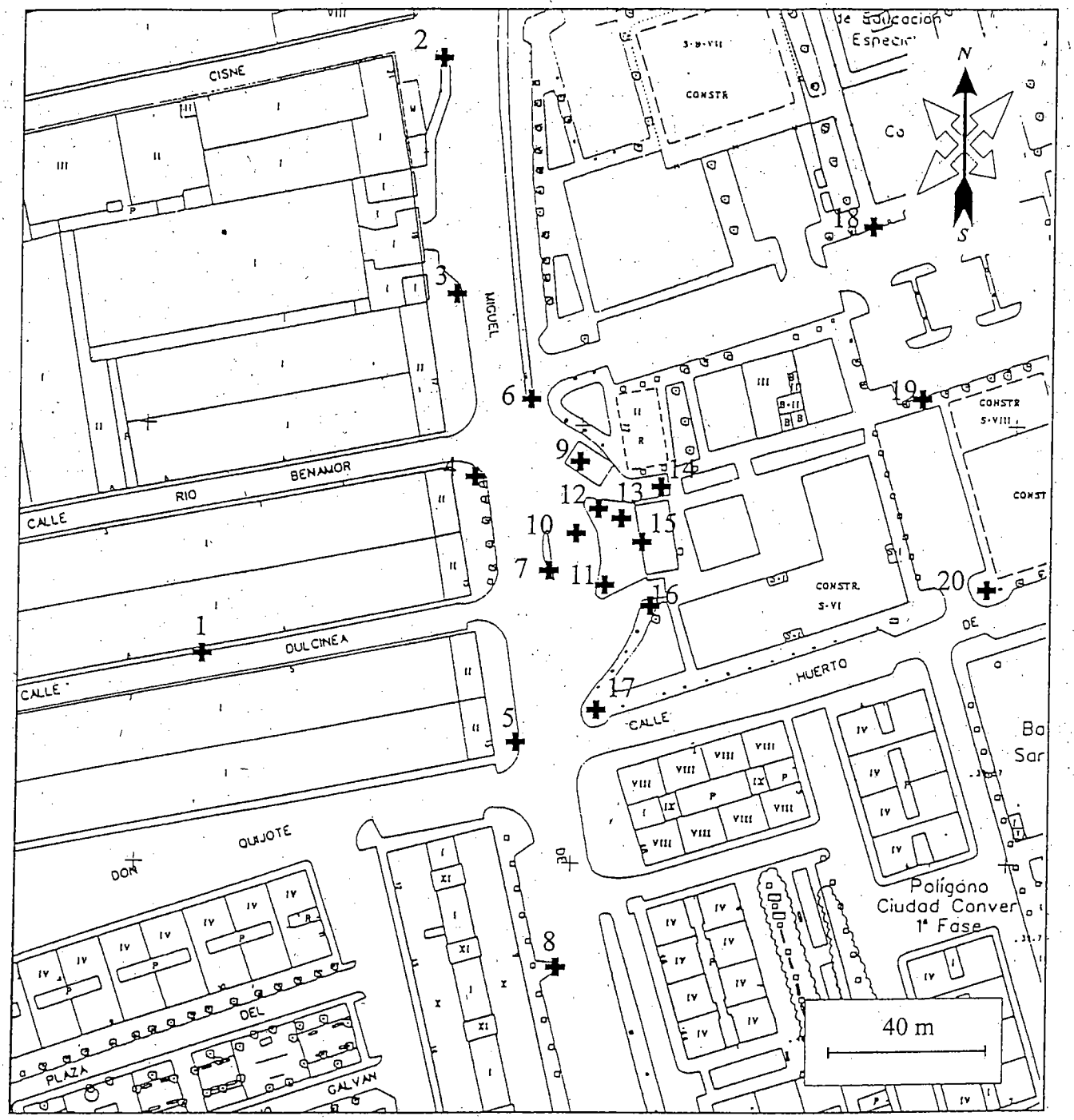

Figure 2: Diffusive samplers positions in petrol station B (Murcia)

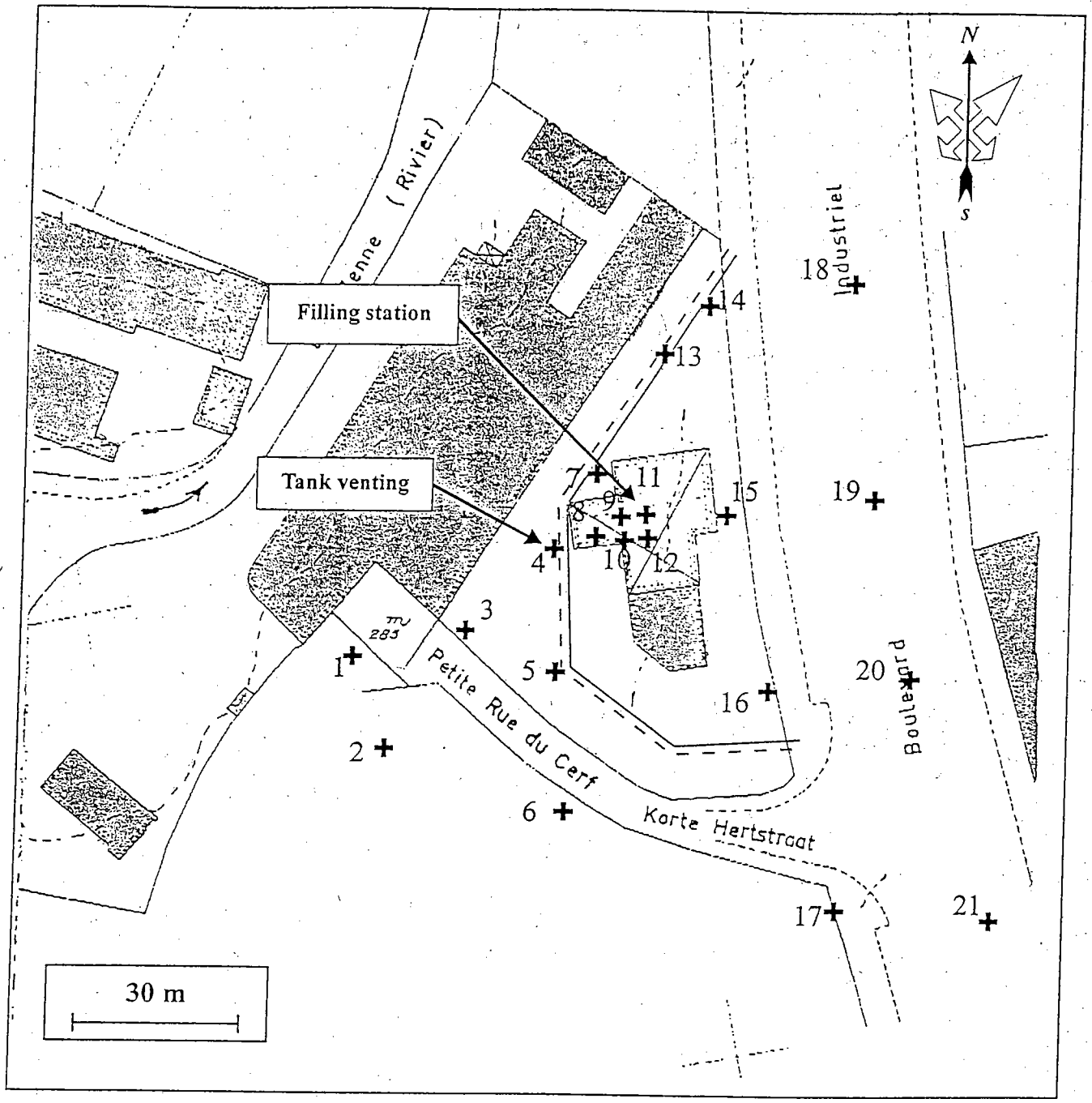

Figure 4: Diffusive samplers positions in petrol station D (Brussels)

Precision of the method

Laboratory experiments have been carried out in order to determine the sampling rates of the diffusive samplers and to establish the effect of ambient variables such as temperature, humidity, changes in concentration, influence of sampling time and concentration levels (amount of contaminants on the adsorbent). With the scope to assess the validity of the diffusion sampling technique in field conditions, duplicate active samples were also installed in a number of sites. The results of this comparison appear in the Figure 5. An acceptable correlation (R^2 = 0.952) was found between active and diffusive samplers that were placed in the same position.

Figure 6 represents the bias of the average concentrations estimated using the diffusive sampling technique with respect to the active sampling technique. The average bias is around -9 % and the absolute average bias is approximately 21 %. It appears that the data obtained by diffusive sampling is underestimated with respect to that obtained by active sampling. In addition, the graph shows an increase in the bias for low concentrations due to the lack of precision of the measurements near to the detection limit.

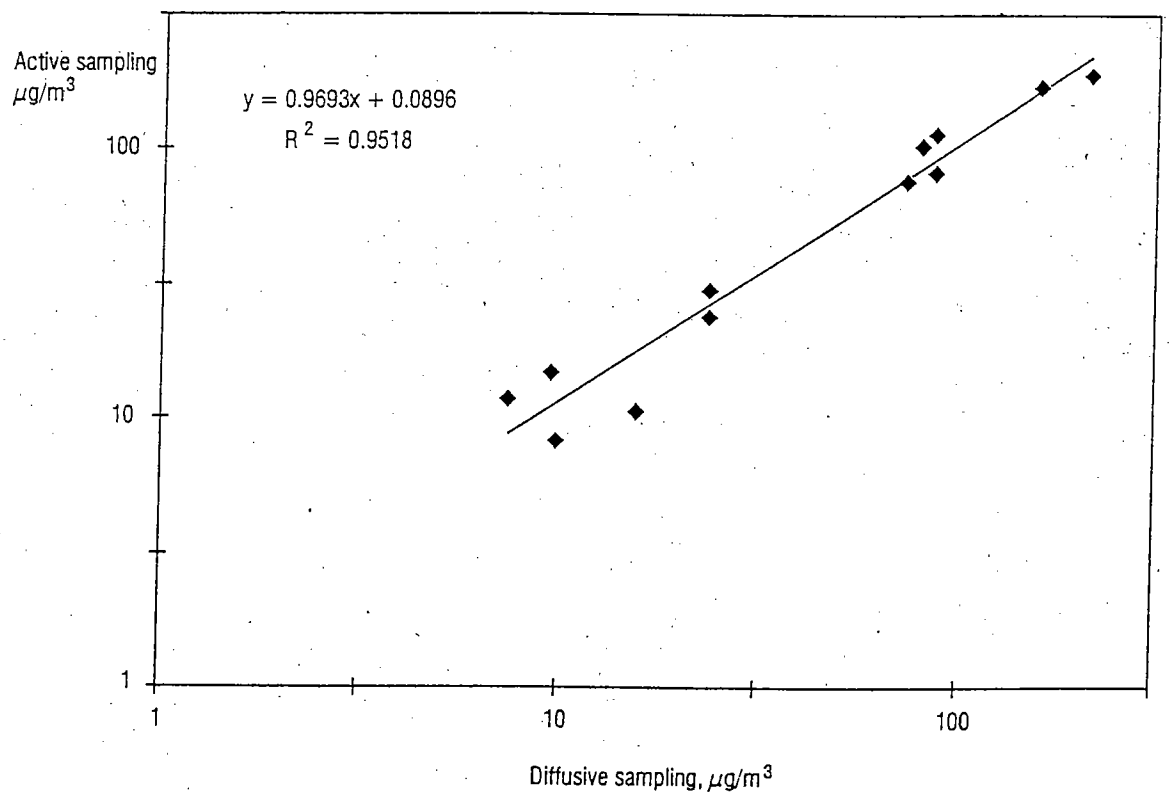

Figure 5: Correlation between active and diffusive samples

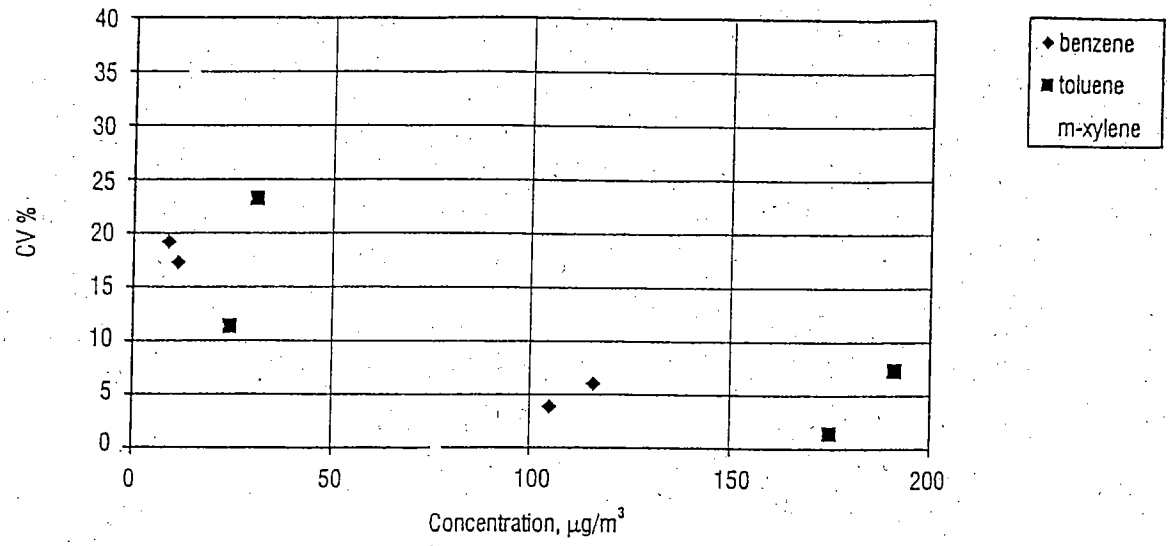

Figure 8: Active samplers' coefficients of variation between sampling periods

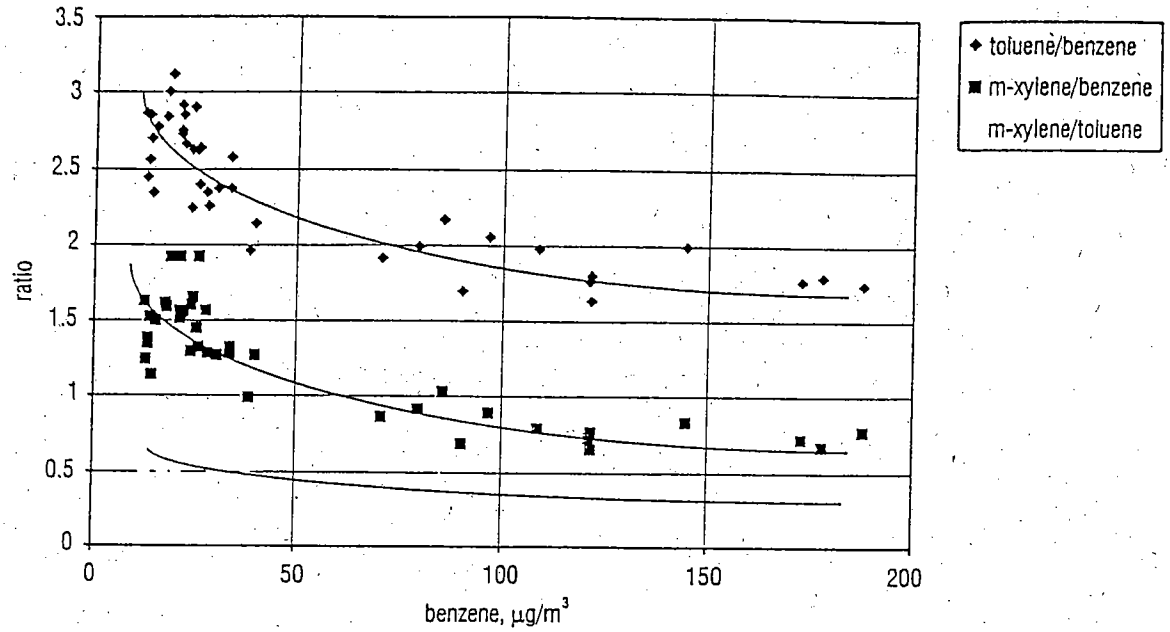

Figure 9: Toluene/benzene, m-xylene/benzene and m-xylene/toluene ratios in function of benzene concentration in Murcia

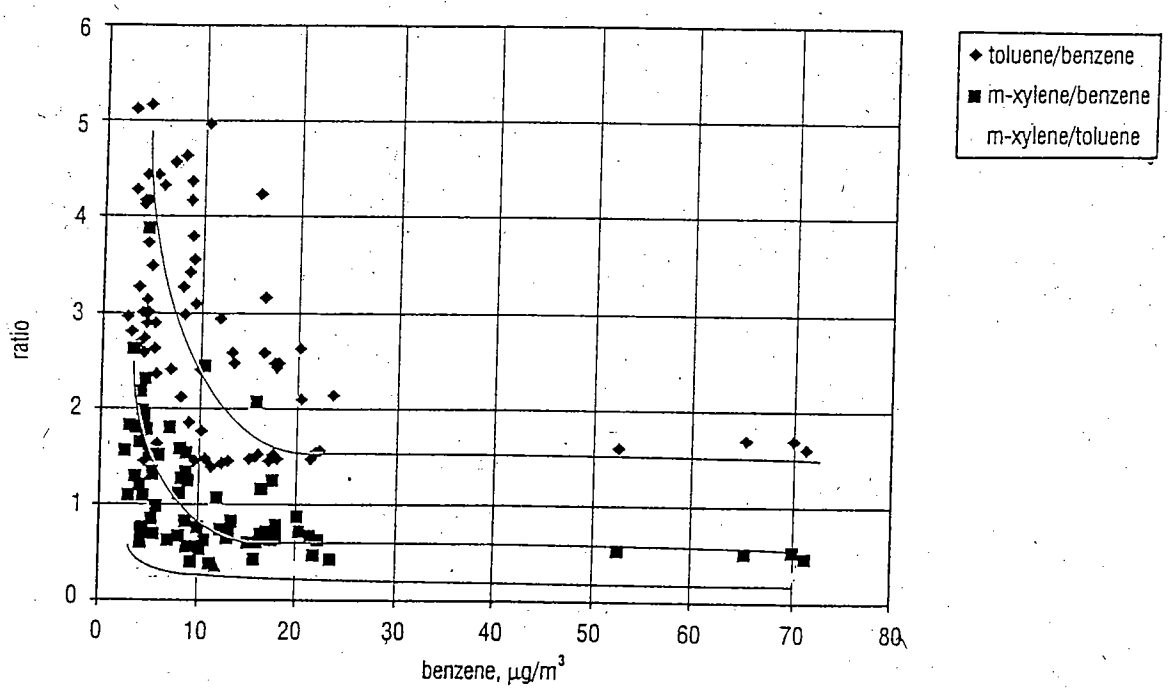

Figure 10: Toluene/benzene, m-xylene/benzene and m-xylene/toluene ratios in function of benzene concentration in Brussels

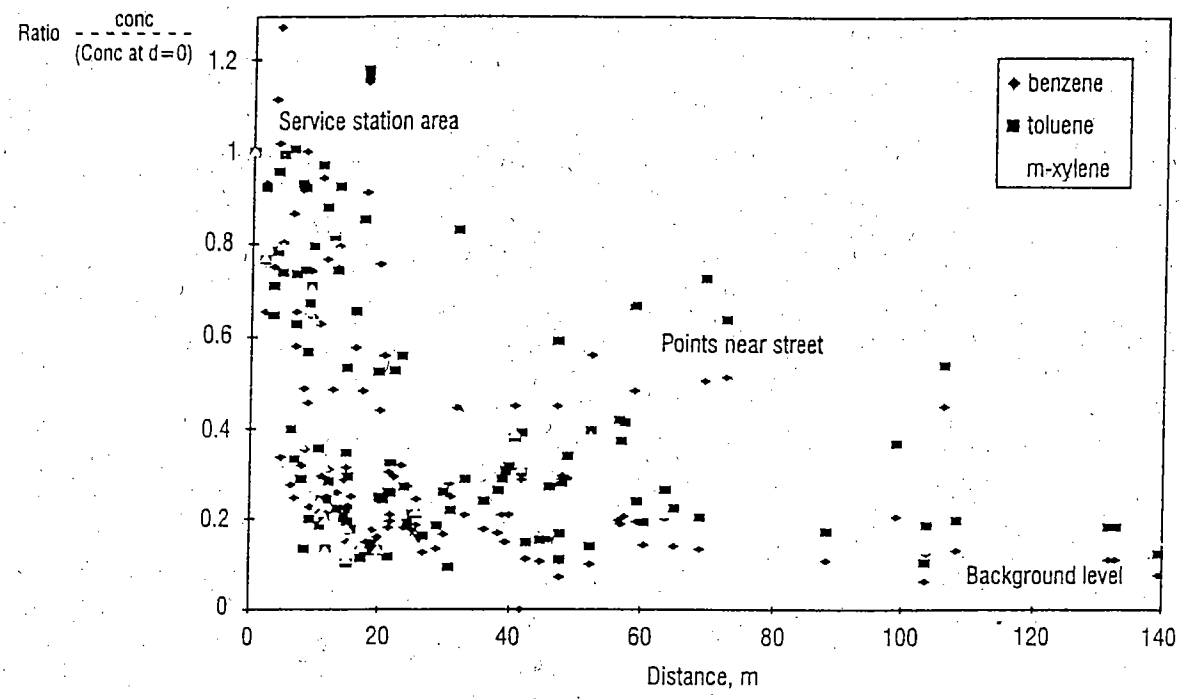

Figure 13: Variation of the airborne concentration with the distance from the service area

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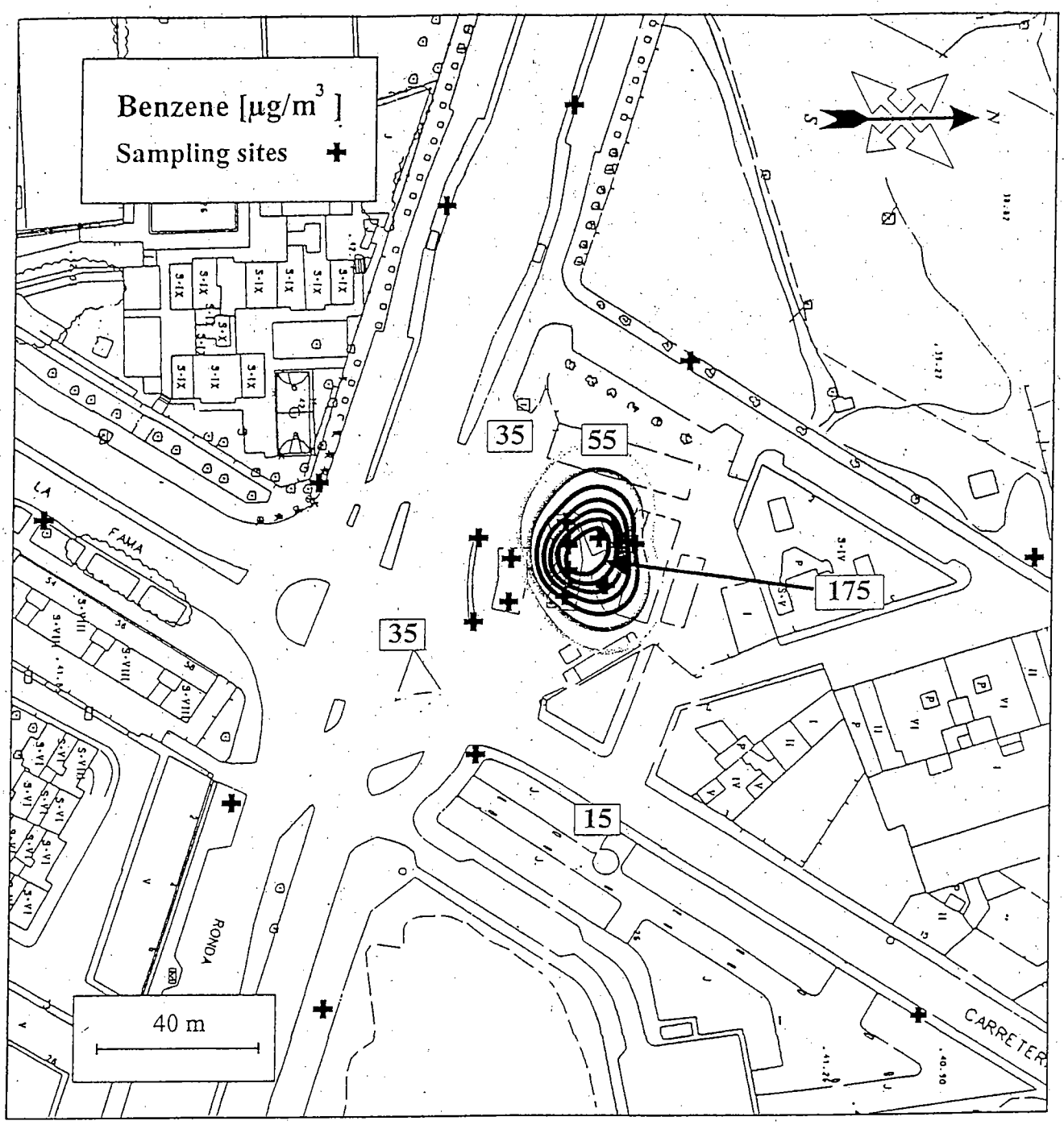
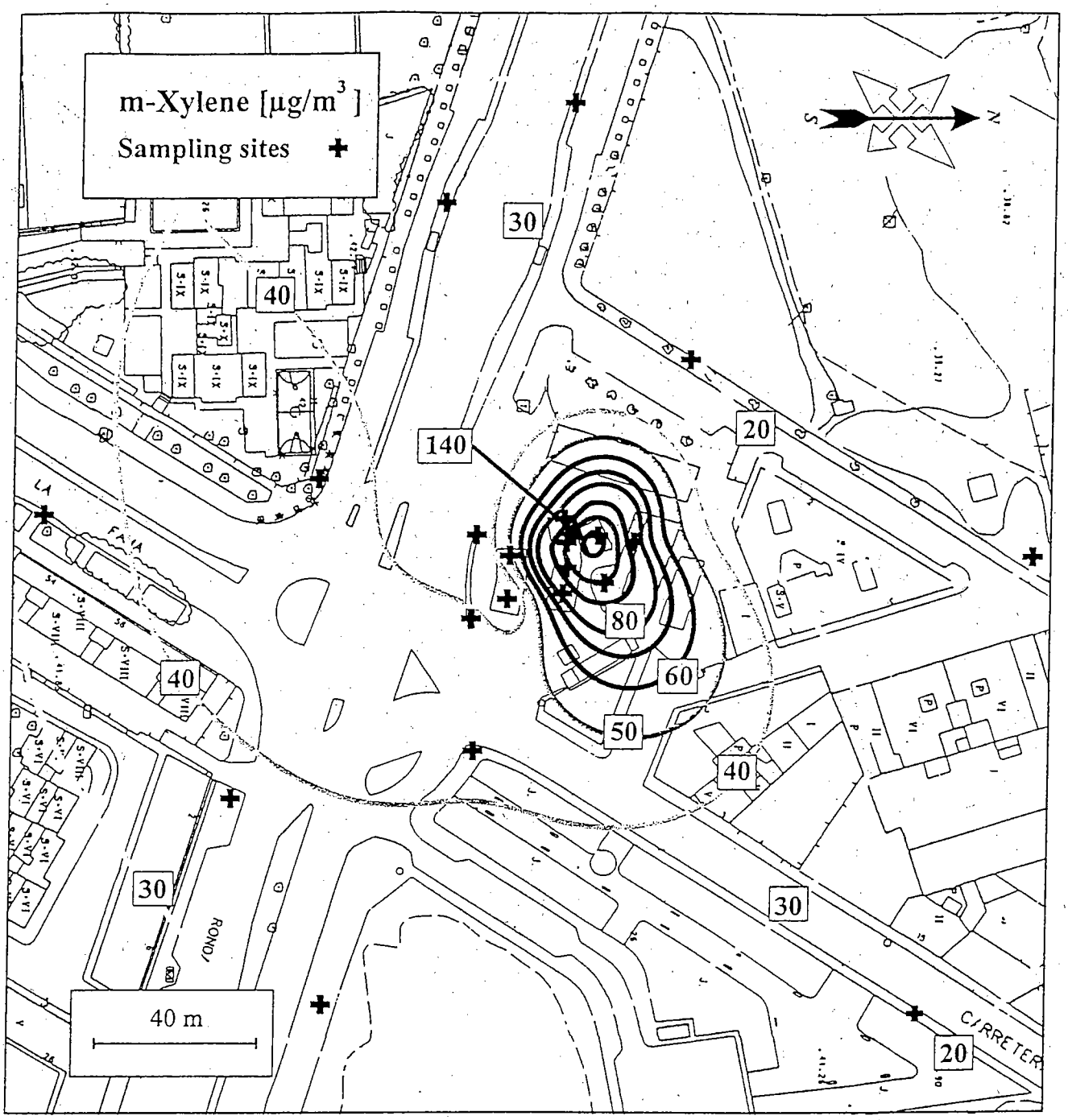
Annex 1

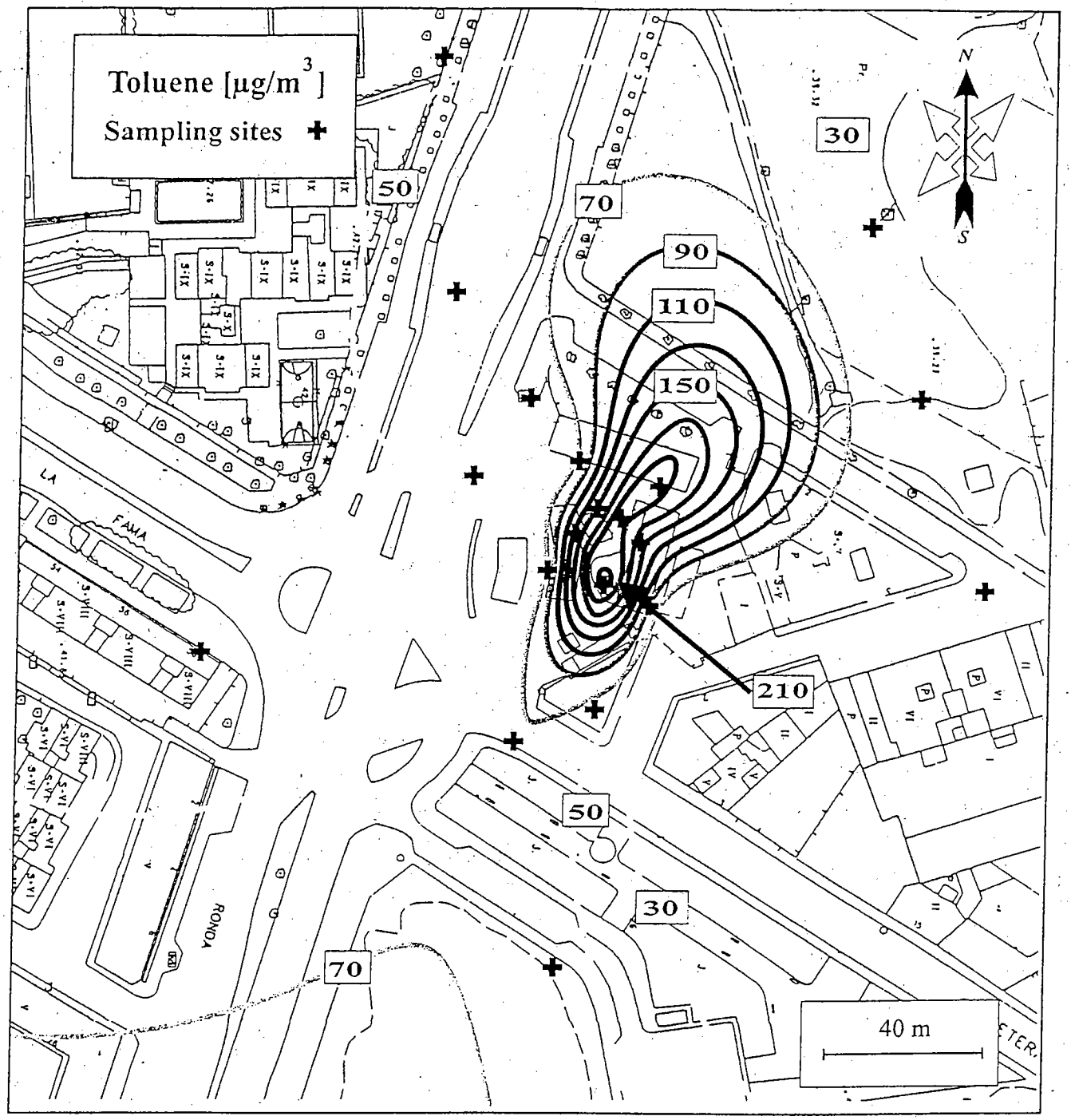
Maps of isoconcentrations



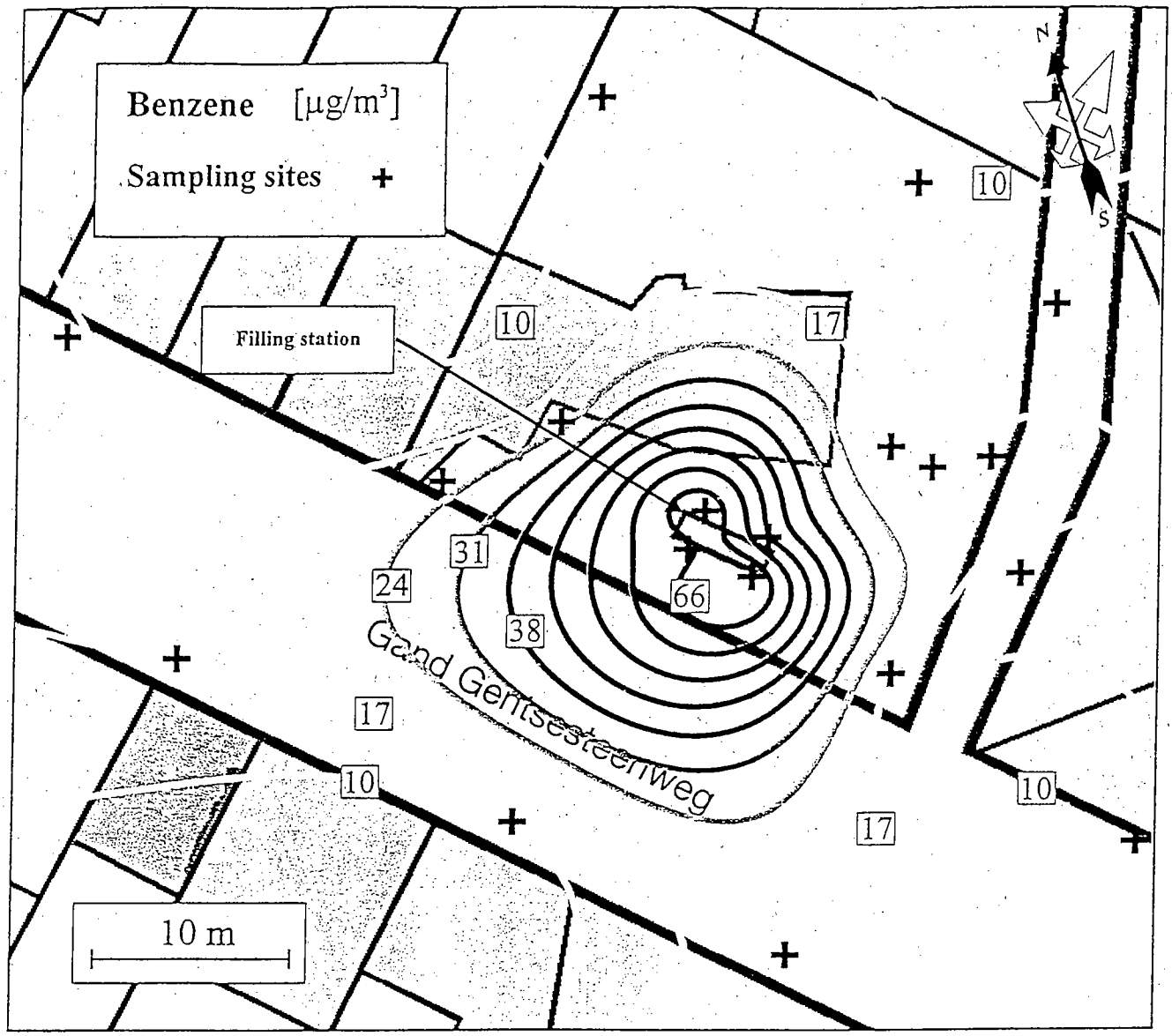
Benzene levels in petrol station A. Murcia 25/09/94 - 05/11/94



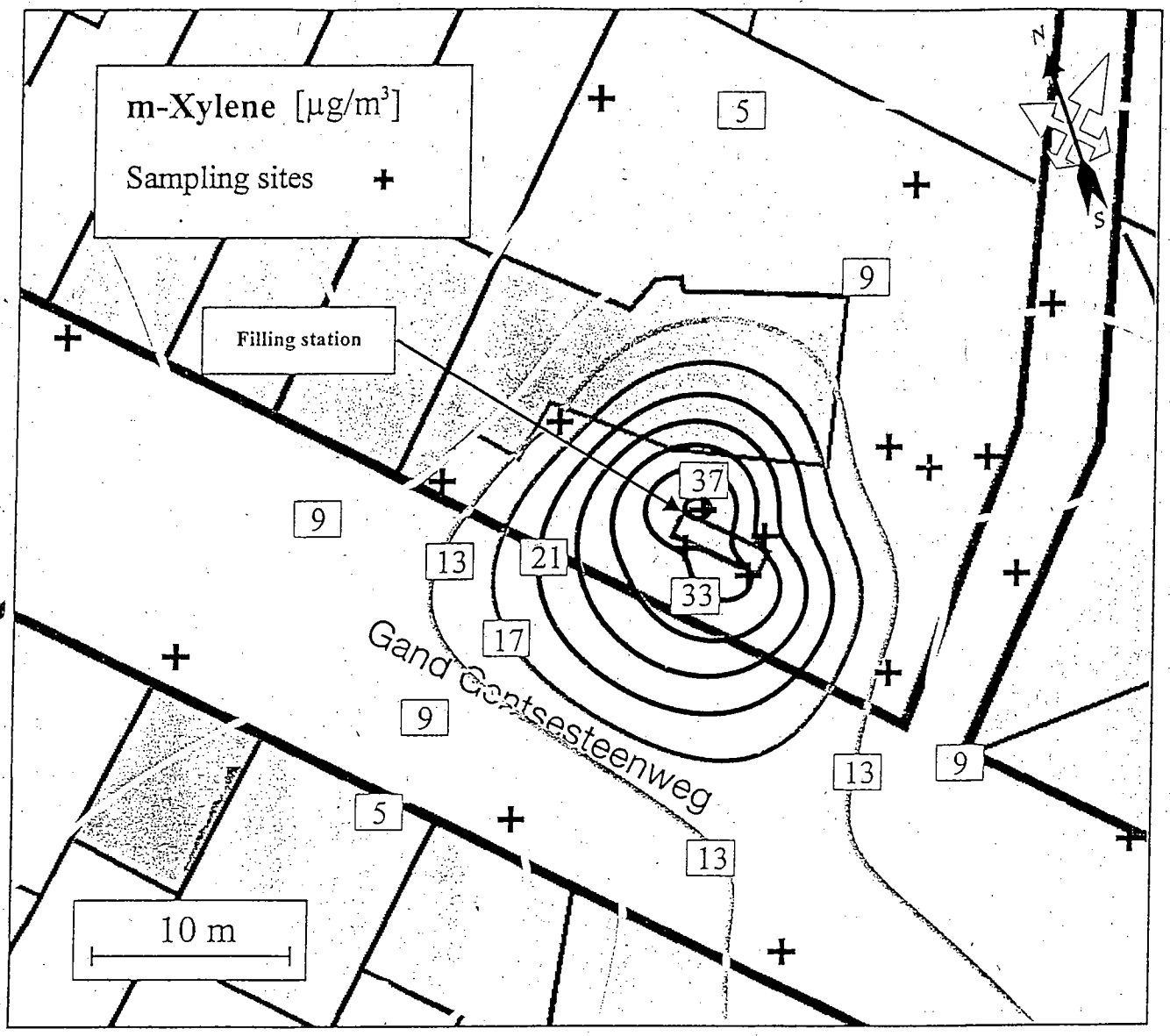
m-Xylene levels in petrol station A. Murcia 25/09/94 - 05/11/94



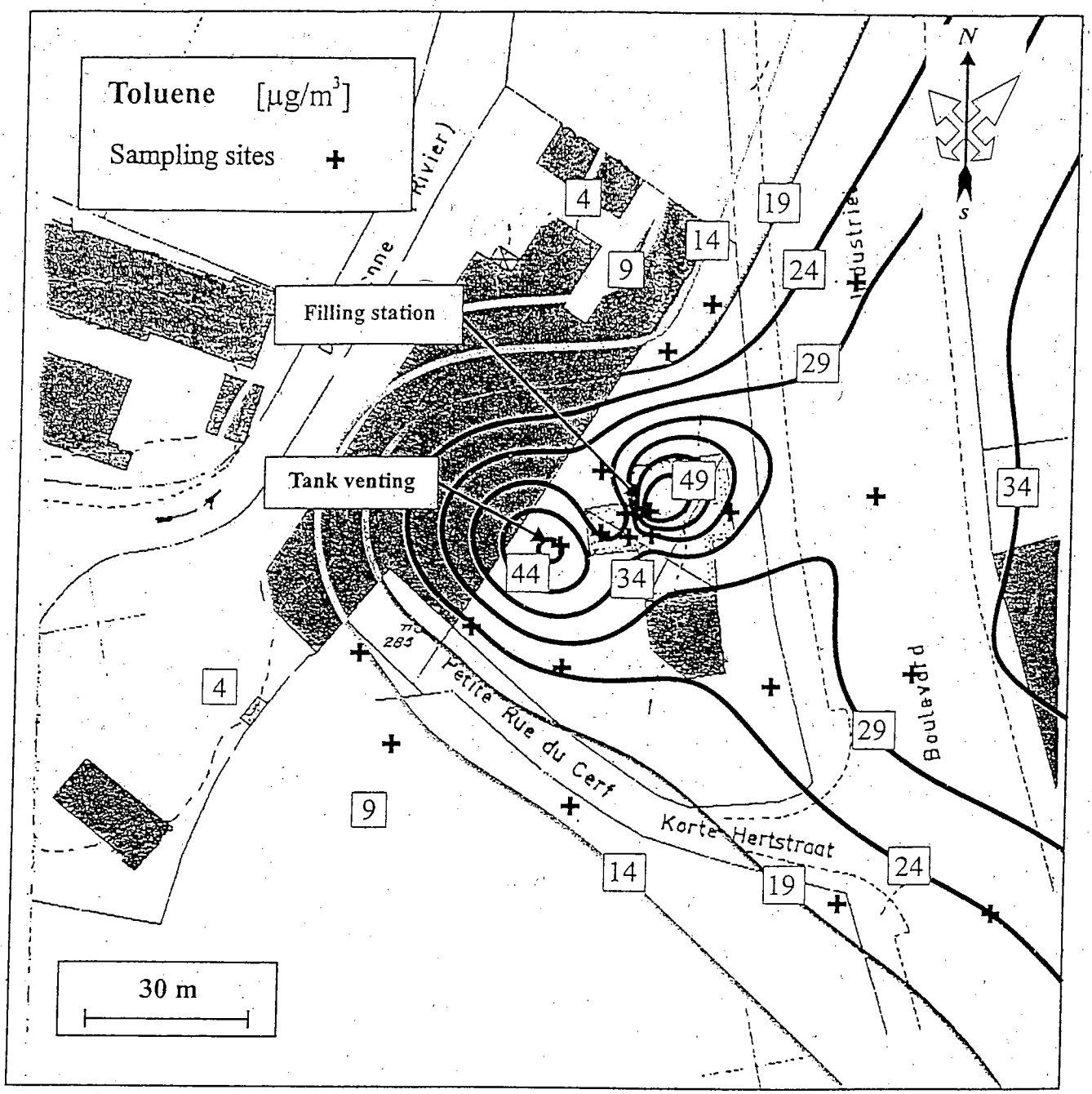
Toluene levels in petrol station B. Murcia 25/09/94 - 05/11/94



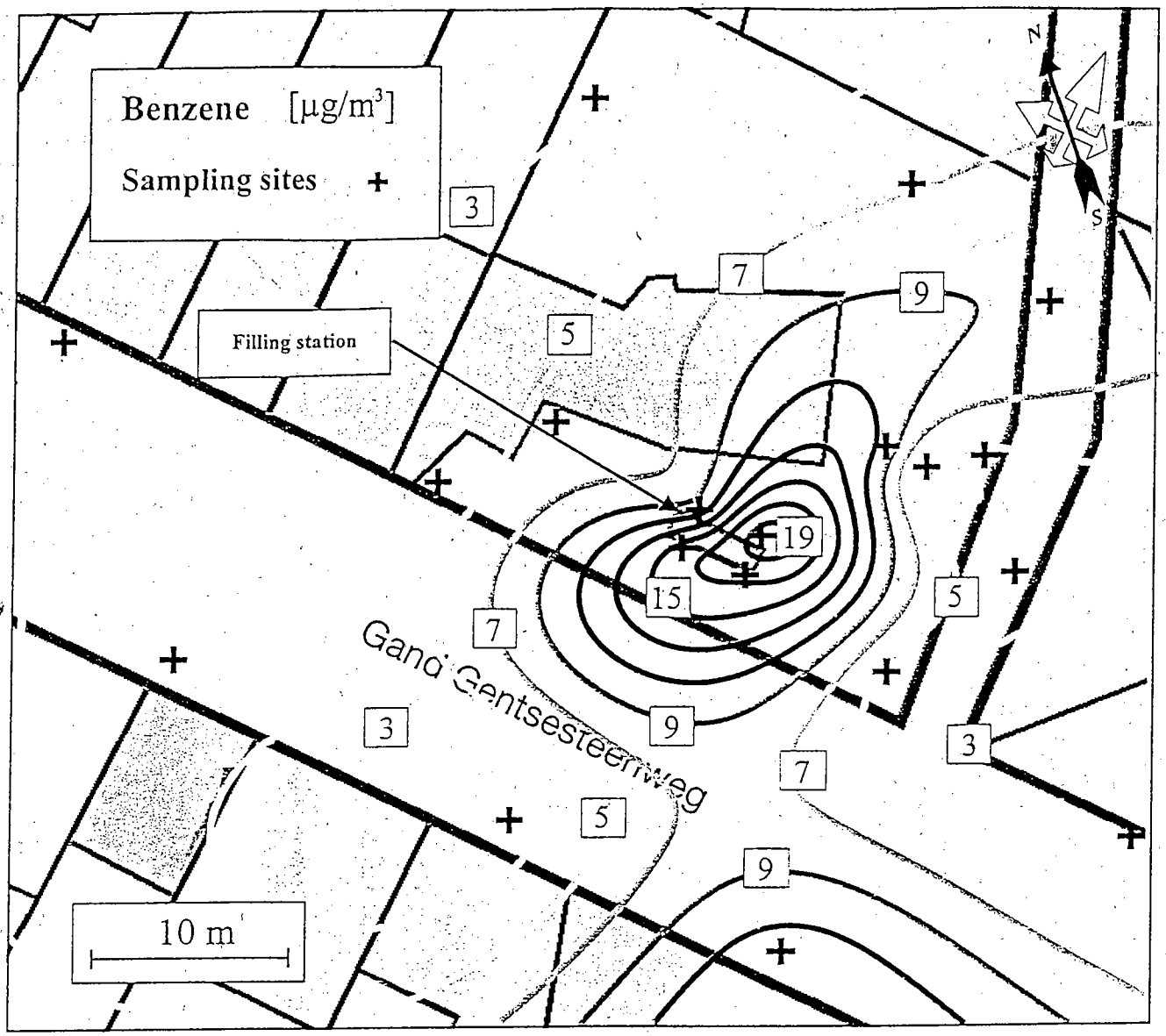
Benzene levels in petrol station C. Brussels 19/09/94 - 03/11/94



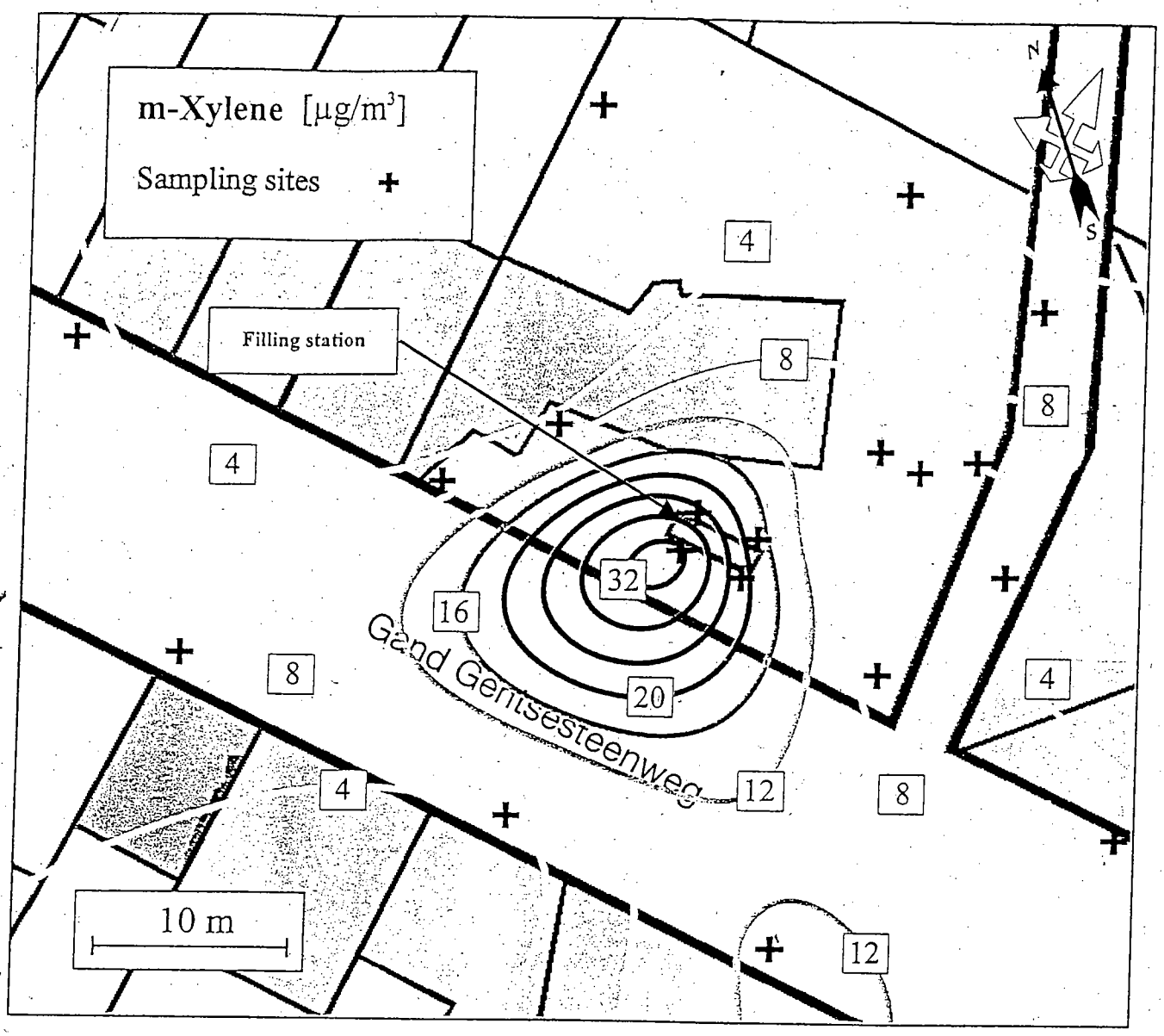
m-Xylene levels in petrol station C. Brussels 19/09/94 - 03/11/94



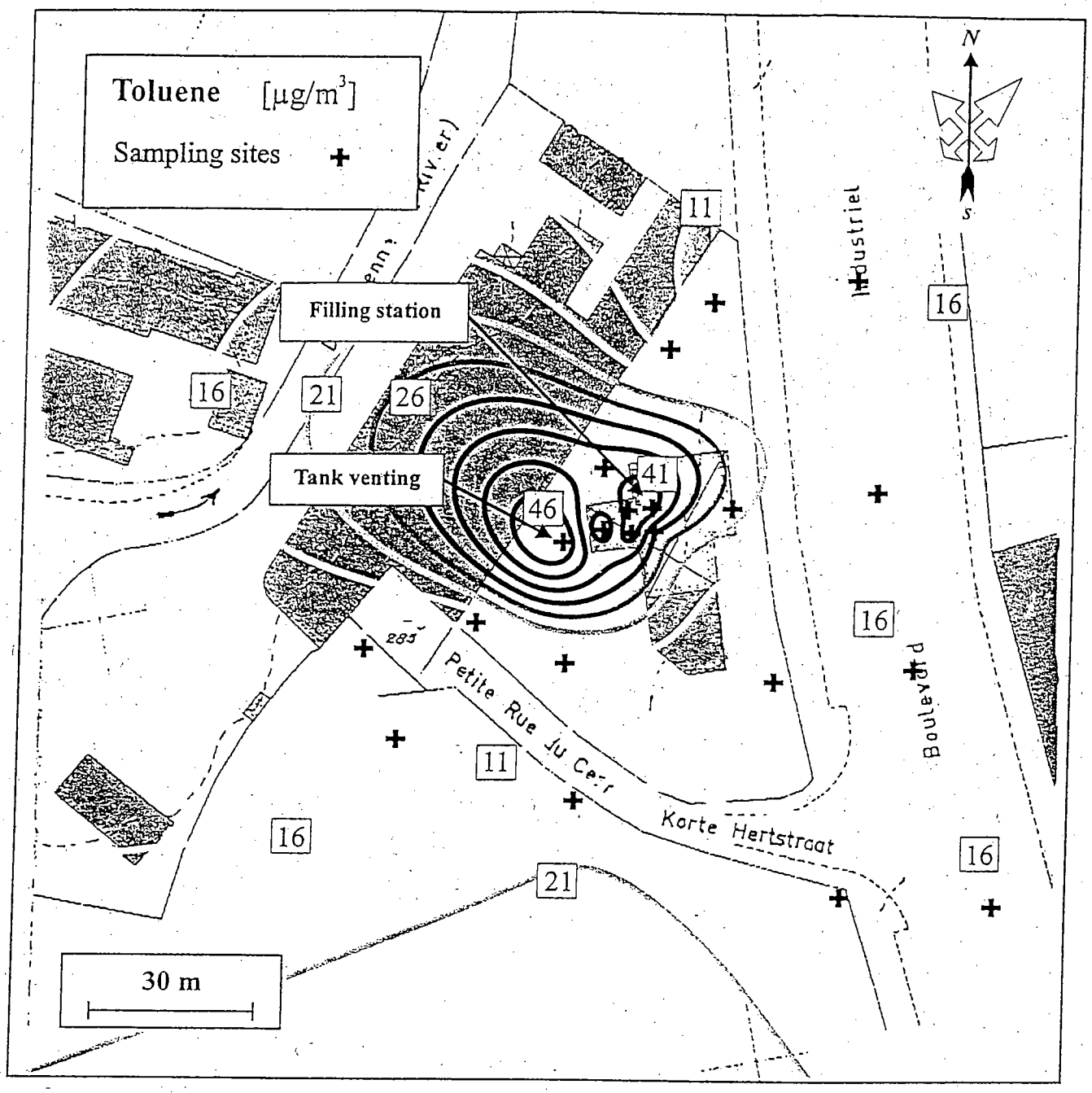
Toluene levels in petrol station D. Brussels 19/09/94 - 03/11/94



Benzene levels in petrol station C. Brussels 22/01/94 - 05/03/94



m-Xylene levels in petrol station C. Brussels 22/01/94 - 05/03/94



Toluene levels in petrol station D. Brussels 22/01/94 - 05/03/94

Annex 2

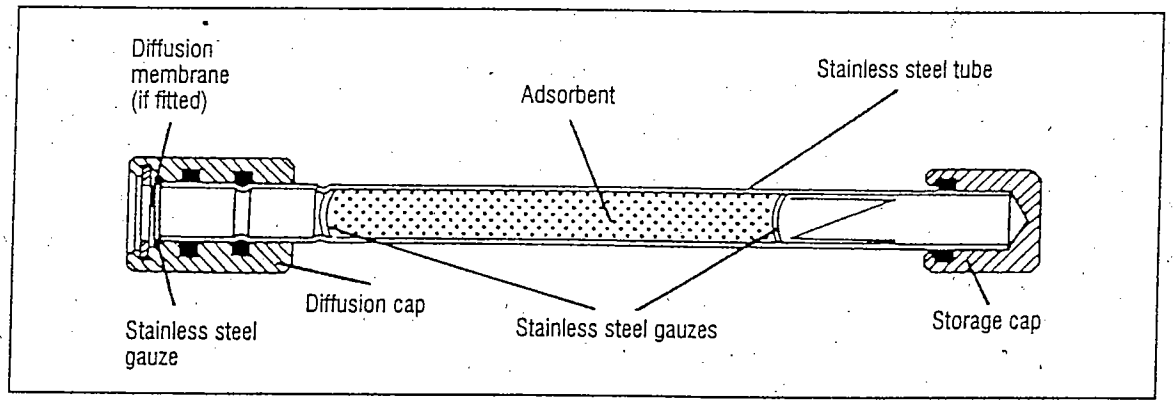
Description and mechanism the BTX diffusive sampler

Introduction

The passive sampling technique has been used for a long time in industrial hygiene as an alternative method to the active sampling for the determination of organic airborne compounds. The agreement between passive and active sampling has been widely discussed and validation protocols have been developed and standardised. Recently, the passive sampling technique has also been applied for indoor and outdoor air monitoring. The low concentrations found in ambient air require long periods of sampling, generally between two and four weeks. On the other hand, the ambient air passive samplers are exposed to variable atmospheric conditions that are quite different from the industrial hygiene environment. As a consequence, it is not possible to transfer the passive sampling validation from the industrial to the ambient environment. A new validation for ambient air passive samplers must therefore be carried out in order to establish this technique as an alternative method for detecting organic airborne compounds. Although the perspectives of this new technique are very promising, the results should be still taken from a semi-quantitative point of view.

Description of the passive sampler

Perkin Elmer passive samplers have been used in this monitoring campaign. This passive sampler (see figure below) has a tubular design where the diffusion path is followed by a long adsorbent bed. The sampler disposes of a silicone membrane, in order to reduce wind turbulence in the diffusion path and humidity effects on the adsorbent.



The length of the diffusion path is 1.5 cm with a diffusion surface of 0.2 cm^2. The length of the adsorbent layer depends on the amount of adsorbent that has been loaded. For the tubes used in this work, the adsorbent bed has a length of 6 cm.

Chromosorb 106 60/80 mesh was used as adsorbent. This is a porous polymer with a surface area between 700 and 800 m^2/g. It is considered as a class III adsorbent according to the Kiselev classification. Chromosorb 106 is a weak adsorbent, although its behaviour could be ranged between Tenax (porous polymer) and other stronger adsorbents like Carbotrap (graphitized carbon), or Carbosieve S-III (carbon molecular sieve).

Passive sampling mechanism

Because of the tubular design of this passive sampler and the fact that weak adsorbent is used, the Fick's first law can not be directly used to describe the adsorption mechanism. A no-stationary state of diffusion should be applied to model this mechanism. The Fick's second law is nor-

European Commission

EUR 16309 – Benzene, Toluene and Xylene measurements in the vicinity of petrol stations

P. Pérez Ballesta, E. De Saeger

Luxembourg: Office for Official Publications of the European Communities

1995 – 54 pp. – 21.0 x 29.7 cm

Environment and quality of life series

Catalogue number CL-NA-16-309-EN-C

In order to assess the impact of petrol stations on ambient VOC levels, a series of measurements has been carried out by ERLAP in the vicinity of four petrol stations in Northern and Southern Europe (Brussels and Murcia). Approximately 20 diffusive sampling sites were selected in the immediate service area and in the vicinity of each petrol stations, covering an area of approximately 200 metres in diameter. In addition, active sampling sites were selected within the boundary of the petrol station. Benzene, toluene and m-xylene concentrations were determined in this study, as the most important health-related compounds emitted by petrol stations.

The levels of hydrocarbon emissions generated by petrol stations mainly depend on factors such as the volume of fuel sales, the type and characteristics of the fuel and the meteorological conditions. The ambient temperature influences greatly the concentration of aromatic hydrocarbons in the gas phase of the fuel. A change in temperature from 5 to 35 °C leads to an increase in the concentration of benzene in the gas phase by a factor of three. In addition, wind speed and atmospheric stability influence the grade of dispersion of the emissions and consequently, the level of contamination around a petrol station. The BTX levels recorded during the measuring campaigns were approximately 5-15 times higher than the background levels, but high concentrations were only measured in the areas adjacent to the petrol station. At a distance of 100 m from the distribution pumps in Murcia and 30 m in Brussels, the levels of contamination due to evaporative emissions were negligible. As could be expected, the highest BTX concentration levels were detected in the locations and during the periods with the highest ambient temperatures. The composition of the hydrocarbons around the petrol stations changed with respect to the background, with an increasing proportion of the more volatile compounds emitted when closer to the petrol station.

The results of the study have shown that the impact of filling stations, when installed in residential areas will lead, to a systematic breaching of the proposed EU limit value for benzene (10 $\mu g/m^3$).

Appendix 6
"Gasoline Storage Tank Evaporative Loss Dynamics"
Presentation by Tedmund P. Tiberi, ARID Technologies, Inc.
US EPA, RTP
20 September 2004

Gasoline Storage Tank Evaporative Loss Dynamics

ARID TECHNOLOGIES INC.

United States EPA
Office of Air Quality Planning and Standards: Stage II Issues
20 September 2004

ARID Technologies, Inc.
Tedmund P. Tiberi
www.ARIDtech.com

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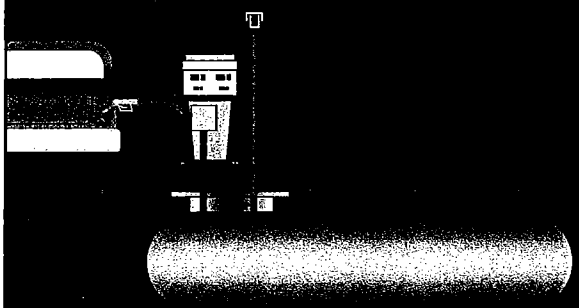
The Uncontrolled System



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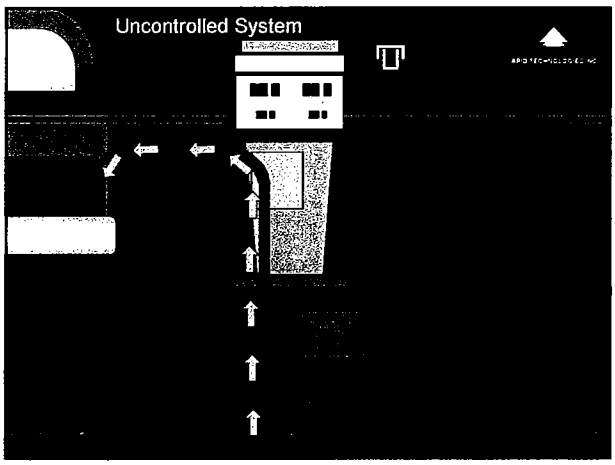
Uncontrolled System



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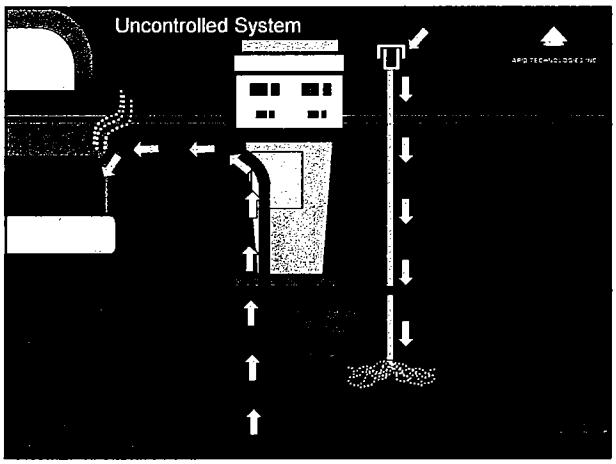

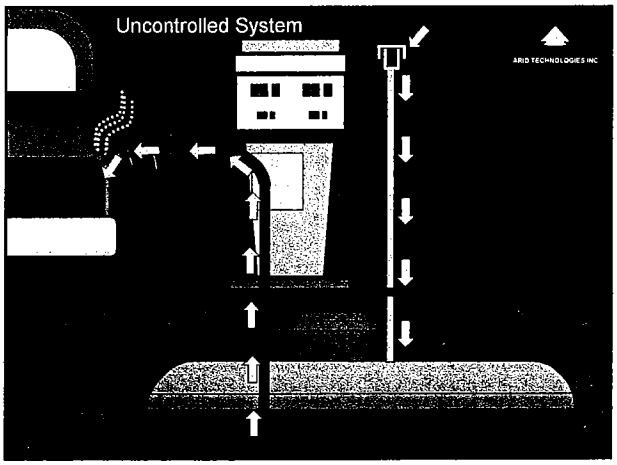
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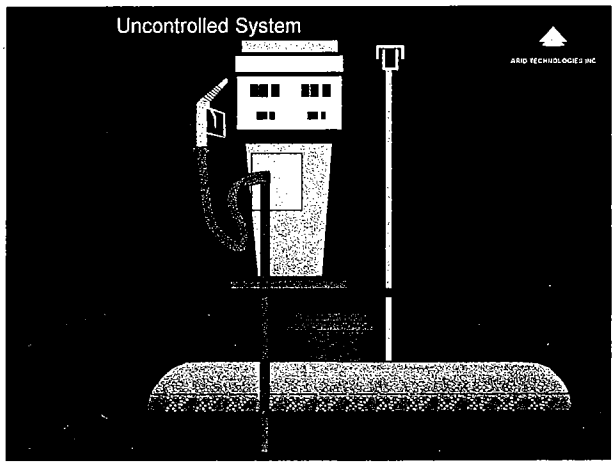
ARID TECHNOLOGIES INC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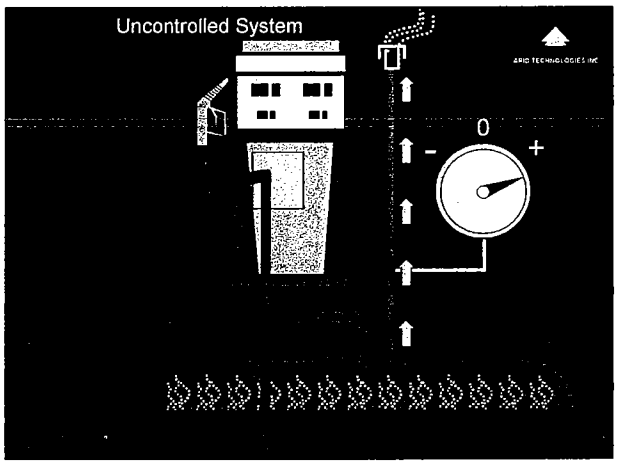
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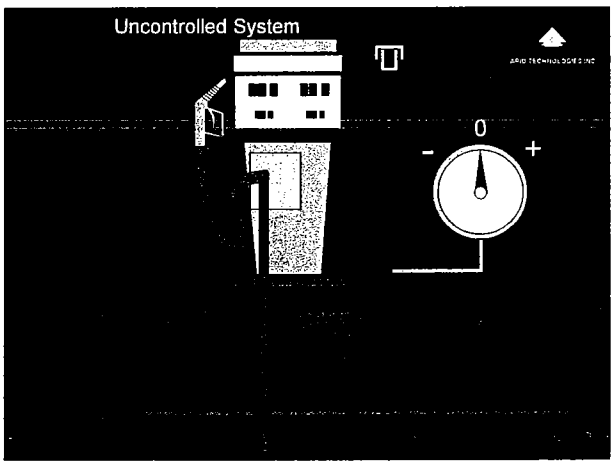
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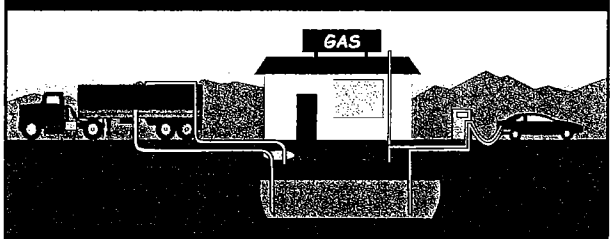
Vapor Recovery at Service Stations



Stage I

Stage II

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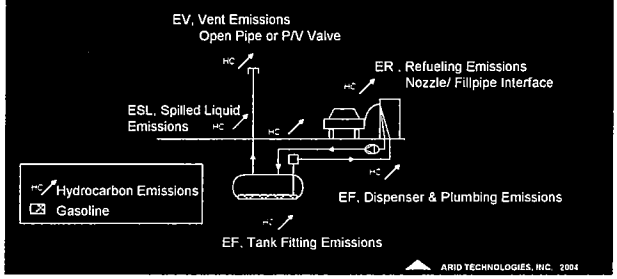
Petrol Station Emissions



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Primary Components of Gasoline Vapor

VOC's and HAPS (Hazardous Air Pollutants)

- Methane
- Ethane
- Ethylene
- Propane
- Cyclopropane
- Propylene
- Isobutane
- N-Butane
- Trans-2-Butene
- Cyclopentane
- Isopentane
- N-Pentane
- 2,3 Dimethylbutane
- 2-Methylpentane
- 3-Methylpentane
- Hexane
- Benzene – known human carcinogen

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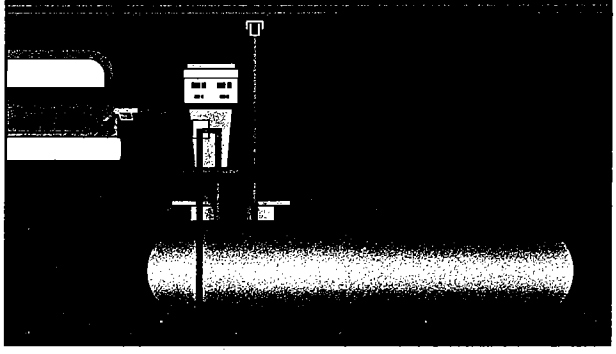
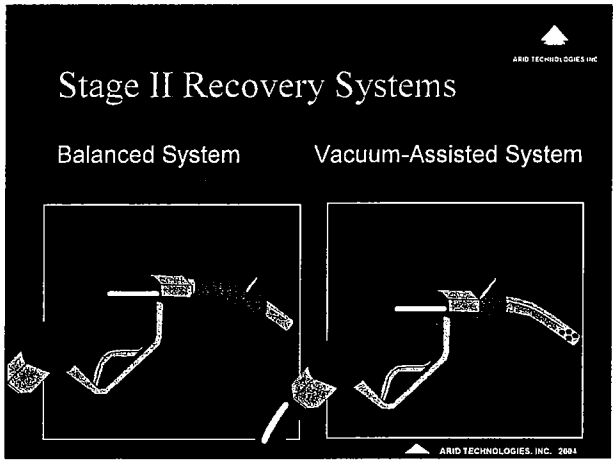
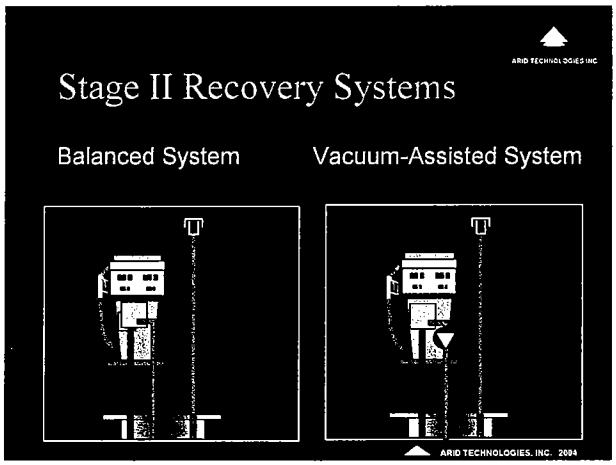
Stage II Recovery Systems




Stage II Recovery Systems
Balanced System
Vacuum-Assisted System
ARID TECHNOLOGIES, INC. 2004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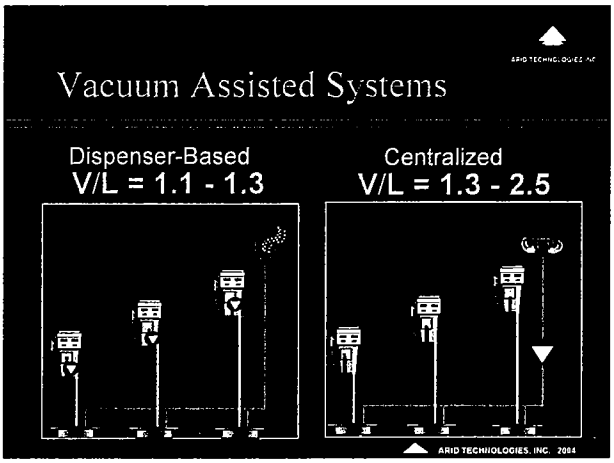
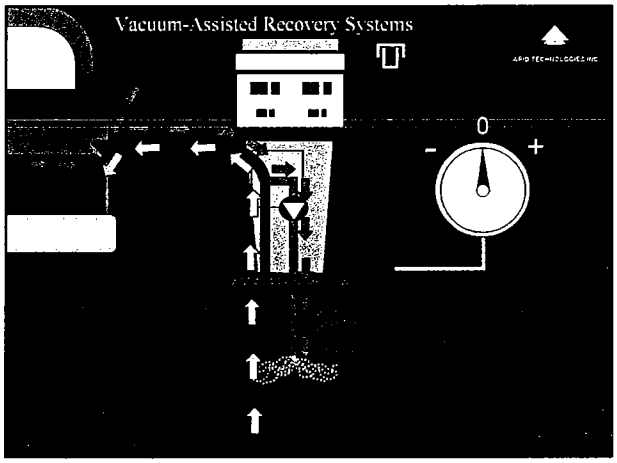
ARID TECHNOLOGIES, INC. 2004


Vacuum Assisted Systems
Dispenser-Based
V/L = 1.1 - 1.3
Centralized
V/L = 1.3 - 2.5
ARID TECHNOLOGIES, INC. 2004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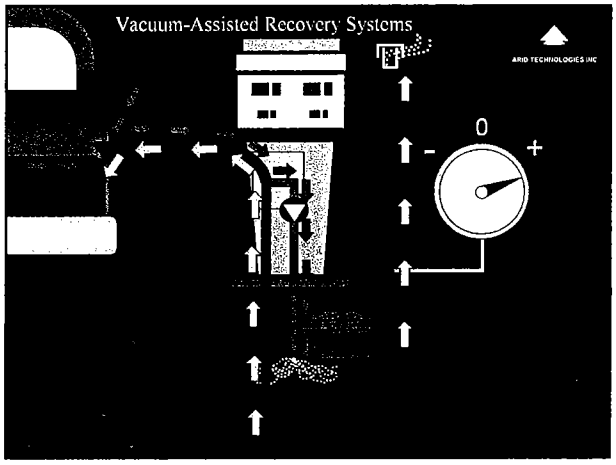
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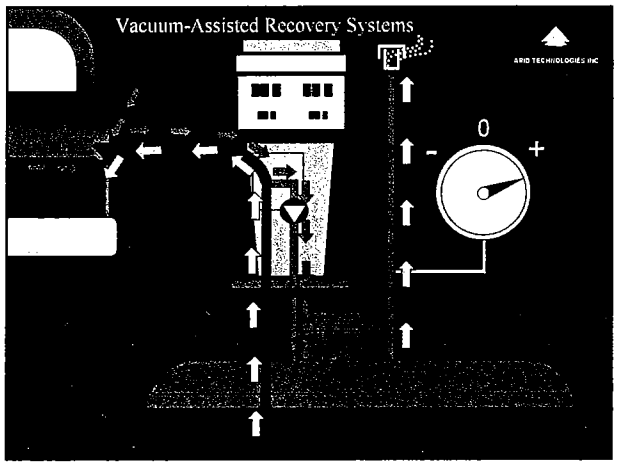
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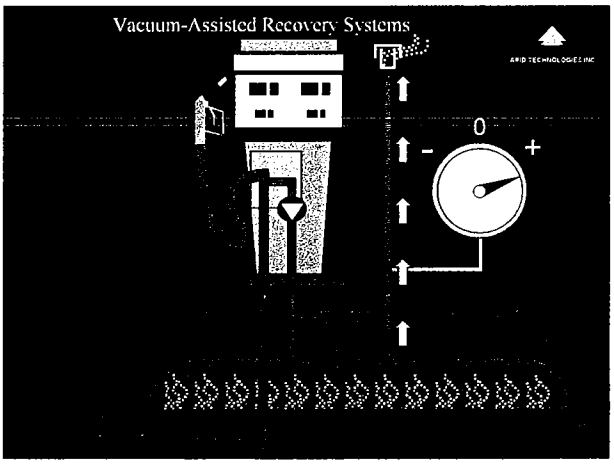
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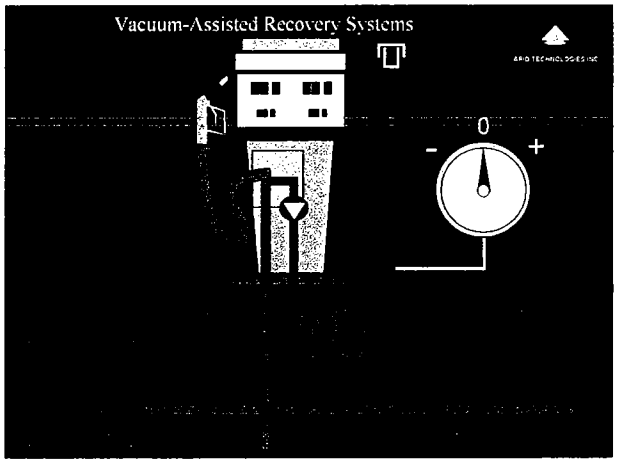
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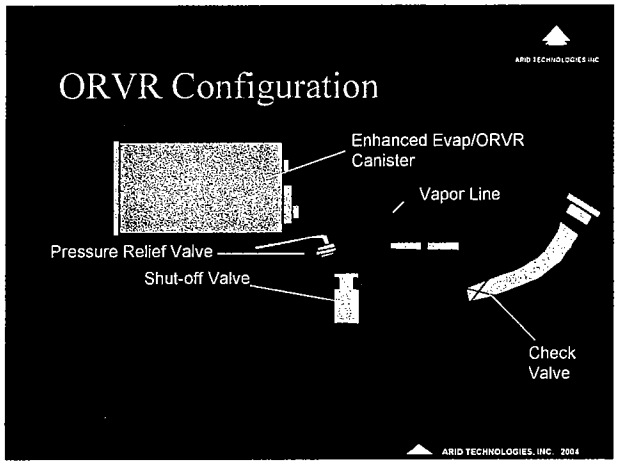
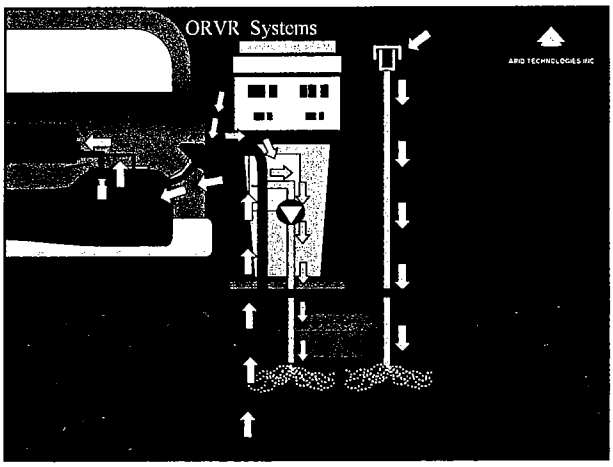
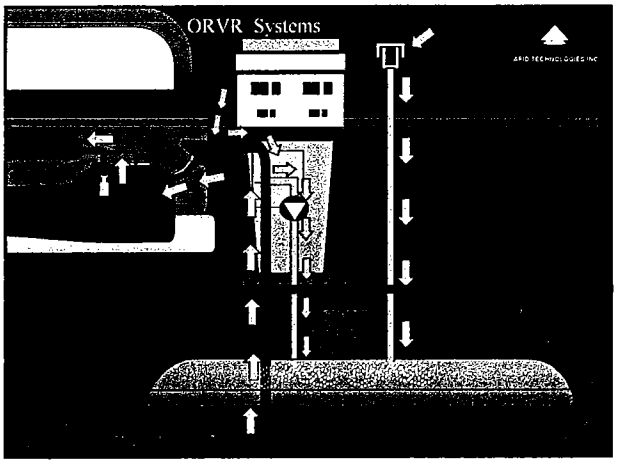

ARID TECHNOLOGIES INC
ORVR Configuration
Enhanced Evap/ORVR Canister
Vapor Line
Pressure Relief Valve
Shut-off Valve
Check Valve
ARID TECHNOLOGIES, INC. 2004


ORVR Systems
ARID TECHNOLOGIES INC


ORVR Systems
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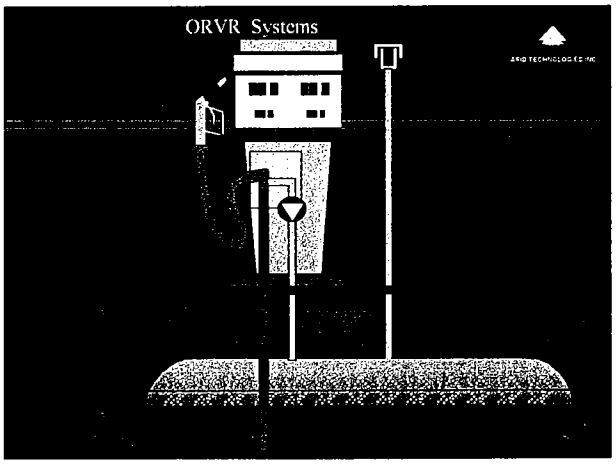
ORVR Systems
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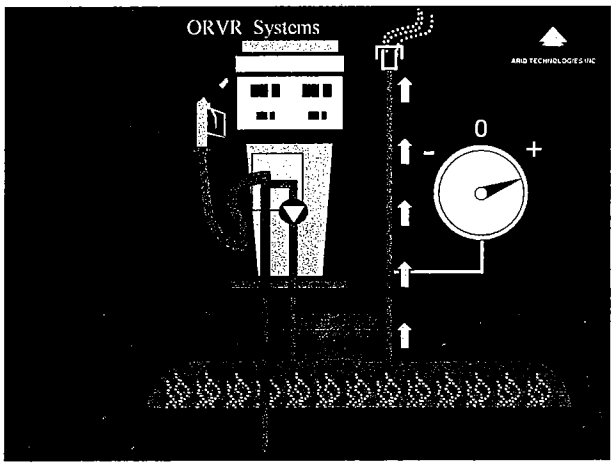

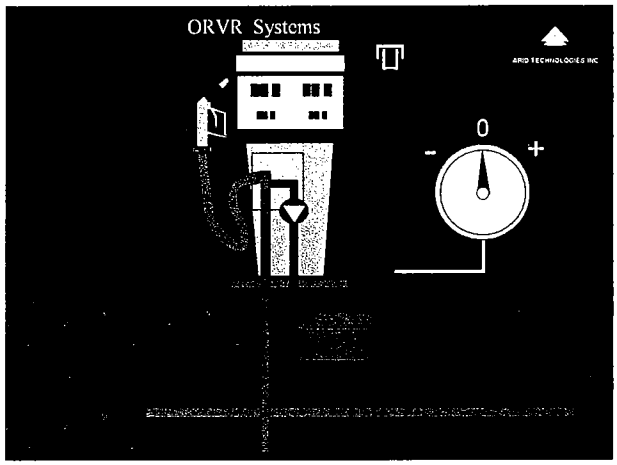

ORVR Compatibility

- Onboard Refueling Vapor Recovery, or ORVR, provides for collection of the refueling vapors in a carbon canister on the vehicle. It performs the same function as a Stage II vapor recovery system for newer cars.
- Minimizing impact of air ingestion while refueling ORVR equipped vehicles

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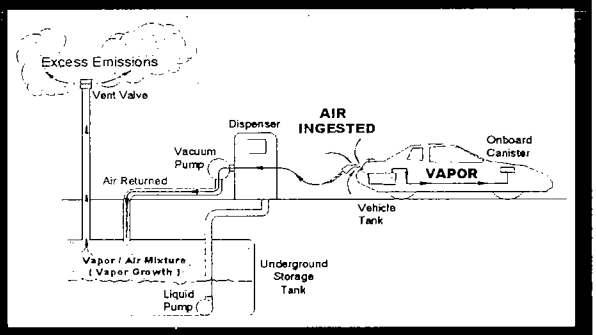
ORVR - Phase II Incompatibility



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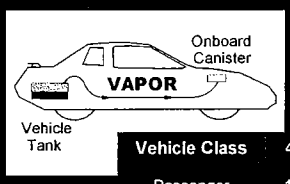
Onboard Refueling Vapor Recovery or "ORVR"



Vehicle Class	40%	80%	100%
Passenger	1998	1999	2000
LD Trucks & MDV (<6000 lbs)	2001	2002	2003
MD Vehicles (6001-8500 lbs)	2004	2005	2006

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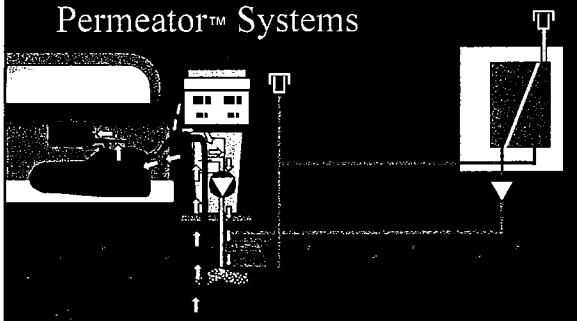
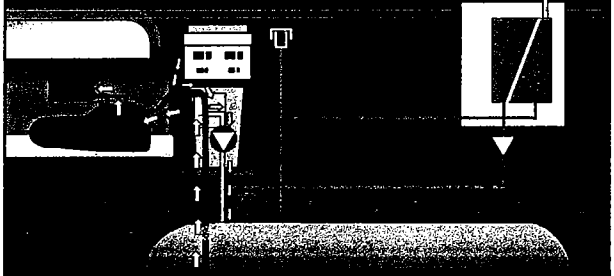
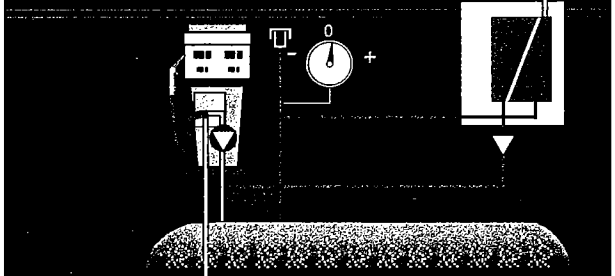
Permeator™ Systems

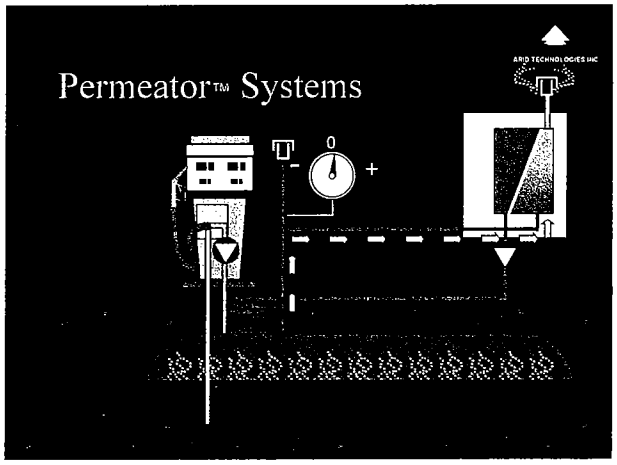


Permeator™ Systems



Permeator™ Systems

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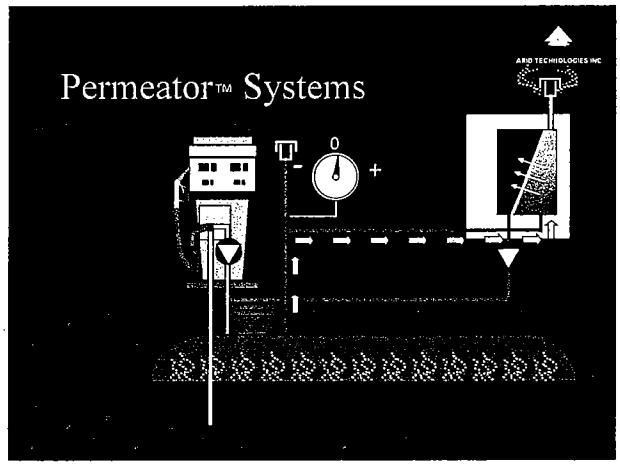
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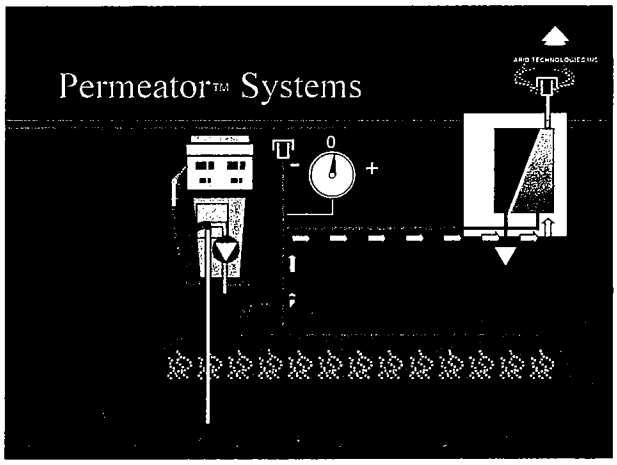
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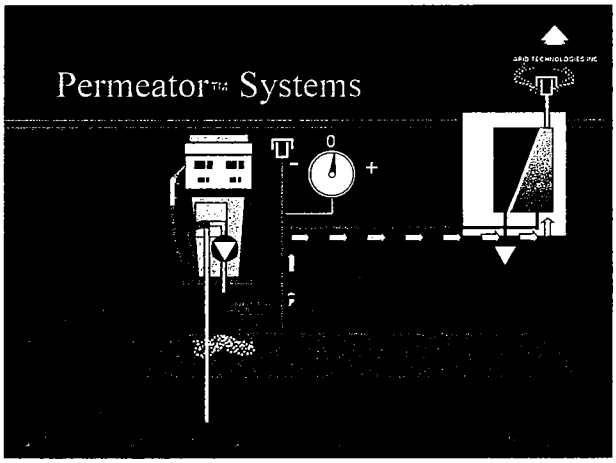
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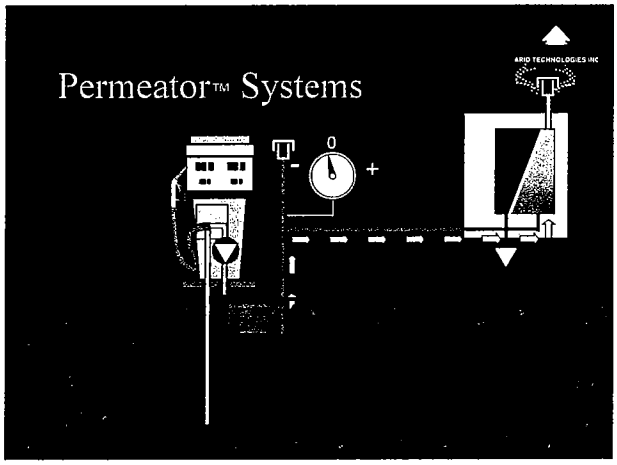
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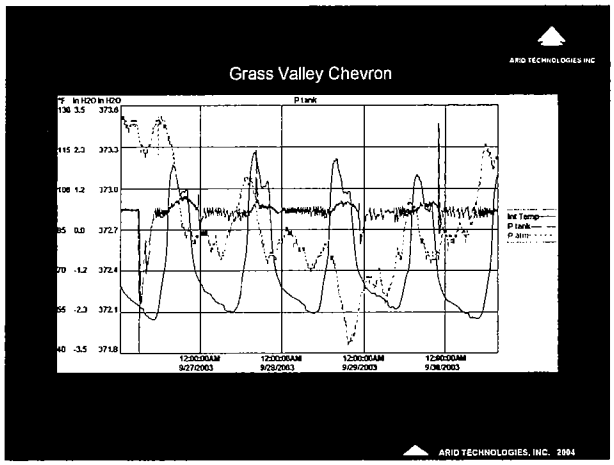
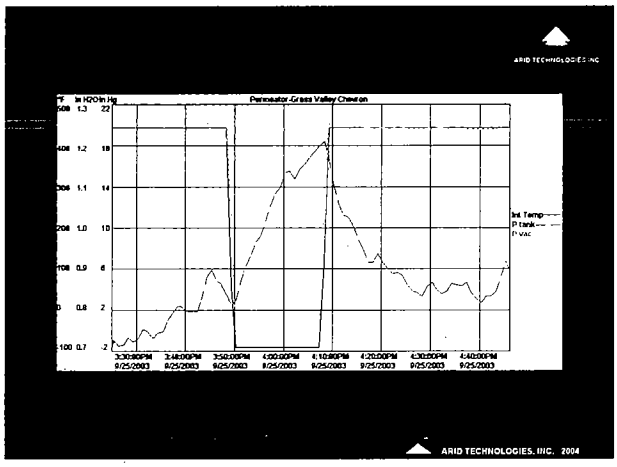
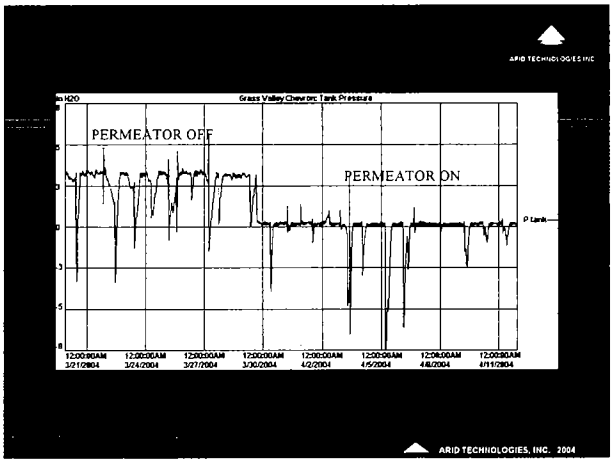

Grass Valley Chevron
ARID TECHNOLOGIES INC
P tank
Int Temp
P tank
P atm
ARID TECHNOLOGIES, INC. 2004


ARID TECHNOLOGIES INC
Permeator Grass Valley Chevron
Int Temp
P tank
P vac
ARID TECHNOLOGIES, INC. 2004


ARID TECHNOLOGIES INC
Grass Valley Chevron Tank Pressure
PERMEATOR OFF
PERMEATOR ON
P tank
ARID TECHNOLOGIES, INC. 2004

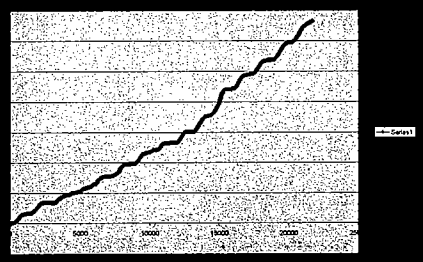
ARID TECHNOLOGIES INC

1045 gal/month = 32.6 Tons/year-station
983 gal/month = 30.7 Tons/year-station

1045/300,000 = 0.35%; 983/300,000 = 0.33%

ARID TECHNOLOGIES, INC. 2004

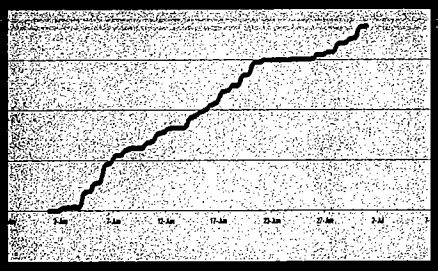
ARID TECHNOLOGIES INC



Monthly Savings	1332.892	gallons
% Throughput	0.464%	
lbm/1,000 gallons	21.003	

ARID TECHNOLOGIES, INC. 2004

ARID TECHNOLOGIES INC



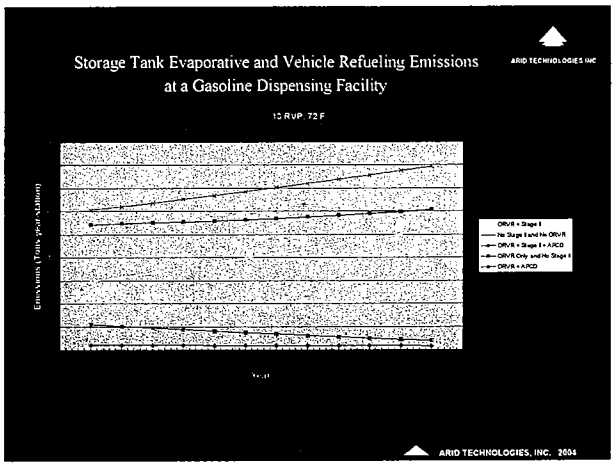
ARID TECHNOLOGIES, INC. 2004

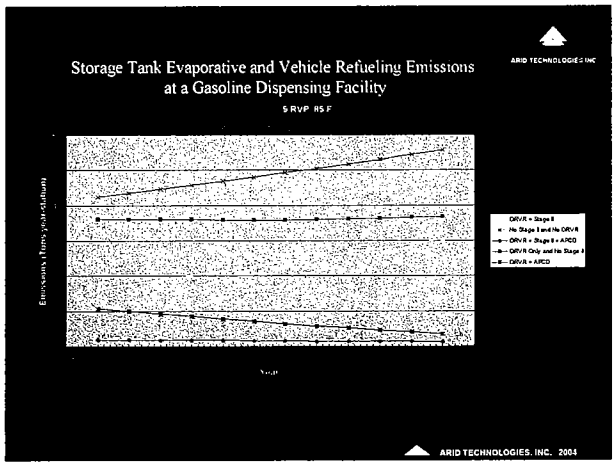
ARID TECHNOLOGIES INC

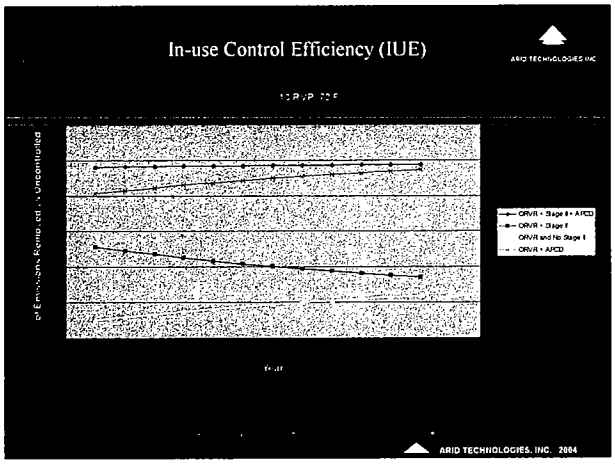
What do we know?

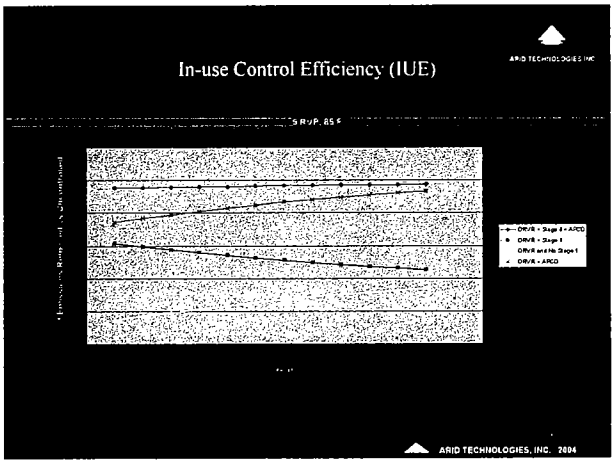
- Evaporation losses are caused by air ingestion into fixed roof storage tanks
- Even with Stage I vapor balancing operations. excess emissions occur due to vapor growth
- Evaporative vapors escape the storage tank system and are emitted to the local surroundings
- Magnitude of evaporative losses is typically 0.10% to 0.50% of throughput: value depends upon RVP. Temperature and air ingestion volume

ARID TECHNOLOGIES, INC. 2004


Storage Tank Evaporative and Vehicle Refueling Emissions
at a Gasoline Dispensing Facility
ARID TECHNOLOGIES INC
ARID TECHNOLOGIES, INC. 2004


Storage Tank Evaporative and Vehicle Refueling Emissions
at a Gasoline Dispensing Facility
ARID TECHNOLOGIES INC
ARID TECHNOLOGIES, INC. 2004


In-use Control Efficiency (IUE)
ARID TECHNOLOGIES INC
ARID TECHNOLOGIES, INC. 2004


In-use Control Efficiency (IUE)
ARID TECHNOLOGIES INC
ARID TECHNOLOGIES, INC. 2004

From: Anne Arnold [mailto:Arnold.Anne@epamail.epa.gov]
Sent: Friday, September 28, 2012 2:49 PM
To: Hiney, Eileen (DEP)
Cc: Ariel Garcia; Dave Conroy
Subject: Re: Addendum to ERG Stage I-II Report

Hi Eileen,

Ariel and I reviewed the report and addendum. Generally, the conclusions presented seem reasonable. However, we have the following specific comments.

1. In Table A of the Addendum, the EPA default for QSII should be 95-97%, rather than the stated 90%. See Table 2 of the August 7, 2012 EPA Stage II Guidance.

2. Appendix A of the report gives an overview of the MOVES modeling runs that were conducted. If MA DEP plans to use any of modeling results in a Stage II SIP demonstration, EPA would like the opportunity to review the MOVES input files.

Anne Arnold, Manager
Air Quality Planning Unit
EPA New England
617-918-1047

CAPCOA Vapor Recovery Meeting

Gasoline Dispensing Facilities

Sacramento, California
October 19, 2005

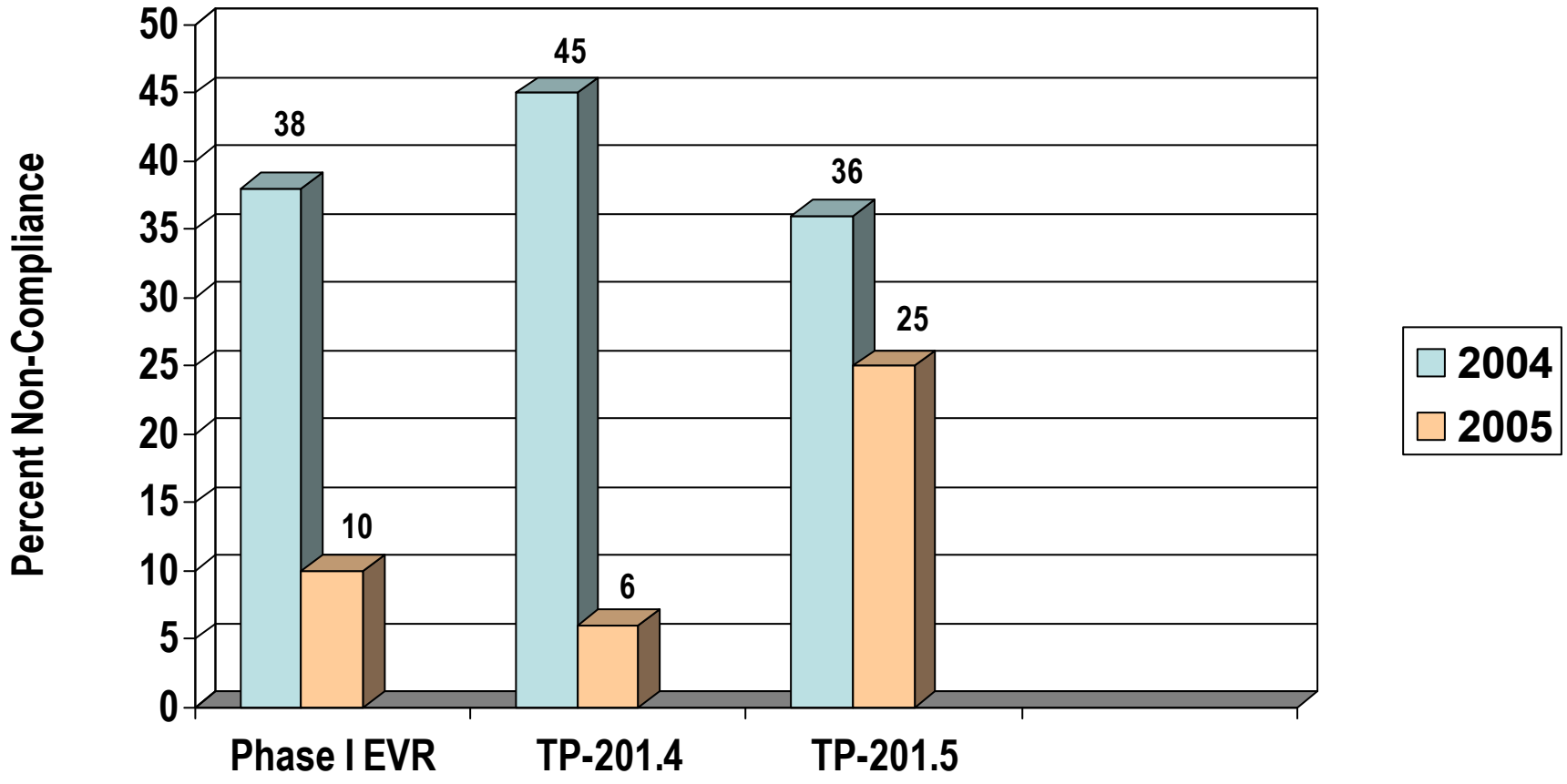
Louis Roberto
South Coast AQMD

Presentation Outline

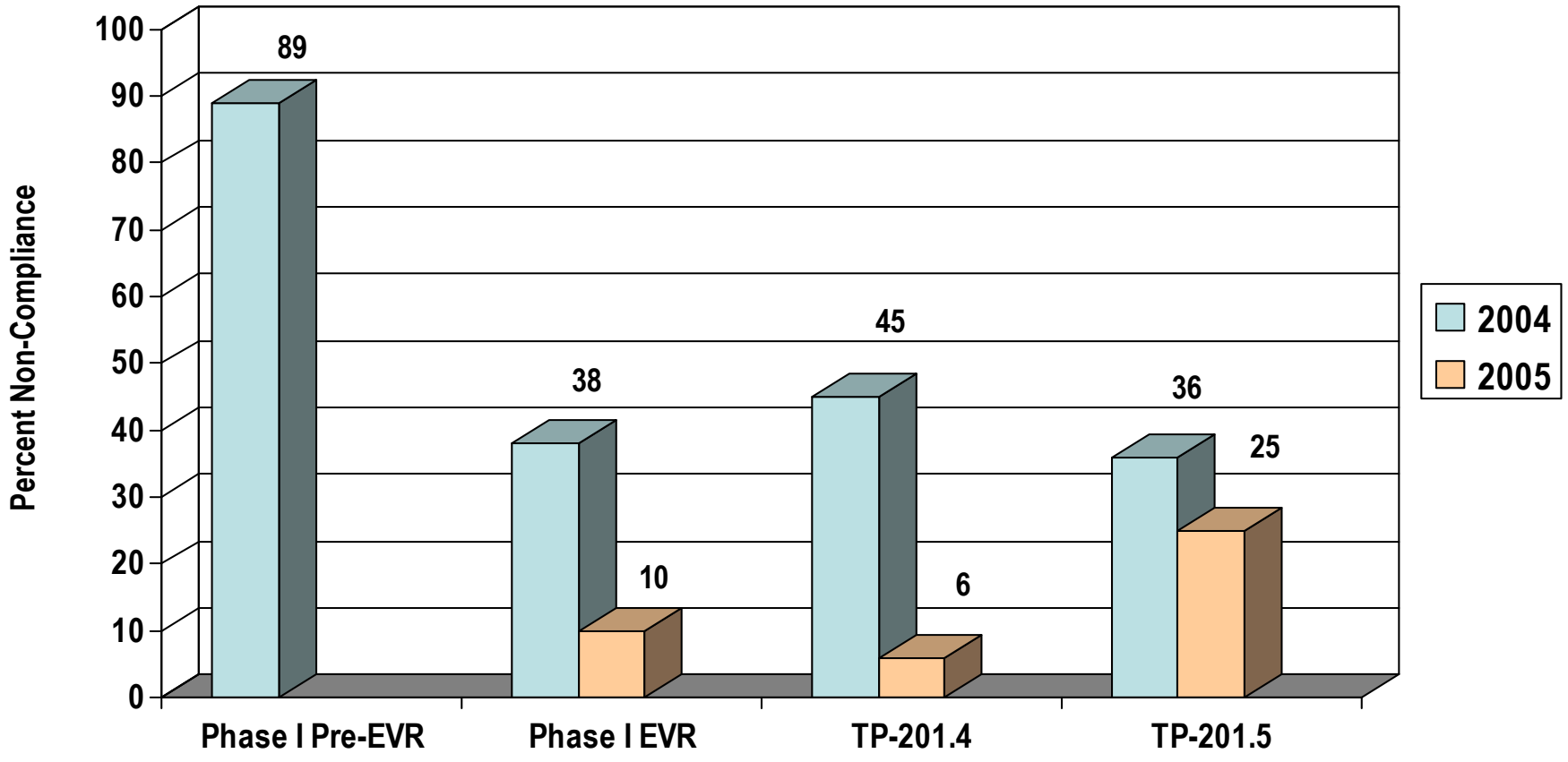
- **South Coast AQMD Audit**
  - Phase I EVR
  - Phase II
  - ORVR Compatibility Conversions
  - Phase II EVR
- **Preliminary Audit Results**
- **Audit Issues & Concerns**

IS IT AUDIT TIME ?"

South Coast AQMD Testing Audits

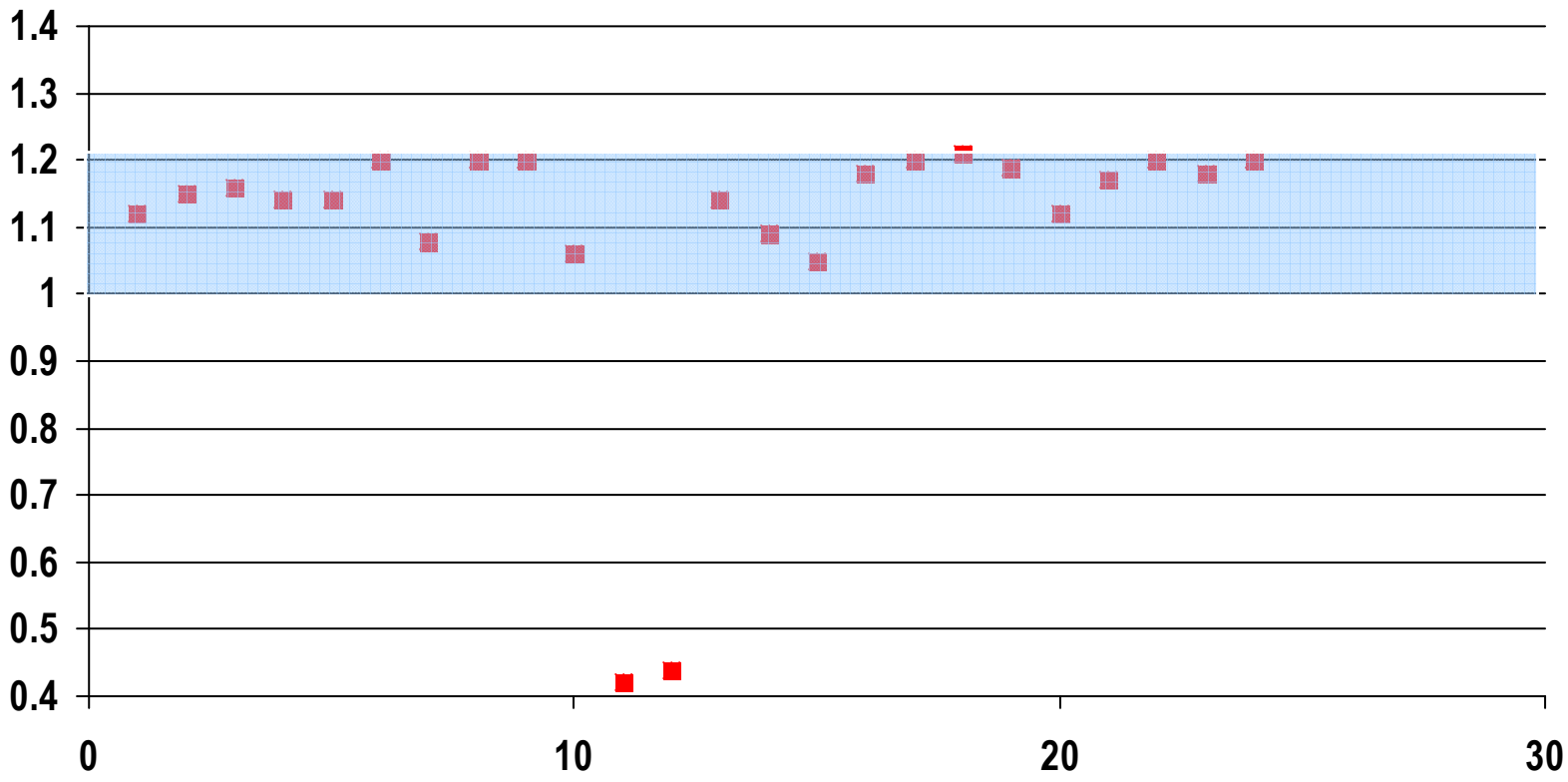


South Coast AQMD Testing Audits



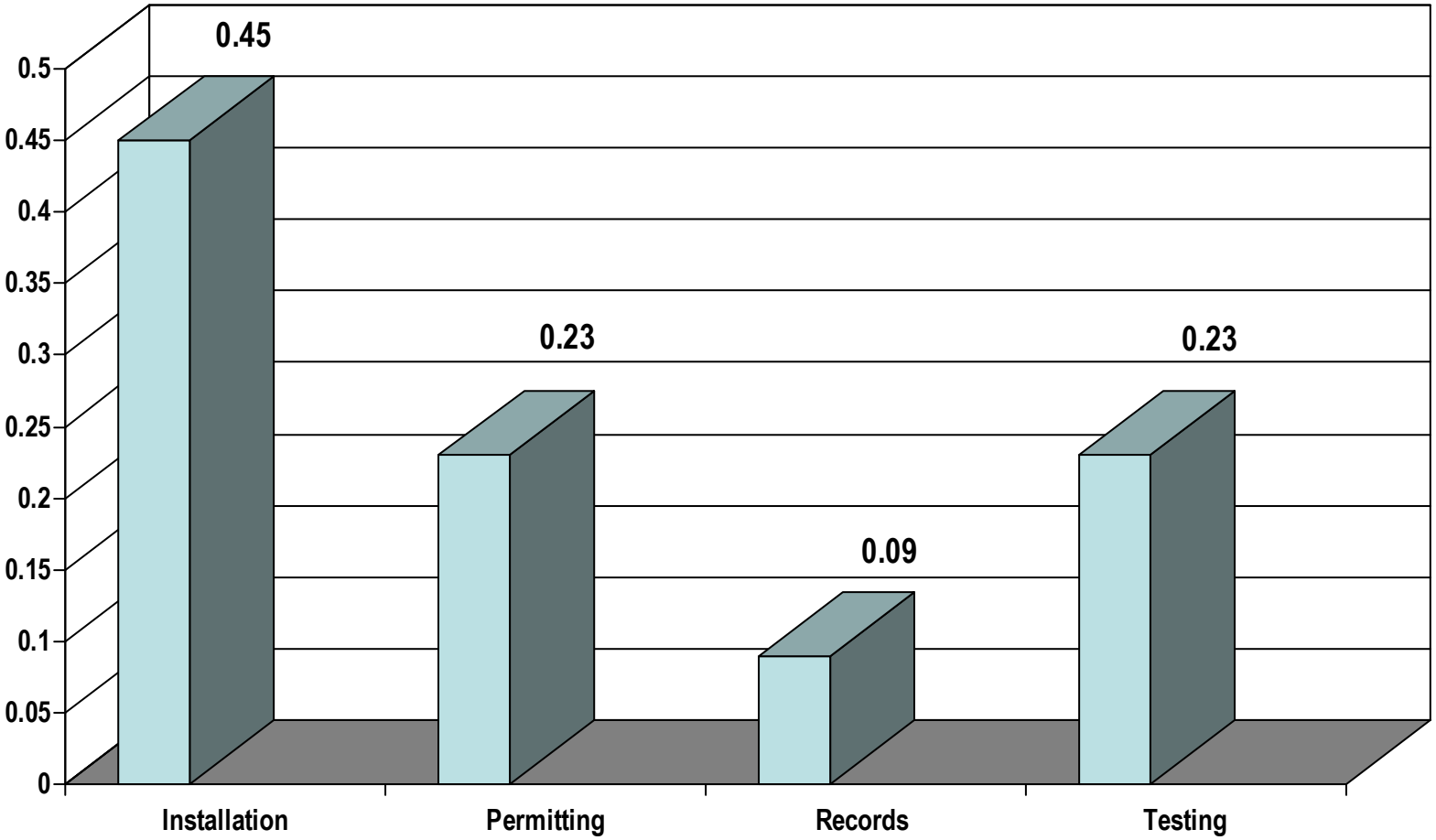
Healy G-70-191-A: Model 900 Nozzles

A/L Ratio Range (1.0 – 1.2)



Non-Compliance Breakdown

Relative Frequency – 22 NOVs

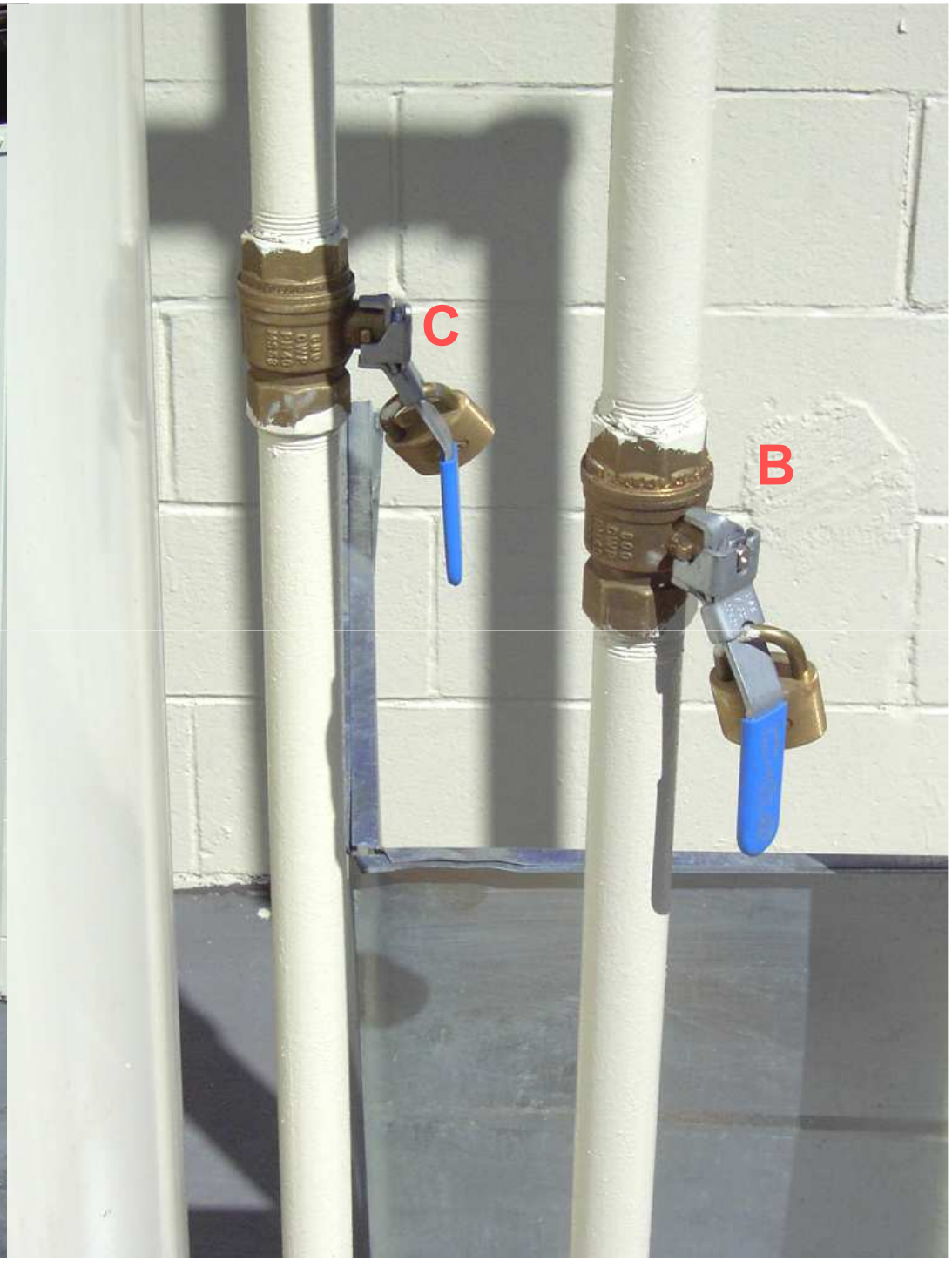


Louis Roberto
October 14, 2005

Vapor Recovery Installation Problems

USA Gasoline
USA Gasoline Corp
3618 Baldwin Ave.
El Monte

A
C
B
D
HEALY


C
B

3
4
3
USA
USA

Rimpco Inc. / Shell Oil
10961 Los Alamitos Blvd., Los Alamitos

- **Phit-Tite Phase I EVR**
- **Healy Phase II (G-70-165)**
  September 15, 2005

Installation Problems

Installation Problems

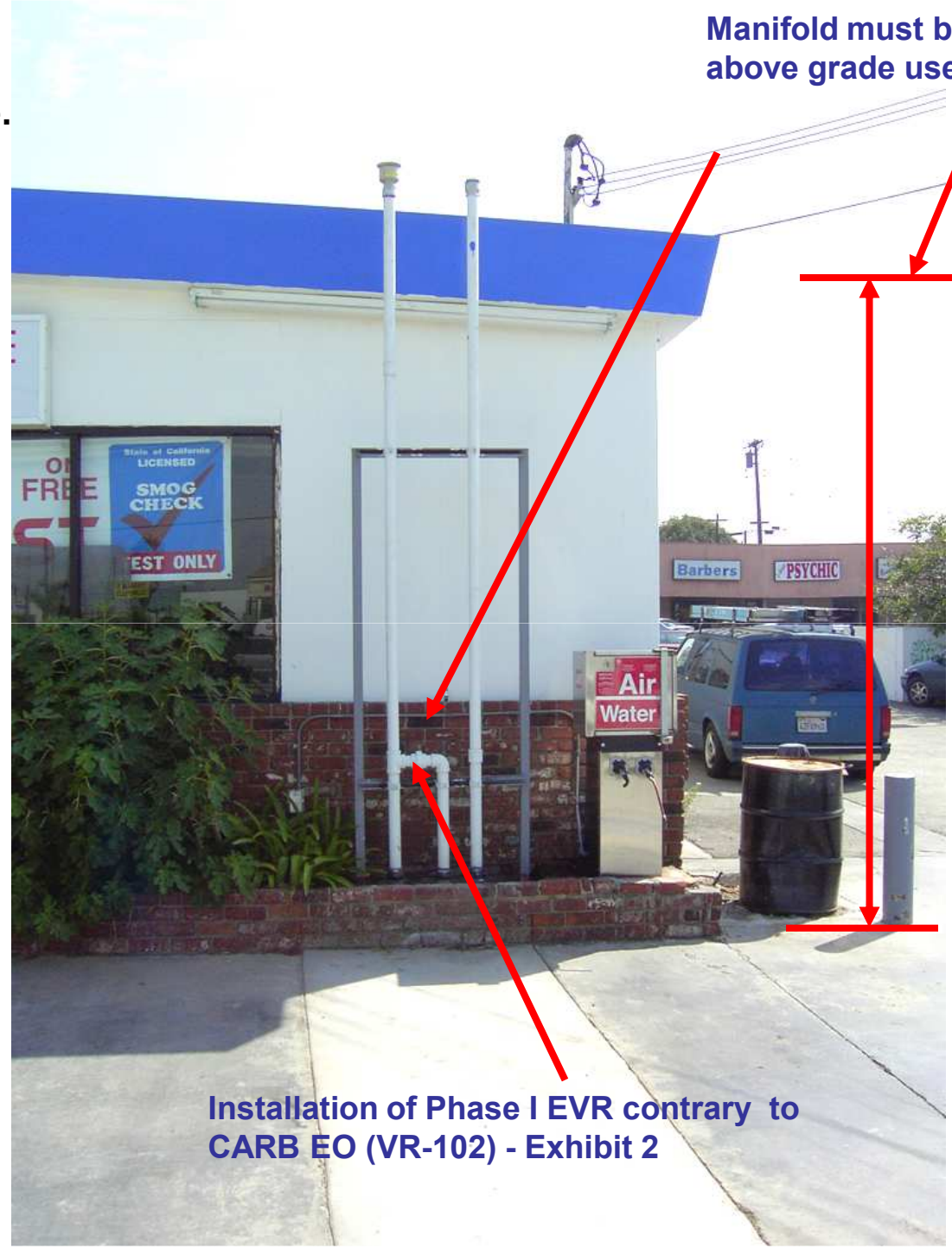
Arrow Car Wash
10075 Arrow Route
Rancho Cucamonga

OPW Phase I EVR

- **Vent piping must be steel or material compatible with gasoline**

PVC Piping

US Gasoline
14204 Rosecrans Ave.
La Mirada



Arco
1001 W. Artesia Blvd.
Gardena

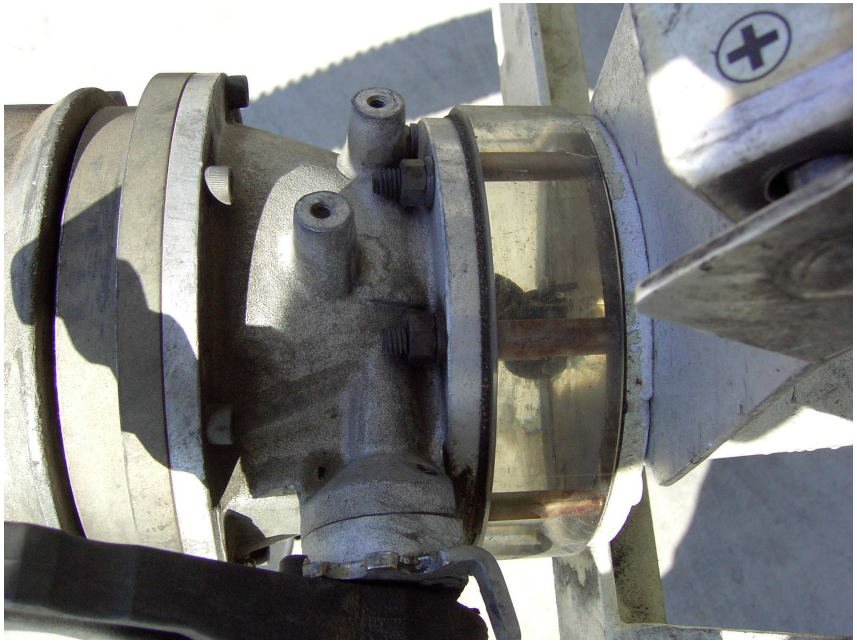
Balance System

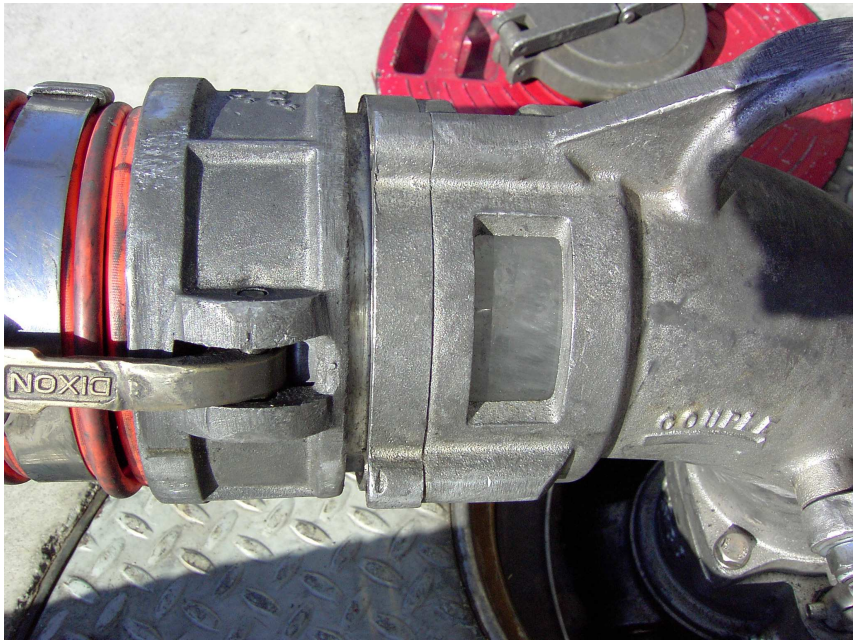
Installation/Operation Contrary to VR-102 EO (Installation of 4 PVVs)

A Express
8850 Foothill Blvd.
Rancho Cucamonga

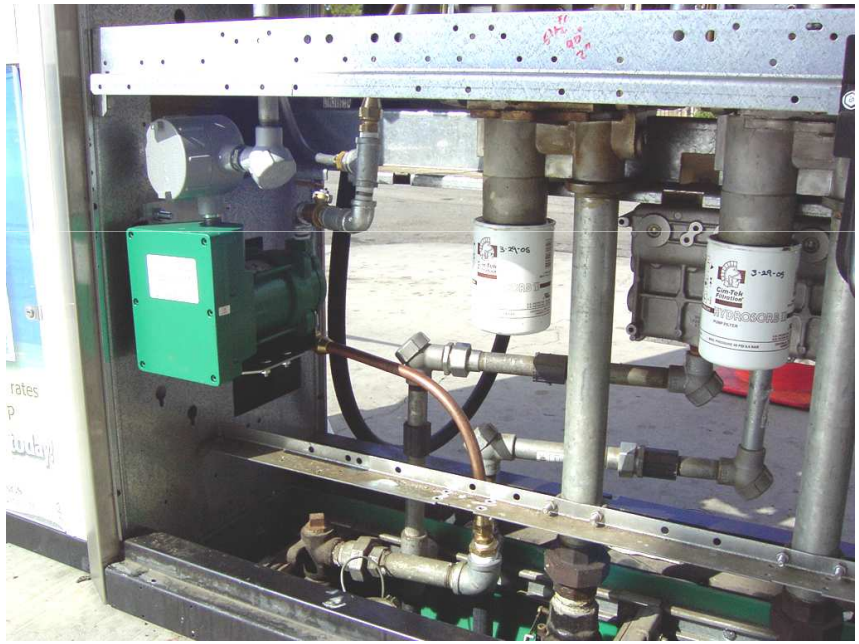
Air Ingestion

Air Ingestion Cont.





Installation Problems



CAS Vacuum Readings
1145 hrs. - 0.92" WC
1150 hrs. - 1.20" WC
1155 hrs. - 1.58" WC
1200 hrs. - 2.04" WC
1205 hrs. - 2.27" WC
1210 hrs. - 2.52" WC
1215 hrs. - 2.55" WC
1220 hrs. - 2.60" WC
Costco Wholesale
6100 Sepulveda Blvd.
Van Nuys

Enhanced Leak Detection (ELD) Testing At Existing GDFs

ELD Testing At Existing GDFs

Independent Oil Marketers Association of New England

September 28, 2012

Ms. Eileen Hiney
Massachusetts Department of Environmental Protection
One Winter Street, 7th Floor
Boston, Massachusetts

Re: IOMA Comments on Eastern Research Group, Inc. (ERG) Reports and Recommendation for Immediate Elimination of Stage II Vapor Recovery

Dear Ms. Hiney:

We appreciate the opportunity to provide comments to the Massachusetts Department of Environmental Protection (MassDEP) regarding the above-referenced Eastern Research Group, Inc. (ERG) Reports and the future of Stage I and Stage II Programs in Massachusetts. The Independent Oil Marketers Association (IOMA) represents independent gasoline service station owners in the Commonwealth of Massachusetts and has a direct interest in any future changes to these programs. To assist us in evaluation of this important matter, IOMA retained Tech Environmental (Tech) of Waltham, Massachusetts to provide a technical review of the ERG report. A copy of the Tech letter report, summarizing their findings and recommendations, is enclosed with this correspondence.

Based on our review of the Tech report, recent Environmental Protection Agency (EPA) guidance and Stage II Program changes occurring throughout New England, **IOMA recommends the following:**

- **The immediate elimination of the requirement for operation of Stage II systems at all Massachusetts gasoline dispensing facilities (GDFs). To delay elimination of Stage II through the time consuming SIP process would represent, in our opinion, an unfortunate and indefensible reliance on form over substance as our neighboring states move expeditiously to avoid excess emissions and unnecessary costs;**

- **Upon decommissioning of Stage II, a pressure/vent (P/V) vent valve approved for any California Air Resources Board (CARB) Stage I system be installed at gasoline dispensing facilities (GDFs) to control underground storage tank (UST) breathing losses; and,**

PO Box 1827
North Falmouth, MA 02556
romano@iomane.com

- **A phased-in approach for the upgrade of Stage I equipment where at the time of UST system replacement, substantial modification to the tank top, or for new sites, Stage I equipment from any CARB-approved Stage I system be installed by GDF owners.**

We believe these recommendations represent sound public policy that is protective of human health and the environment, and is in line with both President Barack Obama's and Governor Deval Patrick's executive orders to eliminate burdensome regulations. The following general and specific comments are provided in support of this and other IOMA conclusions:

1) **Immediate Removal of Stage II systems in Massachusetts is fully supported by EPA**. In a public presentation the week of September 17, 2012 at the Connecticut Business and Industry Association fall meeting, Environmental Protection Agency (EPA) Office of Air and Radiation Assistant Administrator Gina McCarthy stated that use of Stage II vapor recovery systems at GDFs was a "mistake" in the context of a discussion on burdensome regulations that are no longer effective. While IOMA acknowledges that Stage II vapor recovery had its time, we agree with Ms. McCarthy that it's time has passed with EPA's determination of widespread use for onboard refueling vapor recovery (ORVR) systems. Consistent with this sentiment, EPA's recently-issued State Implementation Plan (SIP) guidance established criteria that would allow states to eliminate Stage II without adopting any additional comparable measures as long as certain criteria were met.

   In fact, this guidance was provided soon after the initial ERG report, and resulted in the publication of the ERG addendum report that documented Massachusetts is well below the 10% de-minimis criteria allowing elimination of Stage II without the need for adoption of any comparable measures. Tech's study demonstrates that we may be even further below the de-minimis criteria, and IOMA believes we are rapidly approaching an excess emissions scenario, especially in areas of Massachusetts where ORVR penetration is higher than the state average. It is reasonable to assume there are a number of large volume GDFs with vacuum assist Stage II systems where excess emissions are already being caused by ORVR incompatibility. To protect public health and not risk any excess emissions, we recommend that MassDEP not wait for finalization of the SIP process, but rather use the EPA guidance and immediately eliminate the requirement for Stage II vapor recovery.

2) **President Obama and Governor Patrick have each emphasized that regulations must be the least burdensome methods for achieving regulatory goals.** With the increasing widespread use of ORVR and its incompatibility with Stage II systems, continuing the use of Stage II clearly does not comply with the intent of both President Obama's and Governor Patrick's administrations to have clear and effective regulations that provide the least burden to commerce. EPA has taken steps to meet this directive, enacting regulatory changes and issuing guidance for removal of Stage II systems. MassDEP must similarly recognize that Stage II systems do not currently meet these administration directives and provide for their immediate elimination.

3) **Massachusetts stands alone as one of the only New England states without a plan to decommission Stage II systems, putting GDF owners at a competitive disadvantage.** Decommissioning of Stage II systems is ongoing in Maine, New Hampshire and Vermont, and Connecticut just announced that it plans to move forward with full elimination in the next few months. In fact, Connecticut was proceeding down a similar path as Massachusetts with the performance of a state specific study, but with the clarity provided by recent EPA guidance, determined immediate removal is appropriate. The longer Massachusetts takes to come to the same decision, the more unacceptable it becomes to stakeholders as they needlessly spend money on testing and maintenance of the obsolete Stage II systems.

4) **Cost benefits do not support the continued use of Stage II system**. According to the Tech report, ERG's costs provided for continued use of Stage II systems are too low. Using available industry information, Tech estimates the cost per ton of volatile organic compound (VOC) removal at approximately $29,000/ton, almost three (3) times the value of $10,000/ton often cited as a cost/benefit threshold for stationary sources by EPA. We additionally believe that these costs do not adequately account for the declining rates of gasoline consumption related to higher fuel economy vehicle use. The cost-benefit value of $29,000/ton will increase even further given the decreased demand for gasoline. Furthermore, rough calculations using a linear extrapolation of the ERG data from 2013 to 2015 shows the cost per ton will double in less than six (6) months.

5) **MassDEP should not wait until a SIP amendment approval to allow Stage II removal**. With the burden of proof to remove Stage II systems already met, the longer the delay in allowing our members to remove the systems from their GDF's, the more unnecessary expenditures they must make to continue to operate and maintain the systems. Rather than delay removals by waiting for approval of a SIP amendment, MassDEP should follow the approach used for new construction and major modification at GDF sites, and issue a notice of intent to not enforce against GDF owners that remove Stage II during the SIP approval process. EPA has not indicated any intention to enforce against such an approach. Nearby states such as Maine, New Hampshire and New York, have successfully implemented such an approach, and Connecticut has declared their intention to do so.

6) **Implementation of Stage II program changes should not be held hostage by discussions around enhancing Stage I**. Emission savings from continuing Stage II are below the EPA 10% de-minimis level without any additional comparable measures, and as such, there is no need for any improvements to Stage I to be incorporated into the revised SIP. IOMA encourages MassDEP to proceed with the Stage II elimination as a separate item to expedite its implementation.

7) **IOMA believes that no credible data exists to support that continuous monitoring and/or pressure management systems are necessary at GDFs once Stage II is removed.** As discussed in a 2005 API study cited in the Tech report, and stated by a retired CARB

employee (Bill Loscutoff) during the August 15th stakeholder meeting at MassDEP, USTs are generally at negative pressures when dispensing without a Stage II system. Pressure in the tanks slowly builds when the tank is idle, however, not to pressures that a proper P/V vent valve cannot hold. Furthermore, for stations that operate 24/7 and/or are only down for short periods of time at night, the continued operation of the station reduces the potential for pressure build-up. Massachusetts use of the EPA guidance clearly documents that no comparable measures are necessary, so GDFs should not be burdened with the additional cost of unnecessary, unproven and very expensive equipment.

8) **The focus of MassDEP with respect to enhancing Stage I should be on the installation and maintenance of a correct P/V vent valve.** As indicated previously, P/V vent valves have been documented by API to control breathing losses from USTs without Stage II vapor recovery. IOMA recommends that Massachusetts require installation of a CARB-approved P/V vent valve at the time of Stage II decommissioning. A CARB-approved P/V vent valve, coupled with both triennial pressure decay test and the recently-enacted UST Operator Training regulations that require monthly inspections of UST tank top and vent caps, is all that is needed to control VOC emissions from USTs at GDFs in Massachusetts.

9) **Adopt a phased-in upgrade to CARB-approved Stage I equipment, not full "systems"**. With the exception of spill buckets, for which there are limited options currently available with respect to CARB-certified equipment, IOMA believes that other Stage I components currently in use at GDFs (e.g., fill caps, swivel adaptors, etc.) are generally listed on CARB-certified Stage I system component lists and will not require new installation. IOMA will accept that at the time of UST system replacement, substantial modification to the UST top, or for new sites, GDF owners be required to have all Stage I components be from CARB-certified Stage I system listings. What is important to IOMA is that MassDEP allow GDF owners to use a "mix and match approach" towards equipment selection, rather than requiring that Stage I components at a site all come from one specific CARB-certified Stage I system. Requiring that a UST system have all Stage I components from one-specific CARB-certified Stage I system will limit the choices of equipment to GDF owners and forces UST owners/operators to use specific vendors, all of which leads to higher costs and potential difficulties down the road with maintenance and sourcing of replacement parts.

In conclusion, IOMA looks forward to working with MassDEP on the immediate elimination of Stage II vapor recovery in Massachusetts since it is now obsolete with the widespread use of ORVR equipment in automobiles. It is widely known that the removal of Stage II results in the elimination of excess emissions associated with ORVR and Stage II vapor recovery incompatibility, which is protective of human health and the environment, and is sound public policy consistent with both President Obama's and Governor Duval Patrick's executive orders.

Please do not hesitate to contact me if you have any questions or would like to discuss the information in this letter further.

Respectfully,

Peter Romano

Peter Romano
President, Chief Operating Officer

Attachments: Tech Environmental Report (include date)

Cc: IOMA Board of Directors

tech environmental
FOCUSED KNOWLEDGE. REAL SOLUTIONS.

September 28, 2012

Mr. Peter Romano
President & COO
Independent Oil Marketers Association of New England
PO Box 1827
North Falmouth, MA 02556

Re: Review of ERG's Report for the MassDEP on Stage I and Stage II *Job 3656*

Dear Mr. Romano:

Tech Environmental, Inc. (Tech) is pleased to provide this letter report summarizing our review of the recent Eastern Research Group Inc. (ERG) report, which provides a technical analysis of potential changes to the Massachusetts Stage I and Stage II vapor recovery programs for the Massachusetts Department of Environmental Protection (MassDEP).[1] As you are aware, the MassDEP is considering the elimination of Stage II vapor recovery requirements and the addition of Stage I enhancements for fleet refueling facilities (i.e., proposed amendments to 310 CMR 7.24).

Tech reviewed ERG's report, "Air Program Support for Stage I and Stage II Programs in Massachusetts", dated July 16, 2012 and updated August 22, 2012. The update was based on the United States Environmental Protection Agency's (EPA's) "Guidance on Removing Stage II Gasoline Vapor Control Programs from State Implementation Plans and Assessing Comparable Measures".[2]

Executive Summary

This letter report focuses on the Stage II vapor recovery programs, with a brief review of concerns regarding Stage I programs in Massachusetts and MassDEP's proposal to require Stage I system enhancements. **Our analysis demonstrates: (1) that continuing the Stage II program is not cost-effective; (2) that a review of data supports an immediate end to Stage II programs in Massachusetts, i.e. today; and (3) that the proposed Stage I continuous monitoring and pressure management proposals should be eliminated.**

The analysis conducted by ERG demonstrates that immediate removal of Stage II controls will result in less than a *de minimis* emissions increase, and thus, the EPA's Stage II removal condition in their guidance document has been satisfied. As shown later in this report, Tech updated Tables 3.6 and 3.7 in the ERG report to show a more realistic cost per ton of volatile organic compounds (VOCs) reduced for continuing Stage II programs of $28,995 in 2013 and increasing to $113,298 in 2015. In addition to becoming less cost effective over time, in the near future the incompatibility excess emissions from the competing ORVR and Stage II emissions controls will outweigh any emission reduction benefits from the continuation of Stage II programs.

[1] Summarized on the MassDEP website: http://www.mass.gov/dep/air/community/stageii.htm#changes
[2] "Guidance on Removing Stage II Gasoline Vapor Control Programs from State Implementation Plans and Assessing Comparable Measures", August 7, 2012, EPA-457/B-12-001.

Our review of the proposed Stage I enhancements concluded that the installation of continuous monitoring and pressure management systems are unproven in Massachusetts's harsh winter climate and that these systems are not a cost effective method to control VOC emissions. We are not aware of any data demonstrating the effectiveness of Stage I continuous monitoring and pressure management systems when used without Stage II in place. As an alternative, Tech presents a study that demonstrates that a CARB certified Pressure/Vacuum (P/V) vent valve is a proven and cost effective alternative to controlling tank breathing losses. Therefore, we recommend the elimination of these proposed Stage I enhancements.

1.0 Review of Stage II

The MassDEP is considering the continuation of Stage II in MA until 2015. Each year, as ORVR systems become more and more common on vehicles being refueled, the emissions benefit of Stage II systems decreases and so the cost of reducing these emissions quickly increases on a dollar per ton of VOCs removed basis. At a point in the near future, the incompatibility excess emissions from the competing ORVR and Stage II emissions controls will outweigh any emission reduction benefits from the continuation of Stage II programs.[3] It is essential that Stage II be removed before this time so that these excess emissions are not released into the atmosphere. Our review of the ERG report found there is strong evidence to support the immediate, full removal of Stage II equipment now, and not in 2015.

1.1 ORVR Penetration Rate Higher Than Reported

The ERG figure of 85% ORVR penetration (% gasoline) in 2013 is too low. Tech has independently calculated the % ORVR penetration using Massachusetts specific MOBILE6 data.[4] Increasing that percent figure shifts the cross-over date closer to today. This is in line with NESCAUM's report "Onboard Refueling Vapor Recovery Systems Analysis of Widespread Use", August 20, 2007, which showed that the emissions from ORVR and Stage II as stand-alone projects were projected to be the same in 2010 and that the emissions from ORVR-only were projected to be equal to emissions from the combination of ORVR and Stage II plus incompatibility excess emissions (IEE) in 2013. This second indicator is used in EPA's preferred definition of widespread use. The studies in this report are an extension of work looking at state-specific data to determine ORVR widespread use, which began in 2002 by API and Tech Environmental for other states.

Although the NESCAUM report is from 2007, the results are still valid. EPA's position is that for an attainment analysis, the relative change in emissions between the base year and the attainment year is more important than absolute emissions.[5] If one were to consider the relative change in emissions, the NESCAUM study with a widespread use determination of 2010 – 2013 would still be considered to be valid. This 2012-2013 timeframe for ORVR to be in widespread use has been demonstrated by other SIP studies in New Hampshire, Connecticut, etc., using the MOVES model.[6,7]

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[3] IOMA Press Release, "House Resolution may lead to 240-ton reduction in Commonwealth's 2011 smog emissions", March 25, 2010.
[4] Note that the MOVES model calculates refueling emissions using the same formula as MOBILE6.2, both of which account for ambient temperature as well as gasoline RVP.
[5] EPA's MOVES training presentation, May 27-28, 2009.
[6] New Hampshire Department of Environmental Services (DES) Draft State Implementation Plan Revision to Terminate Stage II Vapor Recovery Program, June XX, 2012.
[7] Robert Girard, CT DEEP Bureau of Air Management, Presentation at ICPA Annual Meeting, September 13, 2012.

Tech calculated the penetration of ORVR-equipped vehicles across vehicle classes that are equipped with ORVR based on the most recent MOBILE6 vehicle age distribution data (2005) supplied by the MassDEP, from national fleet characterization data from EPA's MOBILE development, and from Massachusetts automobile/truck distributions from the Federal Highway Administration. These data were used to calculate ORVR penetration in the years 2005, 2007, 2009, 2011, and 2013.

Estimated Massachusetts ORVR Penetration:

Year	%
2005	42
2007	56
2009	69
2011	80
2013	87

To perform the calculations, we started with the most recent MOBILE6 vehicle classifications for Massachusetts, obtained from the MassDEP. We then analyzed these files, along with ORVR phase-in rates, to give estimated ORVR penetration rates out to 2013. MOBILE6 gives data on the percent of each vehicle class for a given year (so for light-duty vehicles, 5.5% are model year 2013, 7.3% are model year 2012, 7.4% are model year 2011 etc.). The percent distribution was assumed to follow the same trends for each year of the study, with more vehicles being phased into ORVR each year. The different vehicle classes from MOBILE6 were considered along with the ORVR phase-in dates (i.e. all light duty vehicles after 2000 were equipped with ORVR, 80% of those after 1999 were equipped with ORVR etc.). A weighted average was calculated for ORVR-equipped vehicles by class, namely automobiles, light-, medium-, and heavy-duty trucks. The trucks were further divided into the three truck weight categories defined in the ORVR regulations using national fleet characterization data from EPA's MOBILE development.

The results reveal that ORVR penetration based on vehicles in the fleet will rise to 87% by 2013. EPA's definition of wide spread use (WSU) is the date when 75% of the gasoline is dispensed to ORVR equipped vehicles; thus, ORVR was in wide spread use in Massachusetts in 2011. As described previously, EPA's position is that for an attainment analysis, the relative change in emissions between the base year and the attainment year is more important than absolute emissions. The supporting data are shown in the Appendix.

This analysis was also repeated after converting the MOBILE6 data to the MOVES data format, using EPA's guidance document. The second analysis using the MOVES model confirmed that given this dataset, the ORVR penetration based on vehicles in the fleet will rise to 87% by 2013. The supporting data are shown in the Appendix.

According to the EPA, in areas where "certain types" of vacuum-assist Stage II control systems are used, the limited compatibility between ORVR and some configurations of this Stage II hardware may ultimately result in an area-wide emissions disbenefit.[2] This is the case in Massachusetts where a vast majority of the gasoline dispensing facilities (GDFs) have vacuum-assist equipment, supporting the argument for the immediate removal of Stage II systems.

1.2 Cost per ton of VOC Removal is Not Cost-Effective

The cost per ton of VOCs reduced for continuing Stage II in 2013, which ERG lists as $20,435, is too low. ERG calculates this cost per ton using annual costs for continuing current Stage II programs (ERG Table 3.5) which we believe are inaccurate based on inflated gasoline prices and the unsubstantiated fuel credit concept. Each of these issues is discussed below.

There are several concerns with the way that ERG calculated the Stage II program costs. The EPA data[8] used by ERG assume an annual cost savings of $4,207 without a fuel credit, adjusted to a cost of $3,277 assuming a $930 fuel credit. That fuel credit is based on $2.30/gallon (2010 average retail gasoline prices without tax). However, ERG further adjusted the cost savings to $2,977 assuming a $1,230 fuel credit based on a $4/gallon price of gasoline in Massachusetts. ERG used a retail gasoline sale cost rather than a wholesale cost and did not remove the taxes, which in Massachusetts account for $0.419/gallon. The calculation of cost savings to the GDF owner should have been based on the amount of money that would have been saved, a lower average annual wholesale Massachusetts gasoline price (for example the average retail cost of gasoline was $3.717 as of August 15, 2012[9]) and should have been adjusted to remove the tax to give a cost closer to $3/gallon, according to industry experts[10]. This correction makes the cost per ton of VOC reduced for continuing Stage II more expensive, assuming that the fuel credit adjustment is a valid assumption.

The fuel credit concept was introduced previously by the EPA in 1991 as a justification for the costs associated with a Stage II program.[11] However, members of the Independent Oil Marketers Association of New England (IOMA) believe that the fuel credit should not be applied because it does not exist. The fuel credit is certainly not well-documented and likely is over estimated, as IOMA members have repeatedly requested data supporting the fuel credit calculations from Veeder-Root, only to be told that the data does not exist.[12] Anecdotally, service stations do not use the fuel savings in their financial data and fuel inventories, which suggests the equipment is not saving money. Industry representatives have cited the large energy, testing, and maintenance costs as reasons to not maintain these systems, as demonstrated by recent decisions in Maine and Vermont to remove Stage II. Even a proponent of ARID's permeator system working in Wawa's Mid Atlantic region has advocated for not installing additional controls as ORVR is increasingly in widespread use.[13] Given the lack of data to support the claims of fuel savings, the tables in ERG's report have been updated to remove the fuel credit and better demonstrate the true costs of maintaining Stage II programs in Massachusetts.

An API report calculated the annual costs for GDFs to continuing Stage II programs to be $4,410,[14] which is in line with the EPA's $4,207 figure, which assumes no fuel credit adjustment. Using the API value, Tables 3.6 and 3.7 in the ERG report have been updated to show a more realistic cost per ton of

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[8] Widespread Use for Onboard Refueling Vapor Recovery and Stage II Waiver; USEPA, July 8, 2011. Costs include fuel savings of $930/yr.
[9] See table: http://www.massachusettsgasprices.com/Prices_Nationally.aspx
[10] Personal communication between Dana Buske, Tech Environmental and James Garrett, Volta Oil, September 12, 2012.
[11] Technical Guidance - Stage II Vapor Recovery Systems for Control of Vehicle Refueling Emissions at Gasoline Dispensing Facilities Volume I: Chapters; USEPA, November 1991, EPA-45013-91-022a.
[12] IOMA member Michele Alabiso, September 12, 2012.
[13] Personal communication between Dana Buske, Tech Environmental and Joshua Worth, Wawa, September 14, 2012.
[14] Refueling Emission Controls at Retail Gasoline Dispensing Stations and Cost-Benefit Analysis of Stage II in Connecticut, Tech Environmental, Inc., September 24, 2007

VOCs reduced for continuing Stage II programs of $28,995 in 2013 and $113,298 in 2015, see Tables 1 and 2, below.

In addition, the predicted VOC emissions are expected to decrease due to a decrease in gasoline sales as the vehicle miles per gallon (MPG) increase and hybrid vehicles become more common.[15,16] Even when not considering a decrease in gasoline sales, these cost effectiveness figures are unreasonable on a cost per ton basis and they support an immediate end to Stage II programs in Massachusetts. ERG's report noted that "the cost-effectiveness of Stage II controls declines significantly between 2013 and 2015". It is our firm opinion that this decline is even greater than that described by ERG and enough to warrant the immediate removal of Stage II.

Table 1 (An Update of ERG's Table 3-6)
Cost per Ton of VOC Reduced for Continuing Stage II: 2013

Annual cost to continue Stage II	Throughput Category (gal/yr)	Stage II Benefits (ton/yr)	$/ton*
$4,410	Less than 120,000	7	$377,856
	120,000 to 240,000	4	$130,038
	240,001 to 500,000	28	$66,409
	500,001 to 1,000,000	127	$35,867
	1,000,001 to 2,000,000	278	$20,998
	Greater than 2,000,000	160	$13,098
	ALL	**604**	**$28,995**

* Declining gasoline sales means that emissions will be decreasing over time and thus, the cost per ton will increase over time.

[15] "The Outlook for Energy: A View to 2040", ExxonMobil, 2012. Available online: http://www.exxonmobil.com/Corporate/energy_outlook.aspx
[16] David M. Parker, Valero, Presentation at the PMAA Board of Directors Meeting, May 18, 2012.

Table 2 (An Update of ERG's Table 3-7)
Cost per Ton of VOC Reduced for Continuing Stage II: 2015

Annual cost to continue Stage II	Throughput Category (gal/yr)	Stage II Benefits (ton/yr)	$/ton*
$4,410	Less than 120,000	2	$1,459,984
	120,000 to 240,000	1	$520,152
	240,001 to 500,000	7	$265,637
	500,001 to 1,000,000	33	$138,032
	1,000,001 to 2,000,000	72	$81,077
	Greater than 2,000,000	42	$49,898
	ALL	**157**	**$113,298**

* Declining gasoline sales means that emissions will be decreasing over time and thus, the cost per ton will increase over time.

1.3 Stage II Removal Below EPA's *de minimis* Criteria

The Clean Air Act (CAA) requires that states in the Ozone Transport Region (OTR), which includes Massachusetts, implement measures that would achieve reductions which are "comparable", but not "equivalent" to, a Stage II control program. The EPA's Guidance document[2] states that the comparable measures requirement is satisfied if phasing out a Stage II control program in a particular area is estimated to have a *de minimis*, incremental loss of area-wide emissions control. According to the EPA, the incremental emissions control that Stage II achieves beyond ORVR is *de minimis* if it is less than 10 percent of the area-wide emissions inventory associated with refueling highway motor vehicles.

The analysis conducted by ERG demonstrates that immediate removal of Stage II controls will result in less than a *de minimis* emissions increase in emissions, and thus, the EPA's stipulation has been satisfied. ERG's Addendum Report cites an incremental percent reduction of 5.92% in 2013, 1.54% in 2015, and – 1.69% in 2018 as reported in Addendum Table B, assuming a Stage II efficiency of 75%. These emissions reductions would allow Massachusetts to immediately remove Stage II with EPA's support. Using similar data, New Hampshire has petitioned the EPA for the immediate removal of Stage II with their informal draft State Implementation Plan (SIP).[6] In support of the proposed New Hampshire SIP update, MOVES modeling results demonstrated that the removal of Stage II would result in a *de minimis* emissions increase.

ERG's calculations of the incremental increase in emissions are consistent with the EPA's August 7, 2012 Guidance document, which cites the following equation:

Equation 1

$$increment_i = (Q_{SII})(1-Q_{ORVRi})(\eta_{iuSII}) - (Q_{SIIva})(CF_i),$$

where the "$increment_i$" is the annual area-wide emission control gain from Stage II installations at GDFs. This equation includes the ORVR fraction (Q_{ORVRi}), which we previously argued should be larger, as well as the Stage II efficiency (η_{iuSII}), which are 60 – 75% based on the EPA's suggested typical current values. The annual GDF certification test failure rates (shown in Tables 4-2 and 4-3 of ERG's report) are listed as an average failure rate of 67% in 2011, with 56% stations failing additional tests conducted 120 days after the initial certification. Given these failure rates, we believe the Stage II efficiency is less than the 75% assumed by ERG and is closer to 70%. Our analysis of the data inputs to Addendum Table B, with a decreased Stage II efficiency rate, makes a convincing argument for removing Stage II.

For the sake of comparison, Table 3 is presented, based on ERG's Addendum Table B, which presents ERG's calculation of the incremental emissions assuming 85% ORVR penetration and 75% Stage II efficiency, as well as an alternate scenario. The incremental emissions increase assuming Tech's calculated 87% ORVR penetration and 70% Stage II efficiency decreases to 3.56% in 2013, 1.44% in 2015, and -2.13% in 2018. This demonstrates the impact of the assumed Stage II efficiency on emissions and may be more accurate for Massachusetts GDFs, given the failure rates which demonstrate how quickly these systems lose their effectiveness on a day-to-day basis. Although nominally the Stage II inspections occur on an annual basis, in reality only a small percentage of Massachusetts's approximately 3000 stations are inspected in any given year. The attached Appendix presents the results of the full analysis.

In addition to the predicted decrease in emissions, as discussed previously the industry gasoline sales data predict a decrease in gasoline sales as the vehicle miles per gallon (MPG) increase and hybrid vehicles become more common. Fuel analysts predict that gasoline sales would decline by 50% by 2040, which will further decrease the annual emissions.

The calculations in Table 3 demonstrate that the emissions increase from removing Stage II is even lower than predicted by ERG, and further below the EPA's 10% *de minimis* emissions increase criteria. However, both ERG's scenario and Tech's update demonstrate that the EPA's 10% *de minimis* emissions increase criteria is met, even without considering predicted decreases in gasoline sales in the future.

Table 3: Comparison of Stage II Efficiencies and Their Incremental Changes in Emissions
(Based on ERG's Appendum Table B, % Reduction in MA VOC Refueling Emissions from Stage II)

Case	Year	Qorvr (ORVR fraction)	Eff(stii) (Stage II efficiency)	*De Minimis* Increment (% reduction in refueling emissions) *
ERG report (75% Stage II Efficiency)	2013	84.87%	75%	**5.92%**
	2015	90.31%	75%	1.54%
	2018	94.31%	75%	-1.69%
Tech Qorvr, 70% Stage II Efficiency	2013	87.00%	70%	**3.56%**
	2015	89.80%	70%	1.44%
	2018	94.52%	70%	-2.13%
			EPA's *De Minimis* Criteria	**10%**

* These figures do not take the future declining gasoline sales into account.

2.0 Review of Stage I Proposal

The ERG report reviewed various Stage I enhancements including: CARB Module I Stage I Enhanced Vapor Recovery (EVR) systems, continuous vapor leak monitoring systems (continuous monitoring), and pressure management systems (emissions processors), as well as the estimated VOC reductions from these systems. According to CARB, EVR refers to a new generation of equipment, meeting stricter standards, which control emissions at gasoline dispensing facilities. The Module I system components include: the couplers that connect tanker trucks to the underground tanks, spill containment drain valves, overfill prevention devices, and vent pressure/vacuum (P/V) valves. Continuous monitoring systems use a sensor to monitor UST systems for vapor leaks. Pressure management systems capture or prevent breathing losses and maintain tank pressures. While the Module I Stage I equipment is generally consistent with that used with UST systems today in Massachusetts, continuous monitoring and pressure management systems are untested in the New England climate and have not been studied as stand-alone systems without Stage II. Furthermore, we are unaware of data documenting their performance in the absence of Stage II and this means that many assumptions have been made about their effectiveness in controlling emissions.

2.1 Continuous Monitoring is Faulty in Wintertime

Section 4.1 of the ERG report "Possible Stage I Enhancements", briefly addresses the reliability of these continuous monitoring systems in winter when they are exposed to snow and extremely cold temperatures, by stating that "ERG believes these systems should work reliably in Massachusetts…" This "belief" seems overly optimistic given the equipment concerns and malfunctions that have occurred during the winter season in California. CARB released a memo entitled "Response to Winter Season

ISD Pressure Alarms"[17] that states that during the "winter fuel season, the number of pressure related ISD alarms increases significantly", such that no service or equipment testing is required prior to clearing the OP alarms from November 1 to March 1. The extent of this problem is wide-spread enough that CARB even offers a training session for GDF operators on how to handle alarms in the winter season.[18] Given that these systems are untested in the harsher New England environment, there is great concern regarding system performance and condensation build-up and freezing during a New England winter.

2.2 Continuous Monitoring and Pressure Management Cost Effectiveness Assumptions

The ERG report's review of continuous monitoring and pressure management systems relied heavily on assumptions regarding the estimated impact of system leaks. While these assumptions were necessary since the EPA has not provided guidance on how to estimate emissions reductions for either system, the extent of the assumptions used in the cost effectiveness calculations raises significant doubts on their reliability and accuracy. Several major issues with these assumptions are presented below, which cast doubt on the cost effectiveness calculations.

First, the testing failure rates for GDFs that have both Stage I and Stage II systems were used to estimate the potential emissions reduction benefits for continuous monitoring. This testing data came from over-pressurized UST systems associated with the Stage II systems. The ERG report correctly acknowledged that without Stage II, it is possible that the leaks would be reduced thereby lowering assumed continuous monitoring emission reductions. This means that once Stage II systems are removed, any potential benefits from the installation of a continuous monitoring system is greatly reduced, making these systems less cost effective.

Second, the ERG report assumed a P/V vent valve efficiency of 90% based upon information provided by the EPA. Again, this efficiency rate is suspect, given that it is based upon GDFs with Stage II systems that result in tank over-pressurization and thus a reduction in the overall efficiency of the devices. As documented further below, a study performed at a non-Stage II GDF in Texas demonstrated a 99% efficiency for a P/V vent valve. This increased P/V vent valve efficiency is expected to occur in Massachusetts, once Stage II systems are decommissioned.

Finally, the ERG reports cites costs for the purchase, installation and maintenance of continuous monitoring and pressure management system equipment that industry experts believe are vastly underestimated. Information from industry representatives indicate that **the expected costs are at least double** those cited, making the cost per ton of VOC reduction more expensive than that documented the ERG report.[19]

It is also noted that the tons of VOCs reduced by the installation of these systems are likely to be lower than estimated, given both the ineffectiveness of an alarm system during the long Massachusetts winter and the anticipated decline in gasoline sales in the future. These factors make the installation and operation of the systems even less cost effective than ERG claims.

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[17] CARB Special Advisory, Response to Winter Season ISD Pressure Alarms", Number 405-B, October 10, 2011.
[18] Course #267.1: Changes in Response to In-Station Diagnostic Alarms: http://www.arb.ca.gov/training/courses.php?course=267.1
[19] MassDEP August 15, 2012 Stage I & II Programs Stakeholders meeting, Jim Howard, Hess.

2.3 CARB Certified P/V Vent Valve as Alternative to Continuous Monitoring and Pressure Management

Given the issues raised above and the fact that continuous monitoring and pressure management systems without a Stage II system are unproven technologies, other more cost effective measures could instead be considered. An alternative is to install P/V vent valves that are part of CARB-certified systems to control tank breathing losses, which have minimal purchase, installation, and maintenance costs, and thus, a more reasonable reduction of VOC emissions on a cost per ton basis. A study commissioned by the American Petroleum Institute (API) demonstrated that high volume stations with P/V valves were quite effective at controlling losses and did not open and release vapors as a result of pressure increases resulting from vapor growth and tanker deliveries.[22]

These tests were conducted at a GDF which was not equipped with a Stage II vapor recovery system, and thus, are comparable to what Massachusetts will soon have. The study found that although the underground storage tanks (USTs) ingested air through the P/V valve during the day and the UST pressures increased in the evening as a result of vapor growth, "all pressure increase associated with vapor growth and tanker deliveries appear to have been controlled by the P/V valve".[22] The report also states: "For the majority of the day, the UST remains at negative pressures corresponding to the vacuum setpoint of the PV valve (approximately -1" wc), indicating that air is flowing into the system through the PV valve." In other words, the P/V valve did not open as a result of pressure increases and did not release vapors to the atmosphere and thus are a more cost-effective alternative to installing continuous monitoring and pressure management systems.

3.0 Conclusion

In 2011, EPA reviewed Stage II vapor recovery system decommissioning. EPA has estimated the national cost savings for facilities decommissioning Stage II vapor recovery systems to be over $88 million annually. The review of Stage II was undertaken as part of the current administration's initiative to review outdated rules and update them to ensure that they are still achieving the environmental benefits that they were intended to achieve. In allowing Stage II equipment to be removed, the EPA is acknowledging that Stage II is no longer "achieving the environmental benefits that they were intended to achieve". Our analysis has demonstrated that the immediate removal of Stage II controls will result in less than a *de minimis* emissions increase, and thus, the EPA's stipulation has been satisfied. The cost benefit analysis demonstrated that the cost per ton of VOCs reduced for continuing Stage II programs in Massachusetts is already prohibitively expensive at $28,995 in 2013 and increasing to $113,298 in 2015. In addition, in the near future the incompatibility excess emissions from the combination of ORVR and Stage II will cause excess emissions. Given the information presented in the report, Massachusetts GDFs should also be allowed to remove Stage II equipment immediately.

Our report has also presented arguments that the use of a CARB certified P/V vent valve to control tank breathing losses is a better alternative to the unproven installation of continuous monitoring and pressure

[22] "Results of pressure monitoring at gasoline dispensing facility", Sonoma Technology, Inc. for American Petroleum Institute, December 9, 2005.

management systems in Massachusetts's harsh winter climate and that these systems are not cost effective methods to control VOC emissions. Therefore, Tech recommends the elimination of MassDEP's proposal for continuous monitoring and pressure management systems.

If you have any questions regarding this report, please let us know.

Sincerely,
TECH ENVIRONMENTAL, INC.

Dana C. Buske, Ph.D.
Environmental Scientist

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Associate

Appendix A – Supporting Data

Table A-1: Comparison of Stage II Efficiencies and Their Incremental Changes in Emissions
(Based on ERG's Appendum Table B, Percent Reduction in MA VOC Refueling Emissions from Stage II)

Case	Year	Qorvr (ORVR fraction)	Cfi Compatibility Factor = (0.0777) x Qorvr	Qstii (% Gas Dispensed to GDFs w/ Stage II)	1-Qorvr	Eff(stii) (Stage II efficiency)	Qstiiva (% Gas Dispensed thru Vac Assist Systems)	Increment (% reduction in refueling emissions)
ERG report (75% Stage II Efficiency)	2013	84.87%	0.065947	0.99	15.13%	75%	81%	5.92%
	2015	90.31%	0.070171	0.99	9.69%	75%	81%	1.54%
	2018	94.31%	0.073283	0.99	5.69%	75%	81%	-1.69%
ERG Qorvr, 60% Stage II Efficiency	2013	84.87%	0.065944	0.99	15.13%	60%	81%	3.67%
	2015	90.31%	0.070171	0.99	9.69%	60%	81%	0.10%
	2018	94.31%	0.073279	0.99	5.69%	60%	81%	-2.53%
Tech Qorvr, 70% Stage II Efficiency	2013	87.00%	0.067599	0.99	13.00%	70%	81%	3.56%
	2015	89.80%	0.069775	0.99	10.20%	70%	81%	1.44%
	2018	94.52%	0.073442	0.99	5.48%	70%	81%	-2.13%
Tech Qorvr, 65% Stage II Efficiency	2013	87.00%	0.067599	0.99	13.00%	65%	81%	2.91%
	2015	89.80%	0.069775	0.99	10.20%	65%	81%	0.94%
	2018	94.52%	0.073442	0.99	5.48%	65%	81%	-2.40%
Tech Qorvr, 60% Stage II Efficiency	2013	87.00%	0.067599	0.99	13.00%	60%	81%	2.27%
	2015	89.80%	0.069775	0.99	10.20%	60%	81%	0.43%
	2018	94.52%	0.073442	0.99	5.48%	60%	81%	-2.67%

Table A-2: ORVR Penetration Analysis for 2013, MOBILE6 Data:

	Light duty Vehicles	Light Light-duty trucks (0-6,6000 lb)	Heavy light-duty trucks (6,001 - 8,500 lb)	Medium duty passenger vehicles (8,501 - 10,000 lb)
M6 code	1	2,3	4,5	6
40%	1998	2001	2004	2004
80%	1999	2002	2005	2005
100%	2000+	2003+	2006+	2006+

40%	0.022	0.029	0.039	0.035
80%	0.025	0.042	0.053	0.061
100%	0.887	0.833	0.73	0.699
total	**92%**	**88%**	**65%**	**59%**
				Total:
wted avg	**57%**	**23%**	**6%**	**2%** **87%**
assume:	62%	26%	9%	3%

			2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989 (or older)
M6	LDV		2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989 (or older)
M5	LDGV	1	0.055	0.073	0.074	0.073	0.078	0.085	0.076	0.069	0.066	0.056	0.059	0.049	0.042	0.032	0.025	0.022	0.017	0.013	0.009	0.006	0.004	0.002	0.002	0.001	0.013
M6	LDT1		2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989 (or older)
M5	LDGT1	2	0.075	0.1	0.083	0.087	0.08	0.088	0.079	0.078	0.064	0.051	0.048	0.042	0.029	0.019	0.014	0.011	0.012	0.012	0.008	0.005	0.003	0.002	0.001	0.001	0.006
M6	LDT2		2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989 (or older)
M5	LDGT1	3	0.075	0.1	0.083	0.087	0.08	0.088	0.079	0.078	0.064	0.051	0.048	0.042	0.029	0.019	0.014	0.011	0.012	0.012	0.008	0.005	0.003	0.002	0.001	0.001	0.006
M6	LDT3		2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989 (or older)
M5	LDGT2	4	0.089	0.118	0.11	0.096	0.088	0.085	0.086	0.058	0.053	0.039	0.041	0.031	0.018	0.013	0.008	0.01	0.013	0.013	0.008	0.006	0.004	0.002	0.002	0.001	0.008
M6	LDT4		2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989 (or older)
M5	LDGT2	5	0.089	0.118	0.11	0.096	0.088	0.085	0.086	0.058	0.053	0.039	0.041	0.031	0.018	0.013	0.008	0.01	0.013	0.013	0.008	0.006	0.004	0.002	0.002	0.001	0.008
M6	HDV2 B		2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989 (or older)
M5	HDVs (con	6	0.086	0.115	0.115	0.102	0.088	0.084	0.07	0.039	0.061	0.035	0.041	0.028	0.017	0.011	0.008	0.01	0.017	0.016	0.012	0.012	0.008	0.005	0.003	0.002	0.013
M6	HDV3		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDVs (con	7	0.066	0.088	0.076	0.08	0.076	0.075	0.076	0.038	0.062	0.037	0.051	0.039	0.028	0.018	0.012	0.015	0.024	0.032	0.025	0.023	0.014	0.012	0.006	0.003	0.025
M6	HDV4		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDVs (con	8	0.061	0.082	0.075	0.078	0.091	0.115	0.103	0.044	0.088	0.041	0.056	0.03	0.018	0.015	0.008	0.012	0.02	0.022	0.007	0.007	0.006	0.004	0.002	0.001	0.017
M6	HDV5		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDVs (con	9	0.078	0.105	0.103	0.082	0.076	0.087	0.091	0.032	0.045	0.027	0.035	0.02	0.017	0.012	0.009	0.015	0.021	0.017	0.031	0.018	0.013	0.012	0.005	0.003	0.045
M6	HDV6		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDVs (con	10	0.063	0.084	0.057	0.067	0.081	0.099	0.083	0.061	0.048	0.038	0.052	0.024	0.021	0.018	0.016	0.016	0.018	0.021	0.022	0.018	0.015	0.011	0.006	0.005	0.054
M6	HDV7		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDVs (con	11	0.05	0.067	0.05	0.077	0.072	0.111	0.07	0.071	0.057	0.042	0.048	0.027	0.021	0.016	0.019	0.023	0.02	0.033	0.033	0.021	0.015	0.012	0.004	0.003	0.039
M6	HDV8 a		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDVs (con	12	0.031	0.041	0.035	0.041	0.052	0.063	0.057	0.049	0.043	0.044	0.079	0.043	0.026	0.024	0.022	0.027	0.039	0.042	0.042	0.036	0.031	0.017	0.01	0.009	0.096
M6	HDV8 b		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDVs (con	13	0.042	0.056	0.055	0.048	0.078	0.098	0.083	0.064	0.051	0.044	0.053	0.036	0.025	0.013	0.011	0.014	0.026	0.04	0.042	0.028	0.024	0.01	0.004	0.005	0.051
M6	HDBS		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDVs (con	14	0.071	0.095	0.063	0.085	0.063	0.151	0.085	0.117	0.108	0.048	0.043	0.01	0.023	0.011	0.007	0.009	0.004	0.004	0.003	0.001	0	0	0	0	0
M6	HDBT		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	HDDVs	15	0.052	0.069	0.074	0.08	0.09	0.108	0.1	0.082	0.058	0.047	0.061	0.018	0.021	0.013	0.014	0.017	0.015	0.01	0.014	0.009	0.009	0.006	0.005	0.002	0.029
M6	Motorcycles		2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981 (or older)
M5	MC	16	0.056	0.075	0.094	0.082	0.08	0.065	0.056	0.042	0.033	0.032	0.026	0.022	0.02	0.016	0.012	0.013	0.016	0.016	0.019	0.028	0.025	0.016	0.018	0.025	0.114

Table A-3: ORVR Penetration Analysis for 2013, MOBILE6 Data converted to MOVES

	Light duty Vehicles	Light Light-duty trucks (0-6,6000 lb)	Heavy light duty trucks (6,001 - 8,500 lb)	Medium duty passenger vehicles (8,501 - 10,000 lb)
M6 code	1	2,3	4,5	6
40%	1998	2001	2004	2004
80%	1999	2002	2005	2005
100%	2000+	2003+	2006+	2006+

40%	0.022	0.025	0.047	0.047
80%	0.025	0.038	0.061	0.061
100%	0.887	0.840	0.686	0.686
total	**92%**	**88%**	**61%**	**58%**

					Total:
wted avg	**57%**	**23%**	**6%**	**2%**	**87%**
assume:	62%	26%	9%	3%	

M6	LDV	1	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	Total
MOVES	Cars	21	0.055	0.073	0.074	0.073	0.078	0.085	0.076	0.069	0.066	0.056	0.059	0.049	0.042	0.032	0.025	0.022	0.017	0.013	0.009	0.006	0.004	0.002	0.002	0.001	0.0005	0.00025	0.000125	0.0000625	0.00003125	0.000015625	0.011016	1.000000
M6	LDT1	2	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	
MOVES	Pass. Truck	31	0.079077	0.105286359	0.091325	0.09005	0.082481	0.087173	0.080442	0.071141	0.061227	0.047283	0.046017	0.03865	0.025735	0.017155	0.012237	0.010738	0.012553	0.012533	0.008256	0.005643	0.003513	0.002176	0.001358	0.001055	0.000895	0.000809	0.000762	0.0007352	0.00072051	0.000709978	0.002262	1.000000
MOVES	Light Comm. Truck	32	0.079156	0.105447484	0.092669	0.090435	0.082816	0.087242	0.080238	0.067859	0.061328	0.046012	0.045703	0.037561	0.024929	0.01665	0.011839	0.010795	0.013143	0.013105	0.008962	0.006418	0.004123	0.002623	0.001584	0.001161	0.000932	0.000804	0.000735	0.0006975	0.00067379	0.000666309	0.003692	1.000000
M6	LDT2	3	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	
MOVES	Pass. Truck	31	0.079077	0.105286359	0.091325	0.09005	0.082481	0.087173	0.080442	0.071141	0.061227	0.047283	0.046017	0.03865	0.025735	0.017155	0.012237	0.010738	0.012553	0.012533	0.008256	0.005643	0.003513	0.002176	0.001358	0.001055	0.000895	0.000809	0.000762	0.0007352	0.00072051	0.000709978	0.002262	1.000000
MOVES	Light Comm. Truck	32	0.079156	0.105447484	0.092669	0.090435	0.082816	0.087242	0.080238	0.067859	0.061328	0.046012	0.045703	0.037561	0.024929	0.01665	0.011839	0.010795	0.013143	0.013105	0.008962	0.006418	0.004123	0.002623	0.001584	0.001161	0.000932	0.000804	0.000735	0.0006975	0.00067379	0.000666309	0.003692	1.000000
M6	LDT3	4	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	
MOVES	Pass. Truck	31	0.079077	0.105286359	0.091325	0.09005	0.082481	0.087173	0.080442	0.071141	0.061227	0.047283	0.046017	0.03865	0.025735	0.017155	0.012237	0.010738	0.012553	0.012533	0.008256	0.005643	0.003513	0.002176	0.001358	0.001055	0.000895	0.000809	0.000762	0.0007352	0.00072051	0.000709978	0.002262	1.000000
MOVES	Light Comm. Truck	32	0.079156	0.105447484	0.092669	0.090435	0.082816	0.087242	0.080238	0.067859	0.061328	0.046012	0.045703	0.037561	0.024929	0.01665	0.011839	0.010795	0.013143	0.013105	0.008962	0.006418	0.004123	0.002623	0.001584	0.001161	0.000932	0.000804	0.000735	0.0006975	0.00067379	0.000666309	0.003692	1.000000
M6	LDT4	5	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	
MOVES	Pass. Truck	31	0.079077	0.105286359	0.091325	0.09005	0.082481	0.087173	0.080442	0.071141	0.061227	0.047283	0.046017	0.03865	0.025735	0.017155	0.012237	0.010738	0.012553	0.012533	0.008256	0.005643	0.003513	0.002176	0.001358	0.001055	0.000895	0.000809	0.000762	0.0007352	0.00072051	0.000709978	0.002262	1.000000
MOVES	Light Comm. Truck	32	0.079156	0.105447484	0.092669	0.090435	0.082816	0.087242	0.080238	0.067859	0.061328	0.046012	0.045703	0.037561	0.024929	0.01665	0.011839	0.010795	0.013143	0.013105	0.008962	0.006418	0.004123	0.002623	0.001584	0.001161	0.000932	0.000804	0.000735	0.0006975	0.00067379	0.000666309	0.003692	1.000000
M6	HDV2	6	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	
MOVES	Pass. Truck	31	0.079077	0.105286359	0.091325	0.09005	0.082481	0.087173	0.080442	0.071141	0.061227	0.047283	0.046017	0.03865	0.025735	0.017155	0.012237	0.010738	0.012553	0.012533	0.008256	0.005643	0.003513	0.002176	0.001358	0.001055	0.000895	0.000809	0.000762	0.0007352	0.00072051	0.000709978	0.002262	1.000000
MOVES	Light Comm. Truck	32	0.079156	0.105447484	0.092669	0.090435	0.082816	0.087242	0.080238	0.067859	0.061328	0.046012	0.045703	0.037561	0.024929	0.01665	0.011839	0.010795	0.013143	0.013105	0.008962	0.006418	0.004123	0.002623	0.001584	0.001161	0.000932	0.000804	0.000735	0.0006975	0.00067379	0.000666309	0.003692	1.000000

White Paper

Options for Controlling VOC Emissions at Gasoline Dispensing Facilities in Response to Widespread ORVR Implementation

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June 30, 2011

Executive Summary

This paper provides a review of options for controlling VOC emissions from gasoline dispensing facilities that states and air quality agencies should consider when responding to the increasing penetration of ORVR vehicles into the general motor vehicle fleet. The feasibility of potential control options will vary among states depending on their need for emission reductions.

Controlling nozzle spillage and reducing hose permeation to hydrocarbons can provide VOC reductions that are independent of other controls. Switching to low spillage nozzles at a 1.2 million gallon per year GDF can reduce VOC emissions by 820 pounds annually at a cost effectiveness of $3.4k per ton ($1.70 per pound). Similarly at the same GDF, implementation of low permeation hoses will achieve a reduction of over 100 pounds of VOC per year at a savings of $0.06k per ton (3 cents per pound).

Retaining Stage II systems and converting assist-type systems to balance systems may make sense where maintaining VOC emission reductions is crucial. The combined benefits of balance system compatibility with ORVR vehicles and capturing emissions from non-ORVR vehicles can maximize VOC reductions without the maintenance, operating cost and negative greenhouse gas impacts of assist systems.

Enhanced inspection and maintenance of Stage I equipment with more frequent vapor tightness testing can significantly improve tank tightness and reduce emissions at GDFs without the expense of going to continuous monitoring or pressure management equipment. For example, vapor tight GDFs that are open 24 hours a day can maintain a negative tank pressure without using a pressure management device. Another lower cost approach to assuring system tightness with PM is to periodically measure tank vacuum or pressure with a gauge temporarily connected to the headspace. Gauge readings can be interpreted to assess tank tightness.

1 Introduction

The federal Clean Air Act requires states with areas that are in non-attainment with National Ambient Air Quality Standards (NAAQS) for ozone to promulgate measures to bring those areas into compliance. Gasoline vapors generated from vehicle refueling are volatile organic compound (VOC) that contribute to the formation of ozone. To capture motor vehicle refueling emissions, 27 states and the District of Columbia encompassing 275 counties nationally have implemented some form of Stage II vapor recovery at gasoline dispensing facilities[1] (GDF). An alternate VOC refueling emission control technique, onboard refueling vapor recovery (ORVR), was introduced in motor vehicles beginning with model year 1998.

The penetration of ORVR in the general vehicle fleet exceeds 80% in some areas and is continuing to increase. With both systems competing for vapors, Stage II may be becoming unnecessary and its usefulness is being questioned. Consequently, this concern raises two questions:

What should be done with the seemingly redundant Stage II vapor recovery systems at gasoline dispensing facilities?

How will regulatory agencies obtain adequate volatile organic compound (VOC) reductions if Stage II systems are removed?

The purpose of this paper is to provide a review of VOC control options available for GDFs that states and other air quality control agencies needing additional VOC control to attain ozone standards should consider when responding to the increasing penetration of ORVR vehicles into the general motor vehicle fleet. A wide variety of control options are examined and discussed. Qualitative and, when possible, quantitative assessments of potential emission reductions (or increases), purchase and electrical costs, a cost-effectiveness ratio and Green House Gas (GHG) impacts are provided. Data used in this paper is limited to that available in the public domain. No attempt was made to obtain rigorous cost, use, lifecycle or installation information. Instead, the authors relied primarily on data available from California's Air Resources Board (ARB) with some data from the New York State Department of Environmental Conservation (NYSDEC) and a California vapor recovery equipment distributor.

2 Background

It is helpful to review the origins of GDF vapor recovery controls in order to understand how future direction may be affected. Virtually all states and regions requiring GDF vapor recovery controls rely on ARB certifications of vapor recovery control systems. Gasoline vapor recovery at GDFs was first required in California in the early 1970s. The San Francisco Bay Area and San Diego air pollution control districts were instrumental in advancing control of this large source of hydrocarbon emissions. Recognizing the need for statewide uniformity, a California statute was enacted in 1975 empowering the ARB with primary authority to adopt performance standards along with appropriate certification and test procedures. The statute directed ARB to

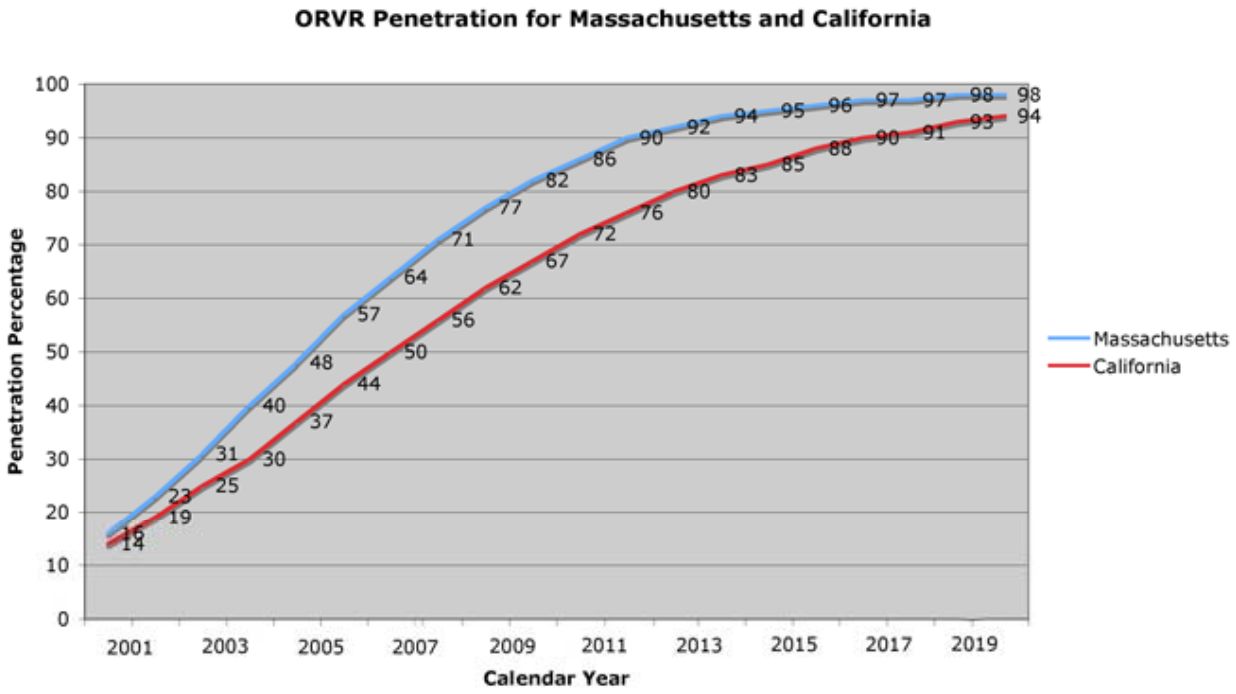
"adopt procedures for determining the compliance of any system designed for the control of gasoline vapor emissions during gasoline marketing operations, including storage and transfer operations, with performance standards which are reasonable and necessary to achieve or maintain any applicable ambient air quality standard"[2]. In this white paper, the recovery of vapors displaced from gasoline storage tanks at GDFs during product deliveries by cargo tank truck will be identified as “Stage I” vapor recovery. Collection and recovery of gasoline vapors displaced during motor vehicle refueling into GDF fuel storage tanks will be identified as “Stage II” vapor recovery. Stage II vapor recovery systems may be grouped into two basic types: 1) Balance systems, which make a tight seal at the vehicle/nozzle interface and utilize the pressure gradient generated during refueling to return vapors to the storage tank, and 2) vacuum assist systems, which incorporate a vacuum pump in some manner to generate a negative pressure at the vehicle/nozzle interface to capture vapors and return them to storage. Balance systems were the first systems to be used in California. Original balance systems used a long bellows to create a "seal" between vehicle and nozzle. However, the convenience of use of assist systems, which did not need to make a tight seal, led eventually to a majority of GDFs in California being equipped with assist systems.

In the late 1990s, concerns about the over-pressurization of the tank ullage space at GDFs with vacuum assist systems began to emerge. The over-pressurization was caused by excess air being introduced into the storage tank during vehicle refueling and generating additional vent emissions. The introduction of ORVR vehicles beginning with 1998 model-year vehicles only served to make the situation worse. California's Enhanced Vapor Recovery (EVR) regulations were developed and adopted in 2000. These regulations were designed to address inadequate performance standards and test procedures that resulted in reduced system effectiveness and durability along with concerns regarding incompatibility of certified assist systems with ORVR vehicles.

ORVR vehicles, as the name suggests, utilize a carbon canister, which is part of the vehicle evaporative emission control system to capture and collect vapors displaced during refueling. During refueling, the vehicle's on-board system effectively "competes" for vapors with the GDF's Stage II system. Balance systems are inherently compatible with ORVR vehicles because they only collect whatever vapor/air mixture is available at the fill-neck during refueling and draw in no outside air. In March 2003[3], the ARB reported on an evaluation they conducted which demonstrated that balance-type Stage II systems do not generate excess VOC emission from the refueling of ORVR-equipped vehicles. Based on the evaluation, ARB certified all balance systems in service as being compatible with ORVR-equipped vehicles. However, assist systems, unless they are designed to be ORVR-compatible, will over-pressurize storage tanks and create excess vent line emissions. Assist systems that are compatible with ORVR have the ability to decrease the amount of air returned to the storage tank or are operated at vapor return rates less than for which they were designed. As the penetration of ORVR vehicles increases and becomes widespread, not only does the necessity for Stage II systems come into question, but the incompatibility of most assist systems requires either their modification to become compatible with ORVR vehicles or their removal.

The issue of ORVR systems in widespread use and Stage II assist system incompatibility is not just a California problem. ORVR penetration will vary by location as shown in Figure 1, which depicts ORVR vehicle penetration in Massachusetts and California. Generally, ORVR penetration is greater in states with colder climates due to the ravages of road salt and other cold weather factors that reduce vehicle life and increase fleet turnover with new car replacements. Figure 1 indicates Massachusetts' ORVR penetration already exceeds 80%[4]. Even in California, ORVR penetration for 2011 exceeds 70%[5].

Figure 1



References: [1] and [6]

The NYSDEC has reviewed options for dealing with widespread ORVR penetration and the need for additional VOC emission reductions. A specific proposal was presented in December 7, 2010. The essence of the NYSDEC proposal is to decommission Stage II systems and utilize the maintenance and operational cost savings to obtain needed VOC reductions through implementation of continuous monitoring (CM) and pressure management (PM) at GDFs. NYSDEC's proposal is not critiqued by the authors. Instead, some of the control techniques expected to be used in New York are described and additional control options are identified and compared in terms of cost-effectiveness to NYSDEC's Reasonably Available Control Technology (RACT) guidelines of slightly more than $6k per ton ($3 per pound) of VOC reduced[7].

3 Scope

The primary topic of this paper is looking at optional Stage II controls identified as "Hanging Hardware" including nozzles, hoses and breakaways. This paper does not deal with Stage I control options other than to discuss continuous monitoring (CM) and pressure management (PM) as presented in the NYSDEC's proposal. It is assumed that robust Stage I controls, similar to EVR certified equipment, but not including CM and PM, would be required and implemented first since such controls strategies are generally cost effective and easily implemented.

GHG impacts of PM systems are discussed qualitatively. Electrical use is assumed to have a negative GHG impact. However, the amount of electrical use is considered. For example, a vacuum pump for an assist system which must operate whenever gasoline is dispensed will have a more significant negative GHG impact than a purge pump for a membrane system which operates very infrequently. Similarly, an oxidation pressure management system is expected to have a greater negative GHG impact than either of the above examples due to its direct emission of carbon dioxide and other combustion gases.

It should also be recognized that control of VOC (in this case, considered to be synonymous with ROG - reactive organic gases) emissions in itself has a positive but unquantifiable GHG impact. As stated in an ARB staff report: "*Overall, strategies for reducing ROG emission are beneficial from a climate change perspective. The Intergovernmental Panel on Climate Change (2007) has provided global warming potentials for a relative small set of ROG species, so it is not possible to quantify this benefit.*"[8].

4 Emission Control Techniques

This section is intended to provide the reader with background on potential GDF VOC emission control techniques. CM, PM and hanging hardware are each discussed in order to establish a foundation for analyses in subsequent sections. Even though hanging hardware is the focus of this paper, discussions of CM and PM are included in order to provide for comparisons.

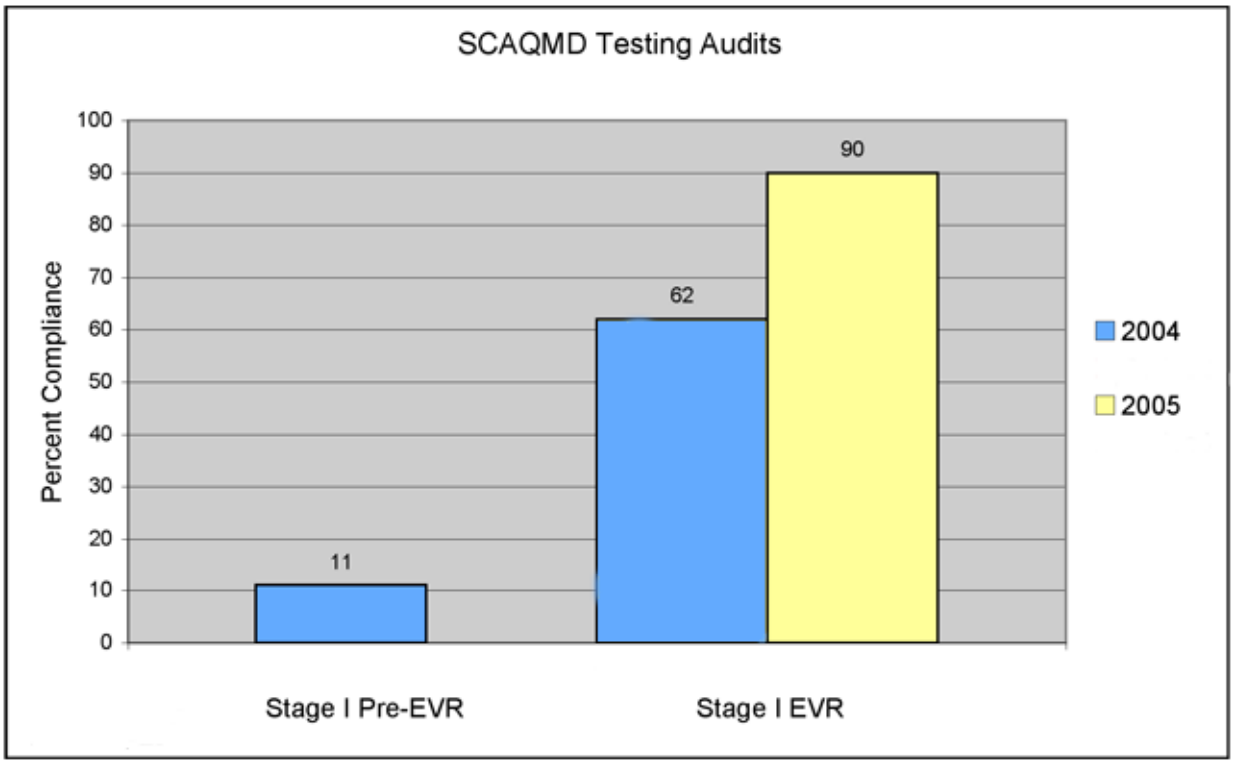
4.1 Continuous Monitoring

NYSDEC's proposal requires Stage II equipment to be decommissioned and CM be installed on all GDFs with annual throughputs of 120,000 gallons or more. Stage I controls are to be upgraded to near-EVR levels. PM is an additional requirement for GDFs with greater than 1,200,000 gallons per year throughput. The logic behind requiring CM is that the monitoring will optimize vapor containment and therefore minimize the release of hydrocarbon vapors from the vent line. Data presented by NYDEC in response to the December 7, 2010, workshop comments indicate that CM for purposes of vapor containment can be cost effective [9]. The question that may be asked is whether there is a viable alternative to NYSDEC's approach to CM.

4.1.1 Alternatives to CM

An alternative to CM is to increase the frequency for testing the leak tightness of tank systems. The South Coast Air Quality Management District (SCAQMD) requires GDF testing every six months. In 2005, after implementation of Stage I EVR controls, but prior to full implementation of Stage II EVR in 2009, which included continuous monitoring in the form of In-Station Diagnostics (ISD), SCAQMD compiled data that are the basis of the values depicted in Figure 2. Figure 2 shows that prior to EVR, compliance with Stage I vapor tightness requirements was at 11%. EVR implementation increased compliance rates to 62% and after two years, compliance improved to 90%; a complete reversal of compliance to non-compliance percentages when compared to pre-EVR levels. The EVR regulations require well-trained and system-specific licensed installers to perform installations and, as do most air quality districts, SCAQMD requires extensive post-installation testing prior to issuing a permit to operate. One conclusion that may be drawn from Figure 2 is that while enhanced testing results in very good compliance rates, it takes multiple years of testing every six months to approach levels which should be easily attainable with continuous monitoring. Costs of testing vary nationwide and therefore, the authors have chosen not to compare enhanced testing and CM relative costs.

Figure 2



Reference: [10]

The semi-annual testing required by the SCAQMD provides a significant improvement in tank vapor tightness over regulatory programs with longer test intervals. The clear advantage of enhanced testing is that it could be implemented without the need for purchasing, installing and maintaining a CM system. An enhanced testing program could be adopted where GDFs would be tested every six months and repairs would be made as necessary to allow systems to pass the test. When considering the testing frequency for a vapor control program, the cost and disruption to GDF operation of testing needs to be compared with the reduced vapor tightness and increased emissions that occur with longer test intervals.

The advantage of the CM system is that it alerts the GDF operator when tank tightness diminishes and tank fittings need to be inspected. An alternative, which can provide information on tank tightness without CM, is to temporarily connect a gauge to the ullage space and observe the pressure level in the tank. This can be done by attaching a pressure gauge to tapped hole in a fill cap that will fit on the Stage I vapor return riser on the tank. Observing the gauge reading for a few minutes will give a good indication of tank tightness. The pressure or vacuum level in a tight system will fluctuate during normal GDF operation and indicate a non-zero reading between vehicle refueling events. If the pressure in the tank is zero (atmospheric pressure) or returns to zero shortly after any dispensing stops, the tank can be assumed to not be vapor-tight.

GDF operators could check and record the readings observed on a regular basis, say weekly or monthly, and take appropriate action when a leak is indicated.

When considering any vapor control program at GDFs, the ability of the regulatory agency having jurisdiction to effectively enforce its regulations and the cost of such enforcement needs to be considered. Any vapor control program where the requirements for tanks, monitoring systems and control equipment are not rigorously monitored will have reduced control effectiveness.

4.2. Pressure Management

A second major aspect of NYSDEC's proposal regarding Stage II vapor recovery at GDFs is to allow the decommissioning of Stage II systems while requiring PM at GDFs with annual throughputs of greater than 1,200,000 gallons. Only PM systems that are EVR-certified by the ARB are allowed in the proposal. At present, certified EVR PM systems include the following:

- Clean Air Separator (CAS) by Franklin Fueling Systems (FFS),
- Carbon Canister Vapor Polisher (CCVP) by Veeder-Root,
- Enviro-Loc ECS membrane processor by VST
- VCS 100 thermal oxidation processor by HIRT.

Component costs for vapor recovery systems including PM systems are included in Table I. The data in Table I are intended to enable regulatory agencies and other stakeholders to calculate some of the costs of options to controlling VOC when considering ORVR penetration.

All of the PM systems have been (or are expected to be) certified in conjunction with balance nozzles. Only the CAS has been certified utilizing an assist (Healy) nozzle.

NYSDEC data indicate PM is cost-effective. That may be true, but the authors cannot unequivocally suggest the same would be true for other states or locales. Certainly, vapor growth has been observed by the authors at GDF's that close over night. However, a 2006 ARB balance system study clearly showed that vapor growth and associated venting would begin only after a GDF had been shut down for several hours[11]. Venting would cease shortly after the GDFs would re-open. It appears the effectiveness of PM is very much a function of how long a GDF remains closed and may not be necessary for "tight" or relatively leak free GDFs which have sufficient business to operate 24/7. Unfortunately, it is difficult to establish regulations to exempt PM only for stations that operate 24/7. Studies assessing the benefits of PM should include consideration of the length of time GDFs in a region are closed.

Table I
EVR / ISD Component Costs

	Conventional		Balance (VST/Emco)		Assist (Healy 900)	
	Cost	Expected Life	Cost	Expected Life	Cost	Expected Life
Hanging Hardware						
Nozzles	45	2 years	325	2 years	350	2 years
Primary Hose	41	2-3 years	140	2-3 years	123	2-3 years
Whip Hose	28	2-3 years	42	2-3 years	88	2-3 years
Breakaway	51	2 years	97	2 years	109	2 years

Pressure Management	
Veeder Root Canister	12,100
Healy CAS	5500
Hirt Oxidizer	8300
VST Membrane	10,500

Other Products - 4-Dispener Site		
Veeder Root ISD - Existing Console	10,500	n/a
Veeder Root ISD - New Console	16,800	n/a
Incon ISD	10,800	n/a
FFS/Healy VP-1000	7800	1-2 years

Installation	**4 Dispenser Site**
EVR only	5000-15,000
EVR & ISD	8000-18,000

Variables that can increase costs include local restrictions (especially for Healy CAS), existing deficiencies in vapor piping, trenching for additional conduits, difficulties working with current dispenser plumbing and other hidden issues.

Reference [12]

4.2.1 Pressure Management Systems

The characteristics of the presently ARB-certified processors are described below in Section 4.2.1.1.

As mentioned above, the CAS is certified to operate with the Healy ORVR compatible nozzles and hanging hardware on the Healy assist system. It is anticipated that the CAS will be certified for use with VST balance system hanging hardware by July 1, 2011. Fundamentally, the CAS is a 400-gallon vapor containment bladder housed within a steel tank. It is a passive system that utilizes the vacuum generated in the underground storage tank (UST) to purge any excess vapor captured by the CAS. A relatively complicated, special nozzle that recognizes ORVR vehicles and limits assist vacuum pump flows through a pair of pressure sensitive diaphragms is required for the CAS to function properly in an assist system.

The VST certification using the CAS relies on inherent balance system compatibility with ORVR vehicles to create a vacuum in the UST thereby eliminating the need for dispenser based vacuum pumps of assist systems. Overall, the CAS, as a PM system, has the advantage of having a low purchase price and being simple to operate and maintain with minimal direct GHG impact. Operating costs are primarily those associated with dispenser vacuum pump operation for Stage II assist systems. As stated earlier, dispenser vacuum pumps are eliminated in the VST certification. Some disadvantages of the CAS as a PM system besides the operating costs of vacuum pumps and associated negative energy use GHG impacts, include visual impact of a 400 gallon steel tank, concrete pad requirements for CAS placement on site and a fixed vapor capacity at 400 gallons which may be insufficient for systems prone to over pressurization such as GDFs that shut down for extensive time periods.

4.2.1.2 Veeder-Root

Veeder-Root's CCVP has been popular in California since its certification in 2008. It is certified to work with balance system nozzles and utilizes vacuum generated by fuel dispensing to purge the carbon canister. The major advantage of the CCVP is a low installation cost since it is designed to be mounted on GDF vapor vent pipes. The CCVP has minimal electrical operating costs and corresponding minimal negative GHG impacts. A distinct disadvantage of the CCVP is its fixed capacity. The system was originally certified to process up to 400 gallons of vapor, but that limit has been nearly doubled with a recently certified "extended capacity" version.

4.2.1.3 VST

The first continuous vapor processing PM system to be certified by California was VST's ECS membrane system. Over pressurization is not an issue for continuous vapor processing systems because processing occurs on-demand. The processor is activated whenever tank pressure reaches a pre-determined level and continues to operate until the pressure is relieved. This may be a significant advantage as ORVR penetration continues to increase since ORVR penetration is suspected of having a role in PM system over-pressurization. Continuous vapor processing at minimal operating cost and minimal negative GHG impact are the primary advantages of the ECS PM system. Disadvantages include a slightly higher purchase price and concrete pad requirements for mounting the processor.

At the time of publication of this paper, VST has completed the testing portion of ARB certification on their "Green Machine", which is essentially their membrane system with activated carbon replacing the membrane; VST has been marketing the Green Machine outside of California. The disadvantages noted for the ECS system are eliminated or mostly ameliorated by the Green Machine . The Green Machine is designed to be mounted on GDF vent pipe support structures, canopy roofs or concrete pads. It still has the advantage of continuous vapor processing by incorporating a pump for on-demand activated carbon purging thereby minimizing negative GHG impacts and addressing potential over-pressurization issues.

4.2.1.4 HIRT

The most recently certified EVR PM system is HIRT's VCS 100 thermal oxidation processor. Unlike the other PM systems, which recover gasoline vapors by returning them to the storage tank, HIRT manages pressures by burning excess vapors. HIRT system advantages include low capital costs, easy installation (canopy or roof mount) and relatively low operating costs. Disadvantages include no product recovery and negative GHG impacts due to oxidation of gasoline vapors. It should also be noted that, as an ARB-defined "destructive processor", the VCS 100 is certified to meet carbon monoxide, oxides of nitrogen, 1,3 butadiene and aldehyde performance standards established by the ARB. This is in addition to a benzene performance standard the ARB specifies that must be met by all EVR PM systems.

4.3 Hanging Hardware

There are three hydrocarbon control options that should be considered by air quality control agencies which are all associated with hanging hardware:

- Utilizing the benefits of EVR nozzle control of spillage emissions;
- Adoption of hose permeation standards being considered by ARB; and,
- Control of non-ORVR vehicle emissions by retaining Phase II systems, but converting them to be ORVR compatible.

Each of these three control techniques are discussed below.

4.3.1 Spillage Benefits of EVR Nozzles

The EVR performance standard for spillage is 0.24 pounds per 1000 gallons dispensed. This compares to an AP-42 emissions estimate of 0.7 pounds per 1000 gallons for conventional nozzles[13]. However, at least one EVR nozzle manufacturer has advertised spillage performance of 0.016 pounds per 1000 gallons with its dripless nozzle[14]. For a typical 1,200,000 gallon per year throughput GDF with 10 fueling points, implementing ARB's nozzle spillage control standards can achieve an estimated 820 pounds of VOC reduction annually at a cost effectiveness of $3.4k per ton ($1.7 per pound) - well within NYSDEC stated Reasonably Available Control Technology policy.

A significant advantage of spillage benefits from EVR nozzles is that the emission reductions are independent of tank system vapor tightness, PM or ORVR vehicle penetration. Spillage benefits are independent of other factors and will occur unless the nozzles are damaged. There are no negative GHG impacts from dripless nozzles and very slight positive impacts from hydrocarbon control. The disadvantage of requiring EVR nozzles is their cost relative to conventional nozzles.

4.3.2 Adoption of Hose Permeation Standards

Hose permeation standards limit the allowable VOC emissions from liquid gasoline diffusing through hose walls to the atmosphere. At this time ARB has yet to formally propose adoption of hose permeation standards, but information from their July 2010 workshop[15] and discussion with staff[16] allow discernment of what is likely to be proposed. At the workshop, a proposed standard of 10 grams per square meter per day (gms/m2/day) per a UL testing protocol was suggested. This standard would apply only to conventional, non-Stage II, and assist hoses; balance hoses would be exempt. The exemption is justified because balance systems have a coaxial hose with a central product hose surrounded by an annular vapor return path. The vapor return path provides a barrier to liquid gasoline that permeates through the product hose from reaching the atmosphere. In addition, increased ORVR penetration over time will lower the average returned vapor concentration in the vapor return path.

A reduction of over 95% in assist and conventional hose emissions was suggested at the ARB workshop. Based on discussion with staff, the proposed standard would equal about 3.23 gms/m2/day of emissions at ambient temperatures. For a 95% reduction, hose permeation emissions will be controlled at the rate of approximately 70 gms/m2/day per hose. Implementation of a hose permeation standard as proposed by the ARB staff for a 1,200,000 gallon per year throughput GDF with 10 fueling points, should achieve over 100 pounds of VOC reduction annually at an estimated $60 per ton (3 cents per pound) cost savings.

Hose permeation control provides the positive GHG impacts of controlling hydrocarbon without the negative GHG impact of electrical power usage. Similar to dripless nozzles, hose permeation control also is independent of other factors such as GDF tightness. If low-permeation hoses are phased in as existing hoses wear out, the program should be quite cost effective.

4.3.3 Retention of Phase II Systems

Retention of Phase II systems is addressed by the NYSDEC proposal, but it is done in the context of systems presently in service in New York. Since most Stage II GDFs in New York are non-ORVR compatible assist systems, the cost of maintenance of such systems seems to offset the potential benefits of any control they may offer. However, using Figure 1 data, assuming 15 billion gallons of gasoline sold annually and an uncontrolled emission factor of 7.6 pounds hydrocarbon per 1000 gallons, the California six percent non-ORVR population in 2020 would result in nearly 9 tons per day of VOC emissions controlled by retaining Stage II controls. Note, in California, where EVR has already been implemented, removal of Stage II systems and replacement with conventional hanging hardware would also result in a loss of over 10 tons per day of VOC control from removal of spillage control. Although the impacts in other states are likely to be less, the analysis should be performed in each affected locale. The issue in NY appears to be the cost of maintenance of prevalent assist systems off-setting potential benefits.

A primary issue with assist systems, even those compatible with ORVR vehicles, is cost of operation and particularly the maintenance and replacement costs of vacuum pumps. Based on Table I, a Healy VP-1000 vacuum pump costs nearly $1500. Including labor and necessary testing, replacement costs could approach $2000. Recognize that a vacuum pump is required in each dispenser of a GDF.

There is also the issue of electrical costs and GHG impact. The vacuum pump draws about two amps in normal operation, which although not high, will add from $15 to $60 to monthly electrical bills for average-sized GDFs in addition to the negative GHG impacts. Assist systems are simply more expensive to operate than balance systems. Based on the information reviewed, the authors suggest retention of existing balance systems should be strongly considered and even conversion of existing assist systems to balance should be analyzed by locales seeking maximum VOC control at reasonable cost.

5 Hanging Hardware Cost Effectiveness Analysis by GDF Size

Although information on the costs and effectiveness of spillage and hose permeation controls was given in the previous section for a 1,200,000-gallon per year GDF, we thought, in this final section, it would be useful to present similar values for a smaller and larger GDF. Table II contains information on hanging hardware costs and effectiveness for three GDFs types: 120,000 gallons annual throughput and 2 fueling points; 1,200,000 gallons annual throughput and 10 fueling points; and, 3,600,000 gallons annual throughput and 12 fueling points.

Table II
Hanging Hardware CE by GDF Size

Control Option	GDF Annual Throughput, 1000 gallons	Fueling Points	Annual Emission Reduction, lbs	Annualized Cost, $	Cost Effectiveness, $/lb
Spillage	120	2	82	280[a]	3.41
	1,200	10	820	1440[a]	1.70
	3,600	12	2460	1680[a]	0.68
Hose Permeation	120	2	20	Savings	0.031[14]
	1,200	10	100	Savings	0.031[14]
	3,600	12	120	Savings	0.031[14]

a. Difference between EVR and conventional nozzle costs.

Nozzle spillage control is independent of other factors such as GDF maintenance characteristics or other controls. Throughput directly affects the emission reductions achieved through nozzle spillage controls. It should be noted that spillage control for a 120,000 gallon annual throughput GDF would likely have a cost-effectiveness number slightly exceeding the NYSDEC RACT guideline. However, spillage control at a 1,200,000 gallon annual throughput GDF would result in over 800 pounds of gasoline vapor captured and application of controls to a 3,600,000 gallon annual throughput GDF would result in over a ton per year of VOC controlled at each site. Costs included in the table are the differences between California EVR style nozzles and conventional nozzles. Some form of adaptor would need to be offered by nozzle manufacturers if conventional, non-Stage II hoses are to be used. At least one manufacturer indicated such an adaptor would be made available if a demand developed[17].

With the assumed cost savings ARB presented at their workshop for hose permeation control in July, 2010, hose permeation should be considered for all sizes and types of GDFs. The emission reductions are completely dependent on the number of fueling points. Each fueling point retrofitted with a low permeation hose results in an average 10 pounds of VOC controlled per year from that fueling point. An important characteristic of hose permeation control is that its benefits are completely independent of other aspects of the GDF.

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[16] California Air Resources Board (CARB), personal communication with Jason McPhee, June 10, 2011.

[17] Vapor Systems Technologies, Inc. (VST), personal communication with Glenn Walker.

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Disclaimer

All of the analyses, statements and opinions in this white paper are solely those of the authors. They are based on public domain information and knowledge gained through over 70 years of experience in the air pollution control arena including vapor recovery.

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William (Bill) V. Loscutoff spent over 36 years in air quality management at the California Air Resources Board (ARB). He retired in November 2009 as Chief of the ARB's Monitoring and Laboratory Division (MLD), a position he held for nearly 22 years.

Under Bill's leadership, the Enhanced Vapor Recovery (EVR) program for gasoline service stations was developed in the late 1990's and adopted by the ARB in March 2000. Other vapor control programs developed under Bill's guidance include EVR for Above Ground Storage Tanks, Evaporative Controls for Small Off-Road Engines and emission controls on Portable Fuel Containers.

Bill graduated with a B.S. degree in mechanical engineering from the University of California, Berkeley and an M.S. degree in environmental engineering from the University of California, Davis.

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Don Gilson is the principal of Gilson Environmental. Prior to starting Gilson Environmental, Don worked as an environmental specialist in the marketing department of Chevron for 28 years. During that time he was involved with all aspects of environmental compliance for gasoline marketing at service stations and terminals. He is past chairman of the American Petroleum Institute's Marketing Environmental Subcommittee and the Western States Petroleum Association's Environmental Marketing Committee.

Before working at Chevron, Don worked at what is now called the Bay Area Air Quality Management District and the Raychem Corporation.

Don graduated with B.S and M.S. degrees in mechanical engineering from the University of California, Berkeley.

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CAPCOA Vapor Recovery Meeting

Gasoline Dispensing Facilities

Sacramento, California
October 19, 2005

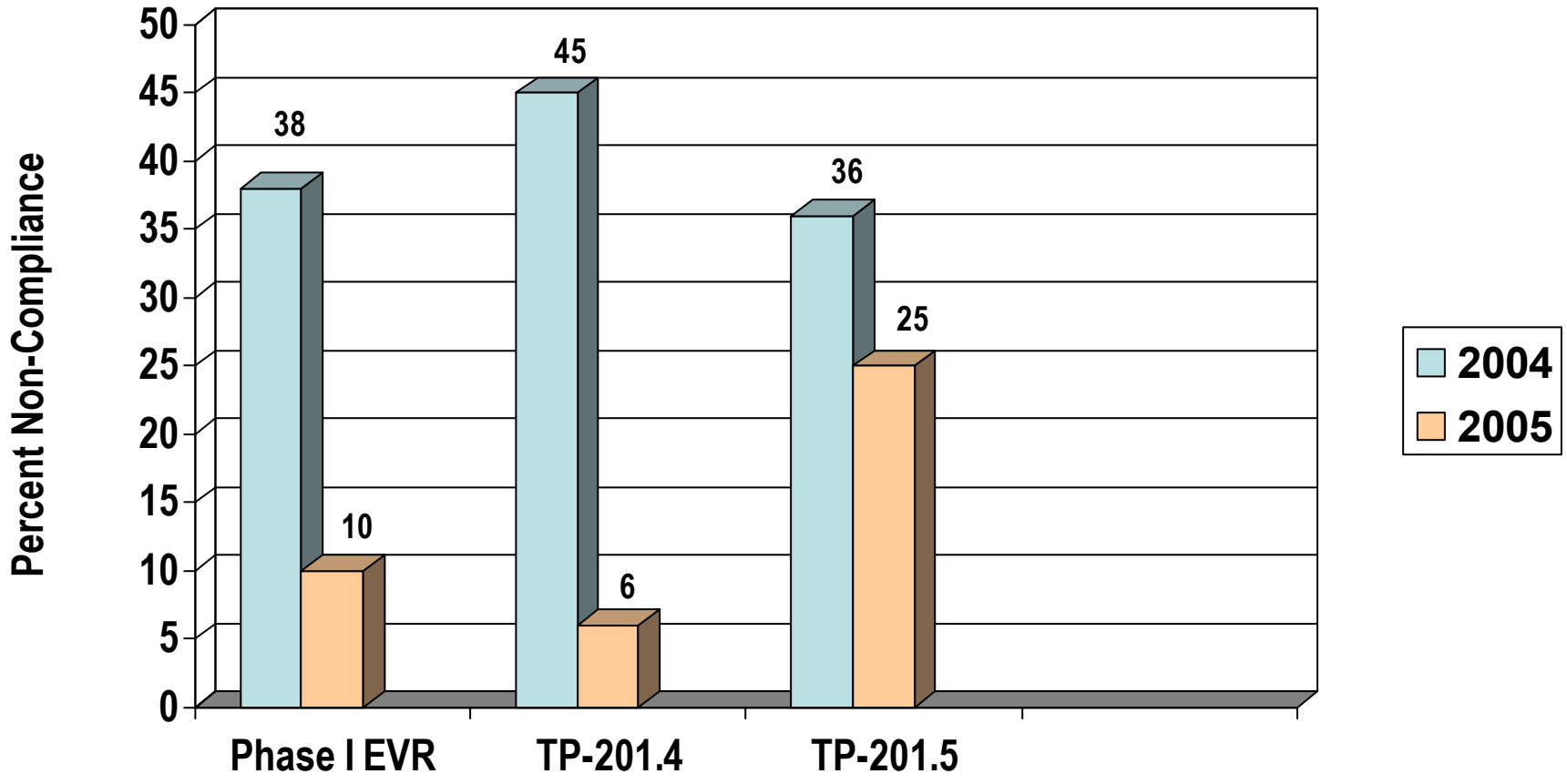
Louis Roberto
South Coast AQMD

Presentation Outline

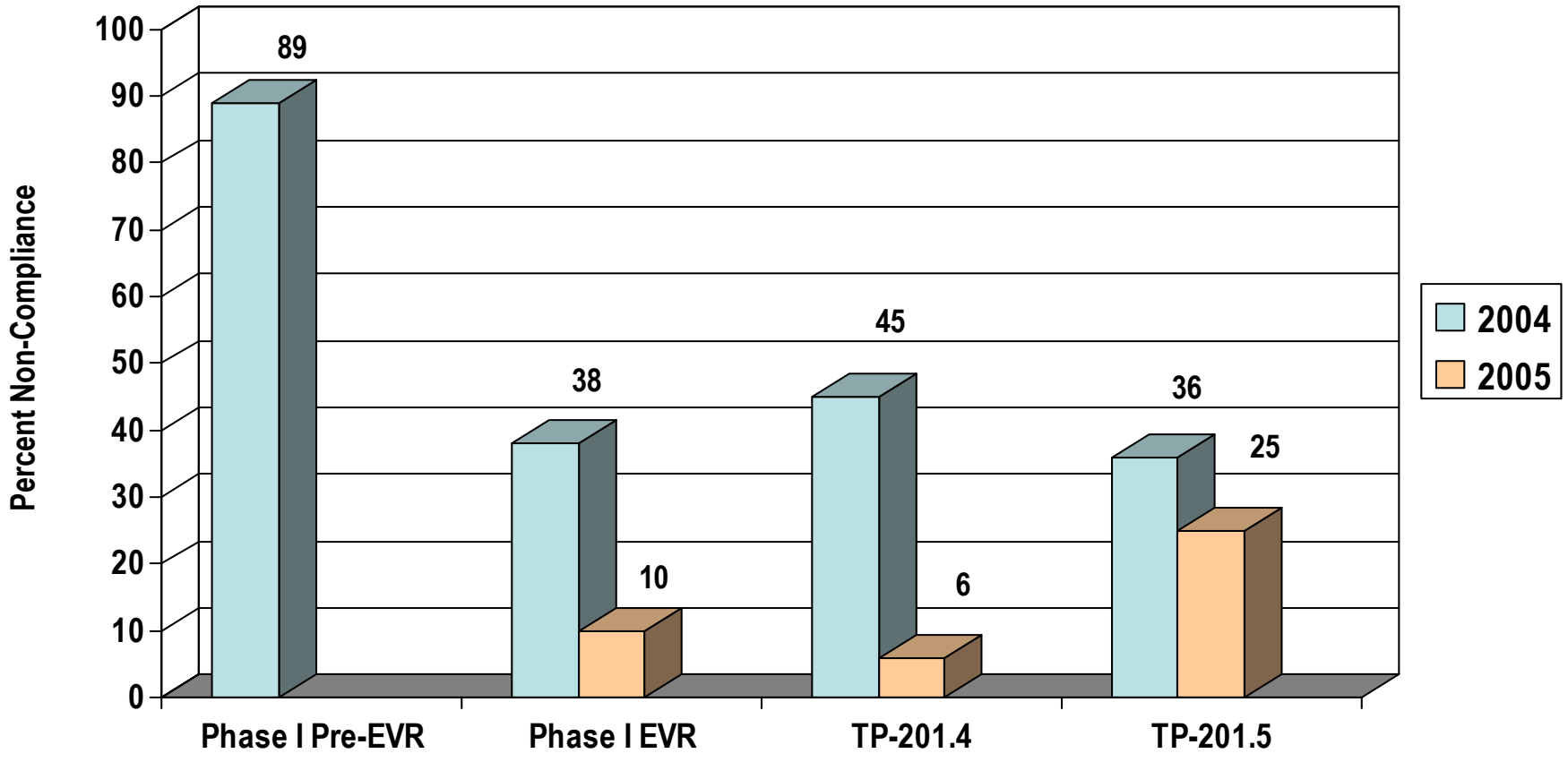
- **South Coast AQMD Audit**
  - Phase I EVR
  - Phase II
  - ORVR Compatibility Conversions
  - Phase II EVR
- **Preliminary Audit Results**
- **Audit Issues & Concerns**

IS IT AUDIT TIME ?"

South Coast AQMD Testing Audits

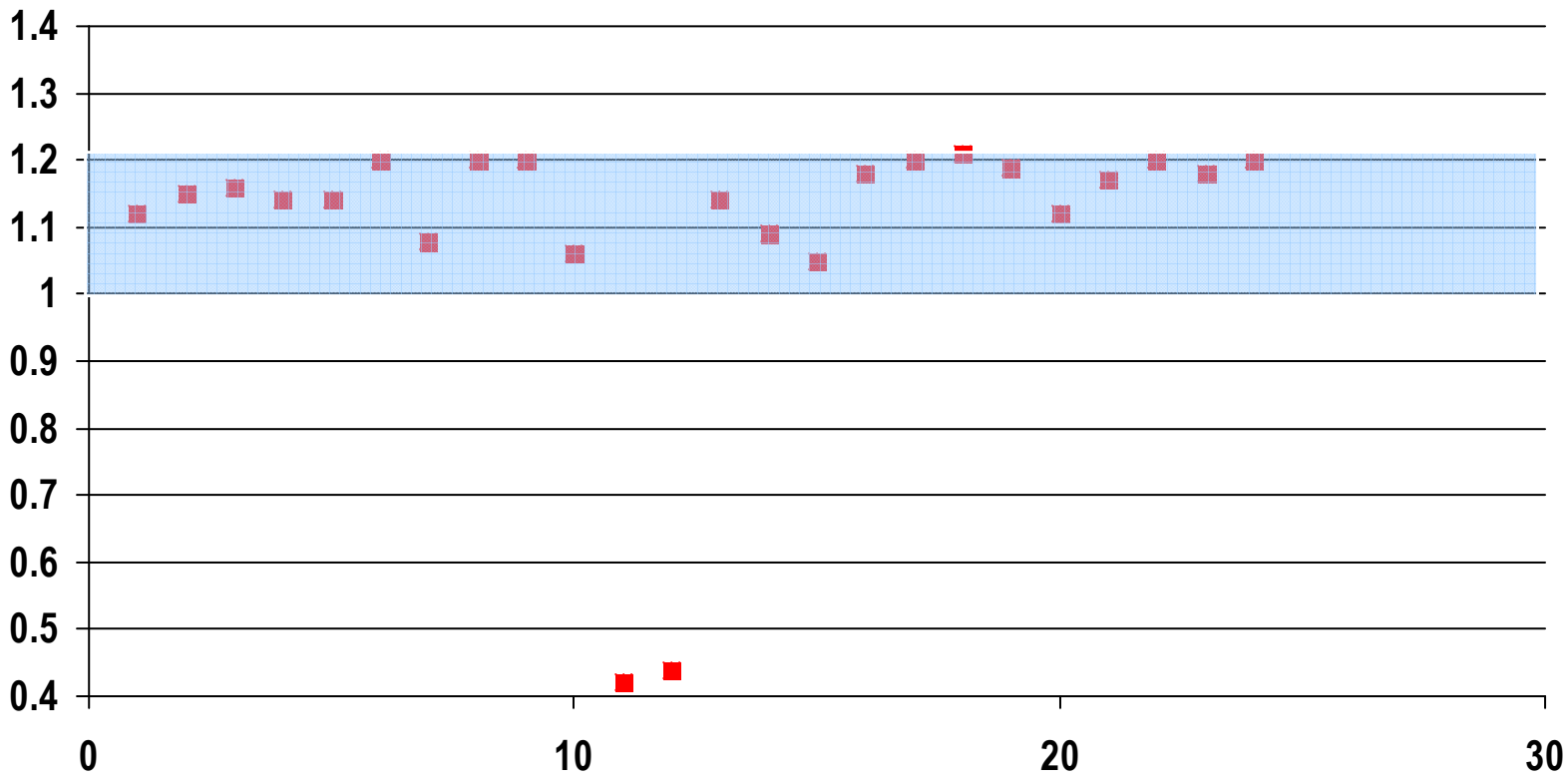


South Coast AQMD Testing Audits



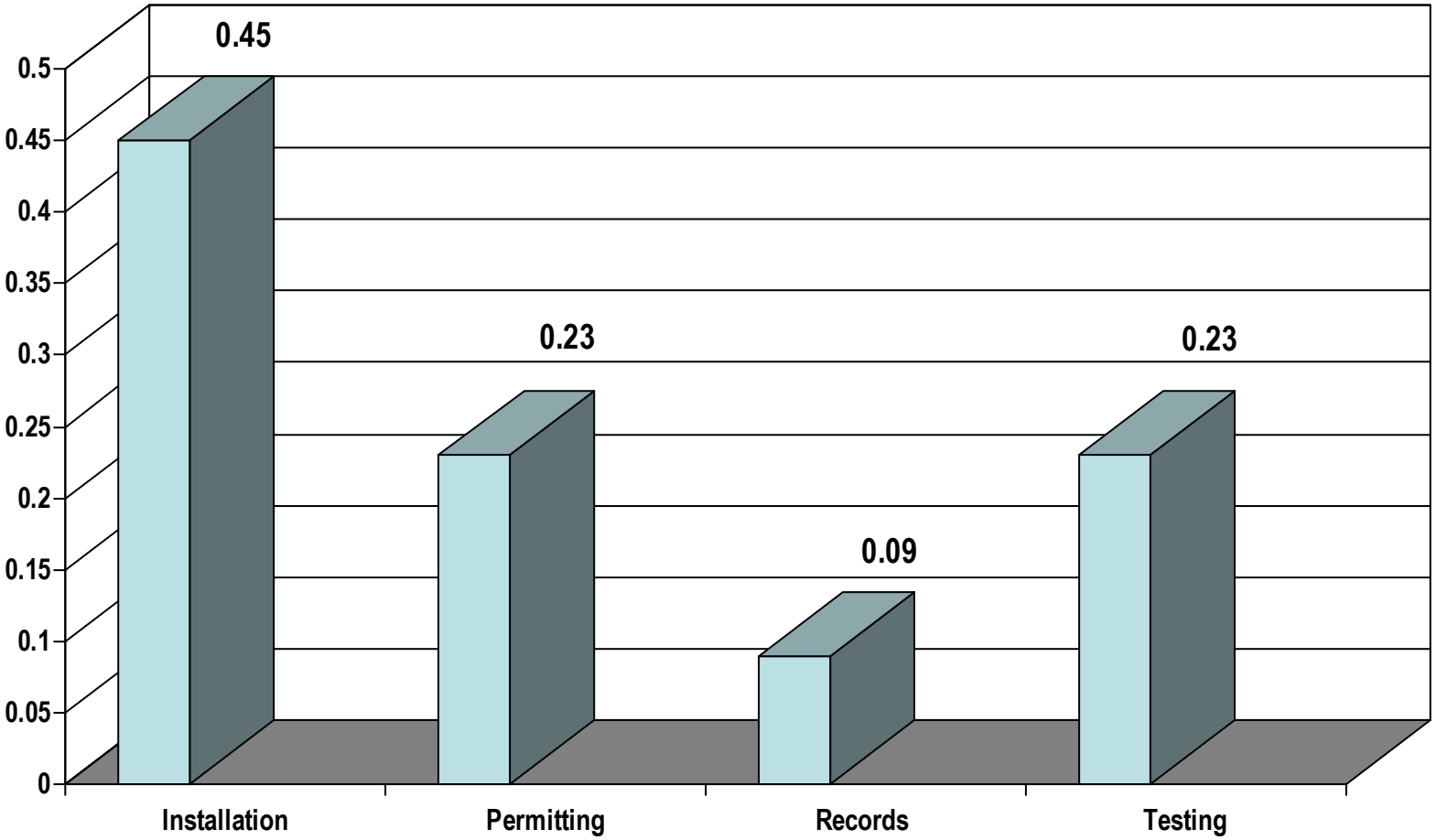
Healy G-70-191-A: Model 900 Nozzles

A/L Ratio Range (1.0 – 1.2)



Non-Compliance Breakdown

Relative Frequency – 22 NOVs

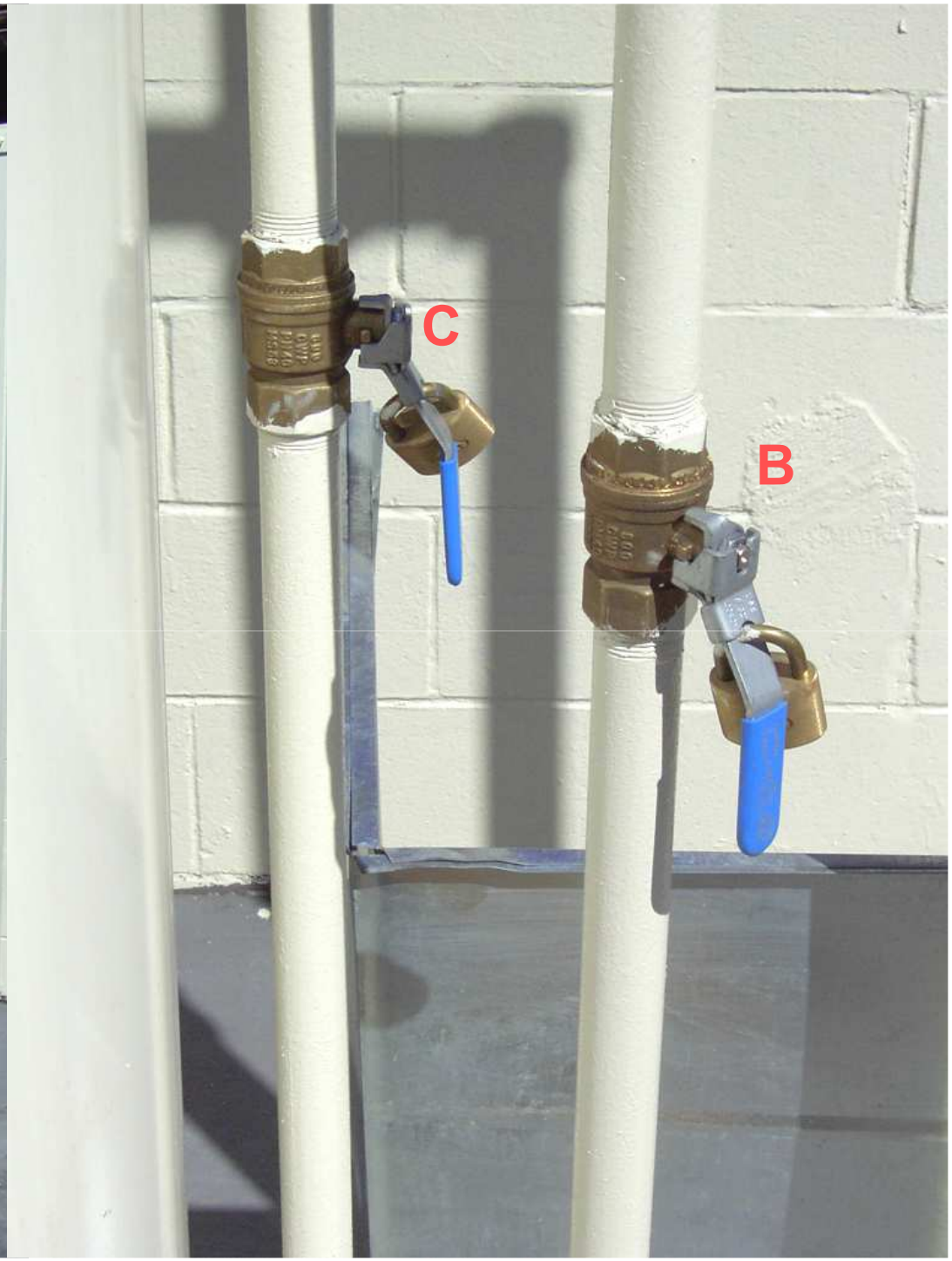


Louis Roberto
October 14, 2005

Vapor Recovery Installation Problems

USA Gasoline
USA Gasoline Corp
3618 Baldwin Ave.
El Monte

A
C
B
D
HEALY


C
B

3
4
3
USA
USA

Rimpco Inc. / Shell Oil
10961 Los Alamitos Blvd., Los Alamitos

- **Phit-Tite Phase I EVR**
- **Healy Phase II (G-70-165)**
  September 15, 2005

Installation Problems

Installation Problems

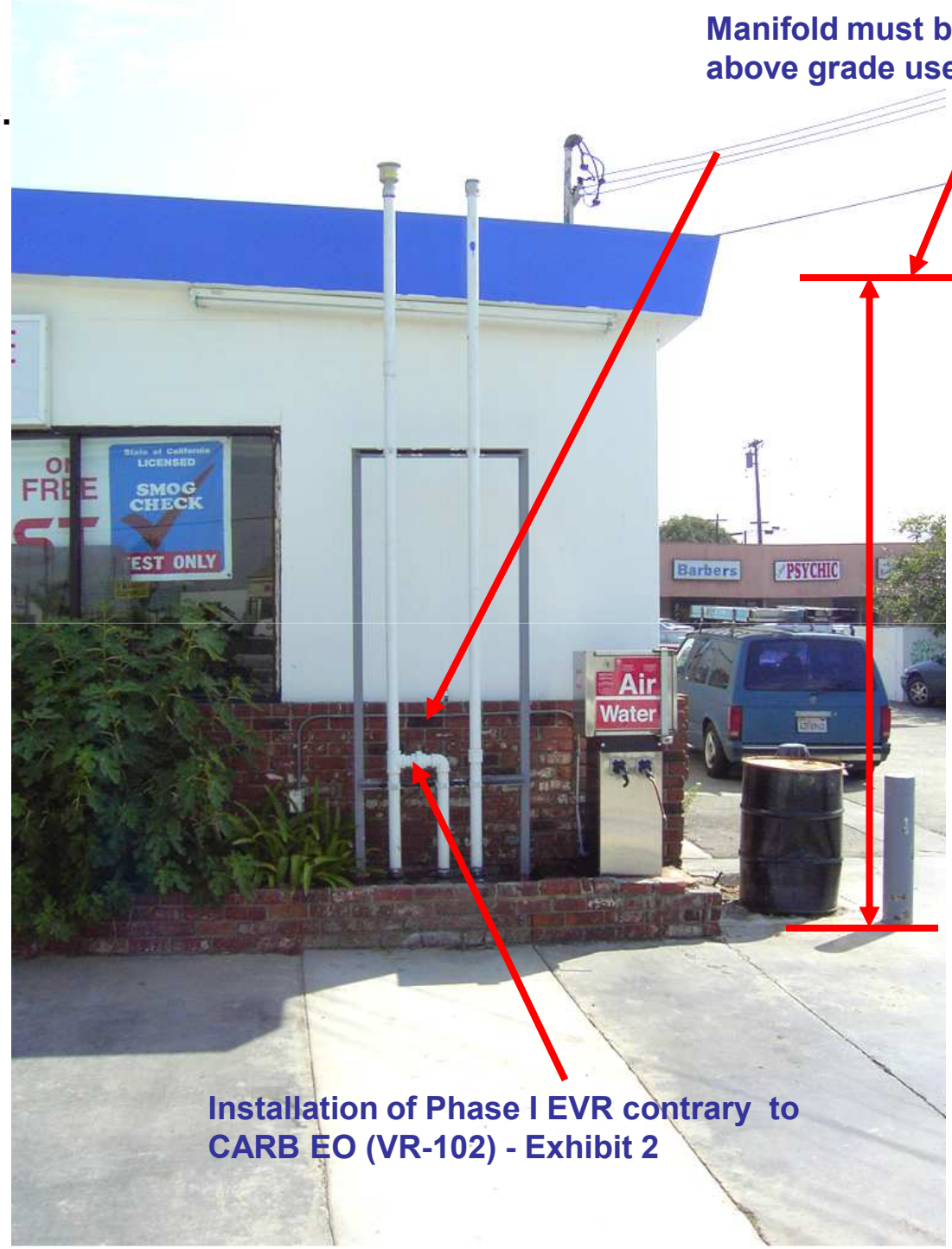
Arrow Car Wash
10075 Arrow Route
Rancho Cucamonga

OPW Phase I EVR

- **Vent piping must be steel or material compatible with gasoline**

PVC Piping

US Gasoline
14204 Rosecrans Ave.
La Mirada



Arco
1001 W. Artesia Blvd.
Gardena

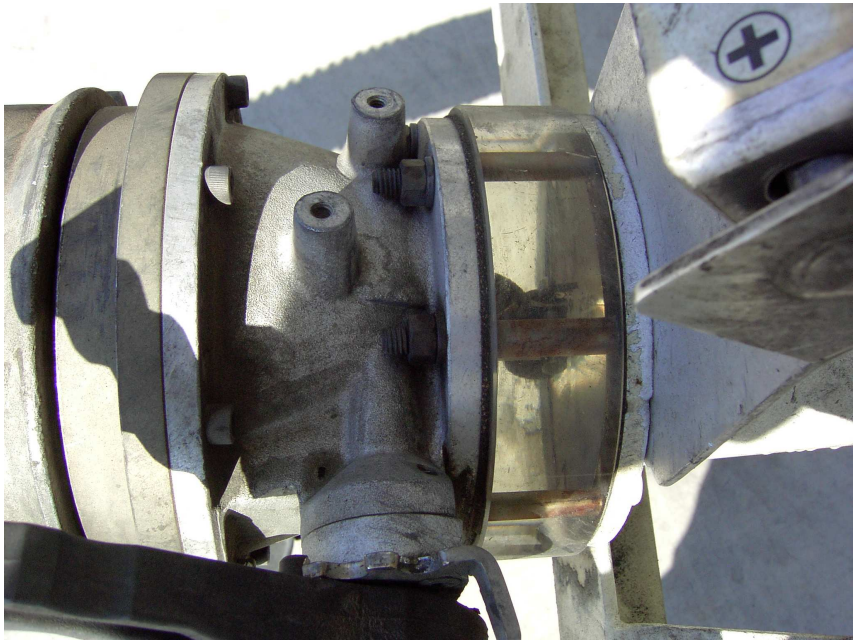
Balance System

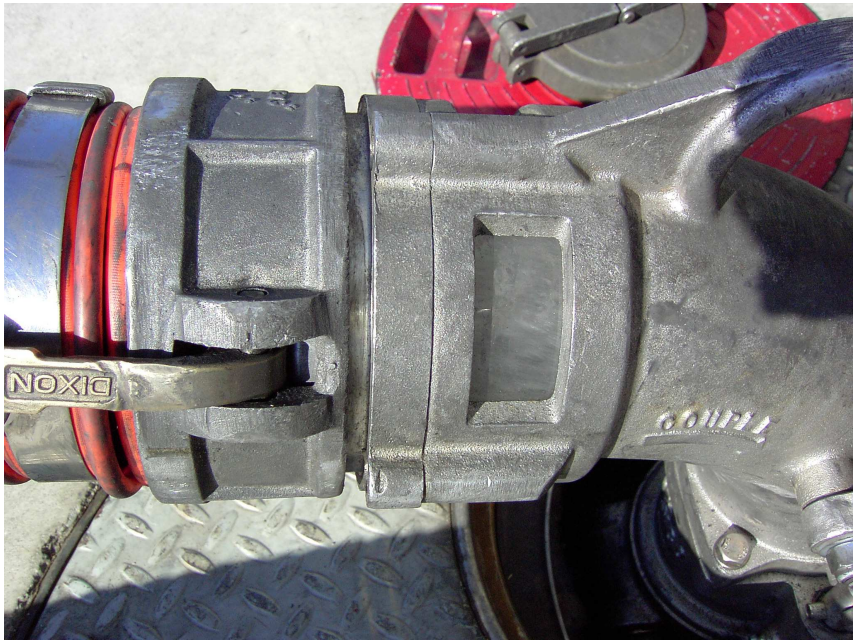
Installation/Operation Contrary to VR-102 EO (Installation of 4 PVVs)

A Express
8850 Foothill Blvd.
Rancho Cucamonga

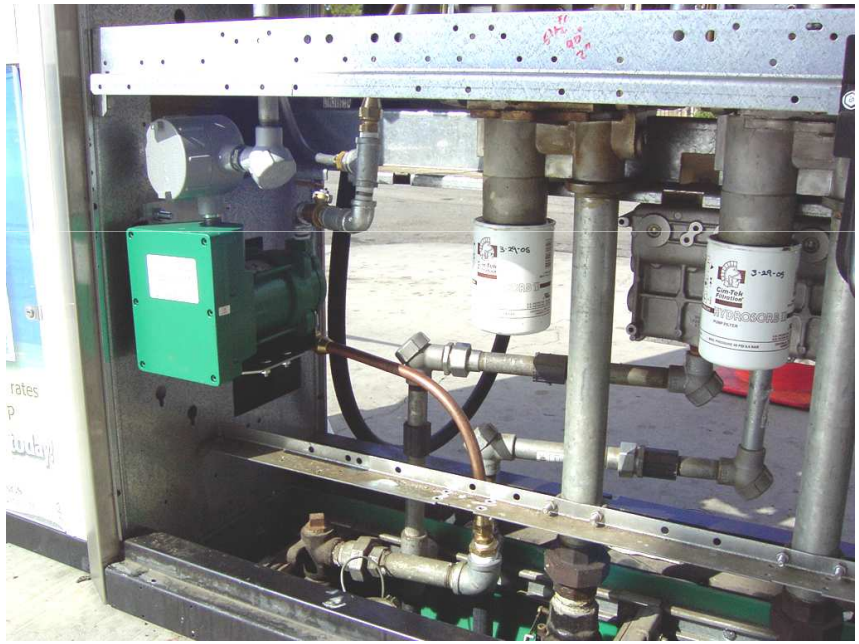
Air Ingestion

Air Ingestion Cont.





Installation Problems



CAS Vacuum Readings
1145 hrs. - 0.92" WC
1150 hrs. - 1.20" WC
1155 hrs. - 1.58" WC
1200 hrs. - 2.04" WC
1205 hrs. - 2.27" WC
1210 hrs. - 2.52" WC
1215 hrs. - 2.55" WC
1220 hrs. - 2.60" WC
Costco Wholesale
6100 Sepulveda Blvd.
Van Nuys

Enhanced Leak Detection (ELD) Testing At Existing GDFs

ELD Testing At Existing GDFs

VST Supports All of EPA's Potential Emission Reduction Programs for GDFs as Identified in their Stage II Decommissioning Guidance

Background

On August 7, 2012, the U.S. EPA released its Stage II decommissioning guidance document titled: **Guidance on Removing Stage II Gasoline Vapor Control Programs from State Implementation Plans and Assessing Comparable Measures**. As part of EPA's guidance, a brief discussion is included regarding potential GDF emission reduction strategies:

"4.4 Potential Emission Reduction Programs for GDFs
By viewing the GDF in its entirety as a fuel storage and dispensing system, existing GDF emissions control systems can be enhanced to achieve a higher level of in-use efficiency, and to deliver more environmental benefit. Of course, additional system design, maintenance, and enforcement provisions add cost to the installation and ongoing operation of the systems. Examples of extra design and monitoring features include: 1) ORVR compatible Stage II nozzles; 2) systems to help better manage UST pressure and control emissions lost from the UST through vent lines and fugitive leak sources during normal operations; 3) post processors to control or eliminate normal UST breathing/emptying loss emissions; 4) standards for specially designed nozzles that reduce emissions from liquid retention, drips, and spills; and 5) low permeation fuel hoses."

VST, as a manufacturer of advanced vapor recovery control equipment, has available or is developing control techniques which address each of the five EPA examples listed above. This paper briefly discusses each of the five GDF emission reduction programs in the context of how they may be considered by regulatory agencies as "substitute strategies" to either enhance existing GDFs so that the impetus to decommission Stage II systems is removed or to meet SIP requirements for additional VOC emission reductions when the decision to decommission Stage II systems has been made.

1) ORVR compatible Stage II nozzles

This strategy would provide for ORVR compatibility for existing GDFs with Stage II vapor recovery. The difference between assist and balance type Stage II must be taken into account when discussing this strategy.

Balance Stage II systems are inherently ORVR compatible and need no additional components or modifications to maintain efficiency. However, balance system technology can be enhanced to both increase in-use effectiveness and gain addition emission reductions by utilizing California Air Resources Board (ARB) certified Enhanced Vapor Recovery (EVR) equipment. EVR regulations included several performance standards which were intended to reduce leaks and improve performance. These performance standards include requirements for vapor check valves, maximum pressure drops and stringent "spillage" controls.

Assist Stage II systems must include some form of ORVR vehicle recognition in order to decrease or stop assist vapor pump flow which over-pressurizes the UST when re-fueling ORVR vehicles. Several manufactures have developed and are marketing nozzles or add-on components to nozzles which perform this task thereby establishing GDF to ORVR vehicle

compatibility. EVR assist system nozzles are certified to similar performance standards as EVR balance system nozzles. However, assist systems are inherently more expensive to maintain and operate due to the added complexity of need for ORVR recognition capability, vapor pump performance and electrical requirements, and need for more dispenser plumbing.

Some pros and cons when considering upgrading an existing Stage II system to be ORVR compatible:

+ Most environmentally effective approach. By converting Stage II systems to be ORVR compatible, not only are excess emissions from incompatibility eliminated, but all non-ORVR vehicle refueling emissions continue to be captured.

+ Balance systems, because of their greater robustness through simplicity, address many of the "costs" identified by EPA as reasons for decommissioning Stage II.

+ Incorporating EVR technology such as spillage control will greatly increase VOC emission reductions.

- Many cost considerations leading up to EPAs Stage II decommissioning logic continue to be applicable with ORVR compatible assist systems. Only a few of the costs identified by EPA, such as increased component costs, apply to balance systems.

- Practically speaking, a regulatory agency will have a difficult task of adopting requirements for GDFs to enhance Stage II performance when EPA has issued regulations and guidance allowing decommissioning of such systems.

Suggestions for Regulatory Agencies: Perform a cost benefit analysis of both converting to ORVR compatibility and EVR technology before allowing decommissioning of Stage II systems. Consider converting all existing Stage II GDFs to balance type systems.

VST Capability: VST has Texas approved components available for converting assist systems to be ORVR compatible and a full line of ARB certified EVR balance system nozzles and components.

2) Systems to help better manage UST pressure and control emissions lost from the UST through vent lines and fugitive leak sources during normal operations

Continuous monitoring (CM) of GDFs allows for better management of UST pressure and an ability to identify when emission control is being lost through vent lines and fugitive leak sources. Existing GDF CM systems have been certified under the California EVR regulations as part of the of larger monitoring systems called In-Station-Diagnostics (ISD). Existing CMs would need to be modified if applied to either existing, non-EVR Stage II GDFs or non-Stage II GDFs.

Some pros and cons when considering requiring CM for GDFs with either existing Stage II systems or after decommissioning Stage II systems:

+ Provides capability for real-time information on GDF "tightness" or leak status.

- Regulatory agency must provide for resources to review information which will obviously be massive.

- Regulatory agency must provide for compliance enforcement capability in order to realize any emission reductions due to CM.

- CM costs are probably in the range of $9,000 to $10,000 (installed) per GDF with no direct VOC emission reduction benefit.

- No CM system has been approved or certified in the more simple, non-ARB EVR, configuration being considered by some states.

Suggestions for Regulatory Agencies: CM can be a very effective tool in preventing VOC emission releases from GDFs. However, the limitations of merely monitoring must be considered before establishing a requirement for GDFs to install such systems. Cost/benefit analyses should consider all aspects of implementing a CM strategy.

VST Capability: VST has devel**o**ped a much less expensive, when compared to ISD, CM system for GDFs which needs approval just like re-configured ISD systems.

3) Post processors to control or eliminate normal UST breathing/emptying loss emissions

A detailed discussion of post processors or pressure management (PM) systems may be found in "**White Paper, Options for Controlling VOC Emissions at Gasoline Dispensing Facilities in Response to Widespread ORVR Implementation"** prepared by Loscutoff and Gilson, 2011.

PM can a very effective approach in addressing ORVR incompatibility if the rest of the system is modified to be ORVR compatible (such as ORVR compatible nozzles). If however, the Stage II system is decommissioned, PM is effective primarily for GDFs that shutdown during extended periods or overnight. PM systems, as certified by ARB, are either passive or active. Passive systems only work in a relatively leak free, tight, GDF environment. Active systems provide much more latitude in GDF tightness and can also provide for water quality benefits by maintaining a constant negative UST pressure.

Some pros and cons when considering requiring CM for GDFs with either existing Stage II system or after decommissioning Stage II systems:

+ Could be a very cost effective technique for controlling VOC emissions from GDFs that are shutdown for extended periods (~6 plus hours).

+ Water quality can benefit from active PM systems maintaining a constant, negative UST pressure.

- The cost of PM systems varies between approximately $5,500 to $12,000. The capital investment required for a PM system could make a regulation difficult to adopt even though it may be cost effective.

Suggestions for Regulatory Agencies: Cost versus benefits are critical when considering requiring PM systems. Analyses need to consider station operation characteristics as the prime factor in determining if PM is viable.

VST Capability: VST has an active PM ARB certified system and is the process of certifying a second active system which would be less expensive.

4) Standards for specially designed nozzles that reduce emissions from liquid retention, drips, and spills

EVR regulations included specific standards to reduce "spillage" emissions. Based on certification data, EVR nozzles far exceed anticipated spillage reductions making this strategy likely very cost effective, especially for high throughput sites, for regulatory agencies considering retaining Stage II. Additionally, VST has committed to developing and marketing a conventional, non-Stage II, nozzle with EVR spillage benefits (tentatively called "ECO" (Enhanced COnventional) nozzles by the ARB) by early 2013 for those regulatory agencies which will proceed with Stage II decommissioning but are seeking additional VOC reductions. The South Coast Air Quality Management District in Southern California felt the benefits of spillage control sufficiently beneficial to require businesses and government agencies with primarily ORVR fleets to utilize EVR Stage II hanging hardware while allowing for Stage II decommissioning of their refueling facilities.

Some pros and cons when considering requiring nozzles with advanced, EVR style spillage control for GDFs with either existing Stage II system or after decommissioning Stage II systems:

+ EVR Stage II nozzles are available for both assist and balance systems.

+ ECO nozzles provide all of the spillage control benefits of EVR nozzle without a vapor path to increase potential leak sources.

+ ECO nozzles provide the safety of insertion interlock mechanisms which present conventional nozzles do not.

+ Nozzle spillage control prevents air pollution, saves gasoline and provides a cleaner forecourt which also leads to water quality protection.

+ Nozzle spillage control is independent of other control measures and can be incrementally implemented to minimize cost.

+ Cost effectiveness improves with higher throughput sites.

- EVR nozzles are $250 to $275 more expensive than conventional nozzles although they are still cost effective in most scenarios.

- ECO nozzles are projected to cost about $40 to $90 more than present conventional nozzles.

- A method of "approving" ECO nozzles may be needed. The ARB is considering adopting regulations but their timeframe, estimated as mid to late-2013, may be later than desired by other regulatory agencies.

Suggestions for Regulatory Agencies: Spillage control nozzles may be the most cost effective control technique for agencies either considering retention of Stage II systems (EVR nozzles) or considering decommissioning (ECO nozzles). It is suggested agencies conduct specific analyses of spillage control nozzle impacts and costs. Agencies should include consideration of adopting requirements for EVR and/or ECO nozzles implementation at all GDFs in their region due to the

cost effectiveness of the measure and in anticipation of more stringent ozone standards now being considered by EPA. Adoption of regulations requiring ECO nozzles will ensure the technology will be marketed in an appropriate time frame and will encourage nozzle manufacturers to consider development of such nozzles if they are not presently committed to do so. A "third-party" certification process may need to be developed if the regulatory agency wishes to test the ECO style nozzles prior to implementing regulations.

VST Capability: VST has **an** ARB certified EVR balance system nozzle and has committed to bring to market an ECO style nozzle by mid-2013.

5) Low permeation fuel hoses

The ARB adopted regulations on September 22, 2011 requiring low permeation fuel hoses for GDFs. In comparison to existing Stage II hoses, low permeation hoses were projected to be cost saving according to the ARB staff report. When compared to conventional, non-Stage II hoses, hose permeation control is still very cost effective. Technology for developing low permeation hoses has been available since the early 2000's and adoption of low permeation standards for GDFs is considered technology transfer. California ambient temperature corrected emission reduction estimates are about 10.8 pounds VOC per (ten foot) hose per year.

Some pros and cons when considering requiring low permeation hose control at GDFs:

+ Low perm hoses will be available for both assist and non-Stage II systems.

+ Low perm hoses should have greater durability than conventional GDF hoses since vapor is hindered from reaching the surface layer of the hoses where most cracks begin.

+ Cost effectiveness appears to be very good for low permeation hoses.

+ Low perm hoses offer significant, quantifiable benefits including both air pollution control and gasoline recovery.

+ Low perm hose control strategy is independent of other control measures and can be incrementally implemented to minimize cost.

- No known negatives at this time.

Suggestions for Regulatory Agencies: Along with spillage control nozzles, hose permeation control may be the most cost effective control technique for agencies either considering retention of Stage II systems or considering decommissioning. It is suggested agencies conduct specific analyses of low perm hose impact and include consideration of adopting requirements for all GDFs in their region due to the cost effectiveness of the measure and in anticipation of more stringent ozone standards now being considered by EPA.

VST Capability: VST is in the process of developing and certifying low permeation GDF hoses per the ARB regulations. It is anticipated that full ARB approval will be received by mid-2013.

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