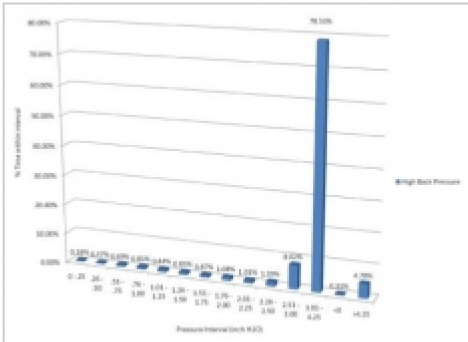
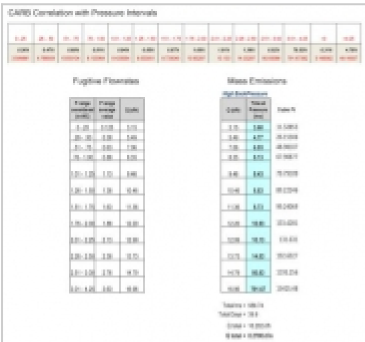
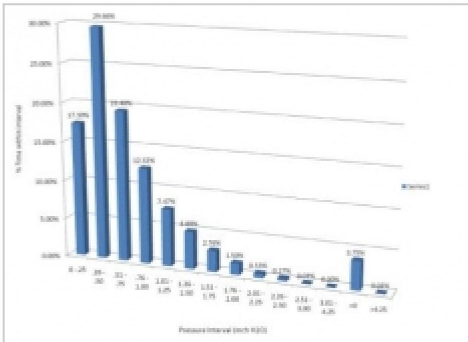
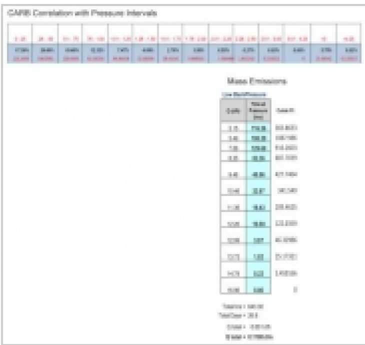
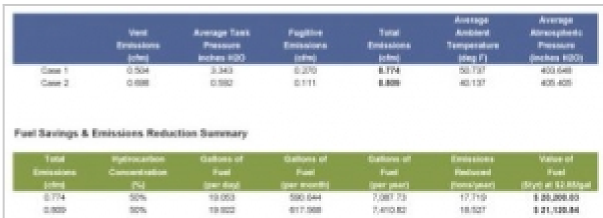
Vent Line and Fugitive Emissions Study at a US Gasoline Dispensing Facility







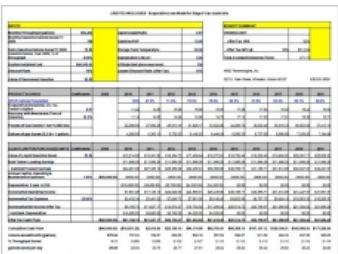


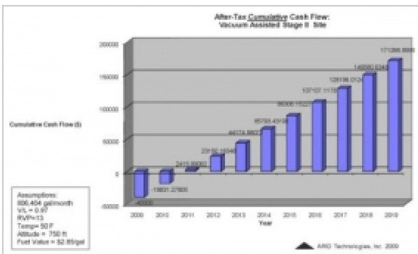


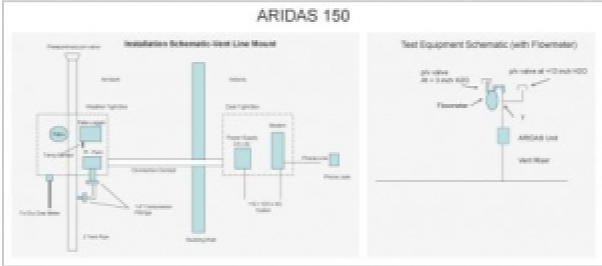
	Vent Emissions (cfm)	Average Tank Pressure inches H2O	Fugitive Emissions (cfm)	Total Emissions (cfm)	Average Ambient Temperature (deg F)	Average Atmospheric Pressure (inches H2O)
Case 1	0.504	3.343	0.270	**0.774**	50.737	403.648
Case 2	0.698	0.592	0.111	**0.809**	40.137	405.405

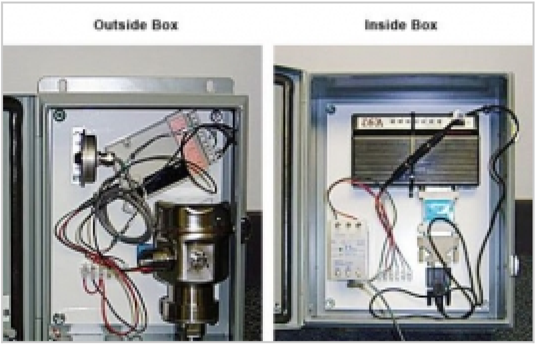
Fuel Savings & Emissions Reduction Summary

Total Emissions (cfm)	Hydrocarbon Concentration (%)	Gallons of Fuel (per day)	Gallons of Fuel (per month)	Gallons of Fuel (per year)	Emissions Reduced (tons/year)	Value of Fuel ($/yr) at $2.85/gal
0.774	50%	19.053	590.644	7,087.73	17.719	**$ 20,200.03**
0.809	50%	19.922	617.588	7,410.82	18.527	**$ 21,120.84**









Overview

A study was undertaken at a US Gasoline Dispensing Facility located in Federal Way, Washington. The primary purpose of this study was to quantify gasoline storage tank evaporative emissions. These emissions are comprised of both vent emissions escaping through a pressure/vacuum (p/v) valve and fugitive emissions, which may be emitted anywhere within the storage tank hardware, fuel dispensers, nozzles and vapor piping system. Two secondary goals of this study were to compare the total measured evaporative losses with the hydrocarbon losses estimated by ARID's proprietary Evaporative Loss Model (ELM), and to assess the impact of elevated storage tank pressures on fugitive emissions for a site passing the standard leak decay test.

Approach

ARID supplied an American Meter AC-250 dry gas flow meter equipped with a pulse counter for recording direct measurements of vent line emissions (Figure 9 for technical specifications and other details on the meter). ARID also supplied our sensors and remote data acquisition gear (ARIDAS – ARID Data Acquisition System. Figure 10 to 12). This equipment includes an ambient temperature sensor, an atmospheric pressure sensor, and a tank pressure sensor. In addition, a modem is included which allows remote data acquisition for monitoring data in real-time and for downloading batches of data at various time intervals.

The AC-250 dry gas meter and ARIDAS sensors were mounted on the vapor vent line as seen in Figure 1. The modem and power supply for the ARIDAS equipment were mounted inside the kiosk at the site.

Total Evaporative losses are equal to the measured vent emissions plus the fugitive emissions. The fugitive emissions, in-turn are a function of the average storage tank pressure. Therefore, ARID applied a CARB correlation for estimating the fugitive component of the total emissions based on the average pressure data collected by our equipment. (For a station passing a standard 2 inch pressure decay test, there are still allowed leakages).

To check the accuracy of the fugitive correlation, we wanted to make a more direct measurement of the fugitive emissions. One straightforward means to accomplish this is to simply reduce the back pressure on the storage tank system. Since the storage tank pressure will be reduced, the flow through various fugitive leak sources will in-turn be reduced, and the fugitive emissions will then be preferentially directed through the meter and be readily measured.

If one assumes that the Total Evaporative Loss rate is relatively constant (with variables such as temperature, RVP, A/L ratio, ORVR penetration, and throughput being held approximately the same), the measured vent emissions will increase and the fugitive emissions will decrease. By reducing the back pressure on the storage tank system, we did not add any incremental emissions to the environment; we simply re-directed a larger proportion of the “fugitive losses” through our meter for direct measurement.

This is pioneering work, and by making direct measurements, we have very accurately quantified the total evaporative losses at this site. Previous attempts at such emissions studies have relied upon sophisticated air dilution schemes to indirectly process a portion of vent emissions through a complicated sampling train of sensors and flow meters, with questionable results.

Results

The equipment was installed and operational at the Federal Way site on 9 October 2009, and the test equipment was removed from the site on 18 December 2009. The pulse counter on the AC-250 meter yields one pulse for each cubic foot per minute of vapor flow. We stored one minute averages on the pulse counter, and during our 70 day test interval, we accumulated 100,600 pulse count data points. On the tank pressure, ambient temperature and atmospheric pressure data logger, we recorded data every 4 seconds and stored 2 minute averages; thus, ARID accumulated 50,300 data points for each sensor.

The US Gasoline Dispensing Facility is a Stage II vacuum-assisted site with 16 refueling points (Eight Dispensers). From 9 October through 20 November, we collected data with a standard p/v valve on the outlet of the AC-250 meter. This configuration resulted in a relatively high average storage tank pressure of 3.343 inches water column – Case 1. On 20 November, we installed a ball valve between the standard p/v valve and the flow meter outlet. Between 20 November and 18 December 2009, the average storage tank pressure measured 0.592 inches water column – Case 2. The average ambient temperatures were 51 degrees Fahrenheit and 40 degrees Fahrenheit for Case 1 and Case 2 intervals, respectively.

The storage tank pressure profiles are presented in Figures 2 and 4 for each case. The storage tank pressure data were used as inputs into the CARB correlation for fugitive emissions; these charts are presented in Figures 3 and 5. The concept is to generate a pressure interval chart, where times at certain pressure intervals are quantified and then used as inputs into the CARB correlation matrix.

The fugitive emissions for each case using the pressure data and CARB correlation were:

Case 1: 0.270 cfm (cubic feet per minute of vapor flow)
Case 2: 0.111 cfm

(see footnote)

The measured vent emissions from the pulse count data were as follows:

Case 1: 0.5038 cfm
Case 2: 0.6983 cfm

(The raw pulse count data is available in spreadsheet format – about 10 MB.)

Thus, the total evaporative emissions for each Case are equal to the sum of vent and fugitive emissions:

Case 1: Total Evaporative Emissions = 0.5038 + 0.270 = 0.7738 cfm
Case 2: Total Evaporative Emissions = 0.6983 + 0.111 = 0.8093 cfm

Footnote

First, to correct the leak rate from 3.343 to .592 inches water; apply the square root of the differential pressures; so SQRT (3.343/.592) = 2.37. (This ratio is from combining Bernoulli equation with Continuity equation, to yield following equation, m = A * SQRT(2 * P atm/RT* (P tank - Patm)); which calculates mass flux through hole of Cross sectional area A as a function of P atm (atmospheric pressure), T, Temperature, and Tank Pressure, P tank). Thus, the actual ratio of fugitive leak rates is 0.27/0.111 = 2.43. Thus, the ratio shows good agreement 2.37 vs. 2.43, within 2.5%, and therefore the data collection appears very accurate.

Discussion of Results

The two cases yield very close agreement, within about 4.5%. Upon further study of this result, an on-going emission rate of 0.8 cfm means that 8,617 gallons of gasoline vapor are emitted from a site passing the standard leak decay test each day. If one assumes fugitive emissions from Case 1 (normal case with Stage II and p/v valves in use) comprise about (.27/.77) or 35% of the total emissions; then roughly (.35*8,617) or 3,016 gallons of gasoline vapor per day are being emitted from a "tight" site at numerous point sources. Of particular concern, a large portion of these fugitive emissions may be released below grade, eventually condensing and finding their way into groundwater. The equivalent liquid fuel volume lost from fugitive emissions for this case is equal to about 7 gallons of liquid gasoline per day (Total liquid fuel losses average about 20 gallons of liquid gasoline per day). Again, these emissions are for a "tight site", passing the standard 2 inch water column pressure decay test.

As seen in Figure 2 for Case 1, the storage tank pressure exceeds +2.51 inches H2O for 91.33% of the time. The impact of elevated pressures on fugitive emissions is significant. By reducing the backpressure with the ball valve, we have shown that the "fugitive" emissions predicted with the pressure correlation are accurately measured as "vent" emissions. Furthermore, the p/v valve does not "magically stop total evaporative emissions"; it simply reduces a portion of vent emissions, while at the same time increasing fugitive emissions w/in the vapor piping of the facility.

Figure 6 presents summary data for Case 1 and Case 2; showing monthly fuel loss of 591 gallons and 618 gallons, respectively. With the use of a vapor processor such as ARID's PERMEATOR, the annual fuel savings are equivalent to 7,088 gallons and 7,411 gallons for Case 1 and Case 2, respectively. In addition, the reduction of emissions with a vapor processor will yield savings of 17.72 and 18.53 tons per year for each case, with an annual fuel savings of approximately $20,200 and $21,120 for Case 1 and Case 2, respectively with fuel price of $2.85/gal.

ARID's Evaporative Loss Model (ELM) is presented in Figure 7 and 8. With inputs as shown, fuel savings of 22.83 gallons per day are tabulated. This figure is within about 3 gallons or 15% of the average measured value. Key inputs into the ELM include gasoline throughput, gasoline storage tank temperature, A/L ratio of Stage II system (sometimes referred to as "V/L ratio"), fuel RVP (Reid Vapor Pressure), and altitude of the fueling station.

Gasoline Throughput Over Test Interval and more detailed figures are available on request. Please use the contact form to get in touch with the author of this article.

Ted Tiberi is founder and President of ARID Technologies, Inc. He has a B.S. in chemical engineering from Penn State University and a Masters in Management from Northwestern University's Kellogg Graduate School of Management. He has twenty five years of experience in air pollution control and vapor recovery technology, and he is the author or co-author of several U.S Patents.