6th International Symposium on Advances in Science and Technology
SASTech
Malaysia | Kuala Lumpur
24 - 25 March, 2012
Scope of the Symposium
Organised by:
Khavaran Institute of Higher Education
Hosted by:
Geospatial Association of South East Asia

Evaluation of the gasoline evaporative losses rate and techno-economical and environmental Comparison of the environmental of the VRU for recovery of volatile vapors emission from chosen gas stations in Tehran

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Paper ref. code: 6-18-12-600

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Abstract

Necessity of Gasoline vapors reduction is clear for every one concerning adverse effects of Gasoline vapors inhalation on human condition and environmental threats from diffusion of them in Atmosphere. Furthermore, reclamation of gasoline vapor will be valuable economically concerning high costs of gasoline production and importation and anomalous consumption of this strategic product in country .Gas stations are one of main diffusion sources of these compounds which are more important because of their establishment in residential areas and civic populous zones. In this research considering important role of gas stations in pollutants diffusion , BTX rate of ventilation pipes output of ground tanks which are more dominant with diffusion part , was measured in Tehran gas stations of numbers 16,26,12,22,28,29 in two different seasons (warm season &cold season) then control ways were introduced to stoppage of evaporation and pollutants diffusion and they were performed in gas station No.29 as a pilot project. Primary studies showed that in warm season average rate of BTX evaporation from tanks was about 415-580 ppm which was higher than standard level and diffused high concentration of pollutants to the environment .Also in cold season average rate of BTX evaporation from tanks was about 222-320 ppm. Gasoline evaporation and pollutants diffusion from ventilation pipes output of ground tanks were reduced about% 95-99

after performance of control stage I. After studying and comparing different types of gasoline vapor reclamation systems, Refrigeration reclamation system was introduced as a favored system in Iran to reproduction of liquid gasoline. With implementing this project and vapors reclamation, in addition to stoppage of vapors diffusion , you will save 180.000.000 Tomans daily economically.

Key words: Gasoline's vapor; Gasoline stations; Emission; Recovery

1. Introduction

Gasoline is a compound of different Hydrocarbons and its vaporization will result in emitting the different kinds of VOCs in atmosphere. Side effects of the compounds are:

1. Physiological effects

1.1. Acute effects

Acute effects in significant concentrations are as below: irritation of eyes, nose and throat, reaction of central nervous system such as confusion, headache and loss of short term memory. These irritations indicate that VOCs first affect on respiratory system- which is more sensitive than other organs- due to gaseous state of VOCs. (EPA. 1993, Blomen H.J.TH., Burn J. 1999).

1.2. Chronic effects

Some VOCs will certainly result in cancer (such as Benzene, Vinyl Chloride etc.)

Although some other VOCs are causing cancer among animals but it's not definite that these compounds are causing cancer among humans and cautionary actions are advised about them (such as Methylene Chloride, Xylene, Toluene, Tri Chloro Ethylene etc.) A group of VOCs are causing genetic jump and birth of incomplete babies (such as Nitro Propane, Propylene Oxide, Ethylene Oxide, Formaldehyde etc.) (EPA.1993, Blomen H.J.TH., Burn J. 1999).

2. Environmental Effects

2.1. Photochemical smog

In the 1950s, role of VOCs was recognized in forming the photochemical smog for the first time. Olphines, Aromatic Hydrocarbons, Aldehydes and Tri Methyl Benzene have the effect in the process. Methane and Alkyles have the least effect in photochemical smog process (Blomen H.J.TH., Burn J. 1999).

2.2. Acid rains

Hydroxyl Radical – which is an active component of photochemical smog process – is an agent for converting Nitrogen Di Oxide to gaseous Nitric Acid and Sulfur Di Oxide to Sulfur Tri Oxide. Eventually Acidic Aerosols will be produced and Acid rain will fall. (Nijmeijer A., 2001).

2.3. Global climate change

In addition to produce the photochemical smog and acid rains, VOCs will cause to destroy the stratospheric ozone layer and create the global warming phenomenon(Blomen H.J.TH., Burn J. 1999).

In addition to the environmental risks, according to the high expenses of producing and importing of gasoline, It's evaporation losses will cause to significant economic losses in Iran.

3. Emission locations of gasoline vapor in the gasoline stations

Fuel stations are the most important sources of VOCs emissions that have been considered in this research because of their location in residential and dense urban places. Emission locations of gasoline vapor in the gasoline stations are as below:

3.1. Output vent pipes from ground storages

3.1.1. Vapor emission at the time of tank discharge into storage

Ground storages have contact with atmosphere via a vent pipe. At the time of gasoline discharge from tank into ground storage, mixture of vapor and ground storage's air will be conducted to the atmosphere by the pipe. If there is no vent pipe in the system, additional pressure at the time of pouring gasoline to the storage and vacuum at the time of storage discharge will be created. This increase and decrease of pressure can cause explosion and snuggle of the storage. Output gas volume from vent pipe equals to gasoline volume that flows in ground storage (volume balance). The gas contains significant gasoline vapor (VOCs). The gasoline vapor which flows in atmosphere along with vent pipe's output gas, is named "gasoline vapor loss at the time of loading". (Nevers.N. 2000).

3.1.2. Vapor emission during day (ground storage's breathing vaporization)

According to increase of temperature during day and its decrease during night, expansion and contraction in liquid and vapor of storage well be created that the process will result in producing vapor which is named "breathing vaporization". During this process at the time of decrease of temperature, air will flow in the storage and will produce vapor (inspiration at night). At the time of increase of temperature, produced vapor in storage will be emitted into out (expiration at day). (Nevers.N. 2000).

3.2. Emission at the time of automobile fueling

With flowing gasoline into automobile gasoline's storage, air that is saturated with gasoline vapor (in automobile gasoline's storage) will flow to atmosphere. This emission is named "Vaporization loss at the time of automobile fueling"(Gene P. 2011). These vapors at saturated state are similar to output vapors of storage vent pipes, with considering their concentration.

3.3. Emission from ground storages

Vapors from ground storages are emitting from head of Dip pipe and fine holes of storage's surface, but it's amount is low. It can be mentioned that exfiltration – which occurs due to technical problems of fuel storages of trucks - would be resulted in emitting the significant amount of VOCs. (Nevers.N. 2000).

4. Methods for control, decrease and recovery of gasoline vapor

4.1. Stage 1

In order to prevent gasoline vapor escape from vent pipes with establishing a back line of the vapor between ground storage and oil tanker and establishment P&V valves on the output of vent pipes, it's possible to prevent vapors from escaping to atmosphere. So the vapors will be conducted to the tanker. (Zink J., 2001. and Gene P., 2011).

4.2. Stage 2

In order to prevent vapors from emitting – which have been produced in the automobile gasoline's storage – at the time of fueling, nozzles have been used. Because of pressure difference and using suction pump at the time of fuel discharge, vapors in the automobile gasoline's storage will be conducted to the ground storage by back line and after that, will be moved to the fuel tanker. (Zink J. 2001, Freda F. and Maxwell B. 2011 and Gene P., 2011).

4.3. Waterproofing of ground storages and oil tankers

4.4. Gasoline vapor recovery

According to gasoline vapor recovery with amount of 1.5-2.5 liter liquid gasoline (from 1000 liter mixture of saturated vapor and air) after finishing the discharge of tanker into storage, the tanker that contains vapors, will return to ground storage and for reloading, these vapors must be discharged (volume balance) and would be conducted to Vapor Recovery Unit (VRU) by a line. In this system, gasoline vapor would be converted to liquid gasoline. (Zink J., 2001, 10-German J., Eni Dacion B.V. 2008).

Typical systems of gasoline vapor recovery are as below:

4.4.1. Refrigeration recovery system

These systems remove organic vapor by making them condense on cold surfaces. These cold conditions can be created by passing cold water through an indirect heat exchanger, by spraying cold liquid into an open chamber with the gas stream, by using a Freon-based refrigerant to create very cold coils, or by injecting cryogenic gases such as liquid nitrogen into the gas stream. The concentration of VOCs is reduced to the level equivalent to the vapor pressures of the compounds at the operating temperature. Condensation and refrigeration systems are usually used on high concentration, low gas flow rate sources. Typical applications include gasoline loading terminals and

chemical reaction vessels. The removal efficiencies attainable with this approach depend strongly on the outlet gas temperature. For cold-water-based condensation systems, the outlet gas temperature is usually in the 40 to 50 F degree, range. The VOC removal efficiencies are in the 90 to 99 percent range depending on the vapor pressures of the specific compounds. For refrigerant and cryogenic systems, the removal efficiencies can be considerably above 99 percent due to the extremely low vapor pressures of essentially all VOC compounds at the very low operating temperatures of -70 F degree to less than -200 F degree. (EPA 2010).

4.4.2. Membrane recovery system

In this method, mixture of air and vapor after passing from Flam Arrestor flow into compressor and its pressure would reach to 2 bar and after that flows into scrubber tower. In the tower, vapor flows against the gasoline shower's direction – which has a lower temperature – and would absorb to the liquid gasoline and flows out of the tower (from under the tower) and would be recovered. In this method, determination of recovered gasoline amount is not possible due to mixing of washer and cooler gasoline with vapor. On the other hand, some of gasoline vapors which hasn't been absorb in the tower along with air flow into membrane unit and membrane plates act so that heavier hydrocarbons molecules pass through them but lighter molecules such as air don't pass through them. Therefore, air after passing through a pressure control valve would be discharged into the free air and gasoline vapors which aren't separated in the membrane, will be conducted to the input of the system again and would repeat the cycle again (I. Echt W. 2008 Nijmeijer A.2001).

4.4.3. Activated carbon recovery system

In this method, mixture of air and vapor after passing through strainer (which liquids would be separated in it) flow in one of two activated carbon towers and gasoline vapor molecules would be adsorbed in the carbon surface. Treated air would be discharged into the atmosphere and at the same time in the another tower, gasoline molecules which that have been adsorbed in the carbon, previously would be separated from the carbon surface by vacuum pump and conducted to the scrubber tower.

In the tower, gasoline vapor's stream in the opposite direction of liquid gasoline shower would move and be absorbed in it and then, will return to the main storage. Recovered gasoline is as a mixture with liquid gasoline stream and measurement of recovered gasoline is not possible, easily. Some of gasoline vapors which haven't been adsorbed in the tower would be conducted to the beginning of the cycle along with air. (Zink J., 2001).

In one of the gasoline stations in Tehran (gasoline station No. 29 on Satar Khan St. of Tehran due to daily selling of 100000 liter and people who complained because of vapor's bad odor) for preventing the emission of gasoline discharge vapors from tanker to ground storage, stage 1 was performed in it. It's stages are as following:

Score weight	Item	Type		
		Membrane	Activated Carbon	Refrigeration
2	Required area	2	1	1
4	Skilled Person	3	3	4
6	Safety	6	4	5
7	Elec. Power Cons.(Kw)	5	7	6
5	Over Load Capacity	3	3	5
6	Media Long Life	3	3	5
5	Temperature Sensitivity	3	4	2
5	Humidity Sensitivity	5	5	4
6	Output Gasoline Quality	5	5	4
8	Output Air Quality	7	6	5
8	Wastes Generated	6	5	7
6	Initial Cost	4	4	6
6	Running Cost	5	5	5
5	Maintenance Cost	4	4	5
7	home made	3	5	6
8	VOC Control Efficiency	7	6	5
6	Ability of Recovery of Various Vapors	4	4	5
100	Total Score	75	74	80

Table 1. Selecting the required devices.

5. Selecting the required devices

Required devices are as following: Pressure and Vacuum valves, pipes with 3 inches diameter, for vapor transferring: a hose connected to the dry coupling. To the storage vapor collection system: manometer (-60 to +100 mbar), VOC meter.

6.Methods

- Pipe installation from ground storage to vent pipes.
- Installation of P&V valves on the outlet vent pipes in order to prevent vapors from escaping from the system. (these pipes prevent vapors from escaping at most 15 mbar and at the time of pressure increase in the system, would discharge vapors to the atmosphere).
- Installation of the vapor collection lines from storage to vapor discharge basin.
- Installation of vapor discharge hose connected to the dry coupling for transfering the collected vapor from system to the tank.
- Equiping the oil tanker by vapor collection system (including: vapor valve, bleeder vavle, pneumatic hoses and vapor collector pipe.
- Installation of manometers for monitoring the pressure in system.
- By using gas meter - for vocs (Benzene, Toluene, Xylene and TVOC) - vapors released from output

  vent pipes of ground storages in five gasoline stations and pilot station (gasoline station No. 29) in active and inactive control system in both warm and cold season, were measured.

7. Results

The date suggest that the evaporation of gasoline and emission of vapor is more in the warm seasons. After performing Stage 1, vapor emissions (VOCs) into the atmosphere when discharging the carrying tanker, were measured. It was observed that ground storage (tank equipped with vapor collection system) and respiratory reduced 90-95 %
(according to table 1).The results of people surrveys indicate that 87 percent of neighborhood residents and complainers, who believe that use of tankers to be equipped with control system, up to a significant odor reduction.

8. Conclusion

The study shows that the vapor produced in three stage:

1. Tanker loading at the gasoline warehouse.
2. Discharging of carrying tanker to the ground storage in gasoline station.
3. Transport gasoline to fuel cars.

The daily evaporation loss is foreseeable 36000 liters of gasoline. (1.5-2.5 liters of fluid per 1000 liters of gasoline vapor and air mixture can be obtained) it is noteworthy that 1000 liters of gasoline – air mixture is equivalent 1000 liters gasoline of displacement.(volume balance)
[(3×60milion liters×2 liters)÷1000]=360000 liters per day

With control system (stage 1 , 2) the gasoline vapor collection, guided and transfered to a refrigeration vapor recovery unit (according to table 2) not only prevents the release of vapors to the environment, but the vapor be recycled, has economic saving. given that every liter of

gasoline cost about 500 toman to reach the consumer, are expected daily 180 milion $ to create return on investment.

Acknowledgements

The authors gratefully acknowledge the support of Mr "Seyed Shaho Ahmadi Dehrashid" for his cooperation in this research.

References:

- Blomen H.J.TH., Burn J. (1999), "Volatile Organic Compounds in the Environment *Butch Institute of Public Health and Environmental Protection,Blackie Academic Professional*.

- EPA. (1993), "In Targeted Risk Information System on Benzene ", Environmental Criteria and Assessment Office, *Cincinati, OH*. P: 831-842.

- EPA(2010), Module6:air pollutant and control techniques-vocs-control techniques,

- Freda F. and Maxwell B. (2011) onboard refueling vapor recovery evaluation of the ORVR program in the united states.

- Gene P., (2011) EPA action to increase benzene emissions beginning in 2013.
-German J., Eni Dacion B.V.(2008) vapour recovery unit-an environmentally friendly business.
- I. Echt W.(2008) integration of membranes into natural gas process schemes
- Nevers.N. (2000),"Air Pollution Control Engineering", *MC Graw-Will*.P:228-289.

- Nijmeijer A., (2001), Shell Global Solution, Current Status of Membrane Development for Gas Separation.

- Zink J., (2001), John Zink Carbon Active Adsorption Vapor Recovery System, John Zink Company LLC, 05-1593.