台灣加油站揮發性有機物（VOC）減量控制

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摘　要

因為國內汽車數量的快速成長趨勢，未來台灣地區計需要有 1,947 座加油站來滿足燃料供應需求。台灣地區加油站揮發性有機物（VOC）排放量約為每年 21,000 噸，它佔台灣地區 1999 年非甲烷 VOCs 總排放量 802,000 噸的 2.62%。這些 VOCs 包括苯、甲苯、…等。它們大部分都是有毒空氣污染物。因此，為了保護人類的身體健康與地球的乾淨環境，減少加油站 VOCs 的排放量是人類生活中最重要的行動之一。

本研究使用了一個重要而且有效的方法，來削減加油站的 VOCs 排放量。這個方法叫「洩漏、偵測、及修護」法。然後用一個被成功發展出來的計算模式來計算加油站 VOCs 的排放量。本研究隨機選取 9 個樣本加油站，來以「洩漏、偵測、及修護」法進行檢測。加油站的 VOCs 排放量然後可以分成兩個部分計算。第一部份可以使用加油站的檢測結果計算獲得。第二部分則使用美國環保署所發展出來的 AP-42 理論排放量計算獲得。

本研究的 9 個加油站 257 支加油槍，從第一部份及第二部分計算所得到的 VOCs 總排放量為每年 81.49438 噸。對於車輛加油操作過程，從第一部份計算所得到的 VOCs 總減側排放量則為每年 3.48505 噸。最後，當加油站業者完成了加油站的空氣污染改善工作，而且「洩漏、偵測、及修護」法的第二次檢測工作也被完成後，加油站使用「洩漏、偵測、及修護」法所獲得的減量就可以被求得。

關鍵詞：排放量，揮發性有機物，洩漏、偵測、及修護，環保署

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Volatile Organic Compounds (VOC) Reduction Control of Gas Station in Taiwan

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Abstract

Due to rapid increase of cars, more gas stations are urgently needed to provide more fuel. The 1974 gas stations in Taiwan are expected to have a rapid growth in the near future. The total emission of volatile organic compound (VOC) volume is 21,000 ton per year, which is 2.62% of the non-methane VOCs of the year 1999. These compounds include benzene, methylbenzene etc, where most of them are hazardous air pollutant. Thus, decreasing of emission of VOCs from gas station is an important camp to protect human health and a clean environment of the earth.

The research used an important and effective method to reduce the emission of VOCs from gas station, which called “emission, detection and reparation”. A computing model is then being developed to calculate the volume of VOCs. This study selected 9 samples gas station to implement the “Leakage, detection and reparation” (LDAR) process and calculate with two methods, where the first used the inspection method from the gas station, and the second applied AP-43 theory from Environmental Protection Agency (EPA), USA.

The 257 refueling guns from the 9 gas stations resulted a total VOCs emission of 81.49438 ton per year from the first and second method. While the emission during the refueling using the first method is 3.48505 ton per year. Finally, the volume reduced of the method can be calculated, after the gas station dealers have improved the air pollution, and applied the “LDAR” method for the second inspection.

Keywords: Emission, Volatile Organic Compound, Leakage, Detection, and Reparation, Environmental Protection Agency

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Introduction

Ozone (O_3) has become the main index of pollution for air quality in local research. Ozone is the result of a complicated photochemical reaction between Nitrates (NOx) and volatile organic compounds (VOCs). In order to reduce the pollution from ozone, both NOx and VOCs have to be controlled. Nevertheless, the harmful air pollutants (HAPs) within the VOCs are yet another important issue. Thus, a deep understanding of the source and quantity of VOCs are needed to pursue a camping for controlling of air pollution.

Gas station is known to be one of the main sources of emission. An estimate from AP-42 emission index shows 21,000 tons per year of VOCs in Taiwan, which is almost 2.62% of 80,200 tons of Non-MetylHydrocarbonate (NMHC) of the year 1999. Under the catalyst of sunlight, these VOCs will react with the NOx in the air and result in Ozone.

Gas stations have been rapidly increased since the privatization of fuel business. Cars are also increase in the other way due to higher living standard, which further result in more rapid increase of gas stations because of the needs. The air quality will be affected shortly if there is no effective method to control the emission of VOCs.

In order to enforce the improvement of environmental air quality, Environmental Protection Agency (EPA), Taiwan, has introduced a gas station emissions recycle system. A 66% of implementations have been achieved within Taoyuan County before the subsidy campaign in Mar 2000, and more then 90% by the end of 2000 under aggressive campaign of Taoyuan Environmental Protection Agency.

Although the government has not announced anything regarding VOCs emission standard and control of gas station, Taiwan EPA has issued some related VOCs control decree, such as: “ The VOCs air pollution control and emission standard”, “artificial leather industry VOCs control and emission standard” and “Semiconductor manufacturing air pollution control and emission standard”.

VOCs is known as the organic compounds of more than 0.1mmHg under the standard atmosphere 20^{o}C, 70mmHg. VOCs emission from the gas station is normally metyl with less then 8 carbons. They will perform a photochemical reaction with NOx in the atmosphere to produce strong oxidized materials, which is the main cause of ozone and photochemical compounds pollution. The concentration of ozone will increase or become Peroxy Acetyl Nitrate (PAN) or Peroxy Benzoyl Nitrate (PBN). Since most of the VOCs are toxic or carcinogenic, they are categorized to be a major of toxic air pollutants (TAPs). The 1990 Clean Air Act Amendment (CAAA) of America has listed many of the VOCs to be TAPs, such as: tetrachloro-ethylene, benzene and dimethylbenzene. The “Standard allowable toxic concentration under labor operating environment” which issued by Taiwan Council of Labor Affair also shows that most of the components are VOCs. Furthermore, a “Organic solution

poisoning precautionary rule” has also been issued, which also show the severe harm of VOCs to the environment and our health, especially to those gas stations within the metropolitan, where higher populations are located. Thus, a control to VOCs has become one of the indispensable issue to every environmental department of the local government.

Instead of achieving a 100% installation of vacuum secondary gas recollection refueling gun, more can be done to enforce the prevention of air pollution by gas stations, such as: the total application of gas recycle system and the maintenance of gas recycle system. This research tends to study the management of VOCs by the gas station, in order to provide a reference and technique to reduce the emission of VOCs effectively.

Gas recycle system for gas station

1. Relation between the total hydro-carbonate compounds emission country wise and the gas station

Gas station is one of the main emission sources of VOCs. According to the estimation by America EPA AP-42 emission index, the VOCs emission within Taiwan is about 21,000 tons per year, which is 2.62% of the total emission of non-methane hydro-carbonate compounds of 80,200 tons per year. The relation between VOCs emission of gas station and other business is shown in Fig. 1. The VOCs emission from the gas stations will perform a photochemical reaction with NOx under the catalyze of sunlight to generate Ozone, which will cause great harm to human body as well as the environment.

2. Gas recycle system

Gas recycle system is divided into 2 stages. The first stage is used to recollect the gas emission during fuel discharging from tanker to the fuel tank in the gas station. While the second stage is used to recollect gas emission during refuel to the cars.

The existing system used for the second stage is the vacuum secondary refueling guns recycle system. The vacuum secondary refueling guns recycle system used a secondary external power to re-collect the emissions during gas refueling back to the fuel tank. This system can either work with or without a back end treatment facility. Table 1[2] shows the comparison and characteristics among the vacuum secondary refueling guns recycle system.

The back end treatment facility being used is a combustion tower. The technical effect of the model is part of our study.

3. The implementation result of gas recycle system in refueling guns

There are 1974 gas stations recorded in Taiwan, where 209 are listed within Taoyuan county, which is 10.59% of the total gas stations and the highest among all the counties. 188 gas stations, or 90%, have installed the gas recycle system, which 187 of them are subsidized by the government. Table 2[3] shows the gas recycle system in each county.

Method to study

1. Calculation of VOCs emission and reduction from gas station

Currently, there were no VOCs emission records of all the gas station according to the EPA-97 database from the 8 counties in north Taiwan. In order to justify the exact result of the VOCs reduction from gas stations, it is important to calculate the VOCs emission before and after the implementation.

We have developed a VOCs emission estimation model base on an “actual value”, in order to control the total VOCs emission, and hence to reduce the VOCs emission.

This model has been used by Taiwan EPA on 8 counties in north Taiwan in a project called “North area air quality improvement project”(project code: EPA-89-FA13-03-056) during Jul 1999 ~ Dec 2000. Three seminars have been held at KeeLung city (2 May 2000), HsinChu city (30 May 2000) and Taipei city (19 Sep 2000) respectively regarding the “Technical seminar for reducing VOCs emission by gas stations”. The method propose at the seminars are “Leakage, detection and reparation” (LDAR). Below is the rules for the method:

- Definition for leakage and emission standard:
  - A. America EPA AP-42 emission index:
    - i) Diffusion of VOCs by gas station should include fuel discharging, fuel tank respiratory process, refueling and fuel splashing.
    - ii) Diffusion of VOCs per liter of gasoline is 2,400mg.
    - iii) Emission of each item is shown in Table 3.
  - B. If the refueling gun is taken as an “opening valve of a petrol-chemical equipment“, the defined leakage value is: net inspection value greater or equal to 10,000ppm.
  - C. the condenser recycle system tank in the gas station will be defined as a non-destructive recycle treatment, as define by the “listed tank in the petrol-chemical business”, where the VOCs emission limit is 300ppm.
  - D. The “vent” in the fuel combustion tower in the gas station is define as a destructive recycle treatment, as define by the “listed tank in the petrol-chemical business”, where the official reduction of VOCs should be

greater or equal to 95%.

- Technical effect:

  It is an aggressive method to apply “leakage, detection and reparation (LDAR)” project on all the air pollution preventive jobs for all gas station. By applying LDAR to all equipments in the petrol-chemical process, we can achieve a 60%[4,5] reduction of VOCs as stated in Table 4 and 5.

- Example:

  The energy technology center of Yuan-Ze University has perform a VOCs inspection in “gas station I in Kee Lung” on 2 May 2000. The results are as in Table 6:

  A. The gas recycles system technical effect for the station is 96.55%.
  B. The gas combustion tower technical effect for the station is 99.9995%.
  C. The diffusion concentration of VOCs for the refueling gun when no refueling process is performing still remains in a high level (6,542.77ppm ~ 7,203.72ppm). Possibly cause by:
     i) The quality of the refueling gun, or
     ii) The maintenance of the refueling gun is not thorough.
  D. The diffusion concentration of VOCs for the refueling gun during refueling process is 189.72ppm, 1,298.72ppm and 2,246.72ppm respectively. Which also shows an issue lying within the variance of quality for the gas recycle system.
  E. VOCs emission per year for each refueling gun can then be obtained by comparing the concentration of emission for each refueling guns and the total loading per year.

- Operation procedure:

  A. Model to calculate VOCs emission for gas station:

  $$E_t = E_{dis} + E_{res} + E_{ref} \text{ ----------(1)}$$

  in which E_t is total emission, E_{dis} is emission during discharging from tanker (emission coefficient), E_{res} is emission for tank respiratory (emission index), and E_{ref} is emission during refueling (inspection value) .

  B. FOXBORO TVA-1000B method[6]:
     i) Emission of refueling gun when not refueling: petrol-chemical process opening valve
     ii) Combustion tower: petrol-chemical process opening valve
     iii) Emission of refueling gun during refueling: petrol-chemical process pump
     iv) Vent for fuel tank: vent for petrol-chemical process tanks
  C. Model to calculate VOCs for gas station:

If all equipments in the gas station (refueling gun, combustion tower or fuel tank vent) are not qualified during the first inspection, a re-inspection will be performed:

VOCs reduction = Total VOCs emission before re-inspection – Total VOCs emission after re-inspection

2. Model to calculate the technical effect of gas recycle system in the gas station

A. Model to calculate the technical effect of gas recycle system in the gas refueling gun:

As defined in "Standard emission and VOCs air pollution control"[7] act 55, the reduction of VOCs should be:

$$R = [(E - E_o)/E] \times 100\% \text{ ----------(2)}$$

where

E = mass flow rate (Kg/hr) of VOCs before implementing pollution preventing equipments

E_o = mass flow rate (Kg/hr) of VOCs after implementing pollution preventing equipments.

Apply equation (2) to the refueling gun:

$$R_{\text{refueling gun}} = [E_{\text{refueling gun}} - E_{\text{o refueling gun}}] / E_{\text{refuling gun}} \text{ ----------(3)}$$

where

$E_{\text{refueling gun}}$ = Fuel tank VOCs detected concentration

$E_{\text{o refuling gun}}$ = VOCs detected concentration during refueling

Fuel tank VOCs detected concentration ($E_{\text{refueling gun}}$) is the VOCs emission value detected by using FOXBORO TVD-1000B when the fuel tank is open before refueling. While VOCs detected concentration during refueling is the VOCs emissions value detected at the refueling gun by using FOXBORO TVD-1000B under normal working of refueling gun and gas recycle system

B. Gas combustion tower technical effect:

According to equation (1), the technical effect for combustion tower is:

$$R_{\text{combustion tower}} = [E_{\text{recycled gas}} - E_{\text{combustion tower}}] / E_{\text{recycled gas}} \text{ -----(4)}$$

where

$E_{\text{recycled gas}}$ = VOCs concentration detected for recycle gas collected

$E_{\text{combustion tower}}$ = VOCs concentration detected at the exhaust of combustion tower

Results and Discussions

1. Results of practical measurement at gas station

The VOCs emission calculation model for gas station developed by the institute has

been successfully implemented in 9 gas stations at Tao Yuan county. Before the calculation, we have applied FOXBORO TVA-1000B FID flame ion detector at the 9 gas stations for practical measurement. The results from gas station A is shown in Table 7:

A. When no refueling process, ie. when gas recycle system is not working, the VOCs emission concentration for the refueling guns numbered 311/231/211/121 have all exceeded the standard emission of petrochemical process equipment opening valve, 10,000ppm, which has fully shown that the refueling guns were not maintained well. The dealer has to perform a thorough maintaining process immediately to avoid abnormal VOC emission.

B. During the refueling process, ie. when gas recycle system is working, the VOCs emission concentration for the refueling guns numbering 331/231/121 also exceeded the standard emission of petrochemical process equipment opening valve, 10,000ppm, which also shown that the gas recycle system didn't function properly and should be repaired immediately.

2. Results of emission calculation at gas station

In order to establish a standard VOCs emission calculation model, we have shown an example on how to work with gas station A as below:

A. Find out the greatest concentration measured from Table 7 during refueling, as shown in item 1 (92 non lead fuel) and 3 (95 non lead fuel), which is 1,147.56ppm and 99,999ppm respectively.

B. The emission of VOCs per year can be calculated by the average total fuel sold per month, which is 13.44170 ton per year as shown in Table 8.

3. Effectiveness analysis of recycle gas at gas station

A. According to America EPA AP-42 emission coefficient (as shown in Table 3), the VOCs emission coefficient for refueling 1 liter fuel when gas recycle system is working should be 132mg compare to 1,320mg without the gas recycle system. Thus, the theoretical technical effectiveness of the gas recycle system by using America EPA AP-42 emission coefficient is:

$$R_{\text{refueling gun}} = (1{,}320\text{-}132)/1{,}320 \times 100\% = 90\%$$

B. According to America EPA AP-42 emission coefficient, when the gas recycle system is working, the VOCs emission of 132mg will hold the total VOCs emission for the gas station 7 of:

$$132/(800+120+131+80) \times 100\% = 10.89\%$$

Fig 2 shows the relative AP-42 emission coefficient percentage between the sample and total of other gas stations.

C. The statistical results of the 9 gas stations in this study are shown in Table 9. According to the results: The total gas emission for the 257 refueling gun

during refueling is 3.48505 tons per year, which is 4.28% of the total emission. The result is less then that from the theoretical value of 10.89%, in other word, 0.39% of the theoretical value. The variance is mainly cause by the inspecting equipment – FOXBORO TVA-1000B, which has a limit of 99,999ppm, while the actual theoretical value during refueling is 300,000ppm, in other word 0.33% of the theoretical value, which is very close to the multiplication. Thus the result is considered highly represent. The total emission of the 9 sample gas station is 78.00933 ton per year, where the relative percentage with the refueling gun during refueling is shown in Fig 3.

D. The percentage of refueling gun of the types of fuel in Table 9 can be seen in Fig 4. 95 non-lead fuel has the largest portion of 33%, where 92 non-lead is 31%, 98 non-lead 25% and diesel of 11%.

E. The result in D of the percentage of refueling gun of the types of fuel where 95 and 92 non-lead fuel are the major also show the same result in the percentage of the total fuel sold as shown in Fig 5. The result met with the trend of needs for the type of fuel. Thus, the result of this study is valuable to the market.

F. Table 10 is the results analysis for the result from refueling guns detection. 92 non-lead refueling guns show the poorest maintenance condition. All of the 20 samples have exceeded the limitation of the gas emission in the petrochemical processes opening valve of 10,000ppm. This study also shows the percentage of the above problem for the refueling guns in Fig 6.

G. Table 10 also shows the worst non-functional gas recycle system in diesel refueling gun. All of the 4 samples have exceed the limitation of the gas emission in the petrochemical process pump of 100,000ppm. In the mean time, 75% of the gas recycle system installed in 95 non-lead refueling gun have also exceeded the limitation. This study shows the percentage of the non-functional gas recycle system for all type of refueling guns in Fig 7.

H. All the results in Table 10 can be compared and analyzed in Fig 8. All the Figures above have shown a serious problem of poor maintenance of refueling gun and non-functional gas recycle system. The problem has to be treated immediately in order to eliminate the VOCs emission and thus pollute our environment as well as human health.

I. This study have performed the practical inspection job for the 9 sample gas station, and issue a “Proposal for the VOCs pollution control” as shown in Table 8. The statistical results before and after the reforming can be compared and calculated the percentage of reduction for the VOCs.

4. Technical effectiveness calculation of the refueling gun gas recycle system and combustion tower

A. Since the practical detection for the 9 sample gas stations have exceeded the limitation of the inspection machine (FOXBORO TVA-1000B), we are not able to calculate the technical effectiveness of the gas recycle system for the refueling gun and the combustion tower by using equation (3) and (4). The results of the sample practical detection conducted on 2 May 2000 of "Gas station I in Keelung" is stated below:

i) Technical effectiveness of the gas recycle system for the refueling gun ($R_{refuling\ gun}$) by using equation (3) is stated as below:

a. E = VOCs concentration in the refueling tank = 37,633.72ppm

b. E_0 = VOCs concentration during refueling = 1,298.72ppm

c. $R_{refuling\ gun} = [E-E_0]/E \times 100\% = 96.55\%$

ii) Technical effectiveness of the combustion tower ($R_{combustion}$) by using equation (4) is stated as below:

a. E = VOCs concentration for gas recycle system
= 37,633.72 – 1298.72 = 36,335ppm

b. E_0 = VOCs concentration at the ventage of combustion tower
= 0.18ppm

c. $R_{combustion} = [E-E_0]/E \times 100\% = 99.9995\%$

Conclusions

The results of the 9 sample gas stations have shown the major problem as stated below:

A. The daily maintenance for the refueling gun is poor

B. The gas recycle system is not function properly

C. The maintenance for the combustion tower is poor

All these problem can be practically detected by using the "leakage, detection and repairing (LDAR)" method suggested in this study. By using the VOCs emission calculation model developed by this study, gas station dealer can be easily guided to reduced VOCs effectively. The results from this study should be conducted as soon as possible to all gas station.

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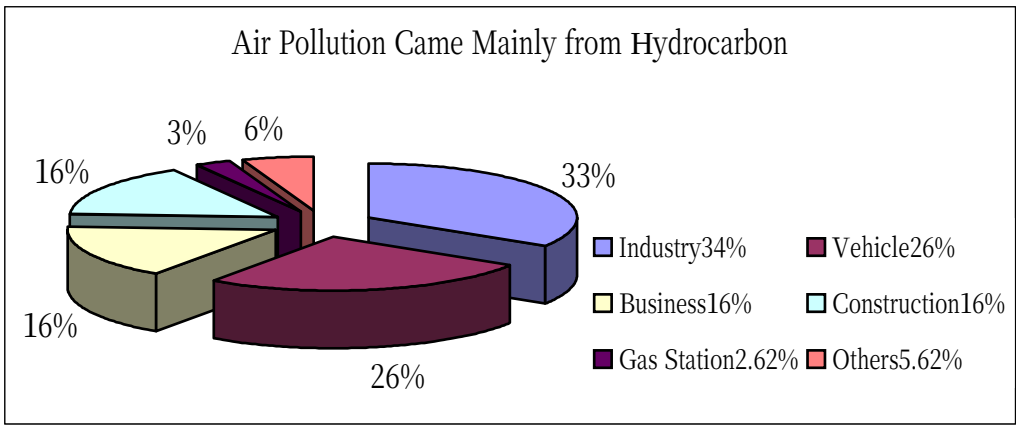

Fig. 1 Comparison table for emission of non-methane carbon hydrates compounds pollutants country wise for year 1999

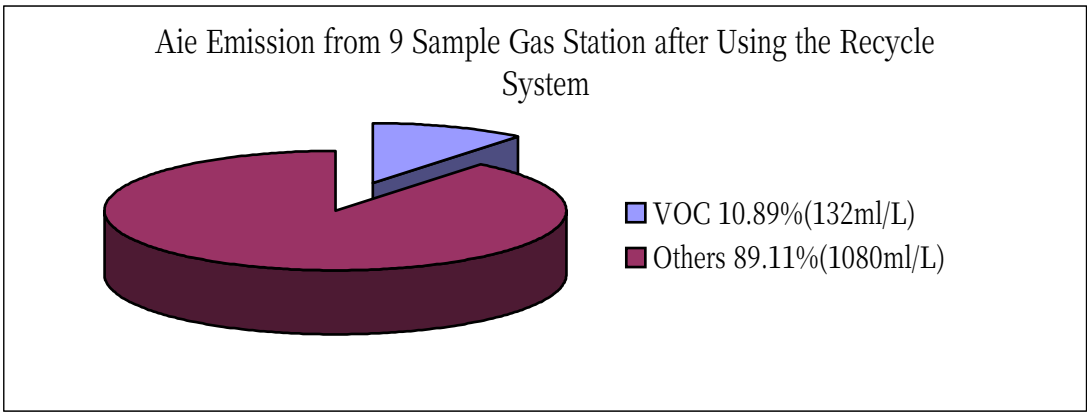

Fig. 2 Percentage of VOCs emissions for gas stations using gas recycle systems

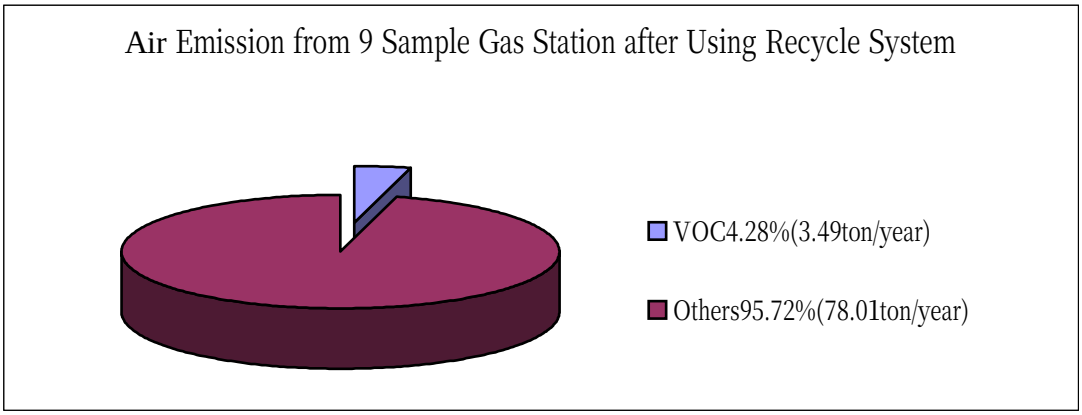

Fig. 3 Percentage of VOCs emissions for 9 sample gas stations using gas recycle systems – results of practical detection

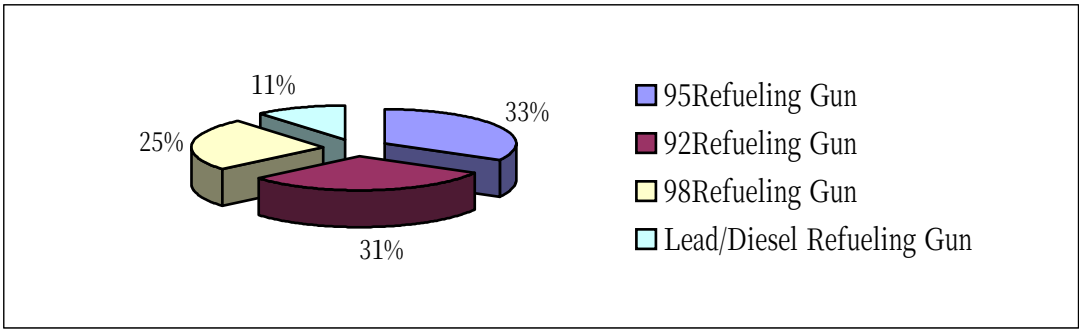

Fig. 4 Percentage of type of refueling guns for 9 sample gas stations

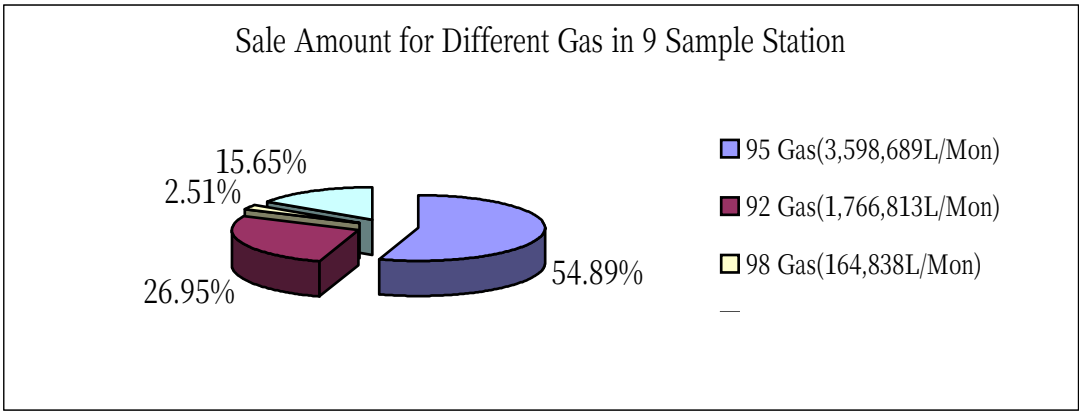

Fig. 5 Percentage of type of fuel sold for 9 sample gas stations

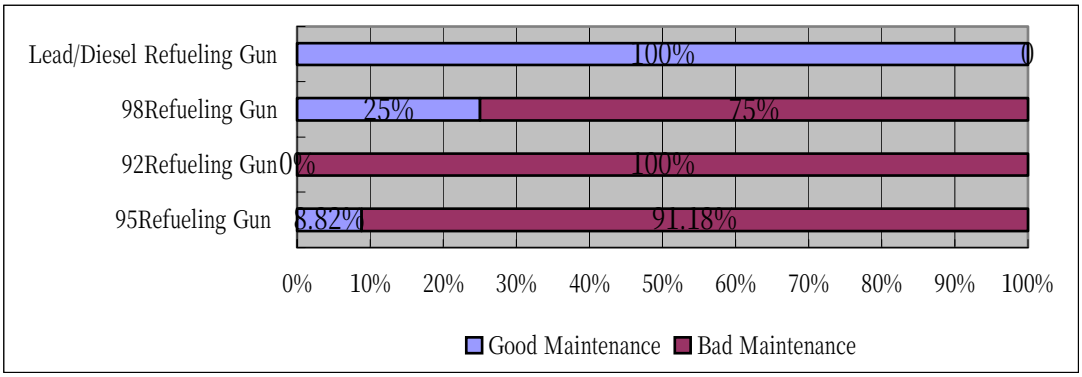

Fig. 6 Results 1 of percentage for detection of the refueling guns for 9 sample gas stations

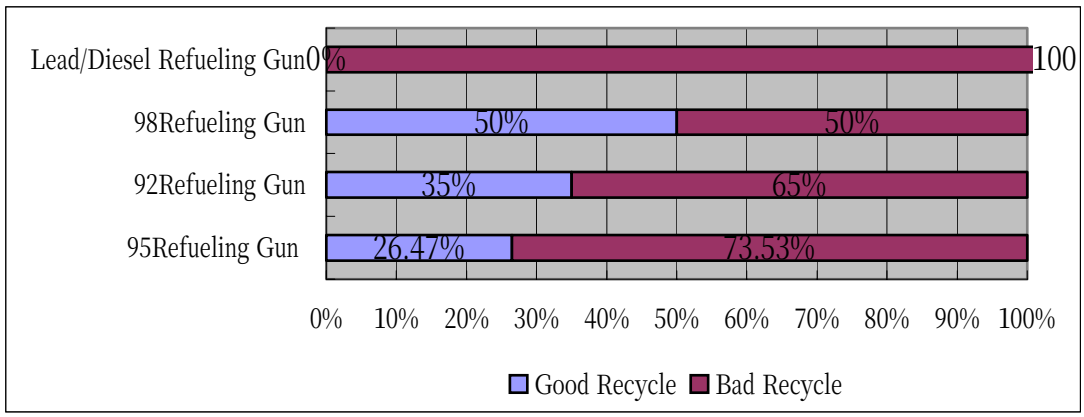

Fig. 7 Results 2 of percentage for detection of the refueling guns for 9 sample gas stations

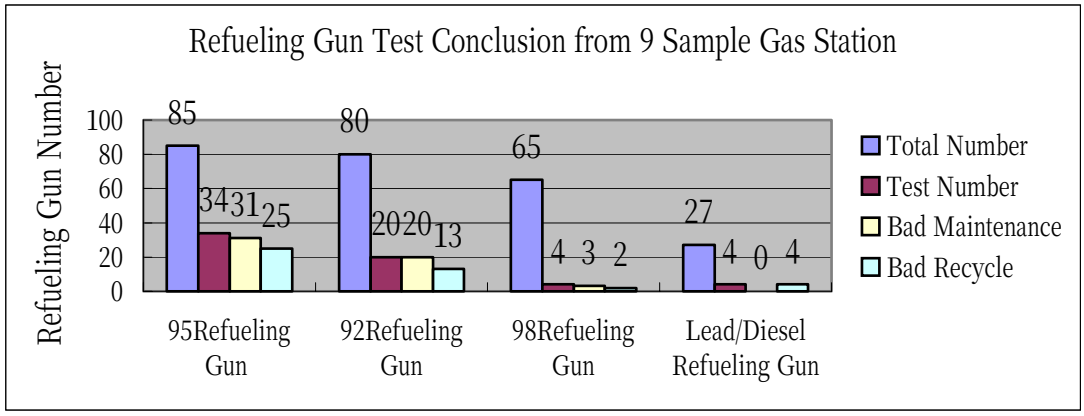

Fig. 8 Results of the detection of the total refueling guns for the 9 sample gas stations

	Hasst-ech	Hirt	Healy	Frank-lin	OPW	Gilbarc-o	Tokhe-im	Catlo-w	Wayne	N.P.	Elafle-x
Suction Method	1	1	2	3	4	3	3	4	3	5	5
Suction Rate	1.40-2.3	over 1.35	1.00-1.20	1.00-1.2	.90-1.10	1.00-1.20	.90-1.10	.92-1.12	.90-1.10	.95-1.05	.95-1.05
Cover Device	N	N	Y	Y	Y	Y	Y	Y	Y	N	N
Combu. Tower	Y	Y	N	N	N	N	N	N	N	N	N
Certify Org.	CARB	CARB	TUV	CARB	CARB	CARB	CARB	CARB	CARB	TUV	TUV
Certified Date	850910	860408	850307	860811	850904	850801	860610	860702	860811	860520	880119

In which :

1:treatment after vacuum pump 2:blowing pump

3:electric pump 4:turbo pump 5:vacuum pump

Table 1 Comparison of different brands of gas recycle system

	Total Gas Station(A)	Install Recycle System(B)	Sponsored by Government(C)	Install Rating(B/A)
Ilan County	53	39	39	73%
Keelung City	19	16	16	84%
Taipei City	65	60	58	92%
Taipei County	150	146	142	97%
Taoyuan County	209	188	187	90%
Hsinchu City	28	27	27	96%
Hsinchu County	75	50	50	67%
Miaoli County	79	62	61	78%
Taichung City	89	66	65	74%
Taichung County	166	135	131	81%
Nantou County	78	53	53	68%
Changhua County	138	75	75	54%
Yunlin County	93	40	36	40%
Chiai City	24	12	8	50%
Chiai County	75	40	32	53%
Tainan City	50	40	28	80%
Tainan County	153	74	65	48%
Kaohsiung City	92	87	86	95%
Kaohsiung County	138	93	89	67%
Pingtung County	97	44	43	45%
Taitung County	40	37	36	90%
Hualien County	52	29	29	56%
Penghu County	11	10	10	91%
Total	1974	1378	1365	72%

Table 2 Gas recycle systems installed at all gas stations country wise

	Source	Emission Coefficient	Remark
1	Filling Underground Tank		
	Submerged Filling	880	A
	Splash Filling	1380	
	Balanced Submerged Filling	40	
2	Underground Tank Breathing and Emptying	120	B
3	Vehicle Refueling Operations		
	Displacement Losses(Uncontrolled)	1320	C
	Displacement Losses(Controlled)	132	
4	Spillage	80	D
Total Emission=A+B+C+D=2,400mg/L			

Table 3 Gas station AP-43 VOC emission coefficients

Emission Source	Control Technology	Control Efficiency(%)
Pump	Monthly leakage test & maintenance	61
	No shaft sealed pump	100
	Double mechanic shaft	100
	Closed suction system	100
Gas Valve	Monthly leakage test & maintenance	73
	Film valve	100
Light liquid valve	Monthly leakage test & maintenance	46
	Film valve	100
Pressure release valve	Crack disk	100
	Closed suction system	100
Open line	Covered & sealed	100
Compressor	Anti-leakage & sealed suction system	100
Connector	Sampling in closed loop	100
Average for three “monthly leakage test & maintenance”		60

Table 4 Equipment leakage control technique and effectiveness

Company	Hour/Day	Day/Year	Emission hourly(kg/hr)	Emission before improve(ton/y)	Reduction hourly(kg/hr)	Reduction yearly(ton/y)
A	24	330	34.29626	271.6264	25.74038	203.8638
B	24	300	0.20085	1.44612	0	0
C	8	300	0.039008	0.093619	0	0
D	24	360	1.25277	10.82393	0	0
E	8	300	2.794737	6.707369	2.249937	5.399849
F	24	360	1.568459	13.55149	0	0
G	24	351	0.55364	4.663863	0	0
H	24	365	0.18425	1.61403	0	0
I	12	280	0.0969	0.325584	0	0
J	24	365	1.049	9.18924	0.0825	0.7227
K	24	365	1.01562	8.896831	0	0
L	24	365	2.18961	19.18098	0	0
M	20	246	0.0078	0.038376	0	0
N	8	300	0.99336	2.384064	0.87405	2.09772
O	8	300	0.079203	0.190087	0.037465	0.089916
P	8	300	0.083029	0.19927	0	0
				350.9312		212.174
Technology Efficiency %						60.46

Table 5 Maximum operating period, emission per year and reduction per year for each company

Test Device : FOXBORO TVA-1000B DATE: 2 May 2000

#	Test Item	Test #	Background Conc.	Initial Conc.	Net Conc.	Suggestion/ Remark
1—1	output of combustion tower		-1.31	-1.31	0.18	
2—1	95 Refueling Gun before Using	A0020556	-1.72	6541	6543	
2—2	95 Refueling Gun before Using	A0020556	-1.72	7202	7204	
2—3	95 Refueling Gun in Using	A0020556	-1.72	188	189.7	
2—4	95 Refueling Gun in Using	A0020555	-1.72	37632	37634	
2—5	95 Refueling Gun in Using	A0020555	-1.72	1297	1299	
2—6	92 Refueling Gun in Using	A0020560	-1.72	2245	2247	

Efficiency for recycle system=((37633.72-1298.72)/37633.72)=96.549% Efficiency for combustion tower=(((37633.72-1298.72)-0.18)/(37633.72-1298.72))=99.9995%
composition: gas/light liquid material/heavy liquid material

Test by : Review by :

Table 6 Results of VOCs detection for sample gas station I at Keelung city

Test Device : FOXBORO TVA-1000B DATE: 3 Sep. 2000

#	Test Item	Test #	Background Conc.	Initial Conc. (ppm)	Net Conc. (ppm)	Leakage	Suggestion/Remark
1	92 Refueling Gun-311	AG8906506A	18.44	1166	1147.56	N	
2	92 Refueling Gun-311	AG8906506A	18.44	＞99999	＞99999	Y	
3	95 Refueling Gun-331	AG8906003B	18.44	＞99999	＞99999	Y	
4	95 Refueling Gun-231	CG8901202A	18.44	＞99999	＞99999	Y	
5	95 Refueling Gun-231	CG8901202A	18.44	19017	18998.6	Y	
6	92 Refueling Gun-211	AG8909081A	18.44	37900	37881.6	Y	
7	95 Refueling Gun-121	CG8901869B	18.44	＞99999	＞99999	Y	
8	95 Refueling Gun-121	CG8901869B	18.44	42935	42916.6	Y	
	Combustion Tower		28.76	34.68		N	
composition: gas/light liquid material/heavy liquid material							

Test by : Review by :

Table 7 Results of VOCs detection for sample gas station A

Gas Station: A							
Tel Number:							
Time	Gas	Input Amount	Sale Amount	Hourly Emission(kg/hr)	Yearly Emission C	Usual Emission A+B+D	Total Emission A+B+C+D(ton/y)
8/1/2000	98	26792	23322	NA	NA	NA	NA
	92	264897	259517	0.00054	0.00237	3.85440	3.85677
	95	627271	605082	0.10976	0.48077	9.10416	9.58493
	Lead/Diesel	107320	94837	NA	NA	NA	NA

			Total Emission(ton/y)	13.44170
Refueling Gun	Amount	Remark		
98	8			
95	9			
92	9			
Lead/Diesel	4			
Suggestion	1	Improve the maintenance for 92,95 refueling gun.		
	2	The 95 recycle system is out of work, correct it.		

Table 8 Results of calculations of emission for sample gas station A

Gas Station	sale amount on 8908(L/Mon)				VOC Emission when refueling(C)	VOC Emission on usual (A+B+D)	Total Emission(ton/y) C+A+B+D
	98	95	92	Lead/Diesel			
A	23,322	605,082	259,517	94,837	0.483134112	12.95857	13.44170
B	16,000	130,000	70,000	75,000	0.116222576	4.78393	4.90016
C	14,498	364,416	174,596	95,831	0.428271919	7.81590	8.24417
D	25,944	520,652	202,646	0	0.574696337	10.95073	11.52542
E	1,836	105,896	56,518	21,146	0.130504817	2.30254	2.43305
F	4,522	135,050	75,781	49,990	0.185617578	3.77737	3.96299
G	3,953	112,594	74,626	43,992	0.148755231	2.95217	3.10092
H	41,400	739,406	240,638	500,252	0.892525347	21.57222	22.46475
I	11,093	446,392	207,355	70,024	0.525322324	10.89591	11.42123
Total	142,568	3,159,487	1,361,677	951,072	3.485050242	78.00933	81.49438

Table 9 Total results of VOCs detection for all sample gas stations

Gas	Total Refueling Gun	Test Amount	Bad Maint.	Bad Recycle	% for Bad Maint.	% for Bad Recycle
98	65	4	3	2	75.00	50.00
95	85	34	31	25	91.18	73.53
92	80	20	20	13	100.00	65.00
Lead/Diesel	27	4	0	4	0.00	100.00

Table 10 Analytical results of detection of refueling guns for all gas stations