TEST REPORT ON Vehicle Exhaust Cleaning Effects For

PROACTIVE PHTOCATALYTIC SYSTEM™

ECORIVESITMENTO FOTOFLUID CEMENT and ACTIVA

(Total Page 22)

Shanghai Academy of Environmental Sciences

Jan. 18. 2007

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1. Introduction

Project Vehicle Exhaust Cleaning Effects For PROACTIVE PHTOCATALYTIC SYSTEM^{TM} ECORIVESITMENTO FOTOFLUID CEMENT and ACTIVA

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Contact man Frank SuiFai Li

Test Date November13~16, December3~4, December 24~25 2006.

Test Place Fuxing-East Road underground passage near Henan South Road

2．Instruments

AC32M chemiluminescent nitrogen oxides analyzer, Testo400 gas detector，FYF-1 portable dogvane and anemometer, HM10 thermo-hygrometer, DYM3 barometer, Traffic flow counters.

3．Methods

3．1 Materials

PROACTIVE PHTOCATALYTIC SYSTEM ^{TM}(PPS) ECORIVESITMENTO FOTOFLUID CEMENT and ACTIVA（Provided and on-spot paving and constructing by Mr. Frank SuiFai Li）

3．2 Locations of the Sites

Summary The monitoring site located in Fuxing East Road Underground Passage for Vehicles. It is a two-way underpass (A small tunnel) which is constructed near Henan South Road to help keep the traffic of Fuxing East Road Tunnel free and unblock. The underpass is 120 meters long, which is divided into three sections. Both ends of the underpass are 24 meters long and light permeating. The middle of the underpass is an entirely close section of 72 meters long. The height of the tunnel is 5.5 meters to 6.2 meters. In this report the underpass with traffic flow from East to West was named tunnel A. The road of tunnel A was paved the PROACTIVE PHTOCATALYTIC SYSTEM^{TM} ECORIVESITMENTO FOTOFLUID CEMENT. The walls at both sides of the tunnel A were sprayed PROACTIVE PHTOCATALYTIC SYSTEM^{TM} ACTIVA. However the top of the tunnel were not applied any photo catalyst. UV lights with a wavelength of 350nm were installed every 3 meters at the top of the tunnel. The UV lights were all used at the night but only used half in the daytime. Another underpass with traffic flow from West to East was called Tunnel B. It was not paved or sprayed any photo catalyst materials and not installed UV lights as contrast.

Site setting Measurements were taken three times. The first measurement was taken on November 13~16 in both tunnel A(North) and tunnel B(south).The monitoring sites of the two tunnels both located in the West. The air quality parameters were Nitric Oxides(NO、NO_2)and carbon monoxide(CO). The second measurement was taken on December 3~4, with one monitoring site at the west of tunnel A. The third measurement was taken on December 24~25, with one monitoring site at the east of tunnel B. Only Nitric Oxides(NO、NO_2) were analyzed for the latter two measurements.

Location of Instruments AC32M Chemiluminescent Nitrogen Oxides Analyzers were set on the light permeating section on both A and B tunnel. The Teflon sampling tube of the analyzer was 4.2 meters long and extended to the overhead of the tunnel. The sampling height is about 1.5 meters high. Umbrellas were used to shade the instruments. The instruments were worked through day and night. The details of Locations refer to chart I and II.

3．3 Sampling Index

Monoxide （ CO ） Nitrogen monoxide/Nitrogen dioxide （ NO/NO_2 ） In-phase meteorological parameter(temperature, humidity, atmospheric pressure, wind direction, wind speed, cloud cover, precipitation) , traffic flow in the tunnel

3．4 Sampling Period

Test Date: Nov.13~16, 2006 (First measurement, Weather 11/13~15 sunny 11/16 rainy Dec.3~4, 2006(second measurement , Weather sunny)Dec 24~25, 2006(Third measurement, Weather sunny turned to cloudy, in the morning of 12/25 drizzle) The details of the weather refer to the attachment, the sampling frequency refer to Table 2-1

Test Place: Fuxing-East Road underground passage near Henan South Road

Table 2-1 Parameter and Sampling frequency

Parameter	Standard or Methods	Sampling frequency (b)	Sampling time (c)	Total sampling days (d)
CO	GB/T18204.23-2000	1 /1h	12h	8 day
NO_2	ISO7996: 1985	1 /1h	12h	8 day
NO				
Meteorological parameter	GB/T18204.13~16-2000	1 /1h	12h	8 day
Traffic flow	Manual counts	1 /h	12h	8day

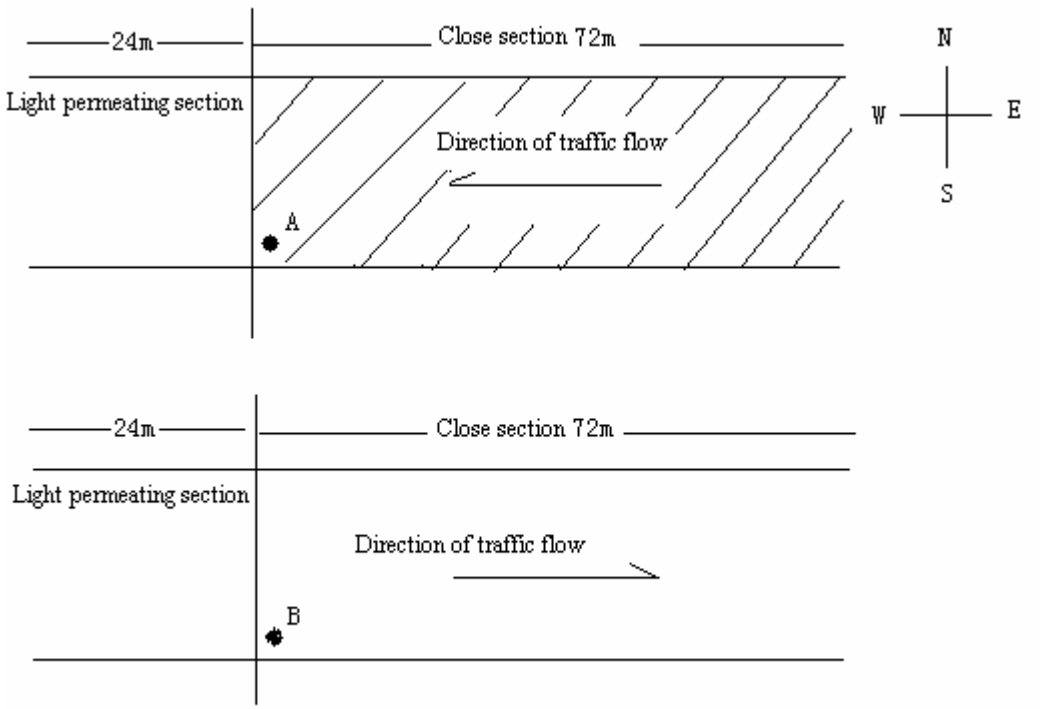


Chart I Location of Monitoring Sites in Fuxing East Road Underpass

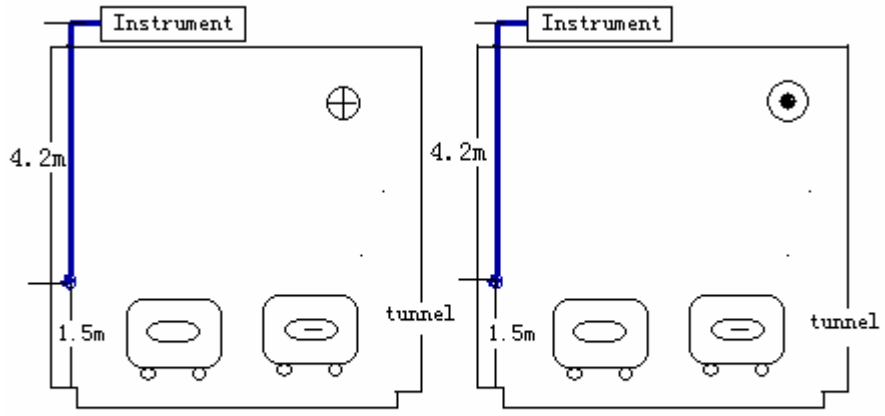


chart II sketch map of section of sampling in the tunnel

3．5 Sampling Methods

1）CO: Testo 400 gas detector was used to measure CO concentration in the tunnel. Every hour some of our staff sat in the car, holding the Testo, the sensor of the Testo was extended out of the window to test the CO in the tunnel. The car was driving slowing along the tunnel(the car decelerate to keep at a low speed and it took about 3 minutes to go through the tunnel.) The measurement began at the entrance of the tunnel, ended at the exit of the tunnel. Three continuous measurements were taken every hour. Each measurement lasted 1minute(Data recorded every 5 seconds in Testo. There are 12 records in 1minute) The

average of three measurements was taken as the test results for every o'clock.

2）NO/NO_2: AC32M Chemiluminescent Nitrogen Oxides Analyzer was used to measure NO/NO_2 concentration in the tunnel through day and night

3）Meteorological parameter: Measurement was taken each hour from 6:00 a.m. to 18:00 p.m. every day. Parameters includes temperature, humidity, atmospheric pressure, wind direction, wind speed, cloud cover, precipitation. Due to the limited conditions, the monitoring site was on the ground above the tunnel. The test results can reflect the wind condition in the tunnel in a way, but not exactly the circs in the tunnel.

4）Traffic flow: Testing covers 12 hours a day. 20 minutes' traffic volume was counted each hour. for 8 days and two tunnels. The Vehicle was defined into gasoline and diesel vehicles. Gasoline vehicle includes cars, microbus and other light duty vehicles. Diesel vehicles includes bus(shuttle bus), minivans and Iveco commercial vehicles.

4. Results

4. 1 Test Results For NO_2

1）Data of Nov 13(Monday) in comparison with Dec.4(Monday)

Since the Nitrogen Oxides Analyzer on the tunnel A functioned improperly on Nov.13(Monday)~14(Tuesday), namely, the data deviated the normal level obviously. A supplementary measurement was taken on Dec.4(Monday) to makeup the losing data. Table3-1 shows the comparison between the data of the two days.

From Table 3-1，It can learned that except the underline periods of time, most time NO_2 concentrations in the tunnel B were higher than those of tunnel A.

From Table 3-2, it can be learned that the hourly traffic flow in the tunnel A(12/4) during the daytime were all higher than that of the tunnel B(11/13). Especially on-spot monitoring showed during 8:00~9:00 and 9:00~10:00 in the morning, obvious traffic jam occurred in the tunnel A.A great deal of vehicle was blocked in the tunnel A. Evident emission aggravation phenomena occurred in the tunnel A when vehicle idling. In tunnel B traffic jam never occurred in the 8-day measurements period.

Due to evident different traffic flow of the two tunnels, in order to exclude the influence of the traffic , Table 3-1 modified the original NO_2 data, which was divided by traffic volume and a ratio was obtained (short for ratio C/T_{NO2}). The fourth and fifth column of Table 3-1 shows the ratio C/T_{NO2}.

After the correction, except the two periods 8:00~9:00 and 9:00~10:00, Ratio C/T_{NO2} in tunnel A were lower than that of tunnel B.

As mentioned above, during 8:00~9:00 and 9:00~10:00, obvious traffic jam occured in

tunnel A while in tunnel B the traffic was free. The measurement was taken in different condition, which would bring about error.（when calculate NO_2 reduction, these two values were removed in order to reflect the real situation ）The average of NO_2 reduction of the periods was 40.3% on condition of exclusion of the two disturbing data.

Table 3-1 Test Results of NO_2 of A and B tunnel

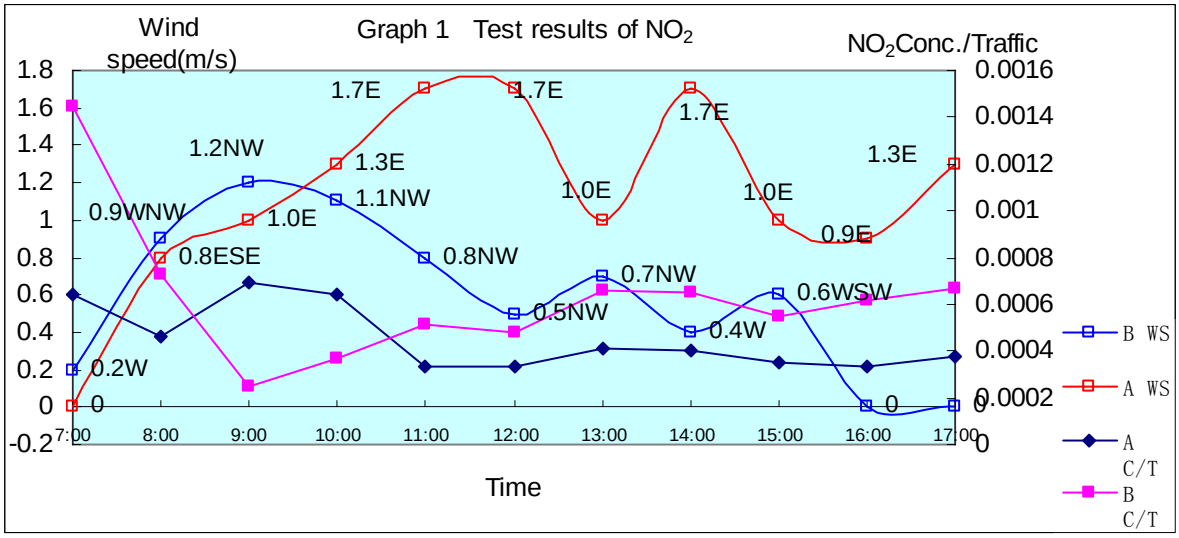
Time	NO_2 concentration（mg/m^3）		NO_2concentration/traffic flow (Ratio C/T_{NO2})		NO_2 reduction(%)
	A	B	A	B	
6:00-7:00	0.120	0.100	0.00064	0.00145	55.9
7:00-8:00	0.134	0.146	0.00046	0.00073	37.0
8:00-9:00	0.440	0.160	0.00069	0.00025	/
9:00-10:00	0.329	0.186	0.00064	0.00037	/
10:00-11:00	0.166	0.178	0.00033	0.00051	35.3
11:00-12:00	0.122	0.165	0.00033	0.00048	31.3
12:00-13:00	0.135	0.167	0.00041	0.00066	37.9
13:00-14:00	0.171	0.177	0.00040	0.00065	38.5
14:00-15:00	0.169	0.200	0.00035	0.00055	36.4
15:00-16:00	0.169	0.243	0.00033	0.00062	46.8
16:00-17:00	0.176	0.255	0.00038	0.00067	43.3

Table 3-2 Traffic Flow of A and B tunnel

Time		6:00-7:00	7:00-8:00	8:00-9:00	9:00-10:00	10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00	17:00-18:00
Traffic Flow	A	187	294	636	516	501	375	328	432	477	511	469	511
	B	69	200	650	497	346	342	254	274	364	395	379	459

Notes Data for A tunnel is data of Dec. 4(Monday) , Data for B is Nov. 13(Monday).

Graph 1 concerning NO_2 data in Table3-1，3-2, and the meteorological data (Wind direction, Wind Speed) of the periods.



Analysis

① From graph 1, except the two periods 8:00~9:00 and 9:00~10:00, a net difference can be seen between Ratio C/T $_{NO2}$ for the two tunnels. The Ratio C/T $_{NO2}$ of tunnel A were lower than tunnel B. As mentioned before, since 8:00~9:00 and 9:00~10:00 obvious traffic jam and emission aggravation owing to vehicle idling in the A tunnel, it will bring bias to the results.

② Meteorological factor On Dec.4, East wind was the prevailing wind. For tunnel A, traffic flow is from east to west, east wind was good for test. On Nov.13, West wind was prevailing wind. For tunnel B, the traffic flow is from west to east and the monitoring site was in the west, therefore west wind is ideal for measurement. The wind condition of the two days were normal for test.

③ Graph1 shows that during different time periods, the reductions of NO_2 were quite different. At 6:00 ~ 7:00 in the morning, the wind speed near the ground is low. Ratio C/T $_{NO2}$ of A tunnel is much lower than B tunnel. The reduction rate of the period was about 55.9%. At 7: 00a.m.~ 15: 00p.m., reduction rates fluctuated between 31.3%~38.5%. At 15: 00p.m. ~ 17: 00p.m. in the afternoon, the reduction rate increased, rose to 40%~50%. During this period, the wind speed near the ground above B tunnel decreased gradually and approach zero. The wind speed near the ground above A tunnel were 0.9m/s or higher all the time and had the ascending trend. The average of NO_2 reduction is 40.3%.

2）Data of Nov. 15

（1）From 6: 00a.m.~9: 00 a.m. on Nov. 15 the NO_2 analyzer is not properly worked. So the valid data is from 9:00~10:00 to 18:00, Data from 18:00~24:00 was also analyzed.

From Table 3-3 column 2 and 3, it can be learned that except 17: 00~18: 00, the original concentration of NO_2 from 9:00~24:00 in tunnel A were lower than tunnel B. The average of

reduction was 42.56％, the Maximal value was 72.6%.

From Table 3-4, it can be seen that traffic flow of tunnel A of every hour was obviously higher than tunnel B. In addition, during 17:00~18:00 rush hour, traffic jam occurred again in the A tunnel while it didn't occur in tunnel B.

According to the above-mentioned ratio of pollutants' concentration to traffic flow comparison method to remove the influence of the traffic. When the original NO_2 concentration divide by traffic flow, Ratio C/T_{NO2} of the tunnel A were all lower than B tunnel on Nov. 15.

Table 3-3 Test results for NO_2 of A and B tunnel

Time	NO_2 concentration (mg/m^3)		NO_2 Reduction (concentration) (%)	Ratio C/T_{NO2}		NO_2 Reduction (Ratio)(%)
	A	B		A	B	
9:00-10:00	0.043	0.157	72.6	0.00007	0.00034	79.4
10:00-11:00	0.105	0.116	9.5	0.00022	0.00032	31.3
11:00-12:00	0.099	0.146	32.2	0.00023	0.00040	42.5
12:00-13:00	0.093	0.138	32.6	0.00025	0.00045	44.4
13:00-14:00	0.110	0.165	33.3	0.00026	0.00057	54.4
14:00-15:00	0.125	0.171	26.9	0.00027	0.00047	42.6
15:00-16:00	0.139	0.200	30.5	0.00026	0.00050	48.0
16:00-17:00	0.063	0.201	68.7	0.00010	0.00048	79.2
17:00-18:00	0.238	0.183	/	0.00041	0.00042	2.4
18:00-19:00	0.138	0.174	20.7	/	/	/
19:00-20:00	0.057	0.191	70.2	/	/	/
20:00-21:00	0.092	0.181	49.2	/	/	/
21:00-22:00	0.068	0.177	61.6	/	/	/
22:00-23:00	0.076	0.153	50.3	/	/	/
23:00-24:00	0.078	0.125	37.6	/	/	/
Average			42.6	Average		47.1

Table 3－4 Traffic Flow of A and B tunnel on Nov. 15

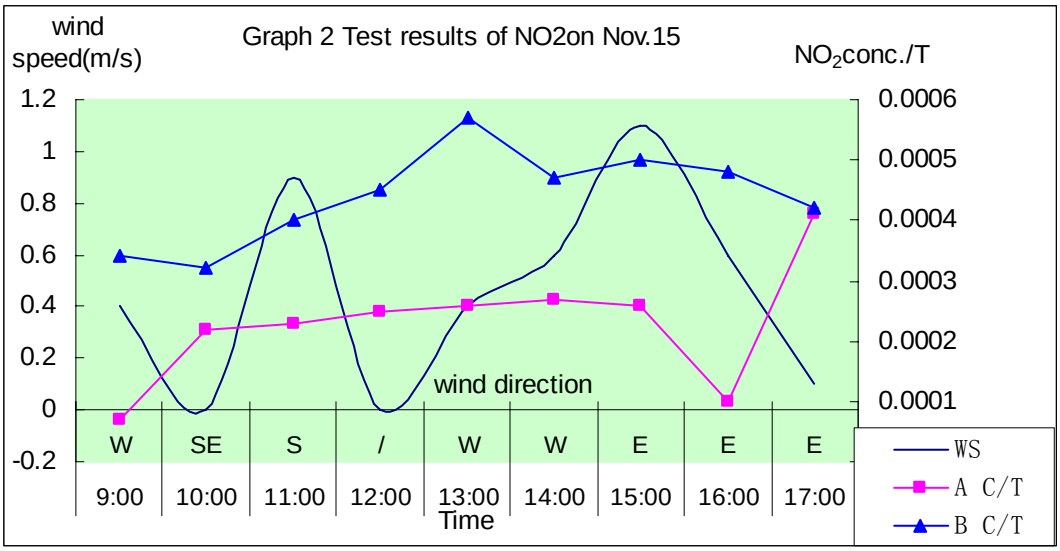
Time		9:00 -10:00	10:00 -11:00	11:00 -12:00	12:00 -13:00	13:00 -14:00	14:00 -15:00	15:00 -16:00	16:00 -17:00	17:00 -18:00
Traffic Floiw	A	616	485	429	377	423	461	532	603	579
	B	465	368	361	309	292	367	400	418	438

In the evening the original NO_2 concentration of tunnel B were all higher than tunnel A(in the evening, traffic flow was not counted).On the condition not excluding the impact of traffic, the pollutant NO_2 reduction effects still can be seen. During this time band(in the

evening), NO_2 reduction rate ranged in 20.7％~70.2%, the average of NO_2 reduction was 48.3%.

According to Table 3-3, the average of NO_2 reduction（Ratio C/T $_{NO2}$）was 47.1%. If removes data in the traffic jam，that is, exclude data of 17:00~18:00，the average was 52.7%。

Graph 2 is drawn according to Table 3-3，3－4 and meteorological data of the day.



Analysis: Graph 2 shows that，after removing the impact of the traffic, the Ratio C/T $_{NO2}$ of tunnel A were all lower than tunnel B in the testing period. At 16: 00~17: 00, data of the two tunnels was very close, it probably resulted from aggravated pollution caused by traffic jam and vehicle idling in tunnel A.

Meteorological factors: On Nov.15, the wind changes frequently, from west to east. When west wind blew, it would bring clean air outside into the tunnel which dilute the air in the tunnel and the NO_2 concentration would become lower. Thus a lower result would be get.

3）Data of Nov. 16

（1）Original data of NO_2

Table 3-5 shows data of the two tunnels on Nov. 16. Due to the unstable power supply, Three data points loss. On the day, traffic flow is not counted (The average of traffic flow of Nov.13 to Nov.15 replace the traffic of the day.)

From Table 3-5 it can be learned that

The original concentration of NO_2 of the A tunnel were all lower than tunnel B.

When excluding the influence of traffic flow, Ratio C/T $_{NO2}$ of the tunnel A were all lower than that of tunnel B.

The average NO_2 reduction of tunnel A was 44.3% of that day.

From table 3-6, the traffic flow of tunnel A was obviously higher than tunnel B.

Table 3-5 Test results of NO_2 on Nov. 16

Time	NO_2 concentration (mg/m^3)		NO_2concentration/traffic flow		NO_2reduction (%)
	A	B	A	B	
6:00-7:00	0.051	0.174	0.00067	0.00285	76.5
7:00-8:00	0.049	0.113	0.00016	0.00056	71.4
8:00-9:00	0.068	0.140	0.00010	0.00021	52.4
9:00-10:00	0.073	0.123	0.00013	0.00026	50.0
10:00-11:00	Loss	0.121	Loss	0.00034	/
11:00-12:00	0.095	0.116	0.00023	0.00033	30.3
12:00-13:00	0.092	0.101	0.00026	0.00036	27.8
13:00-14:00	0.106	0.112	0.00028	0.00039	28.2
14:00-15:00	Loss	0.068	Loss	0.00019	/
15:00-16:00	0.110	0.111	0.00023	0.00028	17.9
16:00-17:00	Loss	0.117	Loss	0.00029	/

Table 3-6 Traffic flow of A and B tunnels (Average Substitute)

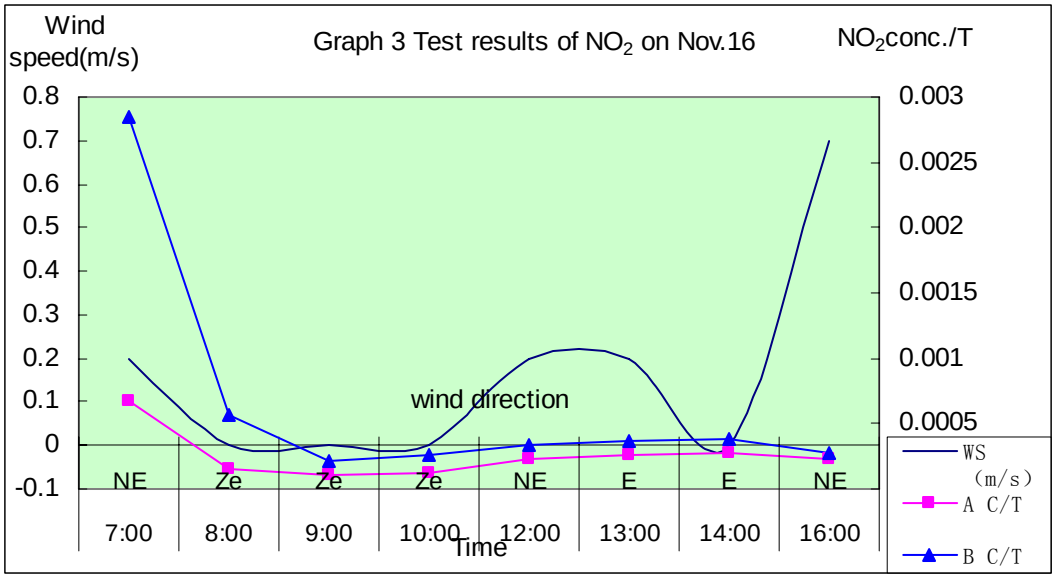
time		6:00-7:00	7:00-8:00	8:00-9:00	9:00-10:00	10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00	17:00-18:00
Traffic Flow	A	76	298	675	546	458	412	349	377	461	488	513	524
	B	61	203	658	474	360	351	284	289	351	402	403	466

Graph 3(Page 10) is drawn according to Table 3-5 and meteorological data of that day.

Analysis

From graph 3, it can be learned that Ratio C/T_{NO2} of the tunnel A were all lower than that of tunnel B.

Meteorological Factor. Nov. 16 was a rainy day. During different time periods, the NO_2 reduction were different. At 6: 00 ~ 8: 00 in the morning, when the wind speed near the ground was low, Ratio C/T_{NO2} of the tunnel A was much lower than tunnel B. The reduction was about 70%. At 8:00~10:00, when it was windless, the reduction was 50%. At 11: 00 ~ 16: 00, the reduction fell gradually, ranged in 17.9%~30.3%. At 15:00~16:00, the NO_2 reduction fell to the lowest point, only 17.9%. The average of NO_2 reduction of Nov.16 was 44.3%.



4) Since in the former two measurements, the monitoring site for tunnel A located near the upward slope of the tunnel. For tunnel B the monitoring site located near the downward slope. Between uphill and downhill, vehicle behavior is quite different. This would probably bias the results. So when the third measurement was carried out on Dec.24~25, the monitoring site was moved to the east of the tunnel B, which was near upward slope of tunnel B to ensure the same condition. Data of Dec.24 were compared with the data of Dec. 3~4.

（1）Data of Dec. 3(Sunday) in comparison with Dec.24 (Sunday)

Table 3-7 Test results of NO_2 of A and B tunnels

Time	NO_2conc.（mg/m^3）		Ratio C/T $_{NO2}$		NO_2 reduction(%)
	A	B	A	B	
6:00-7:00	0.100	0.113	0.00123	0.00191	35.6
7:00-8:00	0.108	0.144	0.00135	0.00175	22.6
8:00-9:00	0.115	0.149	0.00061	0.00125	51.7
9:00-10:00	0.096	0.147	0.00039	0.00099	60.9
10:00-11:00	0.100	0.139	0.00034	0.00072	53.1
11:00-12:00	0.130	0.139	0.00045	0.00067	32.1
12:00-13:00	0.155	0.131	0.00055	0.00057	4.0
13:00-14:00	0.142	0.132	0.00045	0.00053	15.5
14:00-15:00	0.145	0.136	0.00042	0.00046	7.8
15:00-16:00	0.165	0.146	0.00046	0.00054	13.9
16:00-17:00	0.181	0.143	0.00050	0.00041	/
17:00-18:00	0.149	0.146	0.00039	0.00047	16.6
18:00-19:00	0.127	0.144	0.00041	0.00049	16.0

Table 3-8 Traffic Flow of the A and B Tunnel

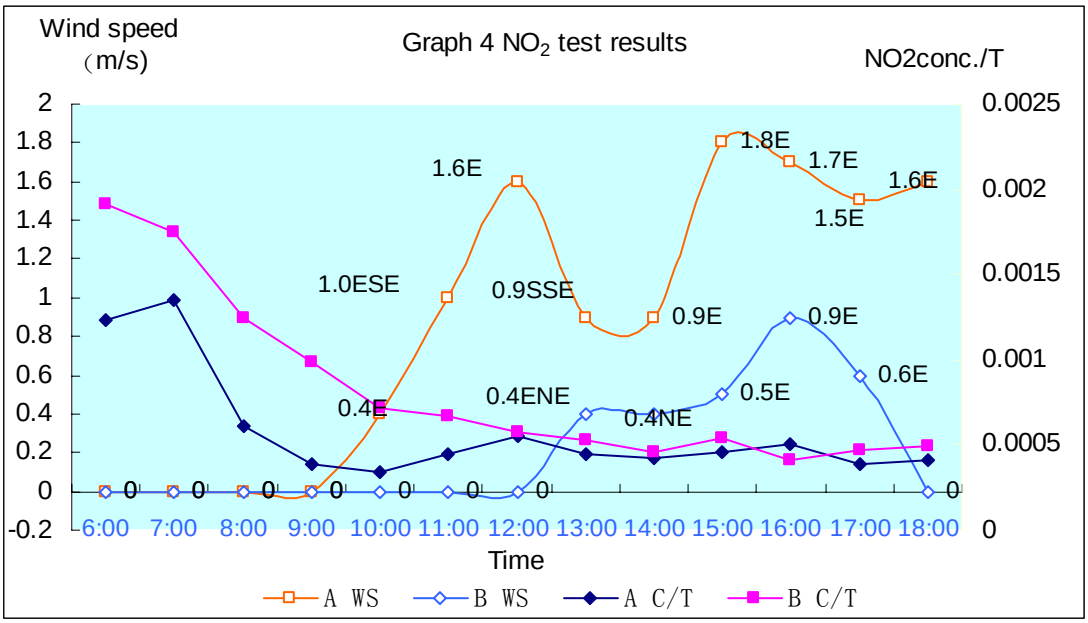
Time		6:00-7:00	7:00-8:00	8:00-9:00	9:00-10:00	10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00	17:00-18:00	18:00-19:00
Traffic Flow	A	81	80	189	248	295	286	282	319	344	356	380	364	309
	B	59	82	119	148	192	208	228	250	298	270	310	346	293

Notes, Data of tunnel A is data of Dec.3. Data of tunnel B is data of Dec. 24.

Table 3-7 shows the original NO_2 concentration, In the morning, NO_2 concentration of tunnel A was lower than tunnel B. In the afternoon the concentration of tunnel B was lower than tunnel A. From 18:00 ~19:00, NO_2 concentration of the B tunnel was higher than A again. From Table 3－8，the traffic flow volume of tunnel A were all higher than tunnel B.

When excluding the influence of traffic, except 16: 00~17: 00, Ratio C/T_{NO2} of the tunnel A were all lower than tunnel B.

Graph 4 is drawn according to Table 3-7 and meteorological data of that day.



Analysis Graph 4 indicates that when removing the influence of traffic, except 16: 00 ~ 17: 00, Ratio C/T_{NO2} of the tunnel B were higher than tunnel A. During different time periods, the reductions of NO_2 were different. At 6: 00 ~ 8: 00 in the morning, when it was windless near the ground, the reduction rate ranged in 20％ ~ 35％. At 8: 00 ~ 11: 00, wind speed near the A tunnel accelerated and the prevailing wind was east wind. The reduction rate increased with the wind speed, floating in the range of 50% ~ 60％. From 12:00, East wind began to blow near the B tunnel, the wind blew the pollutants to the opposite direction away from the sampling tube so the test result was probably deflect to a lower value. During that period, the

NO_2 reduction drop gradually and fluctuated between 4%~17%. At 16: 00 ~ 17: 00, the wind speed went to the peak, at the same time, Ratio C/T_{NO2} of the tunnel A became higher than tunnel B instead. The wind was potentially bias the results.

To remove the effect of the wind, data from12: 00 ~ 18: 00 was excluded. Under this condition, the average of reduction was 42.7%.

（2）Data of Dec.4(Monday) in comparison with Dec.25(Monday)

Table 3-9 shows the comparison of data of Dec.4(Monday) of tunnel A and data of Dec.25(Monday) of the tunnel B.

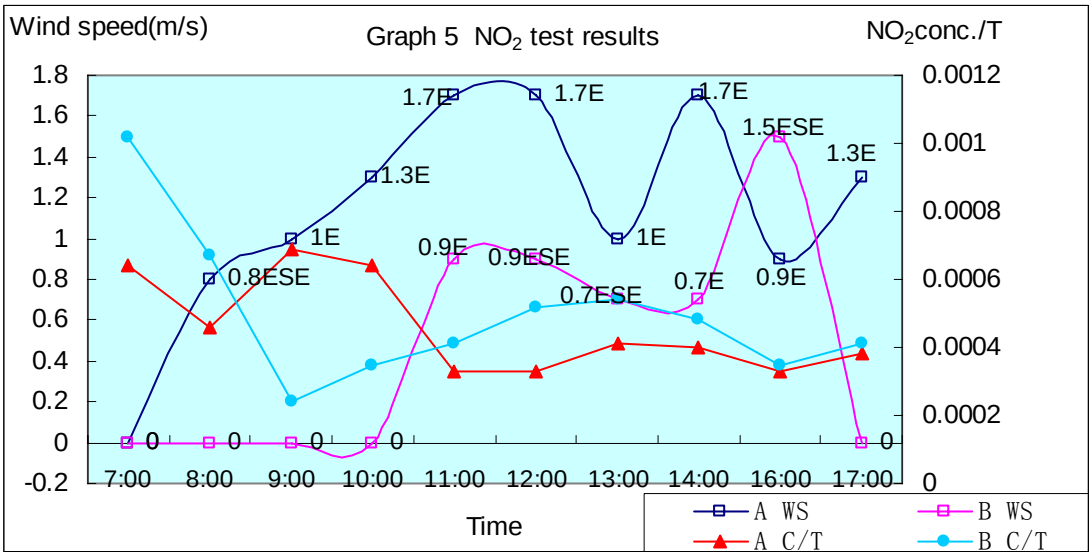
Table 3－9 Test results of NO_2 of A and B tunnels

Time	NO_2conc.（mg/m^3）		NO_2concentration/traffic flow		NO_2 reduction(%)
	A	B	A	B	
6:00-7:00	0.120	0.129	0.00064	0.00102	36.9
7:00-8:00	0.134	0.161	0.00046	0.00067	32.2
8:00-9:00	0.440	0.157	0.00069	0.00024	/
9:00-10:00	0.329	0.166	0.00064	0.00035	/
10:00-11:00	0.166	0.154	0.00033	0.00041	19.4
11:00-12:00	0.122	0.160	0.00033	0.00052	37.5
12:00-13:00	0.135	0.142	0.00041	0.00054	23.2
13:00-14:00	0.171	0.149	0.00040	0.00048	18.2
14:00-15:00	0.169	Loss	0.00035	Loss	/
15:00-16:00	0.169	0.134	0.00033	0.00035	6.6
16:00-17:00	0.176	0.152	0.00038	0.00041	8.7

Notes, At 14: 00－15: 00 on Dec. 25, the power supply broke off. The data of the time loss

Table 3-10 Traffic Flow of the A and B Tunnel

Time		6:00-7:00	7:00-8:00	8:00-9:00	9:00-10:00	10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00
Traffic Flow	A	187	294	636	516	501	375	328	432	477	511	469
	B	127	239	645	474	375	307	265	309	320	377	369



Graph 5 is drawn according to Table 3-9 and meteorological data.

Analysis

①From Graph 5, except 8:00 ~ 9:00, 9:00 ~ 10:00, Ratio C/T $_{NO2}$ of tunnel B were higher than tunnel A. As mentioned before, during 8:00 ~ 9:00 and 9:00 ~ 10:00 traffic jam and vehicle idling brought aggravated exhaust pollution in tunnel A, which would bias the results. Under this condition, the two tunnel were not comparable

②Meteorological Factor. For tunnel A , the traffic flow is from east to west. East wind was ideal for the measurement. On Dec. 4, the prevailing wind was east wind. Under this condition measurement can reflect the real situation well. For tunnel B, the traffic flow is from west to east. The ideal wind direction should be west. While on Dec.25, East wind was prevailing. It likely bias the results to a lower value.

③ Since during 8:00 ~ 9:00 and 9:00 ~ 10:00 in tunnel A, traffic jam and vehicle idling occurred, which would aggravate emission and bias the results. The data of the two periods were excluded. From Graph 5, during different time periods, the NO_2 reduction was different. At 6: 00 ~ 8: 00 in the morning, when it was windless near tunnel B, Ratio C/T $_{NO2}$ of the tunnel A was 30% less than tunnel B. During 12:00~14:00., when the wind direction near tunnel B was east-south-east, the reduction was 20％ ~ 40％. The rest periods when the wind direction was east, the NO_2 reduction fell to 6％ ~ 10％.As mentioned above, East wind in the B tunnel will probably bias the results to a lower value. Therefore, when calculating, data of four periods with high speed east wind (10:00 ~ 11:00，13:00 ~ 14:00，15: 00 ~ 17: 00) were excluded. On this condition, the average of NO_2 reduction was 32.5％.If not excluding these points, the average of NO_2 reduction was 22.8%.

4．2 Test results for CO

（1）Original Data of CO concentration

Table 3－11　Original data of CO concentration by Testo 400 gas Detector

Unit: mg/m^3

Time	Nov.13		Nov.14		Nov.15	
	A	B	A	B	A	B
6:00	/	/	0.10	1.26	5.07	5.76
7:00	/	/	0.00	0.40	8.78	9.06
8:00	/	/	4.10	5.30	7.10	9.10
9:00	/	/	4.61	3.62	7.62	4.75
10:00	/	/	2.01	2.00	3.60	3.47
11:00	/	/	1.17	3.39	1.17	1.17
12:00	/	/	0.51	2.38	3.74	4.05
13:00	/	/	0.33	0.61	1.14	2.09
14:00	1.36	4.18	3.02	1.78	2.22	4.90
15:00	2.53	4.67	1.40	3.16	3.83	3.82
16:00	2.52	3.26	4.50	9.63	6.80	6.46
17:00	4.17	5.39	2.84	2.82	5.54	8.77

（2）Ratio of CO concentration to traffic flow

Due to the unequal traffic flow status of the two tunnels, namely, the traffic flow volume of A tunnel was higher than that of tunnel B. The original data were corrected by dividing the hourly traffic flow to exclude the impact of traffic.

Table 3-12　Ratio of CO concentration to gasoline vehicle and total number

Time	Nov.13				Nov. 14				Nov.15			
	Ratio1		Ratio 2		Ratio 1				Ratio1		Ratio 2	
	A	B	A		A	B	A		A	B	A	
6:00	/	/	/	/	0.002	0.029	0.001	0.022	0.101	0.156	0.078	0.103
7:00	/	/	/	/	0.000	0.002	0.000	0.002	0.032	0.051	0.028	0.045
8:00	/	/	/	/	0.006	0.008	0.006	0.008	0.011	0.015	0.010	0.014
9:00	/	/	/	/	0.010	0.008	0.010	0.008	0.013	0.011	0.012	0.010
10:00	/	/	/	/	0.005	0.006	0.005	0.005	0.008	0.010	0.007	0.009
11:00	/	/	/	/	0.003	0.010	0.003	0.010	0.003	0.004	0.003	0.003
12:00	/	/	/	/	0.002	0.009	0.001	0.008	0.011	0.014	0.010	0.013
13:00	/	/	/	/	0.001	0.002	0.001	0.002	0.003	0.008	0.003	0.007
14:00	0.004	0.013	0.003	0.011	0.007	0.006	0.006	0.006	0.005	0.014	0.005	0.013
15:00	0.006	0.013	0.005	0.012	0.003	0.008	0.003	0.008	0.008	0.010	0.007	0.010
16:00	0.006	0.009	0.006	0.009	0.010	0.025	0.009	0.023	0.012	0.016	0.011	0.015
17:00	0.010	0.013	0.009	0.012	0.006	0.006	0.006	0.006	0.010	0.021	0.010	0.020

Notes: During 6: 00a.m.~13: 00p.m. on Nov. 13, Testo 400 Detector malfunctioned, data of the period lost. Ratio 1 CO concentration to gasoline traffic volume Ratio 2 CO concentration to Total traffic volume

According to Ratio 2，Graph 6 ~ 8 were drawn and the reduction rates was calculated in Table 3-13.

Table 3－13 CO Reduction

Time	Nov. 13			Nov. 14			Nov. 15		
	A	B	Reduction (%)	A	B	Reduction (%)	A	B	Reduction (%)
6:00	/	/	/	0.001	0.022	95.5	0.078	0.103	24.3
7:00	/	/	/	0.000	0.002	100.0	0.028	0.045	37.8
8:00	/	/	/	0.006	0.008	25.0	0.010	0.014	28.6
10:00	/	/	/	0.005	0.005	0.0	0.007	0.009	22.2
11:00	/	/	/	0.003	0.01	70.0	0.003	0.003	0.0
12:00	/	/	/	0.001	0.008	87.5	0.010	0.013	23.1
13:00	/	/	/	0.001	0.002	50.0	0.003	0.007	57.1
14:00	0.003	0.011	72.7	0.006	0.006	0.0	0.005	0.013	61.5
15:00	0.005	0.012	58.3	0.003	0.008	62.5	0.007	0.010	30.0
16:00	0.006	0.009	33.3	0.009	0.023	60.9	0.011	0.015	26.7
17:00	0.009	0.012	25.0	0.006	0.006	0.0	0.010	0.020	50.0
Average	/	/	47.3	/	/	50.1	/	/	32.8

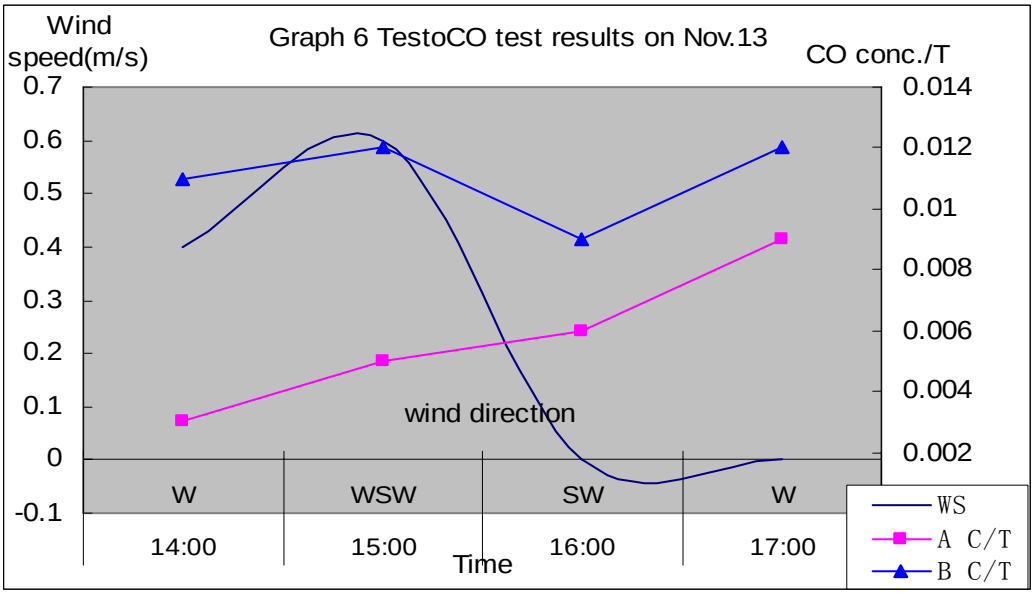
Notes. The calculation of CO reduction of Nov.14 and Nov.15 removes the data of 9:00, Since traffic jam occurred in the period in the tunnel A which will bias the results.

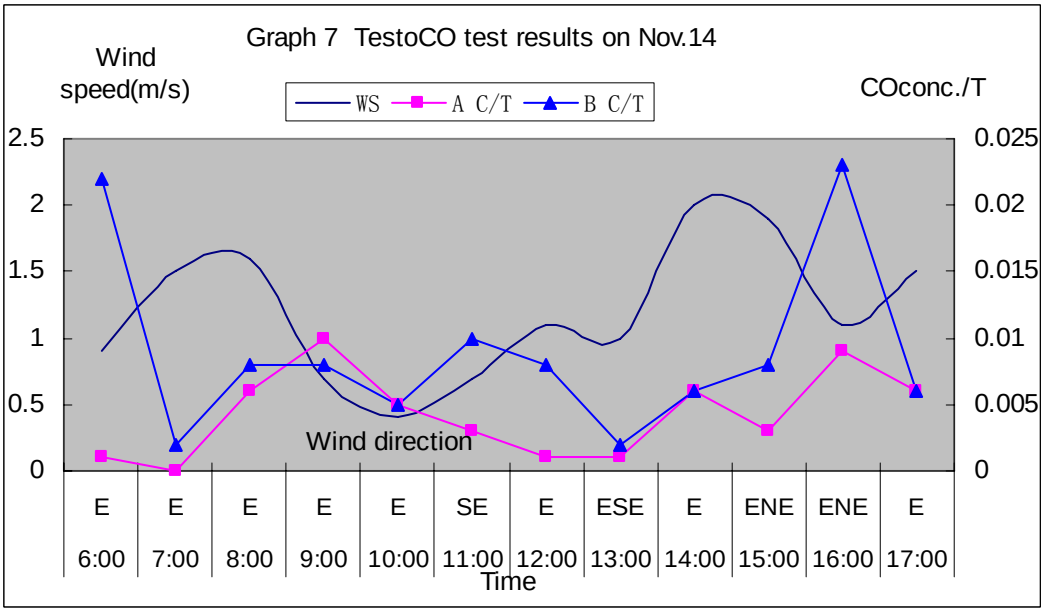
Graph 6~8 were drawn according to Table 3-11~3-13(See next page)

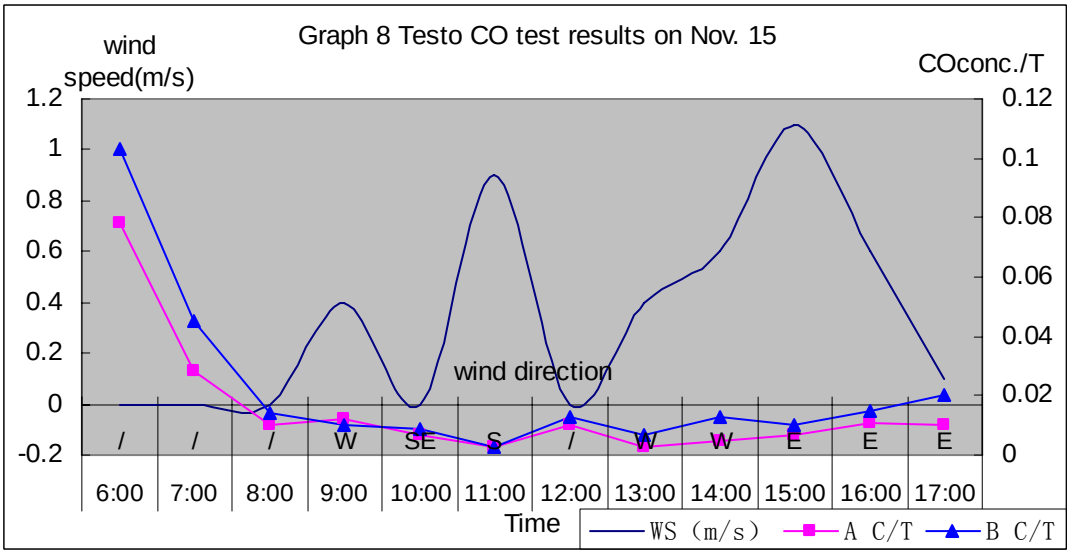
Analysis

The CO measurement was taken in the completely closed section. On Nov.13，west wind was prevailing wind near the ground, which will probably bias the result to a lower value. On Nov. 14, east wind was prevailing wind, which was ideal for test. On Nov. 15, the wind changed frequently, from west to east. When west wind blew at 9:00, the ratio of CO concentration to traffic volume(ratio C/T_{CO}) of the tunnel A was higher than tunnel B on the contrary. When the wind speed accelerated, ratio C/T_{CO} of the two tunnels became equal, the reduction rate fell to zero. It was likely the dilution effect of the wind covers the effects of the photo catalyst.

Not obvious association between CO concentration and the wind condition near the ground (speed and direction) was observed. CO concentration was mainly affected by the process of diffusion and homogeneousness of distribution of the air mass or air flow formed by vehicle exhaust. It was also tightly related to the intensity of the air current field in the tunnel too.


Graph 6 TestoCO test results on Nov.13
Wind speed(m/s)
CO conc./T
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0.014
0.012
0.01
0.008
0.006
0.004
0.002
wind direction
W
WSW
SW
W
14:00
15:00
16:00
17:00
Time
WS
A C/T
B C/T


Graph 7 TestoCO test results on Nov.14
Wind speed(m/s)
WS
A C/T
B C/T
COconc./T
2.5
2
1.5
1
0.5
0
0.025
0.02
0.015
0.01
0.005
0
Wind direction
E
E
E
E
E
SE
E
ESE
E
ENE
ENE
E
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
Time


Graph 8 Testo CO test results on Nov. 15
wind speed(m/s)
COconc./T
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0.12
0.1
0.08
0.06
0.04
0.02
0
wind direction
/
/
/
W
SE
S
/
W
W
E
E
E
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
Time
WS (m/s)
A C/T
B C/T

5. Conclusions

Quantitative statistic of NO_2 reduction of tunnel A compare with tunnel B

Table 5-1 NO_2 Reduction Effects

Unit %

Pollutant	Day average reduction						Hour average reduction		
	11/13 compare with12/4	11/15	11/16	12/3 compare with12/24	12/4 compare with 12/25	Average of 5days	Max	Min	Median
NO_2 ①	40.3	52.7	44.3	36.3	22.8	39.3	79.4	4.0	36.4
NO_2 ②	40.3	52.7	44.3	42.7	32.5	42.1	79.4	17.9	42.5

Notes In nitric oxides family NO_2 and NO are primary substance which will cause serious air pollution NO is a colorless gas and with an unstable chemical character，it will be oxidized to NO_2 when meets O_2.The toxicity of NO_2 is 4 ~ 5times stronger than NO. Its main toxicity is lung damage. Since NO_2 is an important air pollutant affecting the environment and public health, more concern was focused on the NO_2 reduction effect in this report.

① Exclusion of the influence of traffic flow.

② Exclusion of the influence of traffic flow and wind.

Table 5-2 CO Reduction Effects

Unit %

Pollutant	Day average reduction				Hour average reduction		
	11/13	11/14	11/15	Average of 3days	Max	Min	Median
CO	47.3	50.1	32.8	43.4	100.0	0.0	35.6

Notes: calculation in Table 5-2 excludes the influence of the traffic

Integrating monitoring data and calculation results, it can be learned that the on-spot measurement for pollutants decomposing effects of the photo catalyst is influenced by many complex factors such as the traffic flow in the tunnel, the flow direction, meteorological factor, sunlight, the trait of the tunnel and emitting, diffusing and distribution process of the gaseous pollutants. According to 8 days of testing results, the maximum catalysis efficiency of the testing photo catalysts is 79.4 % for NO_2 and 100% for CO respectively. The average catalysis efficiency is 43 % for NO_2 and 43.4% for CO respectively. It can be concluded that although under various kinds of weather conditions (sunny, cloudy, rainy, disadvantage wind direction)and many adverse condition such as in the complete close section of the tunnel only install a few UV lights which caused not enough brightness, the top of the tunnel was not applied any photo catalyst, the traffic volume of A tunnel was obviously higher than tunnel B etc .The testing photo catalysts still showed preferable evident effects.

Shanghai Academy of Environment Sciences

Jan.18-2007

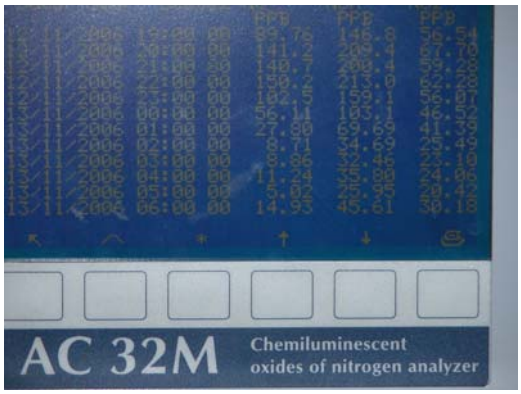
Appendix 1：Pictures

CO sampling

The visage of the underpass

Location of the sampling tube

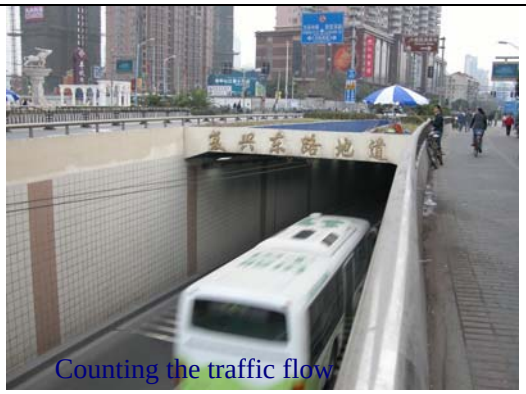
Location of instrument



AC32M NOx analyzer

Calibrating the instrument

Testo detector measuring CO



Counting the traffic flow

Appendix 2: Meteorological data

Table F-1、Nov.13 Meteorological Data

Time	WD	WS (m/s)	AP (kPa)	Temp (℃)	Humid (%)	CC	prec (mm)	Weather
6:00	NW	0.4	101.7	14.5	64	8	0	cloudy
7:00	W	0.0	101.7	15	68	9	0	cloudy
8:00	WNW	0.9	101.7	17	61	8	0	cloudy
9:00	NW	1.2	101.7	23	48	6	0	cloudy
10:00	NW	1.1	101.7	26	37	2	0	cloudy
11:00	NW	0.8	101.6	24	38	5	0	cloudy
12:00	NW	0.5	101.55	27	35	1	0	cloudy
13:00	NW	0.7	101.47	27	34	2	0	cloudy
14:00	W	0.4	101.43	27	33	9	0	cloudy
15:00	WSW	0.6	101.4	26	37	9	0	cloudy
16:00	SW	0.0	101.4	22	44	7	0	cloudy
17:00	W	0.0	101.5	20	45	9	0	cloudy

TableF-2 Nov.14 Meteorological Data

Time	WD	WS (m/s)	AP (kPa)	Temp (℃)	Humid (%)	CC	prec (mm)	Weather
6:00	E	0.9	102.20	15.0	70.0	6	0	cloudy
7:00	E	1.5	102.25	16.0	68.5	8	0	cloudy
8:00	E	1.6	102.35	17.0	64.0	8	0	cloudy
9:00	E	0.7	102.45	19.0	58.0	8	0	cloudy
10:00	E	0.4	102.50	20.0	56.0	8	0	cloudy
11:00	SE	0.7	102.50	20.0	53.0	9	0	cloudy
12:00	E	1.1	102.50	19.5	42.0	4	0	cloudy
13:00	ESE	1.0	102.45	18.0	44.5	5	0	cloudy
14:00	E	2.0	102.45	19.0	44.0	5	0	cloudy
15:00	ENE	1.9	102.40	19.0	45.0	4	0	cloudy
16:00	ENE	1.1	102.40	16.0	46.0	3	0	cloudy
17:00	E	1.5	102.55	15.0	49.0	1	0	cloudy

TableF-3 Nov. 15 Meteorological Data

Time	WD	WS (m/s)	AP (kPa)	Temp (℃)	Humid (%)	CC	prec (mm)	Weather
6:00	/	0.0	102.60	13.0	54.0	1	0	Sunny
7:00	/	0.0	102.60	13.0	58.0	1	0	Sunny
8:00	/	0.0	102.65	13.0	51.0	1	0	Sunny
9:00	W	0.4	102.65	14.5	45.5	1	0	Sunny
10:00	SE	0.0	102.65	24.5	24.5	0	0	Sunny
11:00	S	0.9	102.60	27.0	19.0	0	0	Sunny
12:00	/	0.0	102.45	24.5	16.0	0	0	Sunny
13:00	W	0.4	102.30	19.0	29.0	0	0	Sunny
14:00	W	0.6	102.30	18.5	30.5	0	0	Sunny
15:00	E	1.1	102.30	25.0	22.0	0	0	Sunny
16:00	E	0.6	102.35	22.5	23.0	0	0	Sunny
17:00	E	0.1	102.25	19.5	32.5	0	0	Sunny

TableF-4 Nov. 16 Meteorological Data

Time	WD	WS (m/s)	AP (kPa)	Temp (℃)	Humid (%)	CC	prec (mm)	Weather
6:00	NE	0.4	102.10	17.0	59.0	10	小	小雨
7:00	NE	0.0	102.20	16.5	62.0	10	小	小雨
8:00	NE	0.0	102.30	15.5	64.0	10	小	小雨
9:00	SE	0.0	102.30	15.5	64.0	10	小	小雨
10:00	NE	0.0	102.20	15.5	66.0	10	小	小雨
11:00	/	0.0	102.10	14.0	75.0	10	小	小雨
12:00	E	0.4	102.09	15.0	74.0	10	小	小雨
13:00	E	0.0	102.00	16.0	73.0	10	小	小雨
14:00	E	0.0	101.95	13.5	81.0	10	小	小雨
15:00	E	0.5	101.85	14.5	85.0	10	小	小雨
16:00	NE	0.9	101.90	13.5	85.5	10	小	小雨
17:00	E	0.0	102.00	13.0	89.0	10	小	小雨

TableF-5 Dec.3 Meteorological Data

Time	WD	WS (m/s)	Temp (℃)	Humid (%)	CC	prec (mm)	Weather
6:00	ESE	0	6.5	53	8	0	cloudy
7:00	SE	0	6.5	56	9	0	cloudy
8:00	E	0	10	50	9	0	cloudy
9:00	E	0	11.5	49	2	0	Sunny
10:00	E	0.4	13	46	0	0	Sunny
11:00	ESE	1	17	36	5	0	Sunny
12:00	E	1.6	17	36	2	0	Sunny
13:00	SSE	0.9	18	35	5	0	Sunny
14:00	E	0.9	17	35	7	0	cloudy
15:00	E	1.8	13	42	8	0	cloudy
16:00	ESE	1.7	12	46	2	0	cloudy
17:00	E	1.5	10	46	2	0	cloudy

TableF-6 Dec. 4 Meteorological Data

Time	WD	WS (m/s)	Temp(℃)	Humid (%)	CC	prec(mm)	Weather
6:00	E	0	8	57	0	0	Sunny
7:00	E	0	8.5	56.5	0	0	Sunny
8:00	ESE	0.8	11	51	0	0	Sunny
9:00	E	1	12.5	48	2	0	Sunny
10:00	E	1.3	16	40	1	0	Sunny
11:00	E	1.7	17	36	1	0	Sunny
12:00	E	1.7	18.5	34	2	0	Sunny
13:00	E	1	19	34	5	0	cloudy
14:00	E	1.7	17	36	7	0	cloudy
15:00	E	1	16	36	9	0	cloudy
16:00	E	0.9	14	40	9	0	cloudy
17:00	E	1.3	12	45	2	0	cloudy

TableF-7 Dec. 24 Meteorological Data

Time	WD	WS (m/s)	Temp (℃)	Humid (%)	CC	prec (mm)	Weather
6:46	SW	0	7	52	3	0	cloudy
7:00	S	0	7.5	60	3	0	cloudy
8:00	SW	0	8	73	4	0	cloudy
9:00	E	0	10	71	2	0	cloudy
10:00	NE	0	11	72	5	0	cloudy
11:00	E	0	13	64	5	0	cloudy
12:00	E	0	14	69	6	0	cloudy
13:00	ENE	0.4	14	58	8	0	cloudy
14:00	NE	0.4	13.5	59	8	0	cloudy
15:00	E	0.5	13	60	9	0	cloudy
16:00	E	0.9	12.5	62	8	0	cloudy
17:00	E	0.6	11.5	65	9	0	cloudy
18:00	E	0	11	68	9	0	cloudy

TableF-8 Dec.25 Meteorological Data

Time	WD	WS (m/s)	Temp (℃)	Humid (%)	CC	prec (mm)	Weather
6:40	E	0	9	80	10	小	阴
7:00	SE	0	10	76	10	小	阴转 cloudy
8:00	NW	0	11	75	8	0	cloudy
9:00	ESE	0	12	74	8	0	cloudy
10:00	E	0	12	73	2	0	cloudy
11:00	E	0.9	13	67	5	0	cloudy
12:00	ESE	0.9	14.5	59	6	0	cloudy
13:00	ESE	0.7	15	56	8	0	cloudy
14:00	E	0.7	15	55	9	0	cloudy
15:00	SE	1.6	15	57	9	0	cloudy
16:00	ESE	1.5	14	60	9	0	cloudy
17:00	ESE	0	13	64	9	0	cloudy
18:00	ESE	0.8	12	63	9	0	cloudy

Notes

Words	Short
Wind Direction	W.D.
Wind Speed	W.S.
Air Pressure	A.P.
Temperature	Temp.
Humidity	Humi.
Cloud cover	C.C.
Precipitation	Prec.