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TOBACCO SMOKE TEST REPORTS
NICOTINE TEST REPORTS

The UNIVERSITY of NEWCASTLE
AUSTRALIA

Department of Chemical Engineering
Telephone: (02) 4921 6103 Facsimile: (02) 4921 8692

12th June 1995

Client: Bio-Oxygen Aust Pty Ltd

Test Report of the operation of a Bio-Oxygen Air Purifier to remove airborne particulates and cigarette smoke.
Test Date: 3rd June 1995

Introduction:
Mr Philipp Leicher of Bio-Oxygen Australia Pty Ltd, approached me and requested tests on the Bio-Oxygen Air Purifier, a product used for the removal of airborne cigarette smoke particulates. The Bio-Oxygen Air Purifier produces negative oxygen ions which react with impurities in the air.

Test Procedure:
The test was carried out by installing a Bio-Oxygen Air Purifier in a room which was sealed from the outside by closing off all the open vents and cracks. A circulating fan was also installed in the room to evenly distribute airborne particulate matter within the room and to circulate the air around the Bio-Oxygen Air Purifier. The fan had a capacity of 380 L/s and circulated the air in the room at a rate of 20 room volumes per hour. No filter of any kind was used in the test. Cigarette smoke was introduced into the room with a small fan which sucked the air through a special cigarette holder that would inhale the smoke from ignited cigarettes and blow it into the room through a 50 mm pipe. The room size was 5.15 m x 5.30 m x 2.50 m giving it a total volume of 68.25 cubic meters. The smoke from 96 cigarettes was introduced into the room which is equivalent to 1.4 cigarettes per cubic meter. Particle size measurements were carried out on the air in the room using a 'Hiac/Royco' Portable particle counter (Serial Number: 9107P501). This instrument is calibrated annually and was last calibrated on the 27th February 1995 by Fotometrk (Hornsby NSW) who have NATA Certification. The instrument takes particle counts on 10 litre samples of air for specified particle sizes of 0.5 µm (microns), 0.7 µm, 1.0 µm and 5.0 µm. Particle counts were taken before and after introducing cigarette smoke into the room. The Bio-Oxygen Air Purifier was then switched on for 2 Hours and particle counts were taken at regular intervals. The room conditions for the duration of the test were 18°C to 20°C, 42% to 44% Relative Humidity.

Test Results:

Particle size (microns)	Pre-Existing Count	Total Count after smoke introduction.	Final Count at completion of test	% removal
0.5	31070	1623189	27368	98.31
0.7	8708	1409915	4238	99.70
1.0	5507	1279844	2081	99.84
5.0	341	13287	17	99.87

#Note: These results are expressed as particles per 10 litres air.

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TEST REPORT

An Independent Evaluation of the
BIO-OXYGEN AIR PURIFIER

By
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BIO-OXYGEN AUSTRALIA PTY. LIMITED
36 Bennett Place
Castle Hill NSW 2154

The information and results contained in this report have been obtained by independent testing and assessment and are submitted without prejudice.

Signed: .....

Test Date
22nd January 1996

ABSTRACT

The University of Newcastle was commissioned by Bio-Oxygen Australia Pty Ltd to test the efficiency of the Bio-Oxygen Air Purifier for the removal of airborne particulates and specifically for the removal of 'cigarette smoke'. The Bio-Oxygen Air Purifier employs an oxygen ionisation process which enhances the oxidation of particulates in the air. This report outlines the experimental method used to test the effectiveness of the process for the purification of air contaminated with cigarette smoke. The results show that the Bio-Oxygen Air Purifier was effective in removing an average of 98.84% of airborne particulates predominantly composed of cigarette smoke.

INTRODUCTION

On a previous occasion, on the 3rd June 1995, tests were carried out to ascertain the effectiveness of the Bio-Oxygen Air Purifier as a means of removing airborne particulates and specifically cigarette smoke. At the time, these tests were carried out using a laser particle counter to determine the concentration of particulates in the air. This was considered to be a passive test method so it was decided that a more positive approach (ie. by using filter papers) be employed to collect particulates present in the air. The test results obtained for the overall efficiency of the Bio-Oxygen Air Purifier for the removal of particulates and cigarette smoke using:

(a) a laser particle counter, was 99.43% and
(b) the filter papers, was 98.84%.

This cross testing conducted initially using a passive test method (laser particle counter) and then employing the positive test method (using filter papers as described in this report), provided test results which are within 0.6% of being identical. The results obtained therefore using the two completely different methods validate not only each of the test methods but also the results obtained.

TEST METHOD

The object of the test was to firstly create an atmosphere containing an excessive amount of cigarette smoke and then to sample this contaminated atmosphere to gauge the extent of contamination both before and after treatment with the Bio-Oxygen Air Purifier.

A diagram of the apparatus used for the tests is shown in Figure 1 and consists of an enclosure with a fixed volume of 200 litres. A small bowl, for burning the cigarettes, and the Bio-Oxygen Air Purifier were placed inside the enclosure. The Air Purifier incorporated a 60 mm diameter built in fan to provide cooling for the high voltage ionising lamp and also to provide a minimum amount of air circulation in the enclosure which in normal installations would be provided by the air conditioning fan. The inlet of the sampling tube protrudes 200 mm into the enclosure through a small hole. The other end of this tube is connected directly to a calibrated gas flow meter (Rotameter). From the rotameter the tube is connected to an in-line filter and then to the suction pump. The filter holder accommodates 0.20 μm Supor 200 BASF Filter papers manufactured by Gelman Sciences (Product No. 60300, Lot No. 5020409).

TEST PROCEDURE

Initially background air samples were taken to determine the extent of pre-existing particulates in the air within the enclosure. The air in the enclosure was vented after collecting each sample.

Two cigarettes were then ignited and allowed to burn freely in a bowl in the test enclosure. When the cigarettes were completely burnt the cigarette bowl was removed from the enclosure. It must be noted that two cigarettes in 200 litres of air is equivalent to 10 cigarettes per cubic metre or 1000 cigarettes for a 100 m^3 room. The Bio-Oxygen Generator was switched on for a period of precisely 15 minutes. The air was then sampled after which the enclosure was vented.

The procedure using the 2 cigarettes was repeated but with the Bio-Oxygen Air Purifier turned off and the samples were taken after a period of 15 minutes had elapsed. After each sample was taken the air in the enclosure was vented.

All tests were carried out in duplicate and the filter papers from each test were placed into individual sealed plastic bags and were labelled accordingly.

All samples were collected at a rate of 1.5 litres per minute for a period of 10 minutes which is equivalent to a 15 litre sample for each test.

Temperature and Relative Humidity was recorded throughout the duration of the tests. The temperature ranged from 25.1 ^{o}C to 27.1 ^{o}C and the Relative Humidity from 46 % to 50 %.

In order to keep a visual record of the tests a photograph was taken of the test filter papers which were placed on a display board depicting the stages at which they were collected. The samples labelled 1 and 2 were the samples collected after each test as carried out in duplicate.

The tests show that the tars which evolve from cigarette smoke appear to be completely removed by the Bio-Oxygen process. This is clearly shown when comparing the photographs with and without Bio-Oxygen treatment. Without Bio-Oxygen the filter papers are a distinctive brown colour and after the Bio-Oxygen process the filter paper is white and is indistinguishable from a new unused filter paper. A copy of the photograph is attached to this report.

RESULTS

The sample filter papers were then taken to the University of NSW for analysis using a Densitometer to measure the differences in colour of the various samples. The analysis was carried out using a Spectrogard Color System Model 96 Densitometer manufactured by Pacific Scientific. The instrument scans the sample for reflected light in the wavelength range of 400 nm to 700 nm in divisions of 10 nm and the data is processed by a computer which produces a plot between 0% and 100% over the specified range. These results were compared with a new, unused, standard filter paper.

The results obtained were plotted against those of a standard filter paper to produce a graph (see Diagrams 1, 2 and 3). The results from each series of tests were averaged and these were plotted against wavelength as shown in Diagram 4.

Efficiency of the Bio-Oxygen Air Purifier was determined over the range of wavelengths as per the following formula:

$$\varepsilon_0 = 100(1 - (\phi-\tau)/(\phi-\chi))\ \%$$

where: ε_0 = Percentage efficiency
ϕ = Reflectance for fresh air
τ = Reflectance for treated air
χ = Reflectance for contaminated air.

This efficiency was calculated and plotted over the full range of wavelengths as shown in Diagram 5.

Examination of the results shows that the Bio-Oxygen Air Purifier effectively removed an average of 98.84% of airborne particles composed predominantly of cigarette smoke.

The data obtained, respective averages and efficiency calculations are listed in Table 1.

CONCLUSIONS AND RECOMMENDATIONS

The Bio-Oxygen Air Purifier effectively removed cigarette smoke and particulates exceeding sizes of 0.2 μm from the atmosphere. The filter material is Supor-200 BASF manufactured by Gelman Sciences Inc. (certification as per statement in Appendix 1) and retains all particles exceeding 0.2 μm in size. The tests show that the Bio-Oxygen Air Purifier removes particles which exceed 0.2μm in size, with an efficiency averaging 98.84%.

Further tests are being pursued in an effort to produce a Standard acceptable by the Standards Association of Australia that is applicable to situations relating to the removal of cigarette smoke in recreation environments in a bid to reduce its detrimental effect on the health of patrons.

BIO-OXYGEN AIR PURIFIER
FILTER TEST RESULTS
22nd January 1996
Untreated Fresh Air

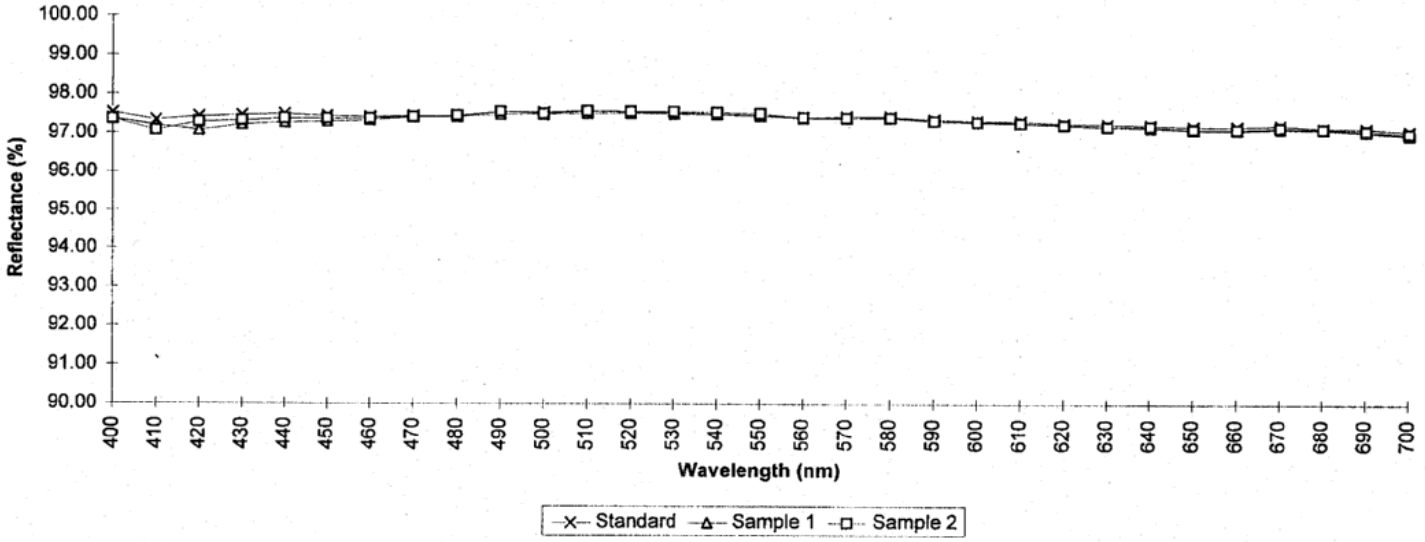


DIAGRAM 1

BIO-OXYGEN AIR PURIFIER
FILTER TEST RESULTS
22nd January 1996
Air Contaminated with Cigarette Smoke after Treatment

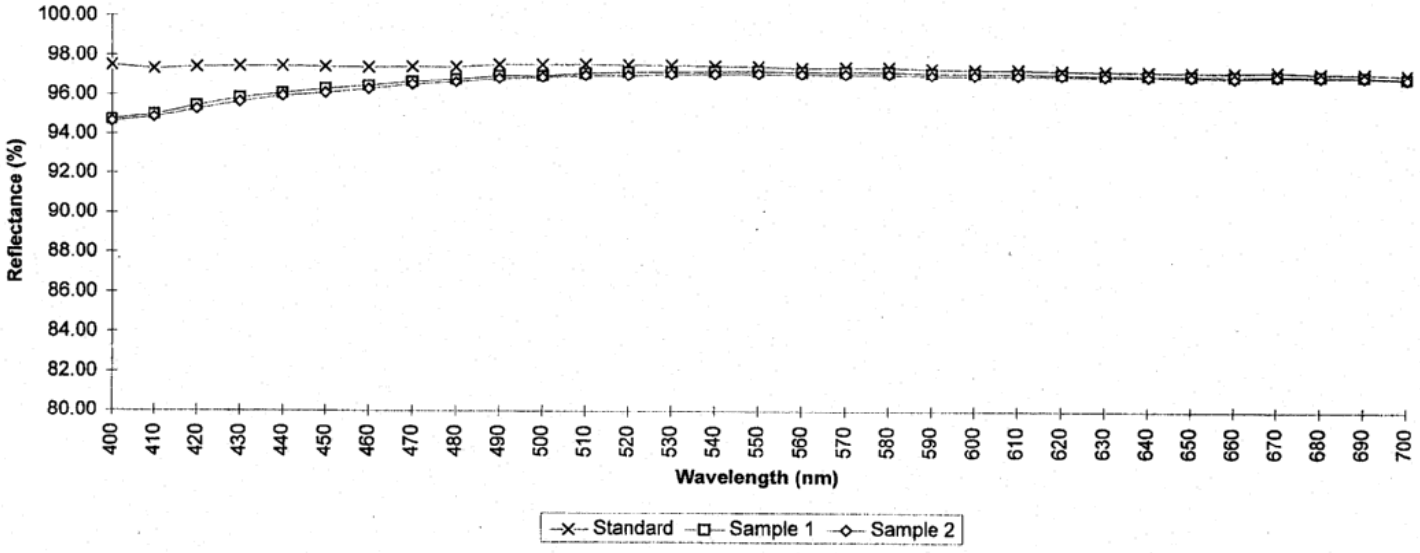


DIAGRAM 2

BIO-OXYGEN AIR PURIFIER
FILTER TEST RESULTS
22nd January 1996
Air Contaminated with Cigarette Smoke and Untreated

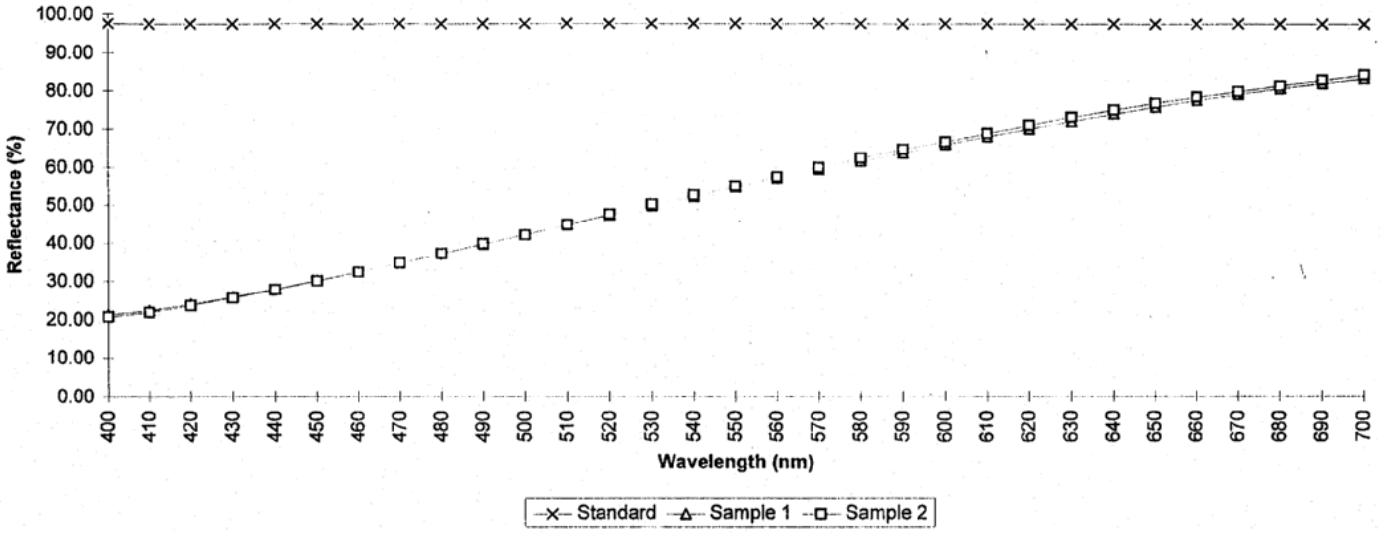


DIAGRAM 3

BIO-OXYGEN AIR PURIFIER
FILTER TEST RESULTS
22nd January 1996

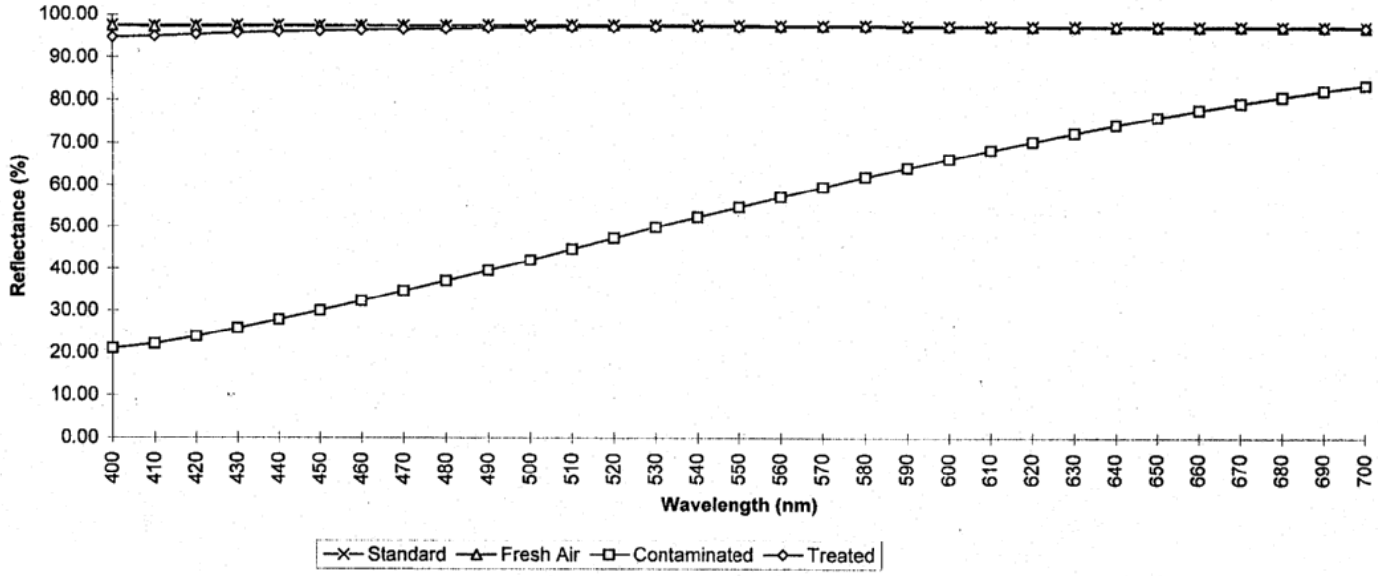


DIAGRAM 4

BIO-OXYGEN AIR PURIFIER
Smoke Removal Efficiency
22nd January 1996

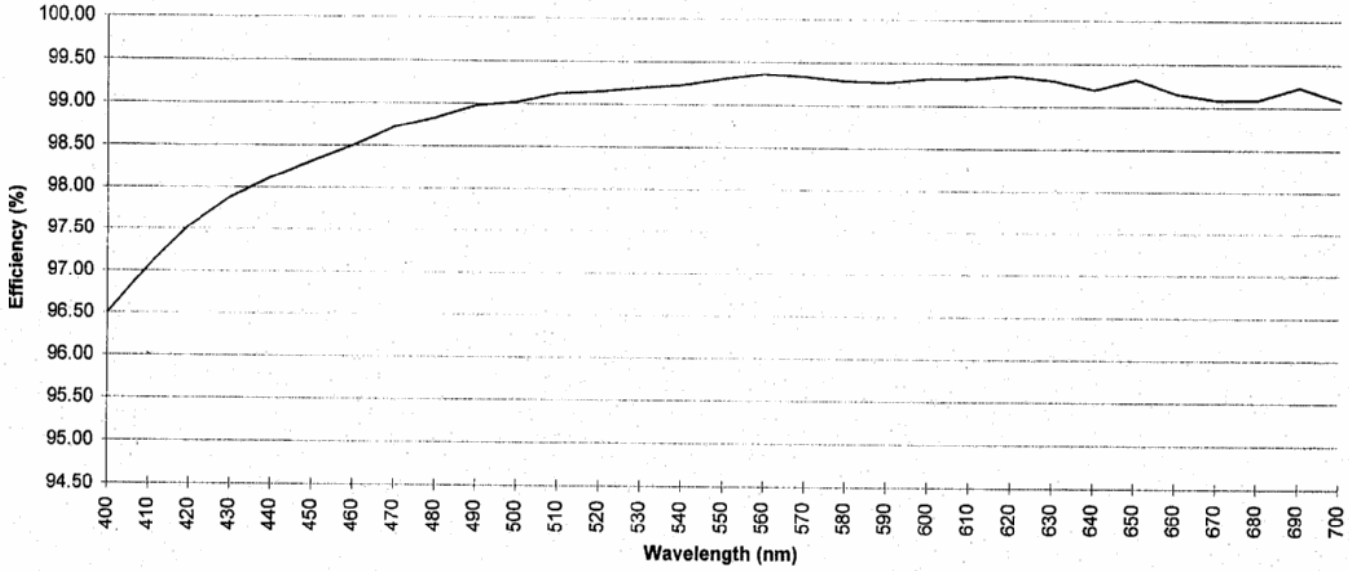


DIAGRAM 5

BIO-OXYGEN AIR PURIFIER TESTS
22nd January 1996

DENSITOMETER RESULTS & CALCULATIONS

		Fresh Air		Contaminated then Treated		Contamined with Cigarette Smoke		Averages			Efficiency
Wavelength	Standard	Sample A	Sample B	Sample B	Sample C	Sample A	Sample B	Fresh Air	Contaminated	Treated	% Removal
400	97.51	97.36	97.35	94.73	94.63	21.25	20.71	97.36	20.98	94.68	96.50
410	97.33	97.20	97.07	95.00	94.85	22.28	21.85	97.14	22.07	94.93	97.06
420	97.43	97.08	97.29	95.46	95.28	23.94	23.58	97.19	23.76	95.37	97.53
430	97.46	97.22	97.32	95.85	95.65	25.87	25.62	97.27	25.75	95.75	97.87
440	97.48	97.27	97.37	96.08	95.94	27.90	27.74	97.32	27.82	96.01	98.12
450	97.44	97.30	97.37	96.31	96.09	30.08	29.99	97.34	30.04	96.20	98.31
460	97.41	97.33	97.37	96.46	96.29	32.34	32.27	97.35	32.31	96.38	98.50
470	97.44	97.40	97.41	96.67	96.53	34.68	34.72	97.41	34.70	96.60	98.72
480	97.43	97.42	97.45	96.80	96.66	37.11	37.18	97.44	37.15	96.73	98.83
490	97.54	97.48	97.55	96.99	96.85	39.56	39.75	97.52	39.66	96.92	98.97
500	97.54	97.48	97.50	96.98	96.91	42.16	42.08	97.49	42.12	96.95	99.02
510	97.57	97.51	97.57	97.13	97.02	44.72	44.77	97.54	44.75	97.08	99.12
520	97.54	97.51	97.56	97.19	97.02	47.18	47.48	97.54	47.33	97.11	99.14
530	97.53	97.50	97.56	97.20	97.09	49.70	50.15	97.53	49.93	97.15	99.19
540	97.50	97.49	97.54	97.23	97.10	52.17	52.58	97.52	52.38	97.17	99.22
550	97.47	97.45	97.51	97.25	97.11	54.56	54.93	97.48	54.75	97.18	99.30
560	97.41	97.39	97.41	97.20	97.08	56.95	57.32	97.40	57.14	97.14	99.35
570	97.44	97.39	97.40	97.21	97.07	59.21	59.80	97.40	59.51	97.14	99.33
580	97.44	97.42	97.40	97.22	97.09	61.45	62.29	97.41	61.87	97.16	99.28
590	97.37	97.33	97.33	97.14	97.03	63.58	64.52	97.33	64.05	97.09	99.26
600	97.33	97.31	97.29	97.14	97.03	65.77	66.50	97.30	66.14	97.09	99.31
610	97.33	97.28	97.27	97.13	97.02	67.87	68.69	97.28	68.28	97.08	99.31
620	97.27	97.24	97.23	97.10	97.02	69.84	70.81	97.24	70.33	97.06	99.35
630	97.25	97.19	97.18	97.05	96.97	71.76	72.90	97.19	72.33	97.01	99.30
640	97.23	97.16	97.19	97.04	96.94	73.68	74.83	97.18	74.26	96.99	99.19
650	97.19	97.11	97.12	97.01	96.93	75.49	76.50	97.12	76.00	96.97	99.31
660	97.19	97.09	97.12	96.99	96.89	77.26	78.15	97.11	77.71	96.94	99.15
670	97.23	97.14	97.16	97.02	96.95	78.89	79.59	97.15	79.24	96.99	99.08
680	97.16	97.12	97.13	97.02	96.93	80.36	81.08	97.13	80.72	96.98	99.09
690	97.15	97.06	97.09	96.99	96.93	81.72	82.60	97.08	82.16	96.96	99.23
700	97.08	96.96	97.01	96.88	96.84	82.98	84.01	96.99	83.50	96.86	99.07
										Average	98.84

TABLE 1

Diagram of Test Apparatus for the testing of Air Purifiers

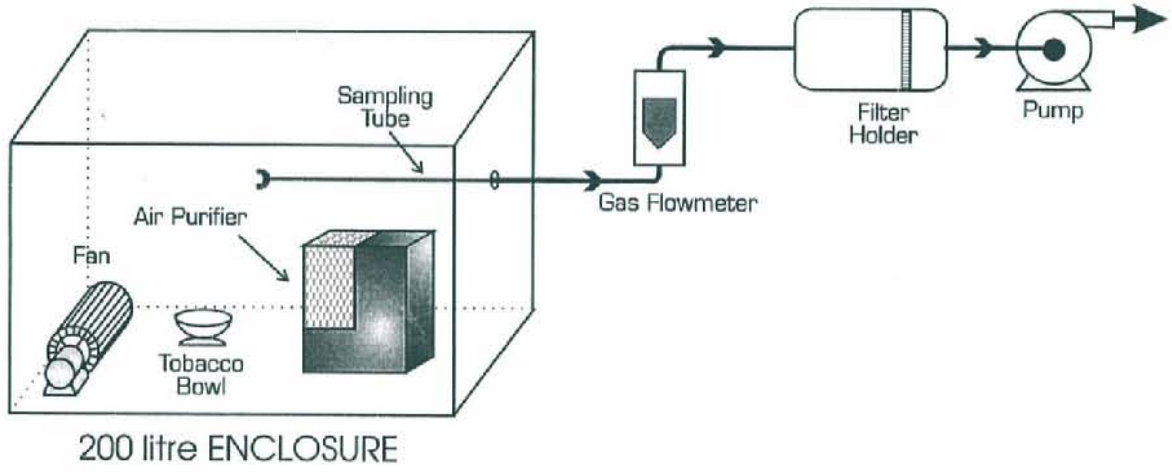
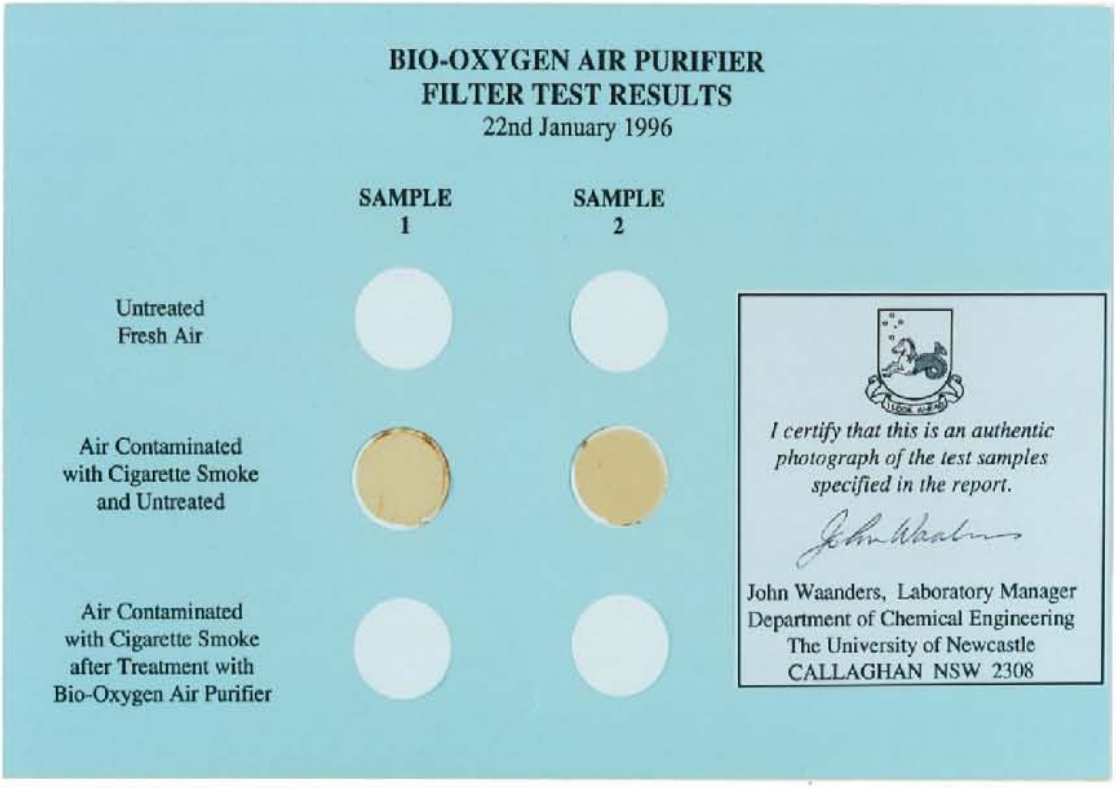


FIGURE 1



The UNIVERSITY *of* NEWCASTLE

AUSTRALIA

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22nd September 1996

Client: Bio-Oxygen Aust Pty Ltd

Test Report of the effect of a Bio-Oxygen Air Purifier on nicotine in air contaminated with cigarette smoke.

Test Date: 7th August, 1996

Introduction

Mr Philipp Leicher of Bio-Oxygen Australia Pty Ltd, requested tests on the effectiveness of a Bio-Oxygen Air Purifier to remove nicotine when being used for the removal of airborne cigarette smoke and particulates. These tests were carried out as a follow up to the testing done on the 22nd January 1996 which showed that the a Bio-Oxygen Air Purifier was effective in removing 98.84% of the airborne particulates from air contaminated with cigarette smoke.

Test Apparatus

A diagram of the apparatus used for the tests is shown in Figure 1 and consists of an enclosure with a fixed volume of 200 litres. A small bowl, for burning the cigarettes, and the Bio-Oxygen Air Purifier were placed inside the enclosure. The Air Purifier incorporated a 60 mm diameter built in fan to provide cooling for the Bio-Oxygen ionising lamp and also to provide a minimum amount of air circulation in the enclosure which in normal installations would be provided by the air conditioning fan. The inlet of the sampling tube protrudes 200 mm into the centre of the enclosure through a small hole. The other end of this tube is connected directly to a calibrated gas flow meter (Rotameter). From the rotameter the tube is connected to an in-line filter and then to the suction pump. The 'Millipore' filter holder holds 47 mm diameter GS/GV filter papers which retain particulates over 0.20 μm in size. The exhaust air is recirculated back to the enclosure to prevent infiltration of outside air.

Procedure

Initially a background air sample was taken (using a 'Millipore' 47 mm diameter, 0.2 μm filter paper) to determine the extent of pre-existing particulates and nicotine which may be present in the air within the enclosure.
Two cigarettes were then ignited and allowed to burn freely in a bowl in the test enclosure. When the cigarettes were completely burnt the cigarette bowl was removed from the enclosure. The air was then sampled by passing through the 'Millipore' filter. During this sampling process the filter papers were changed 3 times because of blockages caused by the retained particulates. After a total of 35 minutes of sample collection the enclosure was vented.
Two cigarettes were again ignited and allowed to burn freely in a bowl in the test enclosure. When these cigarettes were completely burnt the cigarette bowl was again removed from the enclosure. The Bio-Oxygen Generator was then switched on for a period of precisely 15 minutes. The air was then sampled using the 'Millipore' filter for a period of 35 minutes (only one filter paper was needed for this test). Considerable effort was made to ensure that all the tests were carried out under the same conditions with the same sampling periods and with continuous circulation of the air within the enclosure.
A photograph of the collected samples was taken and the samples were then sent to the Department of Chemistry at the University of Newcastle for 'nicotine' analysis.

Results

The results of the tests showed that the cigarettes produced a total of 0.14 mg of nicotine and use of the Bio-Oxygen Air Purifier reduced the quantity of nicotine collected down to 0.003 mg. This is equivalent to a removal efficiency of 97.9 %. A copy of the photograph of the samples is attached and a more comprehensive report will be available upon request.

John Waanders B.E., M.Eng.Sc., M.I.E.Aust., C.P.Eng., Grad.I.Chem.E.
Laboratory Manager, Chemical Engineering

Diagram of Test Apparatus for the testing of Air Purifiers

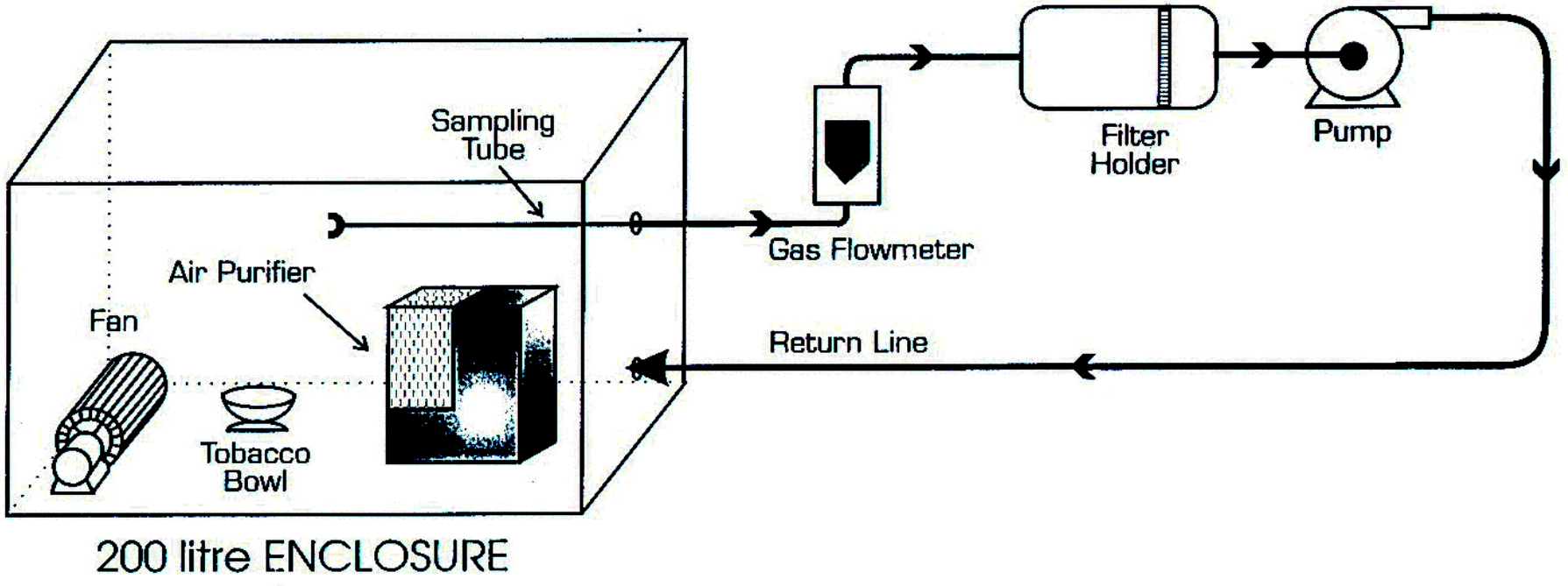

FIGURE 1

BIO-OXYGEN AIR PURIFIER
FILTER TEST RESULTS
7th August 1996

TEST 1

1. Enclosure contained untreated, smoke free, fresh air.
2. Sample was withdrawn from the enclosure through a 0.2µm filter paper.

Sample Period: 23 mins

TEST 2

1. 2 cigarettes were allowed to burn inside the enclosure.
2. Samples were withdrawn from the enclosure through 0.2µm filter papers.

Sample Period:

5 mins	6 mins	11 mins	13 mins

Total Duration: 35 mins

The filter papers were changed at specified time intervals because of substantial reductions in flow.

TEST 3

1. 2 cigarettes were allowed to burn inside the enclosure.
2. Bio-Oxygen Air Purifier was turned on.
3. After 15 minutes Bio-Oxygen Air Purifier was turned off
4. Sample was withdrawn from the enclosure through a 0.2µm filter paper.

Sample Period: 35 mins

I certify that this is an authentic photograph of the test samples specified in the report.

John Waanders

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Mr John B. Waanders

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8th October 2001

Mr Philipp Leicher
Bio-Oxygen NSW Pty Limited
36 Bennett Place
Castle Hill 2154

Dear Sir,

Re: Use of Dilution Techniques for the Removal of Cigarette Smoke and Odour

You requested information on the efficiency of dilution techniques for the removal of cigarette smoke and odours from rooms where smoking is permitted. The reality is that while the room air is constantly purged and replaced with fresh air, the smokers occupying the room constantly add cigarette smoke and odour.

I have assessed the problem by measuring the time it takes to smoke a cigarette and I have determined that the average time is 4 minutes with a deviation of +/- 10 seconds. Consider a room containing a number of smokers. If the room is purged completely with fresh air every 4 minutes the smoke retained in the room will remain unchanged whilst the smoking continues in the room. If purging is increased to every 2 minutes the smoke concentration will be reduced to 50%. In other words 15 air changes of fresh air per hour will keep the smoke concentration at a constant level and 30 air changes per hour will reduce the smoke concentration by 50%. The following table shows the overall effect of varying the purge rates on the smoke levels after one hour, in a room occupied by a consistent number of smokers.

Room Air replaced with Fresh Outside Air	Residual Smoke/Odour Concentration
After 3 Air Changes	500%
After 6 Air Changes	250%
After 9 Air Changes	165%
After 12 Air Changes	125%
After 15 Air Changes	100%
After 18 Air Changes	82%
After 21 Air Changes	71%
After 24 Air Changes	62%
After 27 Air Changes	55%
After 30 Air Changes	50%
After 33 Air Changes	45%
After 36 Air Changes	41%
After 39 Air Changes	38%
After 42 Air Changes	35%
After 45 Air Changes	33%
After 48 Air Changes	31%
After 51 Air Changes	29%
After 54 Air Changes	27%
After 57 Air Changes	26%
After 60 Air Changes	25%

What this table shows is that even after 60 air changes the retained smoke concentration in the room is 25% of the level at which it is being introduced into the room. These figures illustrate that to achieve some effective smoke reduction requires unreasonably high air change rates, which are not feasible, and they show that the use of dilution techniques is a futile method of smoke removal.

Yours truly,

John Waanders, B.E., M.Eng.Sc., C.Eng., M.I.Chem.E., M.I.E.Aust., C.P.Eng.