THE EFFECTS OF AIR POLLUTION ON STORED PAPERS

by T. F. NIELSEN

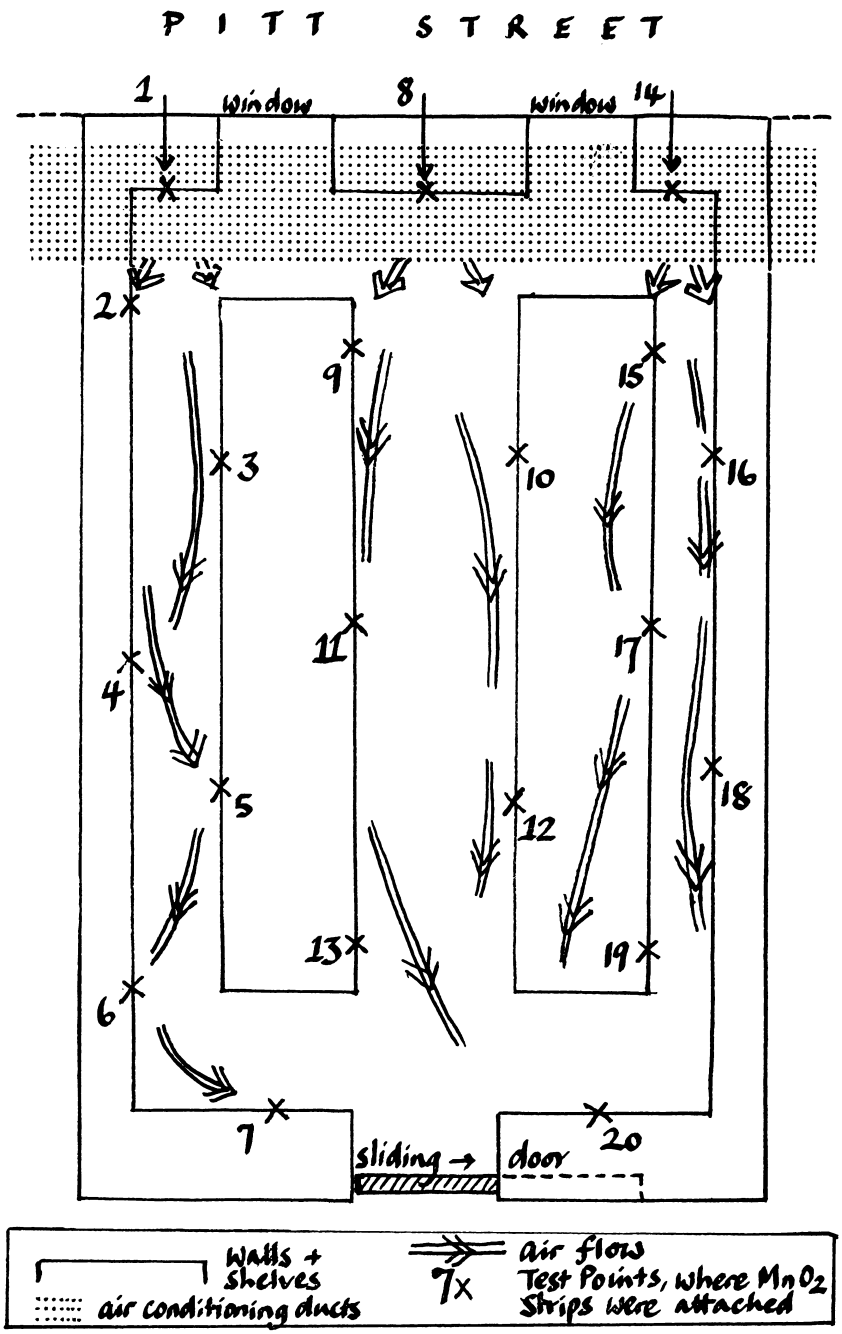
WITHOUT the use of expensive and sophisticated test equipment, it is usually quite difficult to arrive at an accurate assessment of the practical effects of air pollution on paper materials. These effects are mainly due to the extreme dilution of the SO_2—sulphur dioxide—in the air.

It has been proved in tests carried out during the past years that badly polluted air (for instance in George Street and Pitt Street, Sydney) contains approximately 1 to $1\frac{1}{2}$ volumes of SO_2 in ten million volumes of air, and also that a badly-deteriorated paper will have picked up approximately .5% to 1% of its own weight of H_2SO_4—sulphuric acid. This means simply that such a paper must have had a very large volume of polluted air passing over it to pick up such a large concentration of sulphuric acid.

The rate of convection, the rate of acid-absorption and the volume of air passing over a given paper can be measured by the use of test strips which will show a noticeable colour change proportional to the volume of SO_2 passing over and being absorbed into the paper. The concentration of SO_2 at any given place in a storage area will often vary considerably from one hour to the next, and in an effort to arrive at an acceptable average reading over any given period of time, some quite elaborate and expensive equipment would be essential; however, if one is prepared to sacrifice a very high degree of accuracy and precision and to accept that approximate values are sufficiently precise for everyday control of this problem, then the coloured strip method (Warren Spring Laboratory) can be used.

MnO_2—manganese dioxide—test strips are made from Whatman Filter Paper No. 1 and are impregnated with colloidal manganese dioxide which will gradually bleach to white in the presence of SO_2. After the strips, one inch by four inches, have been immersed in a solution of potassium permanganate (1 gram), potassium acetate ($2\frac{1}{2}$ grams) and water (50 c.c.) they should be dried in warm, dry air. Afterwards they must be kept in a completely dry place until they are to be used. I find it best to make them just before I want to use them. These test strips are fairly cheap and easy to make and can be placed in any position—on walls and shelves, in boxes and in books. The change of colour is sufficiently noticeable to avoid constant attention.

It is very difficult to find any practical experimental and test results on which to base further work, or even to draw some general conclusions in relation to SO_2 absorption into paper, and it was because of this that I decided to set up a small-scale experiment. The room was on the first floor of a building in Pitt Street, Sydney, and the storage was mainly of loose, unbound paper materials on metal shelving. The layout of the room was according to the accompanying illustration. One manganese dioxide test strip sample together with one non-acid paper (pH=7) sample strip were placed at each test point as indicated


PITT STREET
1
window
8
window
14
2
9
15
3
10
16
11
17
4
5
12
18
13
19
6
7
20
sliding →
door
Walls + shelves
air conditioning ducts
air flow
7X
Test Points, where MnO2 Strips were attached

in the drawing. The Low test-point was one foot off the floor, the High test-point was six feet off the floor.

As the rooms and contents had not previously been treated against mould infestation, it was no surprise to discover at the end of the third experiment that mould organism had started to develop on books, boxes and shelves. The result was that immediate fumigation became essential, and this was carried out over a period of two days using thymol fumes. It should also be pointed out that there was no evidence in any way that

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FIRST TEST: A three-month investigation carried out in fully air-conditioned (24 hours a day) conditions with humidity control.

LOW Test Point	HIGH Test Point	Days MnO_2 strip lasted out of box	pH of non-acid paper samples after 1 month	2 months	3 months
1		5		6.5	6.2
	1	5		6.6	6.2
2		5		6.5	6.1
	2	4		5.9	5.6
3		4		5.9	5.5
	3	3		5.6	5.2
4		3		5.4	5.1
	4	2		5.5	5.1
5		3		5.6	5.3
	5	3		5.6	5.2
6		4		6.0	5.6
	6	3		5.5	5.1
7		4		6.0	5.5
	7	3		5.6	5.0
8		5		6.6	6.3
	8	5		6.6	6.3
9		3		5.6	5.0
	9	2	All	5.6	5.0
10		3	readings	5.8	5.3
	10	2	taken	5.4	5.1
11		3	after one	6.0	5.5
	11	2	month	5.4	5.0
12		3	were	5.8	5.4
	12	2	above 6.8	5.5	5.1
13		3		6.1	5.5
	13	2		5.6	5.0
14		5		6.6	6.2
	14	5		6.6	6.3
15		5		6.4	6.2
	15	3		5.8	5.3
16		4		5.9	5.6
	16	3		5.6	5.2
17		3		5.4	5.2
	17	3		5.4	5.1
18		3		5.4	5.2
	18	3		5.4	4.9
19		3		5.3	5.0
	19	2		5.4	4.9
20		3		5.4	5.1
	20	2		5.5	5.0

All test strips inside boxes and books lasted more than three months.

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the organism had spread or developed to any greater degree in the path of the air flow.

I should like to make the following comments on the three experiments but I will leave the reader to draw his own conclusions from my results and hopefully to expand on these experiments.

1. The MnO_2 test strips lasted longest in the third experiment, medium in the first experiment, and shortest in the second.
2. The non-acid test strips, similarly, absorbed most acid in the

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SECOND TEST: A three-month investigation carried out in well-ventilated conditions with no air-conditioning or humidity control.

LOW Test Point	HIGH Test Point	Days MnO_2 strip lasted out of box	pH of non-acid paper samples after 1 month	2 months	3 months
1		3		6.3	5.8
	1	3		6.3	5.8
2		2		6.3	5.7
	2	2		6.1	5.3
3		2		6.0	5.3
	3	2		5.7	5.0
4		2		5.7	4.8
	4	1		5.8	4.8
5		2		5.8	5.0
	5	2		5.7	5.2
6		2		5.9	5.4
	6	2		5.4	5.1
7		2		5.8	5.3
	7	2		5.6	4.9
8		3		5.8	5.6
	8	2		5.8	5.7
9		2		5.6	5.1
	9	2	All	5.5	5.1
10		2	readings	5.6	5.1
	10	1	taken	5.2	4.8
11		2	after one	5.4	5.0
	11	1	month	5.0	4.8
12		1	were	5.3	4.9
	12	1	above 6.5	5.0	4.8
13		2		5.6	5.3
	13	1		5.4	5.0
14		3		6.0	5.6
	14	2		6.0	5.5
15		3		5.6	5.0
	15	3		5.6	5.0
16		2		5.4	4.9
	16	2		5.0	4.8
17		2		5.0	4.7
	17	1		5.1	4.7
18		2		4.9	4.6
	18	2		4.8	4.6
19		2		5.0	4.8
	19	1		5.0	4.7
20		2		4.9	4.7
	20	1		5.0	4.7

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second experiment, medium acid in the first experiment and least acid in the third.

3. Figures obtained from the three trials show very definitely that the period of time which the MnO_2 strips lasted and the length of time during which the non-acid test strips were left in the room, together with the exact spot where these strips had been

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THIRD TEST: Carried out as an afterthought: a three-month investigation carried out with no air-conditioning, humidity control or ventilation. The room was not used at all during the period except once daily when checks had to be made on the test strips.

LOW Test Point	HIGH Test Point	Days MnO_2 strip lasted out of box	pH of non-acid paper samples after 1 month	2 months	3 months
1		7		6.7	6.5
	1	7		6.7	6.4
2		7		6.7	6.4
	2	7		6.8	6.3
3		7		6.8	6.4
	3	7		6.7	6.4
4		7		6.8	6.3
	4	6		6.8	6.4
5		5		6.7	6.4
	5	6		6.6	6.4
6		7		6.7	6.3
	6	7		6.7	6.3
7		7		6.7	6.3
	7	7		6.7	6.5
8		7		6.7	6.4
	8	7		6.7	6.4
9		7	All	6.9	6.3
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	10	7	after one	6.7	6.3
11		5	month	6.6	6.3
	11	6	were	6.5	6.3
12		7	above 6.8	6.6	6.3
	12	7		6.6	6.4
13		5		6.6	6.4
	13	5		6.7	6.3
14		7		6.7	6.4
	14	7		6.7	6.5
15		7		6.7	6.4
	15	7		6.7	6.4
16		7		6.6	6.4
	16	7		6.6	6.3
17		6		6.6	6.3
	17	6		6.7	6.4
18		5		6.7	6.3
	18	5		6.7	6.3
19		7		6.7	6.4
	19	7		6.6	6.4
20		7		6.6	6.3
	20	7		6.6	6.3

All test strips inside boxes and books lasted more than three months.

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placed in the room in relation to the air flow affected the relative amount of acid each absorbed. Where the air-flow past the test samples was the greater, the MnO_2 test strips lasted the shortest time, and the pH of the non-acid test strips was most acid. Where the air-flow was the least, the MnO_2 strips lasted the longest and the non-acid strips absorbed the least volume of acid.

This makes it reasonable to affirm that Pitt Street pollution affects stored paper materials to a very considerable degree, even though most air-conditioning systems do recycle a large volume of air. Consideration should be given to more work in this field in an effort to solve the problem of acidity in stored paper materials—perhaps by the 'deacidification' of the air used in storage areas.