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Programme 2/64 (supersedes 2/63)

PES/TU.1206/3493/63

Project No.33

The Penetration of Built-Up Areas by Aerosols at Night

INTRODUCTION

1. When an aerosol cloud is generated in the atmosphere above a temperature inversion, it diffuses downward only slowly, and at night-time therefore it may drift over a wide area without penetrating to the ground to an appreciable extent. It has been suggested however, that in the vicinity of a large town the inversion is destroyed by the heat emitted from factory furnaces, domestic heating appliances, etc., and that sufficient turbulence is set up for aerosol material to be brought to ground level in larger concentrations than in the open country far outside the town.
2. An attempt was made to verify this hypothesis by trials in Salisbury, but the results were inconclusive: the smallness of the town and the unevenness of the surrounding country were such that any effect of the type sought was masked by topographical effects. The experiments are being repeated in another, larger, town, which is a more powerful heat source, and which is situated in a district as free as possible from topographical irregularities; the City of Norwich has been selected for this purpose.
3. It has been found that opportunities to stage a trial on the basis of a 36 hr weather forecast occur with insufficient frequency; accordingly the programme has been modified to allow a decision to be made on a 9 hr or 10 hr forecast. In an effort to improve the value of a trial, the programme has been further modified so as to permit the fixing of Trial Zero at a time later than $\frac{1}{2}$ hr after evening crossover, whenever flying conditions are favourable.

DATE AND TIME

4. It is aimed to carry out two trials in each of the weeks commencing on the following dates:-

January 13th; February 10th; March 16th; and April 13th, 1964.

R.A.F. Swanton Morley are not able to confirm the dates February 10th, March 16th and April 13th so far in advance. These must, therefore, be considered subject to cancellation if necessary.

A trial will normally extend from midday on the "day of the trial" until the early morning of the following day.

PLACE

5. Norwich and its environs.

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WEATHER

6. Gradient wind not less than 15 mi/hr.
No precipitation.
Cloud base not less than 1000 ft above ground.
Strong Inversion near the ground.
Visibility good enough for visual navigation in the air.

FORECASTING

7. A forecast of the suitability of conditions for a trial in the evening of the same day will be made at C.D.E.E. at 7.15 a.m. on the Tuesday of each week in which trials are projected. If a trial is to be attempted, a detailed forecast including wind direction and time of evening crossover must be available at the Control Point at noon.

If a trial is not carried out on the Tuesday, the above procedure will be repeated on the Wednesday (and again on the Thursday if the trial is not carried out on the Wednesday).

If a trial is carried out on the Tuesday, no forecasts will be required on the Wednesday but the procedure described above will be repeated on the Thursday.

SOURCE

8. The substance to be dispersed will be silicone-treated F.P. (zinc cadmium sulphide). This substance is quite innocuous in the concentrations that will occur near the ground, and the cloud will moreover be so diffuse that members of the public will be oblivious of its presence.

9. 120 lb of the material will be released at a rate of 2 lb/mi from a dispenser, operated by members of the staff of C.D.E.E. in a "Devon" or "Valetta" aircraft, flying at 400 ft above ground level along one of the tracks listed in Appendix I. Any breaks in the emission will be reported by RT to the Control Point.

SAMPLING

Location of Sampling Stations

10. In the city sampling will take place at as many of the 30 positions listed in Appendix II as will be available on the day of the trial. In a few cases alternative sampling positions may be nominated by the City Police in lieu of the listed sampling stations. Outside the City sampling will take place at 15 roadside positions, 3 lines of 5 positions being chosen from Appendix III on the day of the trial.

11. A code designation will be allotted to each station, consisting of a letter followed by a number. Each station inside the city will have the letter T and the number appearing beside its name in Appendix II; each station outside the city will have the letter R, F, or L, according as it lies to the right, to the front or to the left of a person in the city looking upwind, and a number indicating the ordinal of its position counted outwards along the sampling line from the city.

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Nature of Sampling Apparatus and its Operation

12. At every sampling station there will be a T.1 pump, 2 x 12 volt, 100 amp hr batteries, a 5 ft long wooden stake and a box labelled with the code designation of the station containing 12 millipore filters in holders. The T.1 pump is a vacuum pump, housed in a wooden box, 2 ft x 1 ft x 1 ft, and weighing about 60 lbs. It will be powered by one of the batteries at a time. The batteries measure 2 ft x 8 in. x 9 in. and weigh about 100 lb each. The battery with the RED marking will be used first at each position, and the battery with the GREEN marking substituted when the vacuum falls below 15" Hg. The time at which the batteries are changed will be recorded. The millipore filter holder is a roughly cylindrical object, made largely of transparent plastic, about $1\frac{1}{4}$ in. long and $1\frac{1}{4}$ in. in diameter, at one end of which is a cap which has to be removed before the filter is put into operation, and at the other end of which is a nozzle to which a rubber tube leading from the pump is attached. The filter holder is held in a clip on the stake, which is either driven into the ground, or lashed to a convenient post etc., so that the filter holder is 5 ft above the ground. The rate of aspiration of the filters in the present experiments will be 10 l/min, and the filters at any one station will be aspirated one at a time in the order of the numerals marked on them. At the stations outside the city the filters will be changed at precise 2-hourly intervals; inside the city they will be changed at intervals approximating to 2 hr as nearly as possible, and the exact times of change at each station will be recorded. (The black filter membranes are rather fragile, so care must be taken not to drop the holders or otherwise handle them roughly).

13. At the 4 Police "Section Boxes" inside the city (see Appendix II) and at the central stations in each line outside it there will be in addition a drum impactor. This is a metal device, roughly cylindrical, 5 in. long and 6 in. in diameter, and weighs about 8 lb. It will be mounted 5 ft from the ground on the stake carrying the millipore filter holder. In its operation air is drawn through a slot in the outer shell (uncovered by the removal of a transit cap) and caused to impinge on the curved surface of a metal drum, where airborne particles are deposited; by simply pressing a lever the drum may be rotated through a small angle, so that a fresh area of the surface is exposed to impingement. The rate of aspiration will be 10 l/min, and the drum impactors will be aspirated by the same pumps as are used for the millipore filters. The levers will be pressed once at intervals of 15 min. A separate drum impactor will be used for each trial.

14. At the stations inside the city the pumps will be switched on and the filters will be changed by 4 members of the staff of C.D.E.E. equipped with Land Rovers and watches, based one at each of the four Section Boxes; each one of these men will have charge of 7 or 8 stations in the neighbourhood of his base, as detailed in Appendix II. The drum impactors at the Section Boxes will be operated until nearly midnight by Police Officers, who will be instructed in the manipulation on the spot immediately before the trial begins. A record of the exact times at which the impactor levers are pressed will be kept. After midnight the impactors will be operated by the C.D.E.E. staff dealing with the filters.

15. Outside the city a man will be posted at each station, 5 of the stations being manned by staff from the Home Office and the remainder by staff from C.D.E.E. Each man will have a timepiece. Throughout the period of sampling three members of C.D.E.E., who will be known as "advisers", will patrol the sampling lines in Land Rovers, one on either side of the city and one upwind of it, and will render assistance, or supply spare parts whenever necessary.

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THE MONITOR

16. A watch will be kept for the arrival of the cloud by means of a monitor unit located at "B Division H.Q." (see Appendix II). The monitor unit is a portable dark-room, measuring 5 ft x 5 ft x 2 ft and weighing about 2 cwt, containing a microscope, a U.V. lamp, and an aspirator pump, by means of which the atmosphere can be continuously examined for the presence of F.P. particles. The unit will be powered by electricity from a power point in the building (15 amp 230 V. A.C.). The first appearance of the F.P. particles, subsequent changes in their concentration, and their ultimate disappearance will be immediately reported to the Control Point over the direct Police telephone line.

THE CONTROL POINT

17. The Control Point will be located in an office at the Police H.Q. in the City Hall. A RT station will be set up at a convenient place in the Police H.Q. and will be connected to an aerial mounted on the roof of City Hall; this will be under the control of a representative of A.F.E.O. (C.D.E.E), who will maintain contact with the aircraft base and with the aircraft itself. A vehicle parked in the adjacent public car park will be reserved for the use of the Project Control Officer (i.e. the senior member of the staff of M.R.D. (C.D.E.E.) present.

WARNINGS AND PREPARATIONS

18. The required warning of an impending trial will be given to Ministry of Aviation by A.F.E.O.

19. All equipment will be loaded into the respective vehicles on the Friday before the week in which trials are proposed and all vehicles will depart for R.A.F. Swanton Morley as early as practicable on the Monday of the trials week so as to arrive in the evening of the same day. There the vehicles will be parked. C.D.E.E. personnel will be billeted and fed (supper and breakfast) at Swanton Morley.

20. At 0745 hr Tuesday the Project Control Officer will obtain from the Forecast Room at Porton a forecast of the suitability of the evening for a trial. If this forecast is favourable he will immediately inform and the Norwich City Police; the Norwich Police will inform him in reply which of the 30 stations listed in Appendix II will not be available and whether any have to be changed. During the morning the four city sampling operators with their Land Rovers, each accompanied by a van carrying sampling equipment, will distribute the equipment to the selected sampling Stations in the City. The flat-bed lorry bearing the monitor unit will proceed to "B" Division H.Q. and park there; the meteorological van will convey instruments to the observation post at St. James' Hill on the allotments adjacent to Valpy Avenue.

21. All staff will make their own arrangements for lunch in Norwich and should provide themselves with a packed meal for the evening, whilst the trial is in progress. During this period hot drinks will be available at the Police Headquarters (i.e. at the Control Point); staff in the City will go there independently, as convenient, but staff outside will be conveyed singly in the advisers' Land Rovers to the Control Point, or alternatively will have drinks brought to them by the advisers.

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22. All C.D.E.E. personnel will wear overalls, duffel coats and gum boots, free from traces of F.P. and not bearing any lettering, such as "C.D.E.E.", where it is visible whilst the garments are being worn. Overalls etc. will not be needed by the Police or by the Home Office staff, though the latter should ensure that they are adequately clothed for a long period of only slight activity in the open air on a cold night.

23. The Project Control Officer the Senior Meteorological member and the RT operator (i.e. A.F.E.O.'s representative) will assemble at the Control Point at noon, when a forecast will be obtained of the time of evening "crossover" and the direction of the gradient wind at Norwich during the subsequent 5 hr. The flight path of the aircraft and the lines of sampling positions outside of the city will be selected on the basis of the forecast wind direction; the pilot of the aircraft will be informed accordingly. The nominal zero-time for the trial will be decided by the Project Control Officer and the pilot jointly; it will be fixed in accordance with the meteorological forecast and the pilot's assessment of the flying conditions at a time as late as possible in the period beginning $\frac{1}{2}$ hr after and ending 2 hr after forecast crossover.

24. The three "advisers" (see para 15) with Land Rovers and vans carrying sampling equipment, the 15 sampling operators and meteorological assistant for the stations outside the city will rendezvous at a point near the intersection of the ring road (A.1074) and the Horsham St. Faith Road (B.1149/A.1140) - map ref. TG.219.116 at 12.30 p.m. The senior adviser will contact the Project Control Officer at the Control Point at City Hall Police Station by telephone for details of which groups of sampling positions are to be used outside the city and for time of zero. He will then inform the other advisers and despatch them to their respective positions.

NOTE If the members of the Home Office, Scientific Advisers Branch participating in the trial travel by private car from London, they will rendezvous with the C.D.E.E. party at the place and time stated above. If however any of them come to Norwich by train these will be met by the Project Control Officer's car and conveyed to the above-mentioned rendezvous. (If they arrive too late they will be conveyed directly to their sampling stations).

25. The four city sampling operators and the two monitor operators (who will be conveyed by the Mile Cross Section sampling-operator's Land Rover) will report to the Control Point for final briefing at 1.00 p.m.

26. All persons will then make their way to their stations so as to be ready at Zero - 2 $\frac{1}{2}$ hr. The following timing will be observed.

Zero - 2 hr.	Sampling begins. Aircraft prepares to take off.
Zero	Aircraft is at beginning of flight path. Emission begins.
Zero + 6 hr.	Police Officers at City Section Boxes hand over operation of drum impactors to Section Sampling Operators.
Zero + 10 hr.	All sampling ceases. Vans for sampling apparatus outside the town report to the outermost station of their respective lines.

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METEOROLOGICAL OBSERVATIONS

27. Records will be kept of:-

- (i) The mean wind profile and direction from ground level to 1000 ft, at St. James' Hill (TG.243.093) for each of the periods, zero-2 hr to zero, zero to zero + 2 hr, zero + 2 hr to zero + 4 hr, etc. etc. by balloon ascents for intervals of 250 ft to 1000 ft.
- (ii) The mean temperature profile from ground to 1000 ft; this will be based on the Hemsby radio-sonde ascents but modified by temperature readings in the area of the trial.
- (iii) The mean wind speed at 2 m., air temperature, relative humidity and ground temperature at three positions, viz.
 - (a) St. James' Hill (TG.243.093) - a high point in the city,
 - (b) Allotments adjacent to Valpy Avenue (TG.215.102) - a low point in the city, and
 - (c) and (d) the middle station in one of the crosswind sampling lines outside the city,for the periods zero - 2 hr to zero, zero to zero + 2 hr, zero + 2 hr to zero + 4 hr etc.
- (iv) The temperature gradient (4 m - 0.5 m), for the same periods as at (iii) above, at two positions, viz:

St. James' Hill and the middle station of one of the cross-wind sampling lines outside the city.
- (v) The mean wind direction on the surface, for each of the above periods, at the St. James' Hill position.

- Notes
- 1. The above observations will require 4 people; Met. R.D. (C.D.E.E.) will supply two, and two non-meteorologists will be appointed from C.D.E.E. staff to complete the team.
 - 2. The above observations must be regarded as a bare minimum. It is hoped that the co-operation of various Meteorological Stations in the trials area will be enlisted, so that much more comprehensive data can be obtained.

PROCEDURE AFTER SAMPLING HAS CEASED

28. The sampling apparatus at the stations outside the city will be completely dismantled, loaded on the van, and taken back with the operators to R.A.F. Swanton Morley. Inside the city only the boxes of millipore filters, drum impactors and red-coded batteries will be collected (by the sampling operators), the other equipment being gathered up the morning following the last trial in any week. All staff will spend the rest of the night at R.A.F. Swanton Morley. If a trial is carried out on the Tuesday, the red-coded batteries will be recharged at Swanton Morley on Wednesday by means of a generator provided by C.D.E.E.

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RESPONSIBILITIES29. Scientific Adviser to the Home Office

Arrangement with the Norwich City Police Force for the provision of the facilities detailed in the Programme (i.e. the provision of a Control Point, a monitor site, 30 sampling sites at the places listed in Appendix II and the appointment of 4 Officers to assist in sampling). Appointment of 5 Home Office staff as sampling operators.

R.S.

Transport and battery charging arrangements; provision of T.1 pumps and batteries, 18 lever watches and generator. Allocation of staff:- 2 for meteorological observations, 8 for operation of sampling equipment, and 3 for duties as "advisers", and additional labour as necessary.

A.F.E.O.

Provision of aircraft and crew; arrangement for flight clearance and accommodation at forward aerodrome; provision of RT link between Control Point and aircraft etc. Arrangements with R.A.F., Swanton Morley for enclosed overnight parking for loaded vehicles and accommodation of staff for the trials period.

M.R.D.

Installation and operation of powder dispenser in aircraft; provision of F.P. powder; provision and operation of monitor; provision of millipore filter holders; installation of sampling equipment; instruction of volunteer sampling operators. Appointment of Project Control Officer, 6 sampling operators, 2 monitor operators and 2 powder dispenser operators. Assistance in analysis of samples. Scientific control of trial and preparation of report.

P.R.D.

Provision of millipore filters and drum impactors; assistance with sampling; analysis of samples.

Met.R.D.

Forecast for the trials; observations as prescribed; liaison with Met. Stations in the Norwich area for assistance with local forecasting; provision of transport for met. staff and apparatus.

CONCLUDING NOTE

30. If the monitor indicates that the cloud has left the city, before the prescribed sampling period is ended, the trial will be stopped earlier accordingly. It is necessary therefore that the following personnel report - in person or by telephone - to the Control Point at 2 hourly intervals, so that they may be acquainted of the decision:-

The sampling operators (C.D.E.E. staff in the town),
the monitor operators,
the meteorological observers,
the advisers on the outside sampling lines, and
the van drivers serving the outside lines.

for Supt. Munitions Research Division.

C.D.E.E.

Porten Down

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Head, Range Section.

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APPENDIX I TO PROGRAMME NO. 2/64

Flight Paths

Forecast wind direction	Track No.	Positions of ends of line	
$360^{\circ} \pm 22\frac{1}{2}^{\circ}$	1	5258 N. 0034 E.	5258 N. 0200 E.
$045^{\circ} \pm 22\frac{1}{2}^{\circ}$	2	5311 N. 0110 E.	5234 N. 0210 E.
$090^{\circ} \pm 22\frac{1}{2}^{\circ}$	3	5212 N. 0150 E.	5304 N. 0150 E.
$135^{\circ} \pm 22\frac{1}{2}^{\circ}$	4	5243 N. 0212 E.	5205 N. 0110 E.
$180^{\circ} \pm 22\frac{1}{2}^{\circ}$	5	5218 N. 0200 E.	5218 N. 0034 E.
$225^{\circ} \pm 22\frac{1}{2}^{\circ}$	6	5205 N. 0127 E.	5243 N. 0024 E.
$270^{\circ} \pm 22\frac{1}{2}^{\circ}$	7	5212 N. 0044 E.	5304 N. 0044 E.
$315^{\circ} \pm 22\frac{1}{2}^{\circ}$	8	5235 N. 0024 E.	5311 N. 0127 E.

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APPENDIX II TO PROGRAMME NO. 2/64

List of Sampling Stations inside the City of Norwich

Ketts Hill Group

4. Ketts Hill Section Box.
1. City Hall (also site of Control Point).
7. Boulton & Paul's Factory, Riverside
(inside main gate).
10. County Police H.Q.. Thorpe Road
11. Cathedral Close (Holland Court).
17. City Road.
22. Pilling Park Road.
25. Heartsease Lane.

Mile Cross Group

3. Mile Cross Section Box.
2. B. Division H.Q., Magdalen Road,
(also site of monitor).
9. Westwick Pumping Station (in yard at side of
pump house).
18. 2nd Close,
Clabon Road.
23. Police House, Valpy Avenue.
28. Half Mile Road.
29. Nelson Street.

Earlham Group

6. Earlham Section Box.
13. Jessopp Road.
15. Maple Drive.
16. Inthank Road.
19. Landringham Road.
20. Tuskin Road.
24. "Sundale", Hellesdon Road.
30. Earlham Green Lane.

Tuckswood Group

5. Tuckswood Section Box.
8. Norfolk and Norwich Hospital (near
Supt. Engineer's Office).
12. Newmarket Road.
14. St. Alban's Road.
21. Chester Street.
26. Lakenham Road.
27. Fountains Road.

NOTE Instruction Sheets will be issued to the sampling staff and to the occupiers of premises in the city where sampling apparatus is stationed.

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APPENDIX III TO PROGRAMME NO. 2/64

Sampling Stations outside Norwich

In order to facilitate trial planning, 40 nominal positions have been chosen and their map references are listed below. These positions have been divided into eight groups, lettered A to H, and the stations in each group numbered 1 to 5. The groups of stations to be used in any trial will depend on which aircraft track is used and details are given below.

Group A.

1. TG.231.131
2. TG.238.167
3. TG.234.197
4. TG.226.231
5. TG.226.266

Group B.

1. TG.256.125
2. TG.281.147
3. TG.299.175
4. TG.322.202
5. TG.350.218

Group C.

1. TG.281.087
2. TG.308.091
3. TG.345.099
4. TG.378.098
5. TG.409.102

Group D.

1. TG.266.053
2. TG.290.035
3. TG.318.018
4. TG.347.996
5. TG.378.975

Group E.

1. TG.236.039
2. TG.235.007
3. TM.233.970
4. TM.240.939
5. TM.235.906

Group F.

1. TG.213.044
2. TG.193.017
3. TM.171.993
4. TM.152.962
5. TM.136.933

Group G.

1. TG.183.082
2. TG.152.077
3. TG.118.073
4. TG.088.074
5. TG.056.075

Group H.

1. TG.199.121
2. TG.175.139
3. TG.145.155
4. TG.117.175
5. TG.104.200

Aircraft Track No.	Groups of Sampling Stations to be used.		
1	A	C	G
2	B	D	H
3	A	C	E
4	B	D	F
5	C	E	G
6	D	F	H
7	A	E	G
8	B	F	H

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APPENDIX IV TO PROGRAMME NO. 2/64

Transport Requirements

CONTROL POINT

Car.

SAMPLING IN CITY

4 Land Rovers.
1 25 cwt van (Earlham Section).
3 1-ton vans.

SAMPLING OUTSIDE CITY

3 Land Rovers.
3 15 cwt vans.

MONITOR

1 7-ton flat-bed truck.
(This will also convey some of the
batteries to and from Norwich).

MET.

25 cwt van PGK 988.

R/T COMMUNICATION

Land Rover 647ELM.

PERSONNEL

Thames Estate car.

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