M3B

Final report

Final report on work for HDC on

"CONTROLLED ENVIRONMENT COMPOSTING"
at Minskip Mushrooms, Boroughbridge,
North Yorkshire

Project Leader

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ADAS

CONTENTS

1. SUMMARY

1.1. Temperatures in the compost were recorded for 2 runs and showed peak levels of almost 80°C. However, compost temperatures at the bottom of the trough never exceeded 69°C.

1.2. Oxygen levels were recorded for only 28 hours in Run I when the apparatus flooded with condensate. In Run II a complete set of recordings was made. Oxygen levels did not fall below 8.5% at any measuring point.

1.3. Ammonia levels were not recorded successfully in Run I. In Run II a complete set of records was made showing a peak level of 1200 ppm. However, the ammonia sampling line did not pass a stringent pressure test on site so the results should be viewed with some caution.

ACKNOWLEDGMENTS

The help given and forebearance shown by John Lockwood, Graham Linfoot and the staff of Minskip Mushrooms is gratefully acknowledged.

2. INTRODUCTION

ADAS was asked by HDC to investigate the composting process which is used in troughs at Minskip Mushrooms, Langthorpe, Boroughbridge.

2.1. Brief

The agreed brief was to measure three components of the composting process:

2.1.1. Temperatures

Temperatures of air and compost were to be recorded throughout the process using automatic data loggers. Temperatures to be logged at up to 12 points.

2.1.2. Oxygen levels

Oxygen concentrations were to be measured at up to four points within the compost, results being recorded automatically by data logger.

2.1.3. Ammonia levels

The objective here was to assess the total quantity of ammonia gas exhausted from the tunnel. Ammonia concentration was to be logged continually automatically at a single point high within the shed.

2.1.4. General

These measurements were to be taken over two full "crops".

The results were be produced in a written report to include an assessment of the degree of errors of the measurements.

2.2. Site

All the investigational work was carried out at Minskip Mushrooms.

The measurements were taken in conventional insulated mushroom tunnels - each some 18 m long and 6.7 m wide. One house was used for Run I and a similar - although not the same house- was used for Run II.

Each house contained 3 deep troughs.

Each house had a plant room which contained the heating and ventilation equipment. The plant room was simply partitioned from the rest of the house by a ca. 100 mm thickness concrete block wall.

The plant room was used to house the monitoring equipment.

3. PERSONNEL, MATERIALS AND METHODS

3.1. Personnel

Project Leader:	S J Doble - ADAS, Pontefract (formerly Leeds)
Design of equipment, instrumention consultant and data processing:	D I Bartlett, ADAS, Silsoe
Also involved in the project:	N Penlington, ADAS, Nottingham
	J K Grundey, ADAS, Leeds

3.2. Materials and methods

3.2.1. Temperatures

Temperatures were measured and recorded electronically by 3 Squirrel data loggers manufactured by Grant Instruments Ltd. Each 'Squirrel' logged temperatures at 4 points - i.e. 12 points in all.

The temperature at three depths in the compost and at three points approximately evenly distributed along the trough was recorded.

"Air" temperature within the plenum chamber and in the headspace above the compost was also recorded. The final point in Run I was, "air" temperature under the polythene "tent" and, in Run II, a further compost temperature point.

Each probe within the compost was placed along the longitudinal centre line of the trough so as to detect the likely maximum temperature at each level.

The temperature data were transferred electronically from Squirrel to computer. The data were analysed and graphs of temperature against time were produced. The original data are held on paper and as computer records so that further analysis is possible, if required.

3.2.2. Oxygen

Samples of "air" from within the mushroom house were drawn along 6 mm dia. plastic tubes by a diaphragm pump. The air sample passed through in turn: a 500 ml flask (to trap condensate); a control valve; a simple water scrubber (to remove ammonia in order to protect the apparatus); a flowmeter and control valve and the oxygen sensor.

Small condensate traps had been used during Run I. However, they quickly filled and flooded the apparatus. The larger traps were fitted for Run II.

The oxygen sensor used was a fuel cell device manufactured by Neotronics Ltd. The output of the sensor, in milliVolts was recorded by a fourth Squirrel data logger.

Four sample pipes were used to draw "air" samples from four points within the mushroom house. Each pipe was controlled by a magnetic valve, in turn controlled by a cam timer. A fifth pipe carried fresh air from well outside the house to allow calibration of the oxygen sensor during each cycle.

The cam timer was geared to complete a cycle in one hour. 10 minutes were, therefore, available for each of the 6 channels. The logger was set to record the readings of each channel at 2 minute intervals and to record which valve and therefore channel was open. When the data were analysed, the last record for each channel during each 60 minute cycle was taken as being most representative.

During each cycle, the oxygen sensor was ventilated with outside air. For each channel, therefore, the record for oxygen level is compared to the nearest (in time) fresh air readings. This allowed a near continuous calibration.

"Oxygen" samples were taken from deep within the compost and from the surface of the compost at two points approximately 4 m and 7m along the trough, from the plant room end. As with the temperature sensors, the sample points were along the longitudinal centre line of the trough.

3.2.3. Ammonia

The sixth channel of the apparatus described above was connected to an ammonia sensor (upstream of the ammonia scrubber). The ammonia sensor was part of a proprietory ammonia meter manufactured by Bionics Corporation Ltd, Tokyo, Japan and supplied by David Bishop Instruments Ltd. The ammonia meter provided a milliVolt output proportional to the ammonia concentration in parts per million (ppm). This output was recorded by the fourth Squirrel data logger.

However, the full scale deflection of the ammonia meter was 200 ppm and the expected maximum within the house, some 2000 ppm. In order to overcome this, the sample from the house was diluted in a ratio of 10 : 1 with fresh air from outside the house. This was achieved by two flow-meters and control valves - one for fresh air and one for the sample.

3.2.4. Operation

Two runs were recorded. The apparatus was intended to be automatic, requiring no manual intervention from beginning to end.

<u>Run I</u>

Run I began on 11 January 1991. The loggers were stopped and the equipment removed on 22 January 1991.

Considerable problems were experienced with condensate flooding the sample pipes and the apparatus.

Before Run II began, larger condensate traps were fitted and the sample pipes were carefully installed to ensure that there were no low points where condensate might collect.

Run II

Run II began on 15 February 1991. (The date was chosen by Mr Lockwood in order to suit cropping). The equipment was checked by ADAS personnel on 17 February and 18 February. The loggers were stopped and removed on 25 February.

3.2.5. Error

TEMPERATURE MEASUREMENTS

The thermistors used have an error band of + 0.5°C. All the thermistors used had been checked by ADAS before this work began and had performed within the band above.

OXYGEN CONCENTRATION MEASUREMENTS

There was a series of potential errors within the oxygen measurement system:

Leakage in the sample pipe system.

Absorption or release of oxygen by the ammonia scrubber.

Flooding of the oxygen sensor.

Error band of the oxygen sensor

Leakage

The assembled apparatus was pressure tested in the laboratory before installation. The negative pressure was found to decline from 3.8 kPa to 3.4 kPa in 32 minutes. This represents a well sealed apparatus.

This was further checked on site by sealing the end of the sample pipe. Here the flow fell to almost zero despite the imposition of very low pressure (not measured).

Hence, it is felt that the oxygen sample lines did not leak.

Absorption/release of oxygen

Some absorption or release of dissolved oxygen is likely to have occurred at the water scrubber. However, it is felt that this would be a short term effect and that a balance would be reached within one hour.

Flooding of the oxygen sensor

This occurred during Run I and was easily identified as a sudden drop in the readings. This was caused by water covering the sensor surface and preventing contact between the sample gas and the sensor.

This did not occur during Run II.

Error band

The oxygen meter was effectively calibrated once per hour during each run. Hence each record was related to ambient oxygen levels which are stable. It is considered, therefore, that the oxygen concentration records were accurate within error band of + 0.5 percentage points.

AMMONIA CONCENTRATION MEASUREMENTS

A range of potential errors existed within the ammonia measurements system similar to those in the oxygen system.

Leakage

The same laboratory pressure test was applied to the ammonia sample line. However, on site, the rigorous test of sealing the end of the sample line did suggest a leak. The total rate of flow was reduced, but not stopped. The leak could not be found.

It is likely that the leak was insignificant at the very low suction pressure needed to draw the sample along the line. However, the ammonia results must be viewed with caution for this reason.

Flooding of the sensor

In a similar way to that occurring with the oxygen measurements, flooding of the sensor caused a sudden drop in the readings. This occurred in Run I.

During Run II, some moisture was found in the sensor housing, but no sudden drop occurred.

Sensor error band

The ammonia meter was not calibrated by ADAS during this work. The meter was new and carries a manufacturers calibration certificate (Appendix I). The meter's supplier (Mr David Bishop) advised that the meter was more accurate than any method by which it might be calibrated.

The meter's manufacturer does not quote its likely accuracy.

The zero level was checked and adjusted before the run began. At the end of the run the zero reading returned to within 10 ppm of zero.

Sample dilution

As detailed at Section 3.2.3, the sample was diluted by mixing with fresh air. The dilution ratio was set manually on 2 flow meters. There was some variation in flow over the period. The maximum error possibly caused was estimated at 15%.

Overall error

The overall error caused is estimated at 18%. That is at a reading of 1000 ppm, the true results lie betweem 820 ppm and 1180 ppm.

The effect of a possible sample line leak cannot be quantified. The ammonia concentration results must be viewed with caution.

3.2.6. Airflow measurements

The air handling system in the mushroom house consists, for each trough, of a Kongskilde FRL10 fan mounted so as to recirculate air from within the house. The system can be altered to allow full recirculation, full fresh air or partial recirculation. The output of the fan can be altered by a hinged flap in the output duct close to the fan. Also, the fan can be reversed so as to blow air up or down through the compost.

During both runs, the fan was set to recirculate air up through the compost and the hinged flap was set to restrict the flow of air. These settings were altered and the fan switched on and off as recorded in 4.2.

Some fresh air was introduced by opening a small part of the recirculation duct on the suction side of the fan.

The total flow of fresh air through the opening was estimated with a hot wire anemometer.

The potential error inherent in this procedure was estimated at 20%. (Although the error was high, there was no other practical method of estimating air flow).

4. RESULTS

All the oxygen, ammonia and temperature results are shown graphically in the following pages.

The detailed numerical results are held on paper and as computer records should further analysis be required.

In each case, results are shown only until they have stabilised. Except for the gas concentrations during Run I, results were recorded for the entire periods and are available if required. However, the other results are stable and show a continuation of the same trends. To include all the results would reduce the clarity of the presentation.

4.1. Oxygen levels

The oxygen and ammonia levels are shown on pages 10 and 14 . The channel descriptions are:

Run I

Channel 3 - Deep in compost - door end
Channel 4 - surface - plant room end
Channel 5 - deep in compost - plant room end
Channel 6 - surface - door end

Run II

Channel 3 - Surface - door end
Channel 4 - surface - plant room end
Channel 5 - deep in compost - plant room end
Channel 6 - deep in compost - door end

4.2. Manual controls

During Run II, Mr Lockwood recorded the dates and times of changes to the heating and ventilation systems.

These were:

15/02 1130 Loading of compost completed

16/02 0930 Fan on (recirc. only) - steam.
1100 Fan and steam off
1600 Fan and steam on
1800 Fan and steam off

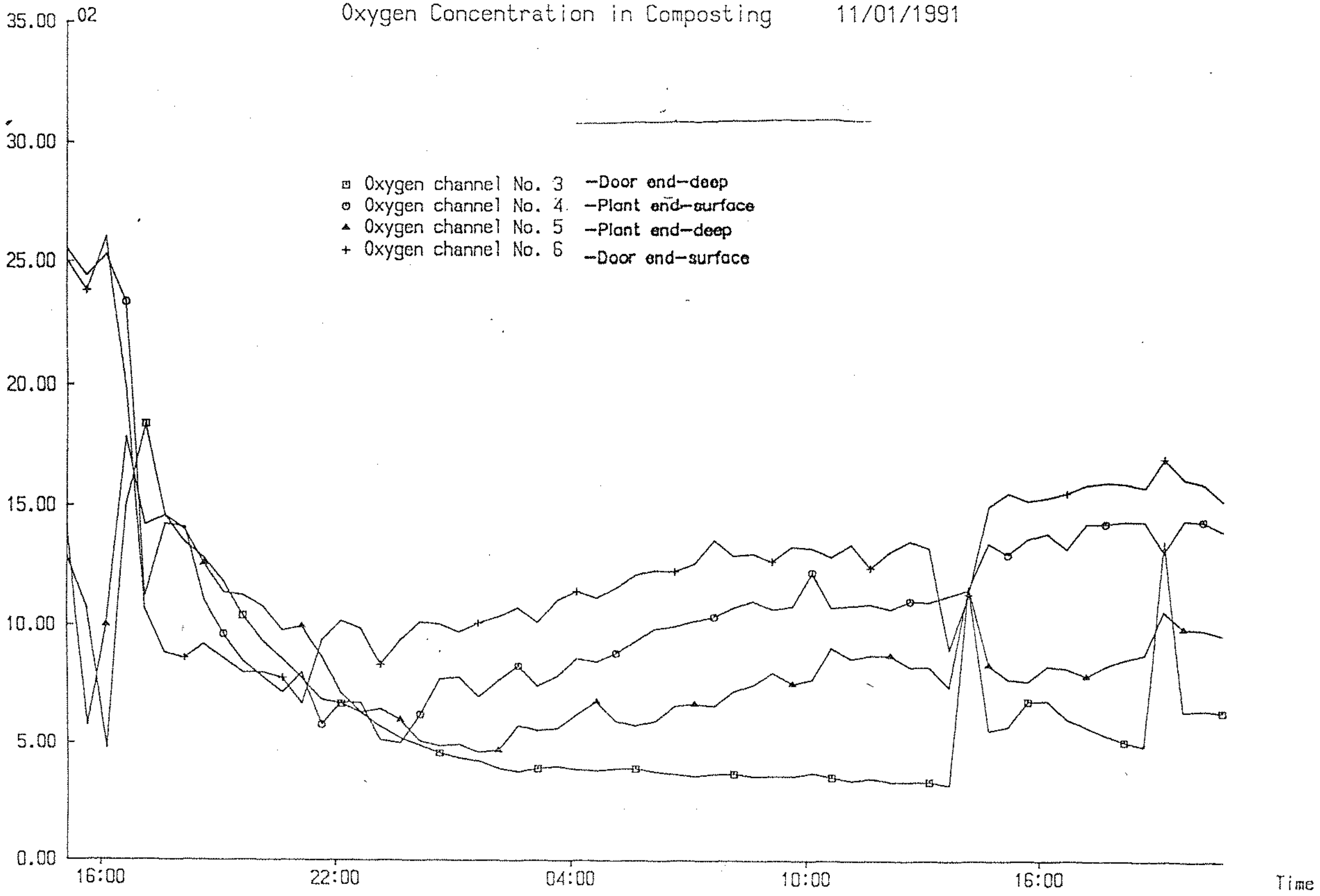
17/02 0800 Fan and steam on
1000 Fan and steam off
1630 Fan only on
1715 Fan off
2100 Fan on
2115 Fan off

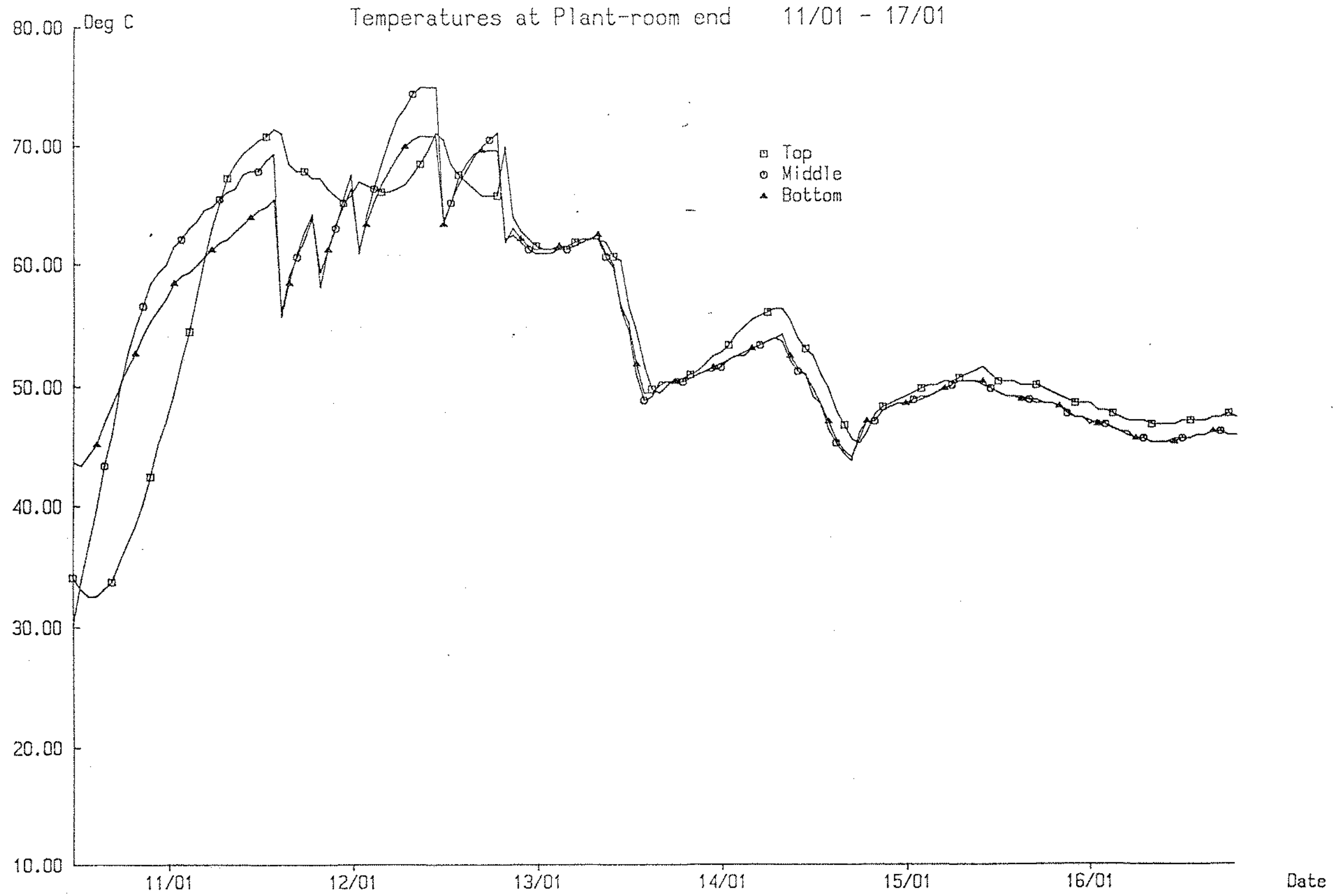
18/02 0800 Fan only on
1200 Full Fan on
1500 Fresh air introduced.

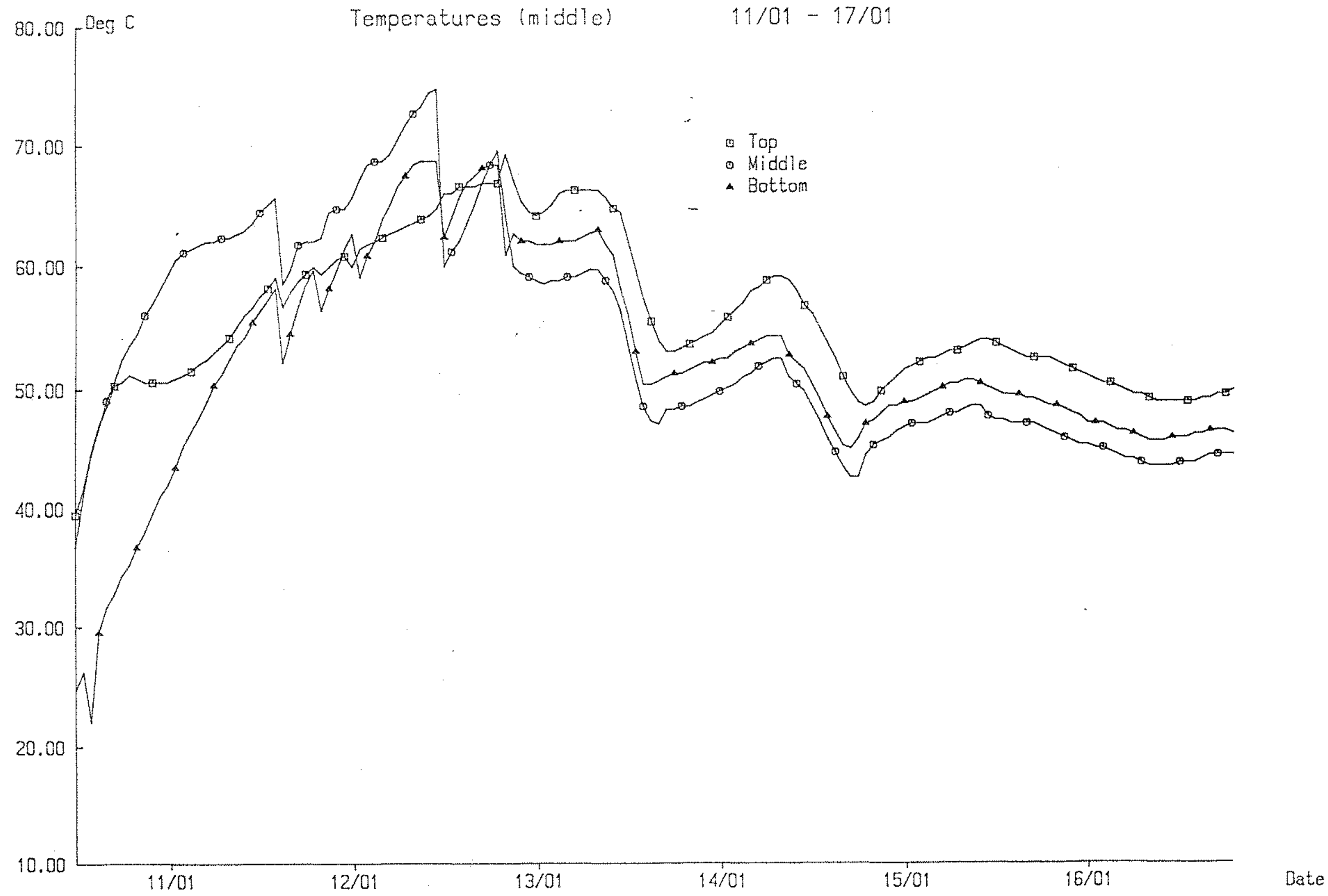
Fan on with fresh air throughout rest of period (to 25/02).

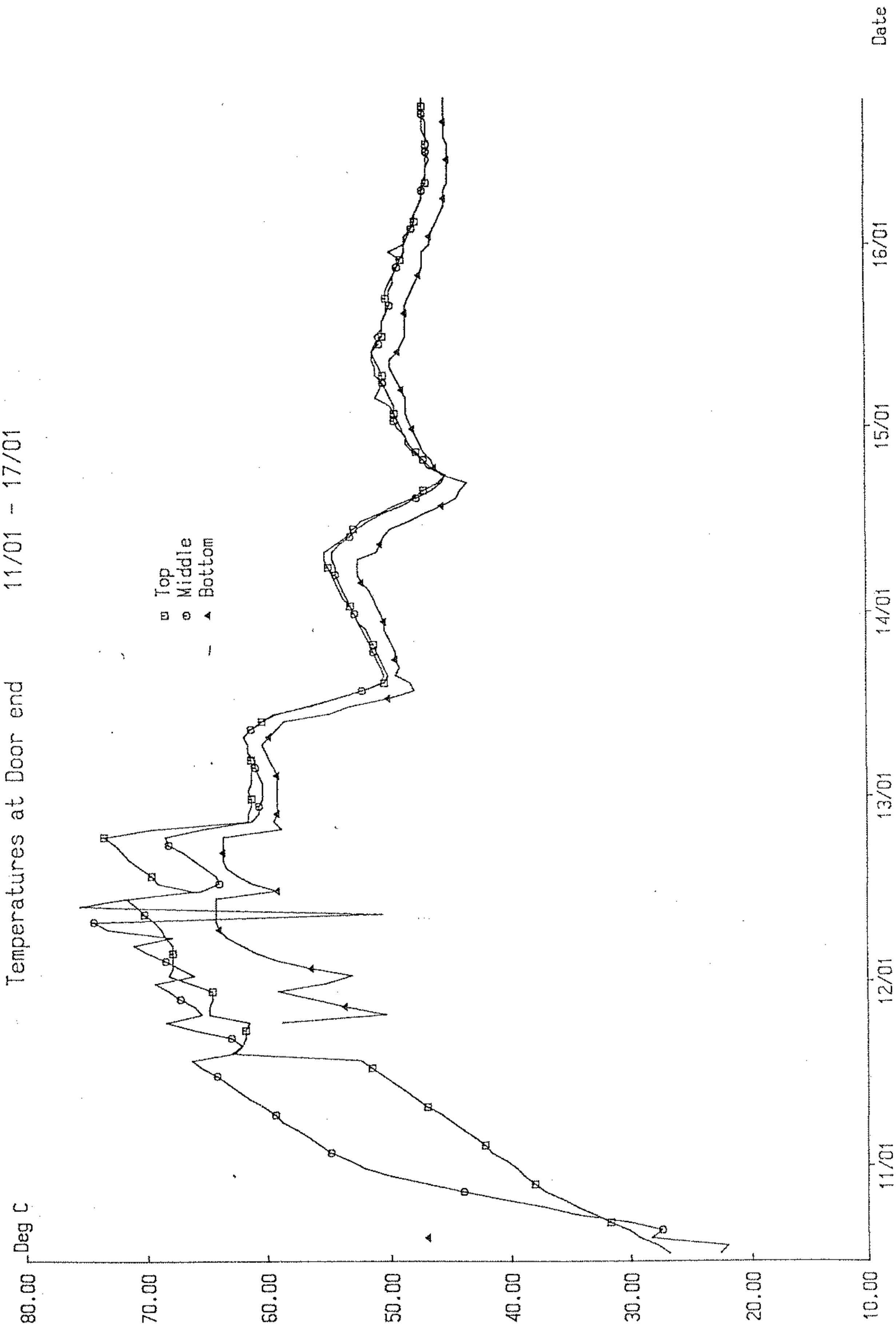
4.3 Air outputs

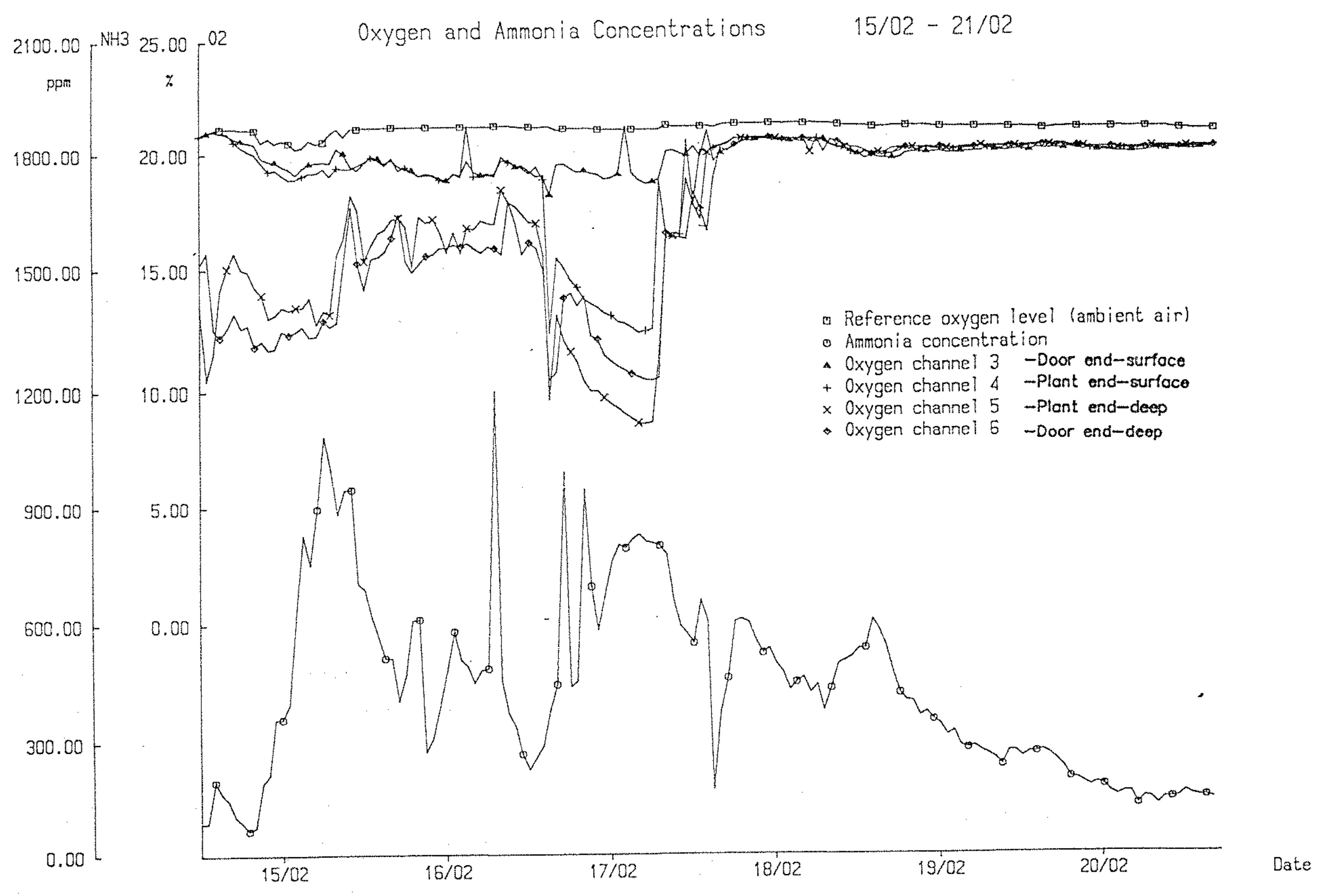
The air outputs of the fans used had been measured by ADAS previously at 0.42 m^3s^{-1} at the low pressures experienced of some 100 - 150 Nm^{-2}. The rate of flow of fresh air into the system was measured after 1500 on 18/02 and calculated at 0.052 m^3s^{-1}. The error inherent in this measurement is such that the true figures was in the range 0.042 to 0.062 m^3s^{-1}. Hence, some 10 - 14% of the fan's output was drawn as fresh air.


Oxygen Concentration in Composting 11/01/1991
02
Oxygen channel No. 3 —Door end—deep
Oxygen channel No. 4 —Plant end—surface
Oxygen channel No. 5 —Plant end—deep
Oxygen channel No. 6 —Door end—surface
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
16:00
22:00
04:00
10:00
16:00
Time

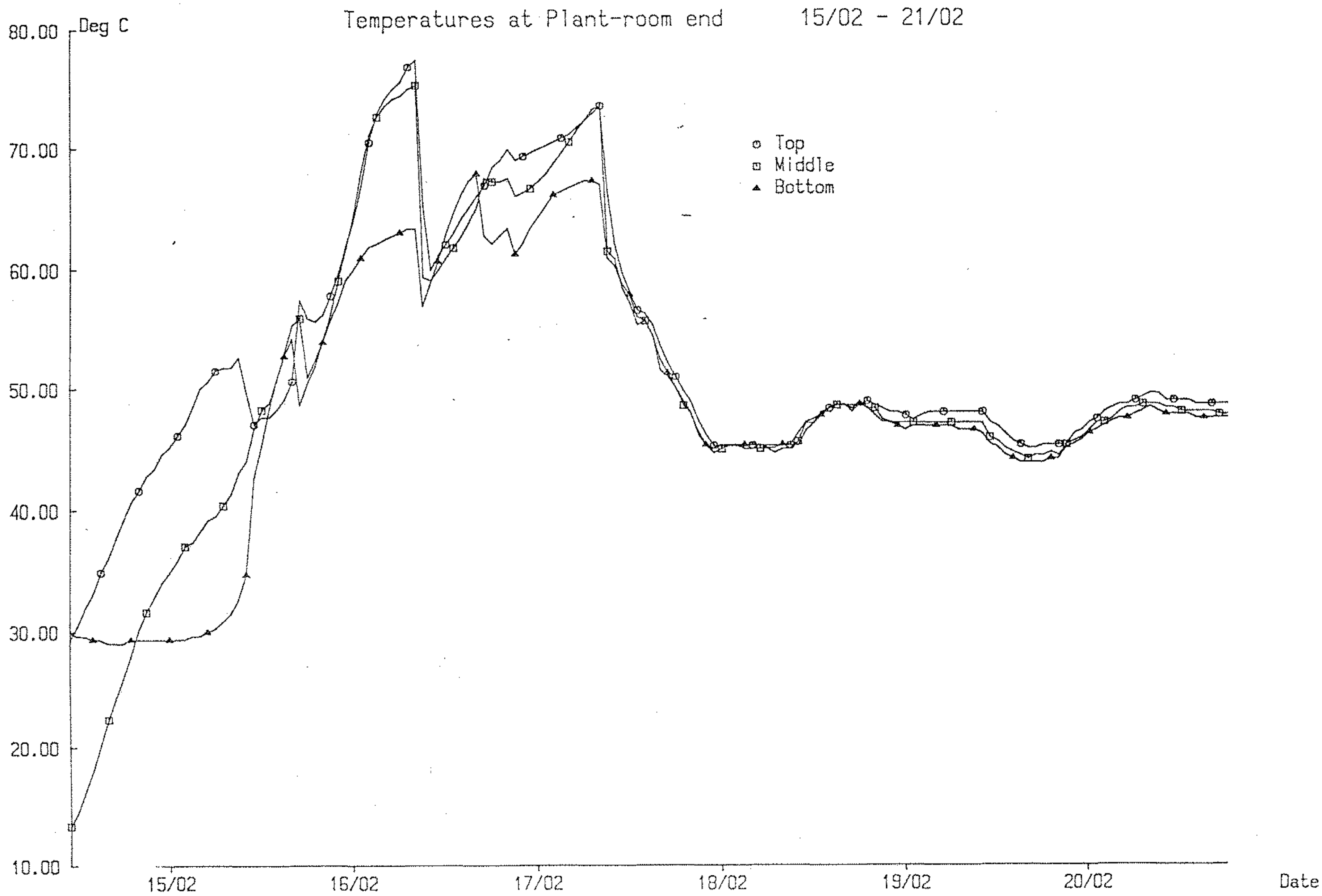

Temperatures at Plant-room end 11/01 - 17/01
Deg C
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
Top
Middle
Bottom
11/01
12/01
13/01
14/01
15/01
16/01
Date


Temperatures (middle)
11/01 - 17/01
Deg C
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
Top
Middle
Bottom
11/01
12/01
13/01
14/01
15/01
16/01
Date

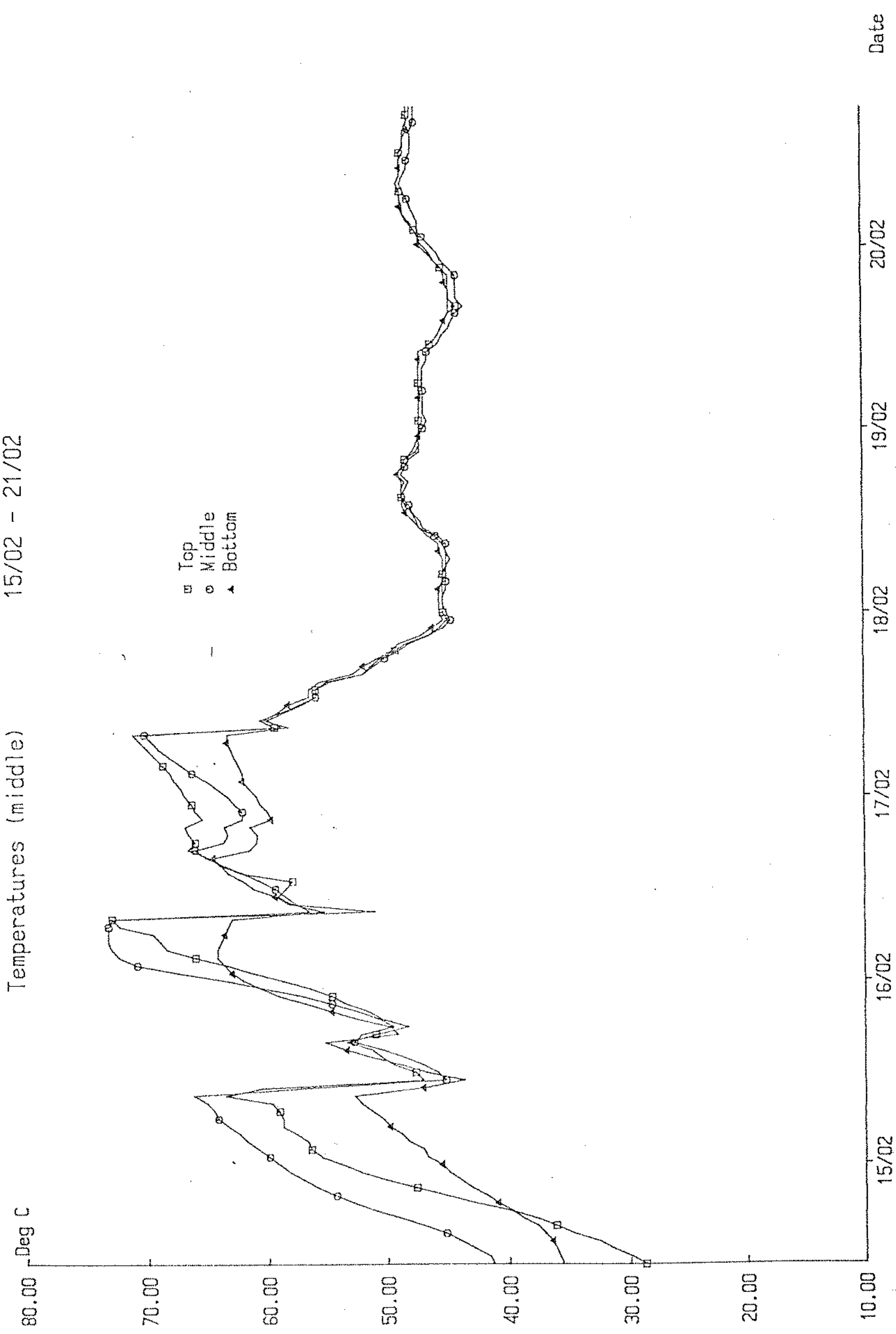

Temperatures at Door end 11/01 - 17/01
Top
Middle
Bottom
Deg C
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
11/01
12/01
13/01
14/01
15/01
16/01
Date



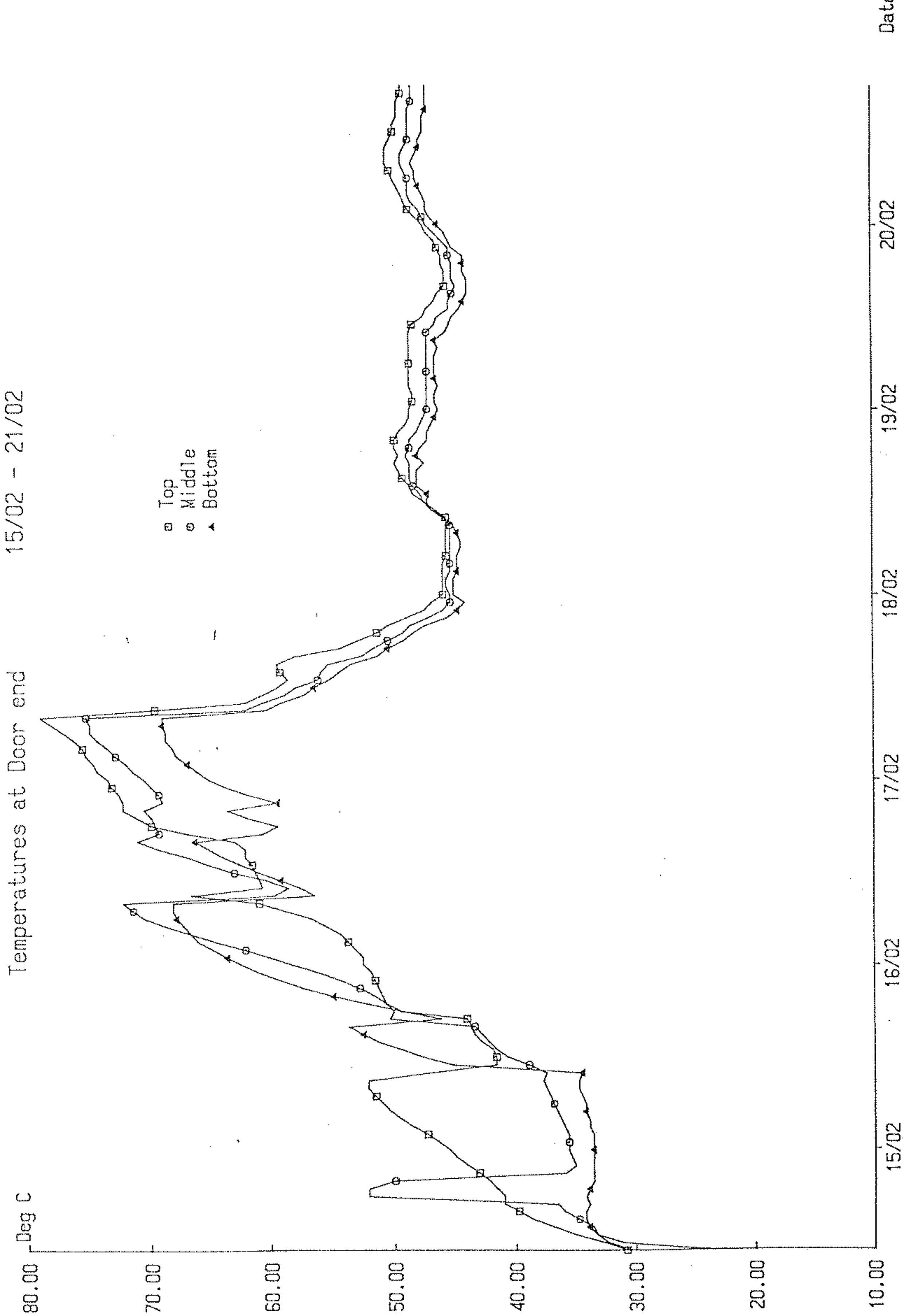
Oxygen and Ammonia Concentrations 15/02 - 21/02
2100.00
ppm
NH3
25.00
%
02
1800.00
20.00
1500.00
15.00
1200.00
10.00
900.00
5.00
600.00
0.00
300.00
0.00
15/02
16/02
17/02
18/02
19/02
20/02
Date
Reference oxygen level (ambient air)
Ammonia concentration
Oxygen channel 3 —Door end—surface
Oxygen channel 4 —Plant end—surface
Oxygen channel 5 —Plant end—deep
Oxygen channel 6 —Door end—deep

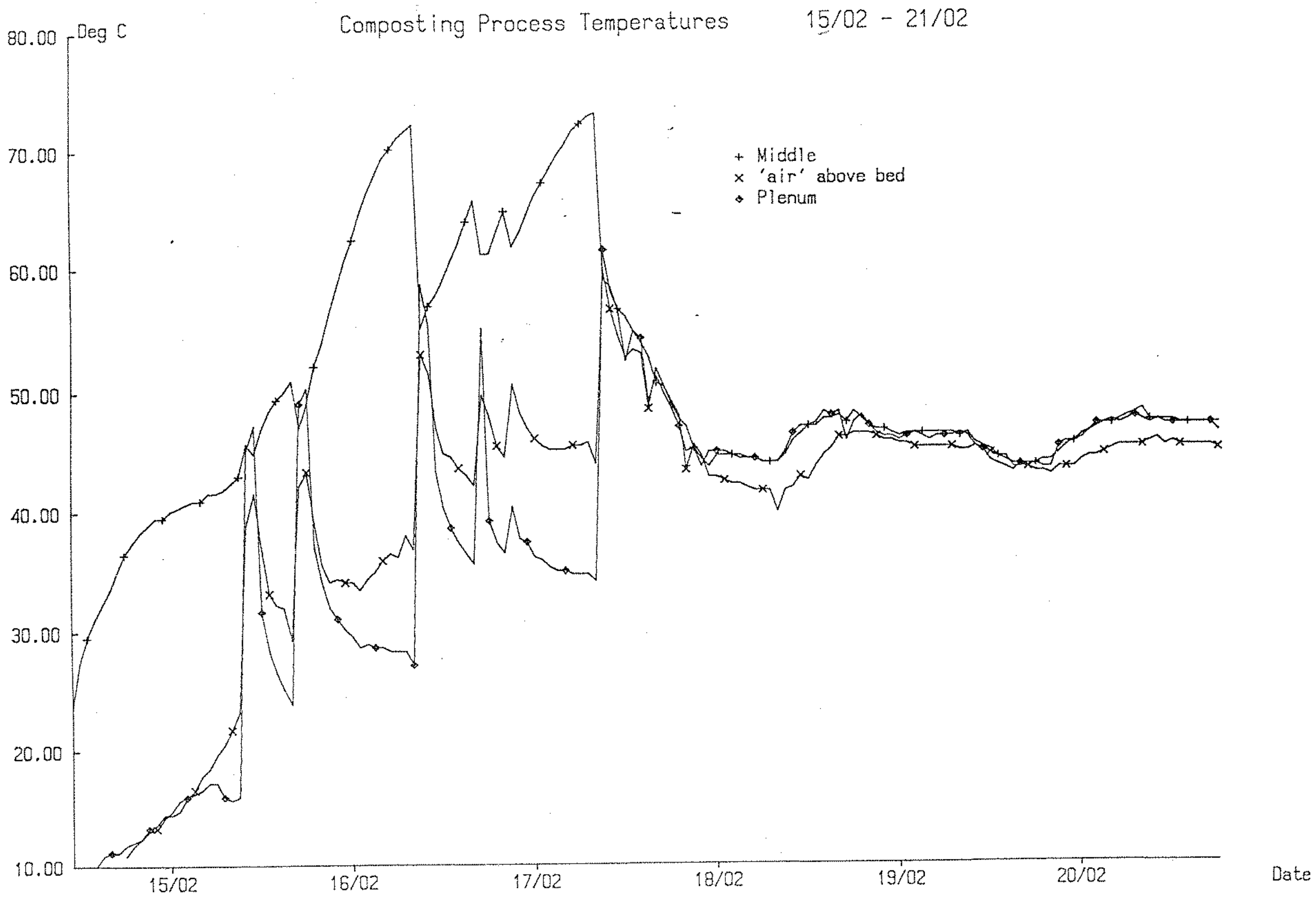


Temperatures at Plant-room end 15/02 - 21/02
Deg C
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
15/02
16/02
17/02
18/02
19/02
20/02
Date
Top
Middle
Bottom



Temperatures (middle)
15/02 - 21/02
Top
Middle
Bottom
Deg C
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
15/02
16/02
17/02
18/02
19/02
20/02
Date


Temperatures at Door end
15/02 - 21/02
Top
Middle
Bottom
Deg C
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
15/02
16/02
17/02
18/02
19/02
20/02
Date


Composting Process Temperatures
15/02 - 21/02
Deg C
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
+ Middle
× 'air' above bed
◊ Plenum
15/02
16/02
17/02
18/02
19/02
20/02
Date

5. DISCUSSION

5.1. Temperatures

Temperature data were recorded for the whole period of both runs. There is reasonable correlation between the two sets of results. In Run II, the temperature peaks occurred later because of lower ambient temperatures and hence lower initial compost temperatures.

One graph, entitled composting Process Temperatures (page 18) is interesting. It shows the effect of the ventilation fans being switched on (in recirculation mode). This rapidly increases the plenum temperature, followed with a short lag by the "air" temperature above the bed and the compost temperature (measured at a single point). In some cases, steam was applied also which explains in part the temperature rises. In other cases, with no steam input, (17/2, 1630, 18/2, 0800) temperature rises also occur.

5.2. Oxygen

During Run I, oxygen levels were recorded successfully for some 28 hours only. Hence, little replication was achieved. Oxygen levels recorded were lower in Run I than in Run II. Run I minimum is some 4% (occurred from 0400 - 1300 on Day 2) and for Run II 8.5% (occurred at about midnight on Day 3). Also, peak temperatures occurred later in Run II.

The oxygen levels in Run II followed the pattern which one might expect with the surface level recording a higher oxygen level than the deep measuring points. Once fresh air was continuously being blown in all channels settled quickly to a similar value.

The very even record for the ambient air reference oxygen level gives confidence in the other oxygen results.

5.3 Ammonia

There were insufficient results in Run I to present.

The results presented for Run II appear reasonable and show the levels which might be expected.

5.4 Airflow

The rate of flow of fresh air to the house after 1500 on 18/02 can be taken to be equivalent to the rate of flow of "air" from the exhausts of the house. If this rate of flow continued for the rest of the composting process, and with a mean ammonia concentration for this period of approximately 350 ppm, the rate of flow of ammonia gas from the house was 1.6 m^3 per day.

There are, however, some important points here:

The airflow measurements are subject to a potential error of 20%

The ammonia concentration results must be viewed with caution.

The ammonia concentration was higher earlier in the process. The rate of leakage from the house at that stage is not known.

The figure for rate of ammonia release must therefore be taken only as a guide.

6. AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described and that this report represents a true and accurate record of the results.

S J Doble

S J DOBLE
BSc (Hons) M.I. Agr. E
Project Leader

Date 13 March 1991

Report authorised by:

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Date 14 March 1991

Photocopy

Original at Silsoe
Tech file 1.47
AB 21/3/90

TEST CERTIFICATE
〔製品検査合格証〕

MODEL〔型　式〕 TG-2400 KA

SER.NO.〔機器番号〕 6828

WE HERBY WARRANT THAT THIS INSTRUMENT CONFORMS TO OUR "BIONICS TECHNICAL STANDARD" AS WELL AS GENERAL SPECIFICATIONS.

この製品は当社の技術基準による厳密な検査に合格し、一般仕様を充分満足していることを保証します。

RESPONSIBLE PERSON〔責任者〕

BIONICS INSTRUMENT CO; LTD

PRELIMINARY PROPOSAL

Comparison of Italian Compost with similar British materials

Objective

The objective of this proposal is to make a comparison of compost produced by the 'instant' method in Italy with compost produced by standard phase I & II composting in order to assess its productivity.

Method and design

It is assumed that enough compost will be available from Italy to fill 20 HRI trays (c. 1,000 kg).

Equal quantities of material should be obtained from 2 phase II block producers in the UK.

The treatments would then be

20 trays 'instant' Compost
20 trays phase II Supplier A
20 trays phase II Supplier B

The experimental design would be 60 randomised plots.
Assessment to be primarily yield with some indication of quality and timing.

Other considerations

To make the comparison meaningful compost from British suppliers should also be supplied in blocked form.

All Compost should be spawned at HRI to ensure uniformity of spawn type and to eliminate any environmental effects on spawn during transit.

Repetition

To ensure a real comparison this trial should be repeated at least twice, ideally three times.

To Mr.Richard Gaze.
Mr.H.J.Linfield.

From A.J.Randall.
31st March 1991.

THE PERFORMANCE OF THE 'ACCELERATED' COMPOST PRODUCED AT H.R.I. LITTLEHAMPTON.

The following information relates to the first five experimental composts which were collected from H.R.I. Littlehampton. The composts were filled and hand-spawned directly into the standard production tray as used by Chesswood at Thakeham. The results from the experimental composts are compared with those obtained from our standard compost cultivated in the same growing house.

The standard compost does contain a measured amount of supplement added at spawning. Whereas the Littlehampton compost does not contain any added supplement, due to the difficulty in manually distributing this material through the compost. This should be considered when interpreting the following results.

Table 1.

Compost Analysis.

Compost	Spawning Date	% Moisture	% Nitrogen	pH
HRI20/90 Tunnel 1	21/11/90	ND	ND	ND
HRI20/90 Tunnel 2	21/11/90	68.9	3.09	7.8
HRI21/90 Tunnel 2	18/12/90	74.0	2.40	7.8
HRI01/91 Tunnel 1	22/01/91	68.2	2.12	ND
HRI01/91 Tunnel 2	25/01/91	43.3	3.12	ND

Table 2.

Yield in Pounds per Square Foot.

Compost	1st Break	2nd Break	3rd Break	4th Break	TOTAL
HRI20/90 T1	1.18	0.87	0.40	ND	2.44
SD +/-	0.44	0.11	0.26	ND	0.70
HRI20/90 T2	1.55	0.84	1.17	ND	3.56
SD +/-	0.19	0.11	0.50	ND	0.34
CONTROL 21/11	1.90	1.82	0.99	ND	4.70
SD +/-	0.22	0.52	0.37	ND	0.72
HRI21/90 T2	0.85	0.96	0.56	0.37	2.74
SD +/-	0.12	0.12	0.07	0.06	0.34
CONTROL 19/12	2.28	2.32	0.81	0.55	5.96
SD +/-	0.09	0.24	0.22	0.16	0.34
HRI01/91 T1	1.20	1.10	0.81	0.12	3.23
SD +/-	0.21	0.18	0.12	0.04	0.46
HRI01/91 T2	0.00	0.00	0.00	0.00	0.00
SD +/-	****	****	****	****	****
CONTROL 06/02	2.22	2.14	1.04	0.24	5.65
SD +/-	0.43	0.17	0.12	0.22	0.36

Table 3.

Yield in Kilo's per Square Metre.

Compost	1st Break	2nd Break	3rd Break	4th Break	TOTAL
HRI20/90 T1	5.75	4.25	1.94	ND	11.93
SD +/-	2.13	0.54	1.29	ND	3.40
HRI20/90 T2	7.56	4.09	5.71	ND	17.36
SD +/-	0.94	0.54	2.45	ND	1.67
CONTROL 21/11	9.26	8.87	4.82	ND	22.95
SD +/-	1.07	2.56	1.78	ND	3.49
HRI21/90 T2	4.15	4.67	2.73	1.81	13.36
SD +/-	0.59	0.59	0.35	0.29	1.65
CONTROL 19/12	11.11	11.35	3.97	2.68	29.10
SD +/-	0.42	1.16	1.08	0.79	1.88
HRI01/91 T1	5.87	5.36	3.93	0.61	15.77
SD +/-	1.04	0.88	0.61	0.20	2.26
HRI01/91 T2	0.00	0.00	0.00	0.00	0.00
SD +/-	****	****	****	****	****
CONTROL 06/02	10.83	10.45	5.10	1.18	27.57
SD +/-	2.08	0.84	0.58	1.09	1.75

Table 4.

Yield in Kilo's per Tonne at Spawning.

Compost	1st Break	2nd Break	3rd Break	4th Break	TOTAL
HRI20/90 T1	74.9	55.1	25.1	ND	155.1
SD +/-	29.3	7.9	16.9	ND	47.3
HRI20/90 T2	92.5	50.0	70.6	ND	213.0
SD +/-	10.0	5.3	30.6	ND	23.2
CONTROL 21/11	110.1	105.9	57.5	ND	273.5
SD +/-	11.9	31.6	21.6	ND	43.4
HRI21/90 T2	44.7	50.3	29.4	19.5	143.9
SD +/-	6.6	6.3	3.2	3.2	17.5
CONTROL 19/12	125.0	127.0	44.4	30.0	326.4
SD +/-	9.4	9.4	12.0	8.9	17.4
HRI01/91 T1	59.9	54.9	40.3	6.3	161.4
SD +/-	8.2	8.7	4.9	2.2	18.8
HRI01/91 T2	0.00	0.00	0.00	0.00	0.00
SD +/-	****	****	****	****	****
CONTROL 06/02	109.6	105.7	51.6	11.9	278.8
SD +/-	21.0	8.5	5.9	11.1	17.7

A.J.Randall.