(2)

Mayflower Vehicle Systems

Determination of Particulates &
Volatile Organic Compounds
Prototype Plant
Holbrook Lane, Coventry
CV6 4AW

14 August 2002

Prepared by: **CES Environmental Instruments Ltd**
Bretby Business Park
Ashby Road
Stanhope Bretby
Burton Upon Trent
DE15 0YZ

Telephone 01283 216334

Report prepared by [redacted]

D.J. Slack
Isokinetic Sampling Engineer AEATE 990019

Report authorised by [redacted]

R.M. Allen
Isokinetic Sampling Engineer AEATE 990018

ISO 9001 - Certificate No. 279

Contents

1 Introduction

Mayflower Vehicle Systems placed an order with CES Environmental Instruments Ltd, to monitor and quantify particulate emissions and volatile organic compounds to atmosphere from the Prototype Plant located at Mayflower Vehicle Systems, Holbrook Lane, Coventry. Test work was carried out 14 August 2002.

2 Plant Details

The Prototype Plant is a dry filter paint system with a carbon filter in the exhaust stack. This is used for compliant and non-compliant coatings on an intermittent basis.

2.1 Materials Used

Prototype Particulates & VOC Monitoring 15/08/02		
Materials Used During Monitoring Exercise		
Manufacturer	**Description**	**Type/ identity number**
Dupont	High Solids Primer	1020 R - UN 1263
Dupont	High Solids Activator	1010 R - UN 1263 (686117)
RM	Diamont Platinum Silver	
RM	Thinners	BCO20
Lechler	Macrofan High Solids Clearcoat	O1722
Lechler	Indutitore High Soilds Hardner	OO362

Notes Parts Sprayed - 2 off MGF FRONT BUMPER ASSEMBLIES
Spraying commenced at 9.10 Two coats of primer laid on both components
9.45 First Base Coat Applied to both components
10.07 Second Base Coat Applied to both components
10.25 Lacquer coat applied to both components
10.30 Spraying finished

3 Sampling Location

Sampling was undertaken in the vertical duct. The duct was measured to be 600mm x 600mm, giving a cross sectional area of 0.36m^2. There are two 4"BSP sample points. Samples were taken from 4 points on each axis, 8 in total.

The sample location is compliant with BS 6069 Section 4.3.

4. Test Programme

Emissions of particulates were monitored from the exit of the Prototype Plant on 14 August 2002. The Prototype Plant was monitored for a period of 40 minutes.

Emissions of volatile organic compounds were monitored from the exit of the Prototype Plant. The Prototype Plant was monitored for a period of 60 minutes.

Full sampling methods are given in Appendix 3.

5. Plant Emissions

All results are corrected to 0°C (273K) and 1013mbar (101.3 kPa)

6. Results

6.1 Particulate Emissions

It can be seen from Appendix 1 that:-

Stack	Test No.	mg/m³	kg/hr
Prototype Plant	1	0.6	0.008
Prototype Plant	2	0.3	0.003
	Mean	**0.5**	**0.006**

6.2 Volatile Organic Compounds

It can be seen from Appendix 1 that:-

The mean Volatile Organic Concentration was measured to be **4.9 mg/m³**.

7. Appendix 1
(Extraction Protocol)

file : 2968PST1.SMP 11.08.02
18:08-18:34

plant : Prototype Stack
measuring place: Mayflower Vehicles
engineer : RA/CR/PW

remarks :
Normal Operation
Dim. = 600mm x 600mm
Product = Primer

constants and parameters :

dyn.pressure	[mbar]	: 1003
normal density	[kg/m3]	: 1.288
water vapour	[%Vol]	: 2.0
cross section of the duct	[m2]	: 0.36

results

density	[kg/m3]	: 1.168
volume flow act.	[m3/h]	: 13538
volume flow norm wet	[m3/h]	: 12280
volume flow norm dry	[m3/h]	: 12034

file : 2968PST1.SMP dust probe : 80134 11.08.02
18:08-18:34

measured values and calculations

axis	depth	p_duct [mbar]	p_dyn [mbar]	T [°C]	v_duct [m/s]	angle [°]
1	1	1.6	0.85	25.3	12.0	-0.3
1	2	1.5	0.80	25.2	11.7	0.8
1	3	1.5	0.80	25.1	11.7	0.6
1	4	1.5	0.76	25.1	11.4	1.0
1	5	1.5	0.78	25.0	11.6	0.4
1	6	1.5	0.81	24.8	11.8	-0.2
1	7	1.6	0.82	24.8	11.8	-0.0
1	8	1.6	0.84	24.7	12.0	0.5
1	9	1.7	0.86	24.7	12.1	-0.4
1	10	1.7	0.87	24.6	12.2	-0.3
2	1	1.4	0.66	24.5	10.6	-0.5
2	2	1.3	0.58	24.7	10.0	0.7
2	3	1.2	0.50	25.2	9.2	0.2
2	4	1.1	0.47	25.7	8.9	-0.6
2	5	1.1	0.46	26.1	8.9	0.5
2	6	1.1	0.45	26.3	8.8	0.5
2	7	1.1	0.42	26.3	8.4	0.7
2	8	1.1	0.43	26.3	8.6	0.8
2	9	1.2	0.45	26.3	8.8	0.8
2	10	1.2	0.42	26.2	8.5	1.1
mean :		1.4		25.4	10.4	

file : 2968PST1.SMP dust probe : 80134 11.08.02
18:08-18:34

plant : Prototype Stack
measuring place: Mayflower Vehicles
engineer : RA/CR/PW

remarks :
Normal Operation
Dim. = 600mm x 600mm
Product = Primer

constants and parameters :

dyn.pressure	[mbar]	: 1003
normal density	[kg/m3]	: 1.288
water vapour	[%Vol]	: 2.0
cross section of the duct	[m2]	: 0.36
diameter of nozzle	[mm]	: 6.4
extraction/point	[h:m:s]	: 00:02:30
tare weight of probe	[mg]	: 18606.4
gross weight of probe	[mg]	: 18606.7

results

volume flow	[m3/h]	: 1.560
extracted vol. act.	[m3]	: 0.520
extracted vol. norm. hum.	[m3]	: 0.473
extracted vol. norm. dry	[m3]	: 0.463
volume flow act.	[m3/h]	: 13397.9
volume flow norm wet	[m3/h]	: 12180.1
volume flow norm dry	[m3/h]	: 11936.5
total extraction time	[h:m:s]	: 00:20:00
dust weight	[mg]	: 0.3
dust conc. act.	[mg/m3]	: 0.6
dust conc. norm. wet	[mg/m3]	: 0.6
dust conc. norm dry	[mg/m3]	: 0.6
particulate flow rate	[kg/h]	: 0.008
extinction	[mA]	: 0.00

file : 2968PST1.SMP dust probe : 80134 11.08.02
18:08-18:34

a	d	p_duct [mbar]	p_dyn [mbar]	T [°C]	v_duct [m/s]	p_orif [mbar]	p_prob [mbar]	I_cal [mA]	q [m3/h]	angle [°]
1	1	1.5	0.78	24.3	11.5	12.49	-59	0.00	2.06	-0.0
1	2	1.5	0.76	24.5	11.4	12.40	-58	0.00	2.06	-0.1
1	3	1.6	0.82	24.6	11.9	13.34	-61	0.00	2.13	0.5
1	4	1.7	0.85	24.8	12.0	12.85	-60	0.00	2.09	0.6
2	1	1.3	0.55	24.7	9.6	3.41	-29	0.00	1.10	4.0
2	2	1.1	0.45	24.8	8.8	2.87	-27	0.00	1.01	0.8
2	3	1.1	0.43	24.8	8.5	2.68	-26	0.00	0.98	2.0
2	4	1.2	0.47	24.9	8.9	3.01	-27	0.00	1.04	0.1
mean :		1.4		24.7	10.3			0.00	1.56	

dust concentration measurement **ERWIN SICK Optic Electronic**
protocol of isokinetic extraction measurement

---

file : 2968PST2.SMP dust probe : 64336 11.08.02
18:38-18:59

plant : Prototype Stack
measuring place: Mayflower Vehicles
engineer : RA/CR/PW

remarks :
Normal Operation
Dim. = 600mm x 600mm
Product = Basecoat + Lacquer

constants and parameters :

dyn.pressure	[mbar]	: 1004
normal density	[kg/m3]	: 1.288
water vapour	[%Vol]	: 2.0
cross section of the duct	[m2]	: 0.36
diameter of nozzle	[mm]	: 6.4
extraction/point	[h:m:s]	: 00:02:30
tare weight of probe	[mg]	: 17356.4
gross weight of probe	[mg]	: 17356.5

results

volume flow	[m3/h]	: 1.178
extracted vol. act.	[m3]	: 0.393
extracted vol. norm. hum.	[m3]	: 0.356
extracted vol. norm. dry	[m3]	: 0.349
volume flow act.	[m3/h]	: 13287.6
volume flow norm wet	[m3/h]	: 12062.9
volume flow norm dry	[m3/h]	: 11821.6
total extraction time	[h:m:s]	: 00:20:00
dust weight	[mg]	: 0.1
dust conc. act.	[mg/m3]	: 0.3
dust conc. norm. wet	[mg/m3]	: 0.3
dust conc. norm dry	[mg/m3]	: 0.3
particulate flow rate	[kg/h]	: 0.003
extinction	[mA]	: 0.00

file : 2968PST2.SMP dust probe : 64336 11.08.02
18:38-18:59

a	d	p_duct [mbar]	p_dyn [mbar]	T [°C]	v_duct [m/s]	p_orif [mbar]	p_prob [mbar]	I_cal [mA]	q [m3/h]	angle [°]
1	1	1.5	0.75	25.1	11.3	4.53	-33	0.00	1.27	-0.5
1	2	1.4	0.72	25.1	11.1	4.47	-33	0.00	1.26	-0.4
1	3	1.5	0.80	25.2	11.7	5.05	-35	0.00	1.34	0.7
1	4	1.6	0.84	25.2	11.9	5.39	-36	0.00	1.38	0.7
2	1	1.3	0.55	25.0	9.7	3.58	-29	0.00	1.13	-0.7
2	2	1.2	0.47	25.0	8.9	2.93	-26	0.00	1.02	0.5
2	3	1.1	0.43	25.0	8.6	2.78	-26	0.00	1.00	2.8
2	4	1.2	0.46	25.1	8.8	2.92	-26	0.00	1.02	0.9
mean :		1.4		25.1	10.3			0.00	1.18	

8 Appendix 2
(Logged Values)

Site: Mayflower Vehicles
Date : 15 August 2002
Plant : Prototype Spray Booth
File Ref. 2968

Date	Time	Total VOC"s ppm	VOC's Expressed as Carbon mg/m³
15-08-2002	09:16:53	3.75	2.01
15-08-2002	09:18:53	13.75	7.37
15-08-2002	09:20:53	18.75	10.04
15-08-2002	09:22:53	7.50	4.02
15-08-2002	09:24:53	3.75	2.01
15-08-2002	09:26:53	2.50	1.34
15-08-2002	09:28:53	2.50	1.34
15-08-2002	09:30:53	3.75	2.01
15-08-2002	09:32:53	8.75	4.69
15-08-2002	09:34:53	12.50	6.70
15-08-2002	09:36:53	5.00	2.68
15-08-2002	09:38:53	3.75	2.01
15-08-2002	09:40:53	2.50	1.34
15-08-2002	09:42:53	2.50	1.34
15-08-2002	09:44:53	2.50	1.34
15-08-2002	09:46:53	1.25	0.67
15-08-2002	09:48:53	8.75	4.69
15-08-2002	09:50:53	30.00	16.07
15-08-2002	09:52:53	32.50	17.41
15-08-2002	09:54:53	11.25	6.03
15-08-2002	09:56:53	3.75	2.01
15-08-2002	09:58:53	1.25	0.67
15-08-2002	10:00:53	1.25	0.67
15-08-2002	10:02:53	3.75	2.01
15-08-2002	10:04:53	25.00	13.39
15-08-2002	10:06:53	36.25	19.42
15-08-2002	10:08:53	13.75	7.37
15-08-2002	10:10:53	5.00	2.68
15-08-2002	10:12:53	2.50	1.34
15-08-2002	10:14:53	2.50	1.34

	Total VOC's	VOC's Expressed as Carbon
	9.1 ppm	4.9 mg/m³

Oxygen Value %
Normalised Result Expressed as Carbon 4.9 mg/m³

Results Correct to

Temperature		Pressure		Oxygen		Gas	
°C/K	0/273	mbar/kPa	1013/101.3	%		Wet/Dry	Dry

9 Appendix 3
(Sampling Methods)

Erwin Sick Sampling Train

Extractive dust measurements were made using the Erwin Sick "Gravimat SHC-5" isokinetic dust sampling system. The equipment uses a stainless steel probe which combines a sampling nozzle and filter, 3 pitot pressure inlets and a thermocouple. Real time velocity, turbidity and temperature measurements are provided for the control processor to modulate the pump speed and continuously ensure isokinetic conditions are maintained.

The Gravimat SHC-5 portable dust concentration measuring system operates on the gravimetric measuring principle as required by BS 3405 and BS 6069. The dust-laden gas is isokinetically extracted by a scavenging probe. A special filter retains the dust. The dust content is determined by differential weighing of the dust collectors together with the filters. This avoids the dust losses which are inevitable when the filters are removed. The dust concentration in mg/m^3 can then be calculated from the relationship between the dust weight and the volume of gas extracted.

The Gravimat SHC-5 gravimetric dust concentration measuring system comprises the following components:

* GS 5 filter head probe with accessories
* SHC-AE control unit
* Evaluation computer (laptop) with SMP5 measuring and evaluation software
* SHC-PS power supply unit
* SHC-TU transport unit, optional.

The SHC-AE control unit performs the isokinetic control that is necessary for precise measurements. It is connected to the multi-chamber hose and the thermocouple of the GS 5 probe as well as to the evaluation computer. All the measured data is automatically collected and recorded together with the extraction measurements time, relieving the operator of control and recording duties during the monitoring process. The operator is simply required to move the probe to the next measurement point at a signal from the control unit.

Before testing all recommended system checks and leak tests were carried out. The filters were assembled and then dried in an oven at 110°C, cooled in a desiccator and then weighed on a 0.1mg resolution balance. After testing the filters are weighed in an identical fashion.

Features:

* Considerably improved measuring accuracy through the newly developed GS 5 filter head probe.
* The probe can be used for both high (several g/m^3) and very low dust concentrations (less than 1 mg/m^3)
* Fully automatic detection and storage of all relevant measured values during extraction of the sample.
* Fully automatic isokinetic control precludes operator error and increases the accuracy of the measurement.
* Automatic logging of all measurements - only the weight of the dust collector and plant-specific comments have to be entered manually.

Volatile Organic Compounds

The Flame Ionisation Detector

The Signal Mode 3030PM Portable Heated Hydrocarbon Analyser is based on the Flame Ionisation Detector (FID). The flame ionisation detector works by ionising the sample gas using combustion in a hydrogen flame. Ions produced in this process are collected at a polarized electrode outside the combustion zone. The polarizing voltage across the detector must be high enough to stop any recombination of the electrons and positive ions produced in the flame.

When the sample gas is composed of gases of different carbon number, the detector will respond to the number of carbon atoms present.

An important characteristic of the flame ionisation detector is the variation in detector response with changes in oxygen concentration in the sample gas. This effect is normally only found in the analysis of combustion gases. It requires a special fuel consisting of 40% hydrogen and 60% helium mix. To compensate for the lower concentration of hydrogen, an analyser using a hydrogen/helium mix requires a greater (x3) fuel flow. Each analyser is built to be used with a specific fuel option. A 100% hydrogen fuel is used for applications rich in oxygen.

In order to give a stable signal, the FID requires a supply of clean, hydrocarbon-free air. As an aid to portability, the analyser air is supplied from a built-in pump. As there is a possibility of the ambient air being contaminated with hydrocarbons, it is passed over an internal platinum catalyst on an alumina substrate at high temperature. Air passed through the catalytic air purifier is also used as zero gas during calibration.

10. Appendix 4
(Calibration Certificates)

TEST REPORT

1513

Customer: CES Environmental Instruments Limited,
Bretby Business Park, Ashby Road,
Stanhope Bretby, Burton on Trent, Staffs

Report No. 25078

Date analysed: 31 May 2002

CYLINDER NO	ANALYSIS % V/V (DRY AIR BASIS)	
	CH_4	Air
91112	0.0346	Balance
Accuracy of Analytical Method	±0.0005	

Method of Analysis: CH_4 - Infra Red Analyst: A Smith

Customer Analytical Requirements CH_4	Authorised by: A Smith

Authorised by: [redacted]

A Smith
Gas Monitoring

Issue Date: 05 June 2002

End of Report

TES Bretby, P.O. Box 100, Burton-on-Trent, DE15 0XD Telephone: 01283 554400 Fax: 01283 554422
TES Bretby is a division of Environmental Services Group Limited Registered in England Number 2880501

Certificate of Calibration

Date of Issue: 15 February 2002

CES Environmental Instruments Ltd
Bretby Business Park, Ashby Road
Burton-on-Trent, Staffordshire, DE15 0YZ
Tel: 01283 216334 Fax: 01283 550939

[redacted]066
of 2

Certified By

Instrument Details

Instrument Type	Gravimat SHC-5
Instrument Make	Erwin Sick
Instrument Serial No.	950151163
Quality No.	C151
Calibration Date	15/02/2002
Calibrated By Name	R. Allen

Ambient Conditions

Air Temperature (°C)	20.3	**
Barometric Pressure (mbar)	1022	
Relative Humidity (%)	42	**

Instruments used to undertake calibration

E Type Pitot	UKAS Certificate No. 00180	(Qu. No. C136)
Manometer Type FC012	UKAS Certificate No. 00350	(Qu. No. C082)
Manometer Type FC012	UKAS Certificate No. 00349	(Qu. No. C081)
Barometer Type 104	UKAS Certificate No. N1072047V	(Qu. No. C138)
Gallus Dry Gas Meter	UKAS Certificate No. N1054538F	(Qu. No. C125)
TM 2030 Thermometer	UKAS Certificate No. 89143	(Qu. No. C135)
K-Type Thermocouple	UKAS Certificate No. N1054537T	(Qu. No. C134)
RIS Supersal XT	Certificate No. IH50788	(Qu. No. C014) *

* Not UKAS traceable ** Indication only

Flow and Extraction

The reference pitot was placed in a wind tunnel located at Bretby Business Park. The Gravimat SHC-5 Sampling Probe under test was mounted within the same wind tunnel in close proximity to the reference pitot. The wind tunnel was operated to generate a differential pressure across each pitot, a direct comparison was made. The differential pressures measured were in the region of the calibration points of the reference pitot. Correction factors were applied to the reference pitot and compared to the differential pressure shown for the pitot under test. The extraction system of the unit was operated for a period of one minute.

Volume Flow

A calibrated dry gas meter was connected to the sampling nozzel ot the Gravimat SCH-5. A volume of air is pulled through the sampling system. The measured value shown on the calibrated dry gas meter is then compared to the indicated value on the Gravimat SCH-5 display.

Temperature

The probe thermocouple was placed in a thermpcouple oven and heated. The temperature was measured using a calibrated thermocouple and temperature indicator. The resultant temperature was compared to the Gravimat SCH-5 display.

Current

A mA current source was injected into the Gravimat SCH-5 using a mA current generator. The injected current was compared to the Gravimat SCH-5 display.

Certificate of Calibration

Date of Issue: 15 February 2002

Certificate No. CES0086 2

[redacted]

Certified By

CES Environmental Instruments Ltd
Bretby Business Park, Ashby Road
Burton-on-Trent, Staffordshire, DE15 0YZ
Tel: 01283 216334 Fax: 01283 550939

Instrument Details

Instrument Type	Gravimat SHC-5
Instrument Make	Erwin Sick
Instrument Serial No.	950151163
Quality No.	C151
Calibration Date	15/02/2002

Ambient Conditions

Air Temperature (°C)	20.3	**
Barometric Pressure (mbar)	1022	
Relative Humidity (%)	42	**
Air Density @ 0°C (kg/m³)	1.277	
Corrected Air Density (kg/m³)	1.199	

Calibration Details

Flow and Extraction

Applied Pressure (Pa)	Pitot Correction	Applied Pressure Corrected (Pa)	SHC5 p-dyn (Pa)	Pressure Factor	Calculated Velocity (m/s)	SHC5 Velocity (m/s)	Velocity Factor	Nozzel Diameter (mm)	Calculated Extraction (m³/hr)	SHC5 Extraction (m³/hr)	Extraction Factor
3.1	0.83	2.6	2.9	0.87	2.072	2.22	0.93	10.0	0.59	0.61	0.96
11.7	0.95	11.1	12.0	0.92	4.306	4.484	0.96	10.0	1.22	1.26	0.97
21.7	0.96	20.8	22.7	0.92	5.895	6.152	0.96	10.0	1.67	1.71	0.98
42.9	0.97	41.6	43.7	0.95	8.331	8.533	0.98	8.0	1.51	1.52	0.99
65	0.98	63.7	67.1	0.95	10.308	10.56	0.97	8.0	1.87	1.88	0.99
93	0.98	91.1	96.9	0.94	12.330	12.719	0.97	6.4	1.43	1.46	0.98
117.3	0.99	116.1	123.4	0.94	13.918	14.356	0.97	6.4	1.61	1.63	0.99
163	0.99	161.4	175.5	0.92	16.407	17.128	0.96	6.4	1.90	1.94	0.98
200	0.98	196.0	214.7	0.91	18.081	18.94	0.95	6.4	2.09	2.14	0.98

Volume Flow

Flow (litres/min)	Required Value (litres)	Indicated Value (litres)	Correction Factor
10	1001.0	1002.0	0.999

Temperature

Temperature Input	
Required Value (°C)	Indicated Value (°C)
25.0	24.8
50.0	49.7
100.0	100.5
150.0	149.2
250.0	249.9

Current

Current Value	
Require Value (mA)	Indicated Value (mA)
0.0	0.0
5.0	5.0
10.0	10.0
15.0	15.0
20.0	20.0