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Stack Emissions Testing Report

Total Particulate Matter
Chlorides

Clarksteel Galvanising Limited

Yaxley

Fume Extraction System

Test Date	9th March 1999
Report by	James Harmer
Checked by	Ben Rose
Authorised by	Alastair Wolff

QUALITY ASSURED FIRM ISO 9001 SGS

NATIONAL ACCREDITATION OF CERTIFICATION BODIES

Job No ENV 1577

Contents

Introduction

Clarksteel Galvanising Limited operate a Hot Dip Galvanising Process at Yaxley which is subject to Local Air Pollution Control by Huntingdonshire District Council under the Environmental Protection Act 1990, Part 1.

Scientifics Limited were commissioned by Clarksteel Galvanising Limited to carry out stack emissions testing to determine the releases of total particulate matter and chlorides from the following Plant under normal operating conditions.

Company	Clarksteel Galvanising Limited
Site	Yaxley
Stack	Fume Extraction System
Test Date	9th March 1999
Time Test Started	12:30
Time Test Ended	14:00
Guidance Note	PG 2/2 (96)
Process	'Hot Dip Galvanising Processes'
Abatement Plant	Bag Filter
Materials Processed	Man Hole Covers, Meshguards & Structural Steel
Operating Conditions	1 Tonne/Hour
Plume Appearance	None Visible

Throughout sampling, the operating conditions were maintained as above.
Any deviations from BS 3405 : 1983 are noted in the conclusion.

Written Summary

Total Particulate Matter **Passed**

Two particulate tests were performed during continuous operating conditions.
The mean sampling time was 16 minutes.

The mean particulate concentration was 0.76 mg/m^3 at reference conditions.
This value is below the emission limit of 15 mg/m^3 specified in PG 2/2 (96).

Results given have been referenced to 273K, 101.3kPa, without correction for water vapour content.

The tests were performed in accordance with the main procedural requirements of BS 3405 : 1983 using a Ströhlein STE 4 isokinetic particulate sampling train.

Chlorides (as hydrogen chloride excluding particulate matter) **Passed**

Two chlorides tests were performed, during continuous operating conditions.
The mean sampling time was 24 minutes.

The mean chlorides (as hydrogen chloride excluding particulate matter) concentration was 0.68 mg/m^3 at reference conditions.
This value is below the emission limit of 30 mg/m^3 specified in PG 2/2 (96).

Results given have been referenced to 273K, 101.3kPa, without correction for water vapour content.

The tests were performed using a glass lined sampling probe and impinger collection containing HPLC grade water with analysis by ion chromatography in an accredited laboratory.

Emissions Summary

Company	Clarksteel Galvanising Limited
Site	Yaxley
Stack	Fume Extraction System
Test Date	9th March 1999

Parameter	Units	Result	Limit	Outcome
Total Particulate Matter	mg/m^3	0.76	15	Passed
Particulate Emission Rate	g/s	0.003	-	-
Chlorides	mg/m^3	0.68	30	Passed
Chlorides Emission Rate	g/s	0.003	-	-
Stack Gas Temperature	°C	16	-	-
Stack Gas Volumetric Flow Rate	m^3/hr	17059	-	-
Stack Gas Velocity	m/s	18.57	-	-

All results are mean values, with pollutant concentrations expressed at reference conditions.

Reference conditions are 273K, 101.3 kPa, without correction for water vapour content.

Total Particulate Matter Summary

Sample	Sampling Times	Concentration	Limit
Run 1	13:11 - 13:27	0.66 mg/m^3	-
Run 2	13:34 - 13:50	0.87 mg/m^3	-
Mean Particulate Concentration		0.76 mg/m^3	15 mg/m^3

Sample	Sampling Times	Particulate Emission Rate	Ratio of Particulate Emission Rates
Run 1	13:11 - 13:27	0.003 g/s	-
Run 2	13:34 - 13:50	0.004 g/s	-
Mean Particulate Emission Rate		0.003 g/s	1.33 : 1

Reference conditions are 273K, 101.3 kPa, withoiout correction for water vapour content.

Chlorides Summary

Chlorides	Laboratory Result mg	Volume Sampled m^3	Concentration mg/m^3	Limit mg/m^3
Run 1	0.04	0.077	0.52	-
Run 2	0.06	0.072	0.84	-
Mean Chlorides Concentration			0.68	30

Reference conditions are 273K, 101.3 kPa, withoiout correction for water vapour content.

Calculations - Run 1

1. Stack Gas Velocity (V)

$V = 0.075 \times C_p \times \sqrt{\Delta P} \times \sqrt{T}$

V = Velocity (m/s)

C_p = Pitot Tube Calibration Coefficient

ΔP = Mean Differential Pressure (Pa)

T = Mean Temperature (K)

2. Stack Gas Volumetric Flow Rate (Q)

Stack Gas Velocity (V)	18.50 m/s
Stack Diameter (D)	0.57 m
Stack Area (A)	0.26 m^2
Stack Temperature (T)	298 K
Atmospheric Pressure (P_A)	100.60 kPa
Static Pressure (P_{St})	-0.10 kPa
Standard Barometric Pressure (P_B)	101.30 kPa

$$Q_{(STP)} = \frac{273}{T} \times \frac{(P_A + P_{St})}{P_B} \times V \times A \qquad Q_{(actual)} = V \times A$$

$Q_{(STP)}$ = 4.30 m^3/s **$Q_{(actual)}$ = 4.72 m^3/s**

3. Cumulative Sampling Mass Emission (M)

No. of Sampling Points (n)	4
Duration at each point (s)	240 s
Nozzle area (a)	28.28 mm^2
Particulate mass (m)	0.0003 g
Stack Area (A)	0.26 m^2

$$M = \frac{(A \times m)}{(n \times a \times s)} \times 10^6 = 2.8E-03 \text{ g/s}$$

M = 0.0028 g/s

4. Particulate Concentration (C) at 273K, 101.3kPa

$C = (M / Q_{(STP)}) \times 1000$

C = 0.66 mg/m^3

Calculations - Run 2

1. Stack Gas Velocity (V)

V = $0.075 \times Cp \times \sqrt{\Delta P} \times \sqrt{T}$
V = Velocity (m/s)
Cp = Pitot Tube Calibration Coefficient
ΔP = Mean Differential Pressure (Pa)
T = Mean Temperature (K)

2. Stack Gas Volumetric Flow Rate (Q)

Stack Gas Velocity (V)	18.63 m/s
Stack Diameter (D)	0.57 m
Stack Area (A)	0.26 m^2
Stack Temperature (T)	298 K
Atmospheric Pressure (P_A)	100.60 kPa
Static Pressure (P_{St})	-0.10 kPa
Standard Barometric Pressure (P_B)	101.30 kPa

$Q_{(STP)} = \frac{273}{T} \times \frac{(P_A + P_{St})}{P_B} \times V \times A$ $Q_{(actual)} = V \times A$

$Q_{(STP)}$ = 4.33 m^3/s   **$Q_{(actual)}$ = 4.76 m^3/s**

3. Cumulative Sampling Mass Emission (M)

No. of Sampling Points (n)	4
Duration at each point (s)	240 s
Nozzle area (a)	28.28 mm^2
Particulate mass (m)	0.0004 g
Stack Area (A)	0.26 m^2

$M = \frac{(A \times m)}{(n \times a \times s)} \times 10^6$ = 3.8E-03 g/s

M = 0.0038 g/s

4. Particulate Concentration (C) at 273K, 101.3 kPa

$C = (M / Q_{(STP)}) \times 1000$

C = 0.87 mg/m^3

Total Particulate Matter Sampling Methodology

Job Preparation

A pre-site survey must first be undertaken to obtain the following information. Client details (full address & contact names), description of stack (name & location), sampling platform / access (Permanent - platform of adequate size & load capability, kick boards, hand & middle rails, free from debris, good drainage, fixed ladders with hoops and chain. Temporary - adequate size & load capability, stabilising legs, valid inspection tag, kick boards, hand & middle rails. Both types of platform must have a secure anchorage point to fix pulley system) hazards (dust, noise, temperature, gases/vapours, vibration, light, moving machinery, electricity etc) power supply and location, additional PPE required (high temperature gloves/overalls, PPE).

The Strohlein STE 4, isokinetic particulate measurement equipment, is fully inspected prior to use and it's calibration status observed. This includes:

Pitot Tube - All pitot tubes are physically checked for damage, paying particular attention to the inlet holes. All dirt and blockages are removed.

Micromanometer - Digital differential pressure meters are used capable of measuring pressure in the range 0 Pa to 2250 Pa with a sensitivity of ±1 Pa. These instruments are checked for obvious physical damage, battery life tested and calibrated status observed.

Thermocouple - Temperature is measured using k type thermocouples. Each thermocouple is inspected for obvious damage and it's calibration status observed. Digital temperature meters are used in conjunction with K type thermocouples. These are also checked for obvious physical damage and their battery life tested.

Nozzles - All nozzles used have been constructed in accordance BS 3405 : 1983, section 5.3.2. Each nozzle is physically checked for damage and removed if necessary. The nozzle calibration status is observed.

Flowmeter - The flowmeter is checked for blockages and obvious physical damage. It's calibration status is also observed.

Balance - A Mettler Toledo balance is used to weigh filters. The balance is positioned on a solid base located in a specially built weighing room. The balance is serviced and calibrated routinely each year by the manufacturer and also checked daily with in-house check weights.

Rope Kit - All lifting tackle i.e. rope, pulleys, karabiners, brakes and slings are physically checked for cuts and contamination.

Should the calibration certainty of any of the above equipment be in question, that item of equipment must be recalibrated and replaced if necessary.

Filter Selection and Preparation

Stack conditions can vary greatly for temperature, moisture, acidity, low and heavy particulate loading. Following the pre-site survey, the stack gas condition should be known and the appropriate filter can be selected and prepared as described below.

Filter mediums - glass wool, quartz wool, Gelman Sciences A/C Glass Fibre filter papers, Gelman Sciences Low Ash PVC membrane filter papers, Schleicher & Schuell Glass Fibre Thimbles or Schleicher & Schuell Quartz Thimbles.

Filters are prepared by drying in an oven at 120°C for a period of one hour and then placed to cool in a dessicator. The filters are weighed accurately on a 4-fiqure balance and then placed in clean individual petri dishes and transported to site in a filter storage box. Spare filters are also prepared to allow for accidents and to obtain blank values.

Sampling Procedure

Suitability of Sampling Location

Before sampling can commence, a preliminary velocity and temperature survey must be undertaken along the two sampling lines at ten equally spaced points excluding the region within 5% of the effective flue diameter from the wall. The stack diameter is measured using a steel rod. If the ratio of the highest to lowest dynamic pressures exceeds 9:1 or if the ratio of the highest to lowest gas velocities exceeds 3:1, another sampling plane should be used. Sampling is undertaken from either four or eight sampling points.

Four sampling points are used when the ratio of the highest to lowest dynamic pressures is less than 4:1 and eight sampling points when the ratio of highest to lowest dynamic pressures exceeds 4:1 but less than 9:1 or the stack area exceeds 2.5 m^2. Temperature is also measured at ten equally spaced points along the sampling lines and an average temperature calculated. Should the temperature at any of the sampling points differ by more than ± 10% from that of the average temperature, then that point must not be used.

The required number of sampling points can now be calculated using the following:
4 point sampling, circular stacks: 0.15 x D and 0.85 x D.
4 point sampling, square stacks: 0.25 x D and 0.75 x D.
8 point sampling, circular stacks: 0.065 x D, 0.25 x D, 0.75 x D and 0.935 x D.
8 point sampling, square stacks: 0.125 x D, 0.375 x D, 0.625 x D and 0.875 x D.

Leak Checks

A leak check should be undertaken before and after the iso-kinetic sampling is carried out. This is to make sure that all ion is taken at the sampling nozzle.

Sampling

Once the iso-kinetic sampling flow rates have been calculated, the probe is inserted into the stack at 90° to the stack gas flow, as not to impinge any particulate matter on to the filter media prior to sampling. Allow the filter head and probe to attain the stack gas temperature. Start the suction device, and set the flowmeter to the correct suction rate for isokinetic sampling. At the same time turn the nozzle into flow and start the timing device.

Duration of Sampling Time

Duration of sampling time depends on :
(a) ensuring adequate quantities of particulate matter on the filter for weighing (> 0.3 % of the filter weight).
(b) whether cumulative or incremental sampling is undertaken.
(c) the number of sampling points i.e. either 4 or 8 point sampling.
(d) the continuity of plant operation.

Cumulative Sampling

After the first sample is taken from the first sampling position the control valve is closed simultaneously turning the pling probe 90° to the stack gas flow, moving the probe to the next sample position. This process should be ated until all the sample points have been used once.

Repeat Velocity and Temperature Readings

At each of the sampling points repeat the readings for the stack gas flow rate and stack gas temperatures. Calculate the new iso-kinetic sampling flow rates. If the stack gas velocity is more than ± 5% from the initial readings the test result shall not be regarded as having the required accuracy. The new temperature reading should not exceed the permitted range calculated in the preliminary survey. i.e. it should be within ± 10% of the original mean temperature.
N.B. The filter head should be cleaned and the particulate matter added to the particulate matter on the filter.

The Sampling procedure should be repeated to obtain a duplicate sample, the ratio of the two particulate emission rates should not exceed 1.5 : 1.

Weighing of Sample

The used filter should be placed in an oven at 105° C and dried thoroughly, cooled and equilibrated in a desiccator and weighed as quickly as possible so as to avoid any errors due to moisture absorption onto the filter. The gross weight of the filter should be measured to within ± 0.1 mg. The filter weight and any residual particulate matter from the filter head can then be used in the final report to calculate the particulate concentration.

On Site Isokinetic Data Sheet

Preliminary Stack Survey		*Sampling Line A*		*Sampling Line B*	
Traverse Point	Distance in Stack (m)	Dynamic Pressure (Pa)	Temperature (°C)	Dynamic Pressure (Pa)	Temperature (°C)
1	0.03	148	25	-	-
2	0.09	265	25	-	-
3	0.14	296	25	-	-
4	0.20	289	25	-	-
5	0.26	271	25	-	-
6	0.31	284	25	-	-
7	0.37	312	25	-	-
8	0.43	386	25	-	-
9	0.48	357	25	-	-
10	0.54	375	25	-	-
Mean	-	298	25	-	-

Lowest Dynamic Pressure (any line) 148 Ratio of Above 2.61 : 1
Highest Dynamic Pressure (any line) 386 (Highest permitted ratio 9:1)
Temperature Range permitted for any point is between -5 to 55 °C

Run 1		Sampling Time (mins)		16	Nozzle size used (mm)		6
Sampling Point	Dynamic Pressure (Pa)		Temperature (°C)		Velocity (m/s)		Flowmeter (m^3/hr)
	Initial	Final	Initial	Final	Initial	Final	
1	148	149	25	24	13.23	13.25	1.22
2	296	295	25	24	18.71	18.65	1.73
3	386	362	25	24	21.37	20.66	1.97
4	375	377	25	24	21.06	21.08	1.95
Mean	301	296	25	24	18.59	18.41	1.72

Difference between Initial Velocity and Final Velocity -0.99 % (Limit permitted is ± 5%)
Start Filter Weight = 0.0942 g Sample Weight = 0.0003 g
End Filter Weight = 0.0945 g Sample as % of Filter Weight = 0.32 %

Run 2		Sampling Time (mins)		16	Nozzle size used (mm)		6
Sampling Point	Dynamic Pressure (Pa)		Temperature (°C)		Velocity (m/s)		Flowmeter (m^3/hr)
	Initial	Final	Initial	Final	Initial	Final	
1	149	158	24	25	13.25	13.67	1.23
2	295	329	24	25	18.65	19.73	1.73
3	362	364	24	25	20.66	20.75	1.92
4	377	383	24	25	21.08	21.28	1.95
Mean	296	309	24	25	18.41	18.86	1.71

Difference between Initial Velocity and Final Velocity 2.37 % (Limit permitted is ± 5%)
Start Filter Weight = 0.0926 g Sample Weight = 0.0004 g
End Filter Weight = 0.0930 g Sample as % of Filter Weight = 0.43 %

Chlorides Sampling Methodology

The concentration of chlorides (as hydrogen chloride excluding particulate matter) was determined using a wet chemistry technique, where a known volume of stack gas is extracted and passed through a suitable reagent.

Equipment

The sampling train consists of the following;

- Three glass impinger bottles with cintered glass bubblers and ground glass connectors.
- A glass lined sampling probe.
- A suitable sampling reagent.
- An in-stack particulate filter.
- A dry gas meter fitted with a NAMAS calibrated thermocouple and vacuum meter.

A 110V pump capable of sucking at a rate of $3m^3$/hr.

All equipment is cleaned and checked prior to arrival on site.

Methodology

- The first and second impingers are filled with a measured volume of reagent and the third is filled with silica gel. All impingers are connected together in series and placed in an ice bath.

- The glass sampling probe is fitted with an in-stack filter and is connected to the first impinger in the train.

- The pump and dry gas meter are connected to the back of the impinger train, the control valve is then opened to attain a flow rate which is determined according to the stack conditions.

- The glass lined sampling probe is placed into the stack and a known volume of stack gas is passed through the reagent in the impingers. The temperature of the gas entering the dry gas meter and the vacuum pressure are noted throughout the sampling run. These are then used to correct the extracted gas volume to standard temperature and pressure.

- The pump is turned off and the liquid sample is poured into a sterile container for storage. All glassware is rinsed in preparation for the next sampling run and the above procedure is repeated. A volume of unused reagent is retained and analysed to determine the blank value of the solution.

- All samples are stored in accordance with set procedures and sent to our accredited laboratory where they are analysed by ion chromatography.

Quality Assurance Checklist

Velocity Measurements:

Water droplets were not present. ✓

Direction of gas flow within ± 20° of stack axis. ✓

Dynamic Pressures > 5 Pa at all sampling points. ✓

Sampling:

Sampling plane correctly positioned. ✓

Area of sampling apparatus not > 10% of stack area. ✓

Sampling from centres of equal areas. ✓

Sampling at each point not less than 3 minutes. ✓

Nozzle facing directly upstream to within ± 10°. ✓

Isokinetic flow maintained during sampling. ✓

Leak check performed after each run and passed. ✓

Sample Handling:

Minimum weight of samples collected > 0.3% of filter weights. ✓

Samples achieved stable weights. ✓

Particulate samples sent for lead analysis. ✓

QA Procedures:

File saved to disk. ✓

Hard copy made. ✓

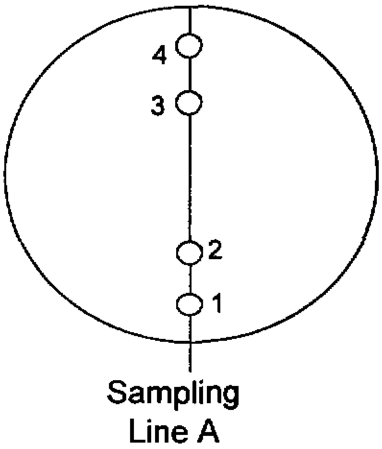
On site isokinetic data sheet filed. ✓

Signed:

James Hamer Team Leader

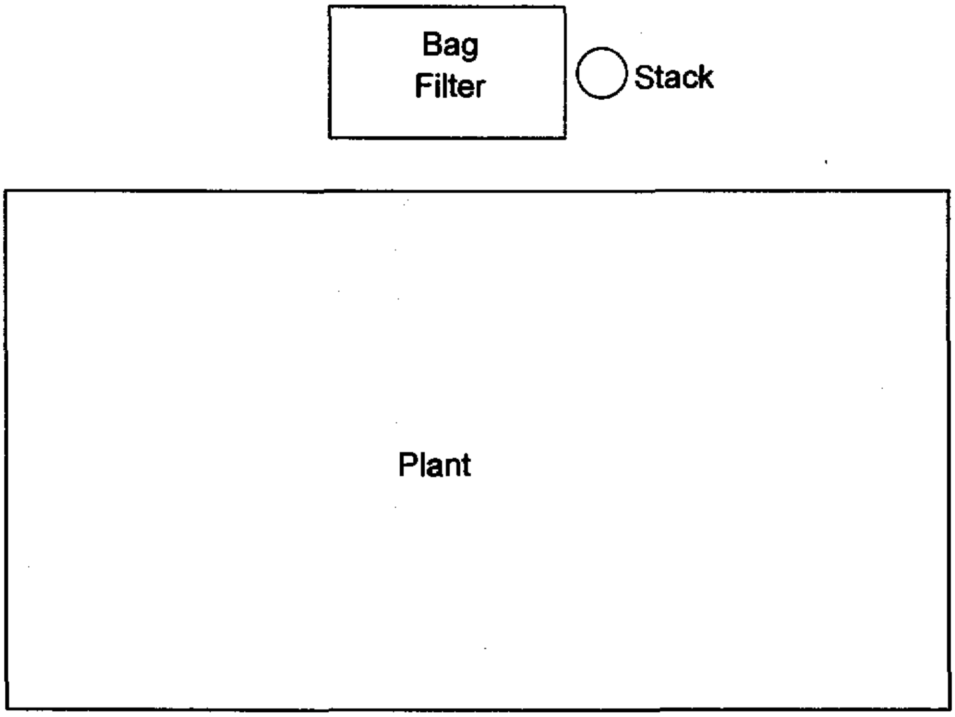
Stack Diagram

Stack Diameter (D) = 0.57 m
Stack Area (A) = 0.26 m^2



Sampling Point	Distance as a % of D	Distance in m
1	6.5	0.04
2	25	0.14
3	75	0.43
4	93.5	0.53

Plant Layout



Environmental Monitoring Team

Environmental Team Leader	James Harmer 3rd Year BEng (Hons) Engineering with Environmental Studies
Environmental Technician	Daniel Pryke BSc (Hons) Environmental Studies

Report by	James Harmer	Signed
Checked by	Ben Rose	Signed
Authorised by	Alastair Wolff	Signed

Conclusion

The results of this test demonstrate that under normal operating conditions, this Plant is being operated in full compliance with both the total particulate matter and chlorides emission limits specified in PG 2/2 (96).

Testing was fully in accordance with BS 3405 : 1983, apart from the fact that only one sampling line was used, as only one of the sampling port caps could physically be removed. However, four sampling points were used on the one available sampling line, instead of just two.

Good housekeeping and maintenence of the ducting and abatement plant should be continued in order to maintain this level of Plant performance.

A regular programme of stack emissions testing in accordance with the Plant's LAPC Authorisation will be required to demonstrate continued compliance.