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# Stack Emissions Survey

## GKN Sinter Metals, Cape Town

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## EXECUTIVE SUMMARY

DDA Environmental Engineers was appointed to perform an emissions survey at the GKN Sinter Metals. The objective of the survey was to determine the stack emissions from the stacks and compare the emissions against the current South African emission guidelines for compliance. The emission measurements were carried out from the 18<sup>th</sup> – 24<sup>th</sup> of January 2017. The overview of the survey, including methods of measurement, duration of measurement and pollutants measured, are presented in Table 1-1 below.

**Table 1-1. Overview of the Emissions Survey**

Locations	Emission Source	Method of Measurement	Duration of Measurement	Pollutants
Werner, Seco and Cremer Stack	LPG combustion and emission from Sintering	EPA Method 17	1 hour	Particulate Matter, O <sub>2</sub> , NO, NO <sub>2</sub> , NO <sub>x</sub> , CO and SO <sub>2</sub>
CNC Machining Extraction Stacks	Dust from grinding and cutting			
Steam Furnace	Dust from grinding and cutting			
Oil Dipping Stack	Emission from dipping process	EPA Method 18		VOCs

The Department of Environmental Affairs (DEA) has published a list of activities which result in atmospheric emissions and the associated minimum emission standards in Gazette No. 37054 of 22 November 2013. Sintering processes employed at GKN Sinter Metals are listed under Category 4: Metallurgical Industry, Subcategory 4.5. The atmospheric emission limits for Sinter Plant are shown in Table 1-2.

**Table 1-2. Emission Limits for Sinter Plant (Subcategory 4.5)**

Description:	Sinter plants for agglomeration of fine ores using a heating process, including sinter cooling where applicable.		
Application:	All installations		
Substance or Mixture of Substances		Plant Status	mg/Nm <sup>3</sup> under normal condition of 273k and 101.3 kPa
Common Name	Chemical symbol		
Particulate Matter	-	New	50
		Existing	100
Sulphur Dioxide	SO <sub>2</sub>	New	500
		Existing	1000
Oxides of Nitrogen	NO <sub>x</sub> expressed as NO <sub>2</sub>	New	700
		Existing	1200

The measured emissions corrected for Normal Temperature and Pressure (NTP) condition, together with the emission limits, are shown in Table 1-3 to Table 1-7 below.

**Table 1-3. Werner Stack Emissions**

Pollutants	Concentration	Emission Limit	Compliance	
	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	Yes	No
Total Particulates	90.9	100	√	
SO <sub>2</sub>	8	500	√	
NOx	12	700	√	
CO	141	-	-	
<sup>a</sup> At 0°C, 101.3kPa, Dry. - None				

**Table 1-4. Seco Stack Emissions**

Pollutants	Concentration	Emission Limit	Compliance	
	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	Yes	No
Total Particulates	5.9	100	√	
SO <sub>2</sub>	0.3	500	√	
NOx	28	700	√	
CO	5	-	-	
<sup>a</sup> At 0°C, 101.3kPa, Dry. - None				

**Table 1-5. Cremer Stack Emissions**

Pollutants	Concentration	Emission Limit	Compliance	
	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	Yes	No
Total Particulates	17.6	100	√	
SO <sub>2</sub>	18	500	√	
NOx	3	700	√	
CO	1,721	-	-	
<sup>a</sup> At 0°C, 101.3kPa, Dry. - None				

**Table 1-6. Steam Furnace Stack Emissions**

Pollutants	Concentration	Emission Limit	Compliance	
	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	Yes	No
Total Particulates	4.7	100	√	
SO <sub>2</sub>	0	500	√	
NOx	0	700	√	
CO	0	-	-	
<sup>a</sup> At 0°C, 101.3kPa, Dry. - None				

**Table 1-7. CNC Machining Combined Stack Emissions**

Pollutants	Concentration	Emission Limit	Compliance	
	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	(mg/Nm <sup>3</sup> ) <sup>(a)</sup>	Yes	No
Total Particulates	4.8	100	√	
SO <sub>2</sub>	0	500	√	
NOx	0	700	√	
CO	0	-	-	
<sup>a</sup> At 0°C, 101.3kPa, Dry. - None				

**Table 1-8. Oil Dipping Stack Emissions**

Monitoring Location	Sample No.	VOCs Concentration		Average VOCs (mg/Nm <sup>3</sup> )
		at Measured condition (mg/m <sup>3</sup> ) <sup>(a)</sup>	at NTP (mg/Nm <sup>3</sup> ) <sup>(b)</sup>	
Oil Dipping Stack	1	519	614	808
	2	714	844	
	3	815	965	
<sup>(a)</sup> Stack conditions at the time of measurements: Temperature: 303k Pressure: 101.3KPa <sup>(b)</sup> NTP: 0°C, 101.3kPa				

The results obtained are considered to be representative of the plant operating conditions that prevailed during the sampling period.

The main conclusions of the measurements were:

- The average concentration of particulate matter measured in the **Werner stack** was 90.9 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup> for an existing sintering plant.
- The average concentration of NO<sub>x</sub> measured in the **Werner stack** was 12 mg/Nm<sup>3</sup> which is well below the emission limit of 1,200 mg/Nm<sup>3</sup> for an existing sintering plant.
- The average concentration of SO<sub>2</sub> measured in the **Werner stack** was 8 mg/Nm<sup>3</sup> and is well below the emission limit of 1,000 mg/Nm<sup>3</sup> for an existing sintering plant.
- The average concentration of particulate matter measured in the **Seco stack** was 5.9 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>.
- The average measured concentration of NO<sub>x</sub> in the **Seco stack** was 28 mg/Nm<sup>3</sup> which is well below the emission limit of 1,200 mg/Nm<sup>3</sup>.
- The average concentration of SO<sub>2</sub> detected in the **Seco Stack** was 0.3 mg/Nm<sup>3</sup> and is well below the emission limit of 1,000 mg/Nm<sup>3</sup>.
- The average concentration of particulate matter measured in the **Cremer stack** was 17.6 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>.
- The average measured concentration of NO<sub>x</sub> in the **Cremer stack** was 3 mg/Nm<sup>3</sup> which is well below the emission limit of 1,200 mg/Nm<sup>3</sup>.
- The average concentration of particulate matter detected in **Steam Furnace Stack** was 4.7 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>. No SO<sub>2</sub>, NO<sub>x</sub> and CO was detected in the stack.
- The average concentration of particulate matter detected in the **CNC Machining Combined Stack** was 4.8 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>. SO<sub>2</sub>, NO<sub>x</sub> and CO were not detected in the stack.
- The average concentration of VOCs detected in the **Oil Dipping stack** was 808 mg/Nm<sup>3</sup>



## TABLE OF CONTENTS

<b>1</b>	<b>INTRODUCTION .....</b>	<b>3</b>
<b>2</b>	<b>LEGISLATIVE REQUIREMENTS.....</b>	<b>4</b>
2.1	Emission Limits.....	5
<b>3</b>	<b>MEASUREMENT METHODS .....</b>	<b>5</b>
3.1	Total Particulates and Lead Emissions .....	5
3.1.1	<i>Sampling Position.....</i>	6
3.1.2	<i>Stack Gas Velocity .....</i>	6
3.1.3	<i>Stack Gas Temperature .....</i>	6
3.1.4	<i>Water Vapour Content .....</i>	6
3.2	Combustion Gases Analysis .....	7
3.3	VOCs Emissions.....	7
<b>4</b>	<b>RESULTS AND DISCUSSION .....</b>	<b>7</b>
4.1	Particulates and Combustion Gases Emissions.....	7
4.1.1	<b><i>Werner Furnace Stack .....</i></b>	<b>7</b>
4.1.2	<b><i>Seco Furnace Stack .....</i></b>	<b>9</b>
4.1.3	<b><i>Cremer Furnace Stack .....</i></b>	<b>11</b>
4.1.4	<b><i>Steam Furnace Stack .....</i></b>	<b>12</b>
4.1.5	<b><i>CNC Machining Extraction Combined Stack.....</i></b>	<b>13</b>
4.2	Oil Dipping Stack VOCs Emissions.....	14
<b>5</b>	<b>CONCLUSIONS AND RECOMMENDATIONS.....</b>	<b>15</b>
	<b>REFERENCES .....</b>	<b>17</b>

<b>List of Tables .....</b>	<b>Page</b>
Table 1-1. Overview of the Emissions Survey .....	i
Table 1-2. Emission Limits for Sinter Plant (Subcategory 4.5) .....	i
Table 1-3. Werner Stack Emissions.....	ii
Table 1-4. Seco Stack Emissions .....	ii
Table 1-5. Cremer Stack Emissions .....	ii
Table 1-6. Steam Furnace Stack Emissions.....	iii
Table 1-7. CNC Machining Combined Stack Emissions.....	iii
Table 1-1. Overview of the Emissions Survey .....	3
Table 2-1. Emission Limits for Sinter Plants (Subcategory 4.5) .....	5
Table 4-1. Werner: Stack Conditions and Particulates Emissions .....	8
Table 4-2. Werner Stack: Combustion Gas Concentrations.....	8
Table 4-3. Seco: Stack Conditions and Particulates Emissions .....	9
Table 4-4. Seco Stack: Combustion Gas Concentrations .....	10
Table 4-5. Cremer: Stack Conditions and Particulates Emissions .....	11
Table 4-6. Cremer Stack: Combustion Gas Concentrations.....	12
Table 4-7. Steam: Stack Conditions and Particulates Emissions.....	13
Table 4-8. CNC Machining: Stack Conditions and Particulates Emissions .....	13

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## 1 INTRODUCTION

GKN Sinter Metals manufactures sintered components, including shock absorber components, sprockets, pulleys, bearings, stainless steel and phosphor bronze filters.

Some of the equipment's used in the sintering are the Werner Furnace, the Seco Furnace, the Cremer Furnace, the Steam Furnace and the CNC Machining. The sintering takes place in the Werner Furnace, the Seco Furnace and the Cremer Furnace. Although all the three furnaces are electric furnaces, LPG gas is used as fuel to create flames which in turn act as heat curtains to prevent fresh air from entering the sintering process. The flue gases are emitted to atmosphere via three stacks at the furnaces.

DDA Environmental Engineers was appointed to perform an emissions survey at the GKN Sinter Metals stacks. The objective of the survey was to determine the stack emissions and compare the emissions against the current South African emission guidelines for compliance.

The stack emissions sampling was carried out on the 18<sup>th</sup> – 24<sup>th</sup> of January 2017. The emissions measurements were carried out at the stacks of the following equipment:

- Werner Furnace ;
- Seco Furnace;
- Cremer Furnace;
- Steam Furnace;
- CNC Machining Extraction Combined; and
- Oil dipping.

The overview of the survey, including the methods of measurement, duration of measurements and pollutants measured, are presented in Table 1-1.

**Table 1-1. Overview of the Emissions Survey**

Locations	Emission Source	Method of Measurement	Duration of Measurement	Pollutants
Werner, Seco and Cremer Stack	LPG combustion and emission from Sintering	EPA Method 17	1 hour	Particulate Matter, O <sub>2</sub> , NO, NO <sub>2</sub> , NO <sub>x</sub> , CO and SO <sub>2</sub>
CNC Machining Extraction Stacks	Dust from grinding and cutting			
Steam Furnace	Dust from grinding and cutting			
Oil Dipping Stack	Emission from dipping process	EPA Method 18		VOCs

## 2 LEGISLATIVE REQUIREMENTS

Locally as well as internationally, air quality issues are perceived as an increasing priority for industry today. The ambient air around major air pollution sources may contain a number of substances which may impair the health of humans, animals as well as plants, to different degrees. The control of emissions from air pollution sources, the establishment of emission limits, as well as the determination of the relevant air quality impacts have been the main focus of the current legislation in South Africa.

The air quality in South Africa is regulated by the National Environmental Management: Air Quality Act of 2004, which replaced the Atmospheric Pollution Prevention Act. The Air Quality Act came into full effect as of April 1, 2010. It increased the requirements for compliance monitoring and has as main objective air quality targets that are not harmful to health.

According to the Act, an air pollution emitting operation will require obtaining a temporary emissions licence. Thereafter, emitters will be given a specific period in which to obtain an emissions licence. This period is expected to vary for different types of operations.

The Act provides for national, provincial and local air quality standards and stipulates that the issuing of an emissions licence will now be handled at local government level.

In order to obtain an emission licence, the operator will have to:

1. Compile an emissions inventory.
2. Determine emissions levels.
3. Undertake an environmental impact assessment, in order to determine the impacts of emissions on receptors. This will probably entail a dispersion modelling exercise to “translate” source emissions into relevant ambient off-site concentrations.
4. Prepare an action plan for the reduction of the emissions and ambient concentrations.

## 2.1 Emission Limits

The Department of Environmental Affairs (DEA) has published a list of activities which result in atmospheric emissions and the associated minimum emission standards in Gazette No. 37054 of 22 November 2013. Sintering processes employed at GKN Sinter Metals are listed under Category 4: Metallurgical Industry, Subcategory 4.5. The atmospheric emission limits for Sinter Plants are shown in Table 2-1.

**Table 2-1. Emission Limits for Sinter Plants (Subcategory 4.5)**

Description:	Sinter plants for agglomeration of fine ores using a heating process, including sinter cooling where applicable.		
Application:	All installations		
Substance or Mixture of Substances		Plant Status	mg/Nm <sup>3</sup> under normal condition of 273k and 101.3 kPa
Common Name	Chemical symbol		
Particulate Matter	-	New	50
		Existing	100
Sulphur Dioxide	SO <sub>2</sub>	New	500
		Existing	1000
Oxides of Nitrogen	NO <sub>x</sub> expressed as NO <sub>2</sub>	New	700
		Existing	1200

## 3 MEASUREMENT METHODS

### 3.1 Total Particulates and Lead Emissions

The objective of particulates sampling from stack is to collect a sample as representative as possible of what is present in the stack gas. This becomes challenging as the velocity of gas is not uniform throughout the stack. In most instances, the velocity is maximum in the centre and almost zero at the walls of the stack. This velocity distribution causes particle size distribution in the stack, i.e. smaller particles move towards the centre of the stack and the larger particles move towards walls. Therefore, it becomes very important to collect samples of stack gas at various points across the diameter of the stack. This is known as traversing the diameter of the stack, and the points of sample collection are known as traverse points. Samples are collected at each traverse point via maintaining the sampling flow rate at the collecting nozzle the same as the velocity of the gases at each traverse point. This velocity matching state is known as isokinetic condition and the sampling is called isokinetic sampling.

During this condition, a known volume of stack gas is made to pass through a weighed filter, where the particulate matter gets deposited. The final weight of the filter is measured and the concentration of the particulate is computed by dividing the weight of particulates deposited by the volume of the gas that passed through the filter.

The solids' emission rates were obtained by means of isokinetic sampling, in accordance with a method that complies with the specifications of the following internationally accepted methods:

- **USEPA Method 17** "Determination of Particulate Matter Emissions from Stationary Sources".
- **ISO 9096** "Stationary Source Emissions – Determination of Concentration and Mass Flow Rate of Particulate Material in Gas-carrying – Manual Gravimetric Method".

These methods are also stipulated in the listed activities, Annexure A of Government No. 893 dated 22 November 2013.

The Environmental Supply Company C-5000 Source Sampling System was used for the sampling of the particulates. The system is engineered for optimal performance of isokinetic source sampling procedures. The isokinetic sampling train for particulates consisted of the following components:

- Sampling probe, nozzle and filter holder with high efficiency filter (thimble),
- Impinger set,
- Vacuum pump,
- Control console fitted with calibrated orifice, thermocouple, manometer, vacuum gauge and a dry gas meter.

#### 3.1.1 Sampling Position

Sampling ports were installed on the stack, in conformance with the relevant sitting and positioning criteria.

#### 3.1.2 Stack Gas Velocity

The gas velocity was calculated via data obtained from multi-point velocity pressure measurements. The location of the sampling points was based on the assumption that the distribution of gas velocity in sections of the stack cross-sectional area adjacent to the wall will approximate the  $1/7^{\text{th}}$  power law curve.

Velocity pressure measurements were taken by means of an S-type Pitot tube and inclined gauge manometer. The stack gas volumes were calculated from the individual point velocities and the internal dimensions of the stack.

#### 3.1.3 Stack Gas Temperature

The gas temperature was measured by means of a Type-K thermocouple connected to a digital thermometer.

#### 3.1.4 Water Vapour Content

The water vapour content of the gas stream was calculated from the temperature of the gas leaving the condenser unit and the mass of water condensed during each test.

### 3.2 Combustion Gases Analysis

An ECOM J2K portable emission analyser was used to measure the concentrations of combustion gases ( $O_2$ , CO, NO,  $NO_x$  and  $SO_2$ ) in the stack gas stream on a volume/volume basis, in accordance with EN 50379-2:2004 - Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances.

### 3.3 VOCs Emissions

The VOCs emissions measurements in the oil dipping stack were carried out in accordance with the **USEPA Method 18** "*Measurement of Gaseous Organic Compounds Emissions by Gas Chromatography: Adsorption Tube Procedure*" and complies with the Department of Environmental Affairs (DEA) requirements.

The process gas samples were collected using coconut shell charcoal sorbent tubes via a sampling train that consisted of a sampling probe, the charcoal sorbent tube and a precision pump. Two coconut shell charcoal sorbent tubes were connected in series to increase the adsorptive capacity of the tubes.

The pump was calibrated on site with a portable flow calibrator to a flow rate of 0.2 l/min. Three samples were collected and analysed at a SANAS accredited laboratory.

## 4 RESULTS AND DISCUSSION

### 4.1 Particulates and Combustion Gases Emissions

The particulates collected were weighted in a laboratory and the concentrations calculated for following conditions:

- Actual stack temperature and pressure.
- Normal Temperature and Pressure (NTP): 0 °C and 101.325 kPa.

#### 4.1.1 Werner Furnace Stack

The particulate concentrations, as well as the parameters for the Werner stack are shown in Table 4-1. As can be seen, the particulates concentrations at NTP and dry conditions were 182 mg/Nm<sup>3</sup> for Test 1, 20.0 mg/Nm<sup>3</sup> for Test 2 and 70.3 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 90.9 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>.

The combustion gas analysis results for the oven stack are shown in Table 4-2. For the estimation of the concentrations, several measurements were obtained during each test and the values were averaged.

The overall average  $O_2$  concentration was 20.5 %. The measured concentrations of CO at NTP and dry conditions were 120 mg/Nm<sup>3</sup> for Test 1, 147 mg/Nm<sup>3</sup> for Test 2 and 157 mg/Nm<sup>3</sup> for Test 3. The average concentration of CO in the stack was 147 mg/Nm<sup>3</sup>.

The concentrations of NO<sub>x</sub> at NTP and dry conditions were 4 mg/Nm<sup>3</sup> for Test 1, 7 mg/Nm<sup>3</sup> for Test 2 and 24 mg/Nm<sup>3</sup> for Test 3. The average measured concentration of NO<sub>x</sub> in the stack was 12 mg/Nm<sup>3</sup> which is well below the emission limit of 1,200 mg/Nm<sup>3</sup> for an existing sintering plant.

The concentrations of SO<sub>2</sub> at NTP and dry conditions detected were 10 mg/Nm<sup>3</sup>, 12 mg/Nm<sup>3</sup> and 4 mg/Nm<sup>3</sup> for Test 1, Test 2 and Test 3 respectively. The overall concentration of SO<sub>2</sub> was 8 mg/Nm<sup>3</sup> and is well below the emission limit of 1,000 mg/Nm<sup>3</sup> for an existing sintering plant.

**Table 4-1. Werner: Stack Conditions and Particulates Emissions**

Parameters	Units	Test No.			Average
		1	2	3	
Time of day		10:00	11:10	12:20	-
Barometric Pressure	kPa	101	101	101	101
Duct Static Pressure	kPa	-0.16	-0.16	-0.16	-0.16
Average Gas Temperature	°C	58	60	60	59
Stack Diameter	m	0.22	0.22	0.22	-
Gas Velocity	m.s <sup>-1</sup>	3.6	3.6	3.6	3.6
Volumetric Flow Rate (Actual)	m <sup>3</sup> .h <sup>-1</sup>	496	496	497	496
Volumetric Flow Rate (NTP)	Nm <sup>3</sup> .h <sup>-1</sup>	406	406	405	406
Total Solids (Actual)	mg.m <sup>-3</sup>	147.7	16.5	56.7	73.6
Total Solids (NTP; dry)	<b>mg.Nm<sup>-3</sup></b>	<b>182</b>	<b>20</b>	<b>70.3</b>	<b>90.9</b>
Total Solids Emission Rate	kg.h <sup>-1</sup>	0.074	0.008	0.028	0.04
Water Content (% Vol/Vol)	%	0.84	0.95	0.93	0.90
Percent Isokinetic	%	97	94	108	
NTP: 0 °C and 101.325 kPa					

**Table 4-2. Werner Stack: Combustion Gas Concentrations**

Time	O <sub>2</sub>	CO	NO	NO <sub>x</sub> as	SO <sub>2</sub>
	%			NO <sub>2</sub>	
mg/Nm <sup>3</sup> (dry)					
<b>Test 1</b>					
10h00	21	85	1	2	3
10h20	20.8	111	1	2	9
10h30	20.6	150	4	6	15
10h35	20.3	135	4	6	12
<b>Average</b>	<b>20.7</b>	<b>120</b>	<b>3</b>	<b>4</b>	<b>10</b>
<b>Test 2</b>					
11h03	20.5	108	4	6	12
11h020	20.8	180	4	6	6
11h35	20.8	169	4	6	13
11h55	20.7	131	5	8	15
<b>Average</b>	<b>20.7</b>	<b>147</b>	<b>4</b>	<b>7</b>	<b>12</b>

Time	O <sub>2</sub>	CO	NO	NO <sub>x</sub> as	SO <sub>2</sub>
	%			NO <sub>2</sub>	
mg/Nm <sup>3</sup> (dry)					
Test 3					
12h10	20.3	123	8	18	10
12h15	20.1	155	9	25	0
12h20	20.2	170	11	29	0
12h25	20.1	179	8	25	5
<b>Average</b>	<b>20.2</b>	<b>157</b>	<b>9</b>	<b>24</b>	<b>4</b>
<b>Overall Average</b>	<b>20.5</b>	<b>141</b>	<b>5</b>	<b>12</b>	<b>8</b>

#### 4.1.2 Seco Furnace Stack

The particulate concentrations, as well as the parameters for the Seco furnace stack are shown in Table 4-3 below. The particulates concentrations at NTP and dry conditions were 4.0 mg/Nm<sup>3</sup> for Test 1, 7.9 mg/Nm<sup>3</sup> for Test 2 and 6.6 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 5.9 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>.

The combustion gas analysis results are shown in Table 4-4 further below. For the estimation of the concentrations of combustion gases, several measurements were obtained during each test and the values were averaged.

The overall average O<sub>2</sub> concentration was 19.3 %. The measured concentrations of CO at NTP and dry conditions were 4 mg/Nm<sup>3</sup> for Test 1, 3 mg/Nm<sup>3</sup> for Test 2 and 7 mg/Nm<sup>3</sup> for Test 3. The average measured concentration of CO in the stack was 5 mg/Nm<sup>3</sup>.

The concentrations of NO<sub>x</sub> at NTP and dry conditions were 26 mg/Nm<sup>3</sup> for Test 1, 30 mg/Nm<sup>3</sup> for Test 2 and 27 mg/Nm<sup>3</sup> for Test 3. The average measured concentration of NO<sub>x</sub> in the stack was 28 mg/Nm<sup>3</sup> which is well below the emission limit of 1,200 mg/Nm<sup>3</sup> for an existing sintering plant.

The overall concentration of SO<sub>2</sub> detected was 0.3 mg/Nm<sup>3</sup> and is well below the emission limit of 1,000 mg/Nm<sup>3</sup> for an existing sintering plant.

**Table 4-3. Seco: Stack Conditions and Particulates Emissions**

Parameters	Units	Test No.			Average
		1	2	3	
Time of day		10:00	11:10	12:20	-
Barometric Pressure	kPa	101	101	101	101
Duct Static Pressure	kPa	-0.16	-0.16	-0.16	-0.16
Average Gas Temperature	°C	200	200	200	200
Stack Diameter	m	0.18	0.18	0.18	-
Gas Velocity	m.s <sup>-1</sup>	8.1	8.1	8.1	8.1

Parameters	Units	Test No.			Average
		1	2	3	
Volumetric Flow Rate (Actual)	m <sup>3</sup> .h <sup>-1</sup>	742	742	742	742
Volumetric Flow Rate (NTP)	Nm <sup>3</sup> .h <sup>-1</sup>	426	426	426	426
Total Solids (Actual)	mg.m <sup>-3</sup>	2.2	4.1	3.8	3.3
Total Solids (NTP; dry)	mg.Nm <sup>-3</sup>	<b>4</b>	<b>7</b>	<b>6.6</b>	<b>5.9</b>
Total Solids Emission Rate	kg.h <sup>-1</sup>	0.002	0.003	0.003	0.00
Water Content (% Vol/Vol)	%	1.09	1.28	2.38	1.58
percent Isokinetic	%	98	99	102	
NTP: 0 °C and 101.325 kPa					

Table 4-4. Seco Stack: Combustion Gas Concentrations

Time	O <sub>2</sub>	CO	NO	NOx as	SO <sub>2</sub>
	%			NO <sub>2</sub>	
		mg/Nm <sup>3</sup> (dry)			
<b>Test 1</b>					
10h00	19.4	4	13	23	0
10h22	19.3	4	15	25	0
10h34	19.4	4	16	27	0
10h45	19.4	5	17	29	3
<b>Average</b>	<b>19.4</b>	<b>4</b>	<b>15</b>	<b>26</b>	<b>1</b>
<b>Test 2</b>					
11h10	19.3	4	14	31	0
11h35	19.2	3	15	37	0
13h00	19.7	2	10	25	0
13h00	19.6	2	10	25	0
<b>Average</b>	<b>19.45</b>	<b>3</b>	<b>12</b>	<b>30</b>	<b>0</b>
<b>Test 3</b>					
13h10	19.1	6	15	27	0
13h35	19	7	15	27	0
14h00	19	7	15	27	0
14h10	18.9	7	15	27	0
<b>Average</b>	<b>19.0</b>	<b>7</b>	<b>15</b>	<b>27</b>	<b>0</b>
<b>Overall Average</b>	<b>19.3</b>	<b>5</b>	<b>14</b>	<b>28</b>	<b>0.3</b>



#### 4.1.3 Cremer Furnace Stack

The particulate concentrations, as well as the stack parameters are shown in Table 4-5 for the Cremer stack. The particulates concentrations at NTP and dry conditions were 24 mg/Nm<sup>3</sup> for Test 1, 15 mg/Nm<sup>3</sup> for Test 2 and 13.4 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 17.6 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>.

The combustion gas analysis results are shown in Table 4-6. For the estimation of the concentrations several measurements were obtained during each test and the values were averaged.

The overall average O<sub>2</sub> concentration was 20.5 %. The measured concentrations of CO at NTP and dry conditions were 1,215 mg/Nm<sup>3</sup> for Test 1, 1,776 mg/Nm<sup>3</sup> for Test 2 and 2,171 mg/Nm<sup>3</sup> for Test 3. The average measured concentration of CO in the stack was 1,721 mg/Nm<sup>3</sup>.

The concentrations of NO<sub>x</sub> at NTP and dry conditions were 4 mg/Nm<sup>3</sup> for Test 1, 4 mg/Nm<sup>3</sup> for Test 2 and 2 mg/Nm<sup>3</sup> for Test 3. The average measured concentration of NO<sub>x</sub> in the stack was 3 mg/Nm<sup>3</sup> which is well below the emission limit of 1,200 mg/Nm<sup>3</sup> for an existing sintering plant.

The concentrations of SO<sub>2</sub> at NTP and dry conditions detected were 40 mg/Nm<sup>3</sup>, 11 mg/Nm<sup>3</sup> and 5 mg/Nm<sup>3</sup> for Test 1, Test 2 and Test 3 respectively. The overall concentration of SO<sub>2</sub> detected was 18 mg/Nm<sup>3</sup> and is well below the emission limit of 1,000 mg/Nm<sup>3</sup> for an existing sintering plant.

**Table 4-5. Cremer: Stack Conditions and Particulates Emissions**

Parameters	Units	Test No.			Average
		1	2	3	
Time of day		10:00	11:30	13:00	-
Barometric Pressure	kPa	101	101	101	101
Duct Static Pressure	kPa	-0.16	-0.16	-0.16	-0.16
Average Gas Temperature	°C	80	79	80	80
Stack Diameter	m	0.31	0.31	0.31	-
Gas Velocity	m.s <sup>-1</sup>	3.7	3.7	3.7	3.7
Volumetric Flow Rate (Actual)	m <sup>3</sup> .h <sup>-1</sup>	1016	1016	1016	1016
Volumetric Flow Rate (NTP)	Nm <sup>3</sup> .h <sup>-1</sup>	782	781	782	782
Total Solids (Actual)	mg.m <sup>-3</sup>	18.5	11.5	10.2	13.4
Total Solids (NTP; dry)	<b>mg.Nm<sup>-3</sup></b>	<b>24</b>	<b>15</b>	<b>13.4</b>	<b>17.6</b>
Total Solids Emission Rate	kg.h <sup>-1</sup>	0.019	0.012	0.010	0.01
Water Content (% Vol/Vol)	%	0.82	0.56	0.91	0.76
Percent Isokinetic	%	100%	91%	102%	
NTP: 0 °C and 101.325 kPa					

**Table 4-6. Cremer Stack: Combustion Gas Concentrations**

Time	O <sub>2</sub>	CO	NO	NO <sub>x</sub> as	SO <sub>2</sub>
	%	mg/Nm <sup>3</sup> (dry)			
<b>Test 1</b>					
10h00	21.0	855	1	2	44
10h20	20.1	1,120	3	4	41
10h35	20.2	1,345	3	4	38
11h00	20.1	1,540	3	4	35
<b>Average</b>	<b>20.4</b>	<b>1,215</b>	<b>3</b>	<b>4</b>	<b>40</b>
<b>Test 2</b>					
11h30	20.3	1,600	2	4	12
11h45	20.3	1,705	2	4	9
12h00	20.4	1,765	2	4	6
12h25	20.1	2,035	2	4	15
<b>Average</b>	<b>20.3</b>	<b>1,776</b>	<b>2</b>	<b>4</b>	<b>11</b>
<b>Test 3</b>					
13h05	20.8	2,120	1	2	6
13h35	20.8	2,150	1	2	6
13h50	20.8	2,195	1	2	3
14h05	20.9	2,220	1	2	6
<b>Average</b>	<b>20.8</b>	<b>2,171</b>	<b>1</b>	<b>2</b>	<b>5</b>
<b>Overall Average</b>	<b>20.5</b>	<b>1,721</b>	<b>2</b>	<b>3</b>	<b>18</b>

#### 4.1.4 Steam Furnace Stack

The particulate concentrations, as well as the parameters for the Cremer stack are shown in Table 4-7 below. The particulates concentrations at NTP and dry conditions were 1.1 mg/Nm<sup>3</sup> for Test 1, 6.7 mg/Nm<sup>3</sup> for Test 2 and 6.4 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 4.7 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>.

SO<sub>2</sub>, NO<sub>x</sub> and CO were not detected in the stack. The overall average O<sub>2</sub> concentration was 20.9 %.

**Table 4-7. Steam: Stack Conditions and Particulates Emissions**

Parameters	Units	Test No.			Average
		1	2	3	
Time of day		10:00	11:30	14:00	-
Barometric Pressure	kPa	101	101	101	101
Duct Static Pressure	kPa	-0.16	-0.16	-0.16	-0.16
Average Gas Temperature	°C	32	32	32	32
Stack Diameter	m	0.28	0.28	0.28	-
Gas Velocity	m.s <sup>-1</sup>	10.1	10.1	10.0	10.1
Volumetric Flow Rate (Actual)	m <sup>3</sup> .h <sup>-1</sup>	2,249	2,238	2,216	2,234
Volumetric Flow Rate (NTP)	Nm <sup>3</sup> .h <sup>-1</sup>	2,005	1,995	1,975	1,992
Total Solids (Actual)	mg.m <sup>-3</sup>	1.0	5.9	5.6	4.2
Total Solids (NTP; dry)	<b>mg.Nm<sup>-3</sup></b>	<b>1.1</b>	<b>6.7</b>	<b>6.4</b>	<b>4.7</b>
Total Solids Emission Rate	kg.h <sup>-1</sup>	0.002	0.013	0.013	0.01
Water Content (% Vol/Vol)	%	0.63	0.38	0.63	0.55
Percent Isokinetic	%	99	100	101	
NTP: 0 °C and 101.325 kPa					

**4.1.5 CNC Machining Extraction Combined Stack**

The particulate concentrations, as well as the stack parameters are shown in Table 4-8 below for the CNC stack. The particulates concentrations at NTP and dry conditions were 5.1 mg/Nm<sup>3</sup> for Test 1, 4.6 mg/Nm<sup>3</sup> for Test 2 and 3. The average concentration of particulate matter in the stack was 4.8 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>.

SO<sub>2</sub>, NO<sub>x</sub> and CO were not detected in the stack. The overall average O<sub>2</sub> concentration was 20.9 %.

**Table 4-8. CNC Machining: Stack Conditions and Particulates Emissions**

Parameters	Units	Test No.			Average
		1	2	3	
Time of day		10:00	11:30	13:30	-
Barometric Pressure	kPa	101	101	101	101
Duct Static Pressure	kPa	-0.16	-0.16	-0.16	-0.16
Average Gas Temperature	°C	30	30	30	30
Stack Diameter	m	0.36	0.36	0.36	-
Gas Velocity	m.s <sup>-1</sup>	2.4	2.3	2.3	2.3
Volumetric Flow Rate (Actual)	m <sup>3</sup> .h <sup>-1</sup>	882	835	851	856
Volumetric Flow Rate (NTP)	Nm <sup>3</sup> .h <sup>-1</sup>	794	752	766	771
Total Solids (Actual)	mg.m <sup>-3</sup>	4.5	4.1	4.1	4.2
Total Solids (NTP; dry)	<b>mg.Nm<sup>-3</sup></b>	<b>5.1</b>	<b>4.6</b>	<b>4.6</b>	<b>4.8</b>
Total Solids Emission Rate	kg.h <sup>-1</sup>	0.004	0.003	0.004	0.00
Water Content (% Vol/Vol)	%	0.24	0.13	0.12	0.16
Percent Isokinetic	%	100	95	97	
NTP: 0 °C and 101.325 kPa					

## 4.2 Oil Dipping Stack

The concentration of VOCs detected in the oven stack is as shown Table 4-8 below. As can be seen, the measured VOCs concentration at NTP conditions were 614 mg/Nm<sup>3</sup>, 844 mg/Nm<sup>3</sup> and 965 mg/Nm<sup>3</sup> for Test 1, Test 2 and Test 3 respectively. The average VOCs concentration was 808 mg/Nm<sup>3</sup>.

**Table 4-9. Oil Dipping Stack: VOCs Emissions**

Monitoring Location	Sample No.	VOCs Concentration		Average VOCs (mg/Nm <sup>3</sup> )
		at Measured condition (mg/m <sup>3</sup> ) <sup>(a)</sup>	at NTP (mg/Nm <sup>3</sup> ) <sup>(b)</sup>	
Oil Dipping Stack	1	519	614	808
	2	714	844	
	3	815	965	
<sup>(a)</sup> Stack conditions at the time of measurements: Temperature: 303k Pressure: 101.3KPa <sup>(b)</sup> NTP: 0°C, 101.3kPa				

## 5 CONCLUSIONS AND RECOMMENDATIONS

The results obtained are considered to be representative of the plant operating conditions that prevailed during the sampling period.

The main conclusions of the measurements were:

- The particulates concentrations at NTP and dry conditions measured in the **Werner Furnace Stack** were 182 mg/Nm<sup>3</sup> for Test 1, 20.0 mg/Nm<sup>3</sup> for Test 2 and 70.3 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 90.9 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>. The average concentrations of NO<sub>x</sub> and SO<sub>2</sub> at NTP and dry conditions measured were 12 mg/Nm<sup>3</sup> and 8 mg/Nm<sup>3</sup>, which are well below the respective emission limits of 1,200 mg/Nm<sup>3</sup> and 1000 mg/Nm<sup>3</sup> for an existing sintering plant.
- The particulates concentrations at NTP and dry conditions measured in the **Seco Furnace Stack** were 4.0 mg/Nm<sup>3</sup> for Test 1, 7.9 mg/Nm<sup>3</sup> for Test 2 and 6.6 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 5.9 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>. The average concentrations of NO<sub>x</sub> and SO<sub>2</sub> at NTP and dry conditions measured were 28 mg/Nm<sup>3</sup> and 0.3 mg/Nm<sup>3</sup>, which are well below the respective emission limits of 1,200 mg/Nm<sup>3</sup> and 1000 mg/Nm<sup>3</sup> for an existing sintering plant.
- The particulates concentrations at NTP and dry conditions measured in the **Cremer Furnace Stack** were 24 mg/Nm<sup>3</sup> for Test 1, 15 mg/Nm<sup>3</sup> for Test 2 and 13.4 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 17.6 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>. The concentrations of NO<sub>x</sub> and SO<sub>2</sub> at NTP and dry conditions measured were 3 mg/Nm<sup>3</sup> and 18 mg/Nm<sup>3</sup>, which are well below the respective emission limits of 1,200 mg/Nm<sup>3</sup> and 1000 mg/Nm<sup>3</sup> for an existing sintering plant.
- The particulates concentrations at NTP and dry conditions detected in the **Steam Furnace Stack** were 1.1 mg/Nm<sup>3</sup> for Test 1, 6.7 mg/Nm<sup>3</sup> for Test 2 and 6.4 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 4.7 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>. SO<sub>2</sub>, NO<sub>x</sub> and CO were not detected in the stack.
- The particulates concentrations at NTP and dry conditions measured in the **CNC Machining Combined Stack** were 5.1 mg/Nm<sup>3</sup> for Test 1, 4.6 mg/Nm<sup>3</sup> for Test 2 and 4.6 mg/Nm<sup>3</sup> for Test 3. The average concentration of particulate matter in the stack was 4.8 mg/Nm<sup>3</sup>, which is below the emission limit of 100 mg/Nm<sup>3</sup>. SO<sub>2</sub>, NO<sub>x</sub> and CO were not detected in the stack.
- The measured VOCs concentration at NTP conditions in the **Oil Dipping Stack** were 614 mg/Nm<sup>3</sup>, 844 mg/Nm<sup>3</sup> and 965 mg/Nm<sup>3</sup> for Test 1, Test 2 and Test 3 respectively. The average VOCs concentration was 808 mg/Nm<sup>3</sup>.

It is required by law to perform emission testing annually. For cost effective sampling in future, the following recommendations have been made:

- 1) Combined emission from the Werner and Seco furnace into a single stack
- 2) Combined the emission from the CNC machining and steam furnace into a single stack.

## REFERENCES

National Environmental Management: Air Quality Act, 2004 (Act No.39 of 2004).

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