# Compliance Monitoring and Emissions Testing of Discharges to Air

Compliance Monitoring and Emission Testing of Discharges to Air A Guide for the Management of Ambient Air Quality

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### Foreword

This guide to *Compliance Monitoring and Emission Testing of Discharges to Air* will assist regional councils, local councils, industries and others who have responsibilities for air quality management under the Resource Management Act 1991. The guide contains information and recommendations on determining compliance monitoring requirements, writing consent conditions and conducting emission testing. By developing useful tools such as this guide, the Ministry for the Environment is striving to promote consistency and good science in the management of discharges to air, with the goal of achieving sustainable air quality in New Zealand.

It is important to have clear and appropriate monitoring conditions because the information they provide is used for checking compliance and may be used in enforcement action. All consent conditions must be effects-based, legal, certain and enforceable.

The information and recommendations are intended to assist in developing appropriate compliance monitoring and emission testing conditions. They do not provide a standard approach that must be adhered to at all times. A document of this nature cannot take account of all the variables that influence decision making and the dynamic nature of our environment. However, having been written and peer reviewed by specialists in air quality management, the guide provides practical advice and useful information.

I am grateful for the input the Ministry has received from local authority staff, scientists, industry and many others in preparing this guide. I hope that you find it's contents useful and that they will aid you in the challenging task of managing air quality under the Resource Management Act 1991.

Hon Simon Upton Minister for the Environment

# Acknowledgments

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# **1** Introduction

## 1.1 Purpose of the guide

This guide is to assist councils, industries, environmental consultancies and others involved in managing discharges of contaminants into the air under the Resource Management Act 1991 (RM Act). In particular, this guide can be used by the following practitioners:

- those who devise conditions specifying monitoring requirements for consents to discharge contaminants into the air
- · those who assess compliance with monitoring conditions of permits
- those who are involved with developing rules in Regional Air Quality Plans
- those who prepare and review assessments of discharges of contaminants to air
- those who undertake sampling and measurement of stack emissions to show compliance with emission limits.

Practitioners involved in these tasks will be able to use the information and recommendations in this guide to devise appropriate monitoring conditions for resource consents and controlled activities. Users will be made aware of the matters that should be considered when determining compliance monitoring requirements and will be advised on how to set unambiguous emission limit conditions and choose appropriate emission sampling methods. The guide also assists in identifying the purpose of proposed monitoring to ensure monitoring requirements are comprehensive and appropriate.

Compliance monitoring conditions include those that are applied to resource consents and those applied to controlled activities specified in Regional Air Quality Plans. Unlike permitted activities, controlled activities in a plan require a resource consent and may require some form of compliance monitoring.

Compliance monitoring requirements should be directly related to assessing the environmental effects of the discharge and for determining whether other conditions, such as emissions limits and environmental performance requirements, are being met. It is vital that proposed monitoring conditions are clear and unambiguous so that the data collected can be used to demonstrate compliance or incompliance and to provide information about the effects of the discharge.

The information and recommendations in the guide are not intended to be used to decide whether or not to grant a permit or make a particular discharge controlled. Rather they are to assist in developing reasonable and appropriate monitoring conditions in accordance with section 108 of the RM Act.

### 1.2 Background

Two discussion documents, "A Guide to Source Testing as a Compliance Tool for Air Discharges" and "Guidelines for Assessing Compliance Monitoring Requirements", released in November 1997, have been combined to create this document. Submissions received in October 1997 were used in developing the guide's information and recommendations. Discussions from a workshop held by the Clean Air Society of Australia and New Zealand in Wellington on 27 November 1996 and a survey of regional councils, to identify categories of industries whose air discharges were of most concern, have also been taken into account.

### 1.3 Format of the guide

Part 1 - Compliance Monitoring describes the types of monitoring that can be used for compliance purposes and outlines the matters that need to be considered when establishing compliance monitoring requirements. The recommendations in Part 1 are intended to provide general guidance. This is because monitoring programmes must always be directly related to the actual and potential environmental effects of the discharge (see appendix A, section 108) and will be influenced by a wide range of factors, not all of which can be considered within the scope of this guide.

Part 1 will be useful for council consents investigations staff, industry staff responsible for applying for resource consents and for monitoring compliance, consultants charged with preparing applications and council monitoring officers. It provides a general introduction to more the detailed information on testing methods contained in Part 2.

Part 2 - Emission Testing provides further details on how to set emission limit conditions and how to measure the concentration and mass emission rates of a number of specific, relatively common contaminants. Although screening methods are briefly discussed, they are not included in the recommended measurement methods. Rather the recommended methods are tried and tested methodologies that provide results with a good degree of accuracy. These methods will be most appropriate for undertaking compliance monitoring, particularly where enforcement action is needed.

Part 2 will be particularly useful for those who have a significant interest in developing appropriate and robust emission testing requirements, those responsible for monitoring contaminant emission rates and those involved with collecting evidence for enforcement action.

# 1.4 Legal status

This guide provides advice to local authorities, industry and others involved in managing discharges of contaminants into the air. It has no legal status. It has however, been peer reviewed by a range of professionals working on compliance monitoring issues. Readers of this document should keep up to date with latest developments in emission testing techniques and case law as it evolves.

The guide is not a national environmental standard as defined in section 43 and 44 of the RM Act.

# Part 1 Compliance Monitoring

# 2 Principles of Compliance Monitoring

## 2.1 Introduction

Part 1 Compliance Monitoring, is divided into two chapters: Chapter 2, Principles of Compliance Monitoring, and Chapter 3, Determining Compliance Monitoring Requirements. Chapter 2 outlines the framework for air quality management under the RM Act and describes types of monitoring available and their limitations. Most types of monitoring commonly used in New Zealand are included, however there will be some cases which do not fall into the precise definitions used in this guide.

Chapter 3 presents a quick reference diagram to outline matters that should be considered when devising appropriate monitoring and contains easy to follow worksheets to determine compliance monitoring for several specific discharges. Two main categories of discharge are considered: those associated with combustion sources (for example boilers and incinerators), and those associated with other activities (for example chemical manufacture, wood processing, composting etc.). We have aimed to keep the categories as broad as possible, while at the same time incorporating all the elements needed to make decisions on the level of monitoring required.

There will be some individual cases which do not fall into the categories used in this guide. In such instances the consent authority should set additional or alternate monitoring conditions to address these site-specific issues. In addition, the applicant usually has a detailed knowledge of the process, site and surrounding environment, so when an application for a permit is made, the applicant should include a proposed monitoring programme.

### 2.2 Air quality management and the Resource Management Act 1991

The RM Act requires regional councils and unitary authorities to manage ambient air quality in their region in line with the purpose of sustainable management outlined in section 5 of the RM Act. The repeal of the Clean Air Act and its replacement with the RM Act with its provisions for ambient air, has brought significant changes to air quality management in New Zealand. The RM Act provides for management of air quality on the basis of effects. This involves assessing the existing situation, determining the standard of air quality desired, evaluating how the situation will change over time, and developing strategies to maintain or improve air quality.

Consent authorities have an obligation to manage air quality as a resource so that the environment can be sustained at least cost. Air quality plans and policy statements, prepared in accordance with the RM Act, outline the approach to air quality management

within a region. They specify policies and rules to ensure that the desired level of air quality is reached and maintained. This framework recognises that pollution sources and air quality characteristics vary though out New Zealand and enables particular issues be addressed on a region by region basis. It also allows for the local community to have input in choosing the desirable level of air quality and in how it should be managed.

Information on existing air quality is often provided by networks of ambient monitoring sites, emissions inventories, airshed modelling and emission testing. When combined with future emission projections, this information can indicate how the situation will change over time. Information about changes in air quality is needed to review policies in a plan and to track progress towards environmental goals. Section 35 outlines how consent authorities must monitor the state of the environment in line with their RM Act functions.

When granting resource consents for discharging contaminants to air, consent authorities can set conditions which limit the quantity and nature of discharges. In this way, resource consents and conditions become an integral part of the strategy to achieve air quality objectives. Compliance monitoring of both the discharges and their effects is therefore an important step in determining that these objectives are being met.

Commonly, air discharge activities are defined in four categories in the rules of a Regional Air Quality Plan. If an activity is:

- *permitted;* it can be carried out without a resource consent provided the conditions in the rule are met
- *controlled;* a resource consent is required, but the regional council must grant the consent if the standards and terms in the plan are met
- *discretionary;* a resource consent is required and the regional council has the discretion whether or not to grant the consent
- prohibited; the activity cannot proceed, and no resource consent can be granted.

### 2.3 The purpose of compliance conditions

The conditions for discharge of contaminants are included in resource consents, and in definitions of permitted and controlled activities. These conditions are based on studies which have assessed the effects of the discharge on neighbouring and regional air quality. The assessments may have involved actual monitoring of the contaminant at its point of discharge, or an estimate based on a published emission factor or raw material consumption rate. The regional council will then have used its knowledge of current local or regional air quality with regard to the contaminant, coupled with any regional goals to maintain or improve air quality, to set the compliance conditions for resource consents or classes of permitted activities. The consent can include conditions relating to future reviews of the consent conditions to take into account advances in technology for measuring certain contaminants or improved scientific understanding on the effects of a contaminant.

Reasons for stipulating monitoring requirements in air discharge permits include:

- monitoring compliance with conditions set out in the consent;
- verifying the results of dispersion modelling studies;
- warning of potential or actual elevated emission levels due to process or equipment failure, thereby minimising damage to the environment; and
- RM Act requirements to monitor air quality.

Conditions which restrict the level of discharge of certain contaminants may be in a variety of forms. These range from specifying a maximum discharge concentration of the contaminant, or a restriction on the fuel permitted to be used in a combustion source, to a restriction on the visual density of smoke allowed to be discharged. An important part of compliance monitoring involves testing emissions from a process, usually at a source (i.e. from the stack), to establish whether discharges fall below values published in the air discharge consent or the Regional Air Quality Plan.

Some industrial processes have the potential to emit contaminants in quantities which can have serious environmental effects if the plant or air pollution control equipment fails. These failures may develop over time, or may result from a serious failure of a process or discharge control. For processes where such releases are possible, some minimum level of process and equipment monitoring is required to warn of the potential for, or existence of, an accidental release. This does not prevent the permit holder from installing more sophisticated monitoring equipment than that required by the consent authority. Nor does it suggest that the consent authority should not require these more sophisticated techniques if the sensitivity of the surrounding environment warrants additional protection or warning systems.

In many cases, the effects on air quality which result from discharges to air are only assessed using computer modelling techniques, and the true impacts are never known. For the vast majority of discharges, this is usually sufficient if the predicted effects are not significant. In some cases, however, the predicted effects are not minor, and contaminant concentrations can approach the limits laid down in ambient air quality standards or guidelines. Ambient monitoring may then be required to assess whether or not the predictions made by the models represent a realistic assessment of the effect of the discharge.

The effects-based focus of the RM Act is significantly different from the best practicable means (BPM) approach of the Clean Air Act 1972. It calls for sampling and analysis of a large number of new emitted species from sources that were not traditionally assessed. This demand for testing services under the RM Act has prompted the development of new consultancies, and an increasing tendency for individual industries to conduct their own emissions testing.

The quality of the information and data obtained from emission testing must be determined, so that councils and the public can critically assess the significance of companies' discharges in conjunction with compliance limits. Part 2 of this document provides information on emission testing as part of compliance monitoring, and aims to promote testing at a consistent and defined standard throughout New Zealand.

### 2.4 Types of compliance monitoring

Compliance monitoring can be divided into three main categories;

- process monitoring
- discharge monitoring
- ambient air or effects monitoring

Given the wide variety of industrial and manufacturing processes present in New Zealand, it is impossible to address specifically every type of contaminant emission source and the types of monitoring that may be required. The following sections discuss the key issues relating to the three types of monitoring in general terms, using examples for illustration.

#### 2.4.1 Process monitoring

For most emission sources, there are a large number of process variables, such as temperature, pressure and flow rates, which not only provide information on the operation of the process, but can also provide an indirect measure of emissions or indicate the potential for elevated emission levels.

For example, in the superphosphate fertiliser manufacturing industry there are a number of parameters which indicate both efficient sulphuric acid production and minimal sulphur dioxide emissions. These include, absorber acid strength, acid flow rates and catalyst bed temperature. Monitoring for these parameters provides an indirect measurement of the potential for elevated emission levels.

Similarly, animal and fish rendering plant operators should monitor the pH of their raw materials to ensure that poor quality or "spoiled" materials are not processed. These are likely to produce elevated odour emissions and result in odour nuisance off-site. Meal dryer temperatures should also be monitored to prevent over-drying and burning of the product, which may also produce elevated odour emissions.

In coal-fired or oil-fired combustion sources, sulphur dioxide emission levels can be estimated indirectly by periodic checks on fuel sulphur content and fuel burning rates. Taking into account a percentage of sulphur that will be retained in the ash, there is a relationship between the amount of sulphur in the fuel that is burned and the quantity of sulphur dioxide emissions.

As these examples show, there is a wide variety of process parameters that can be monitored to provide an indirect measure of air emissions. There is also a range of possible approaches to carrying out process monitoring. Sometimes emission control is a by-product of monitoring undertaken for manufacturing purposes. However, there may be difficulties in linking a process parameter to an effect. When specifying conditions in an air discharge consent, it is important that appropriate process monitoring requirements are included, based on an adequate level of knowledge about the processes involved, including potential accidental release scenarios.

#### 2.4.2 Discharge monitoring

Within the category of discharge monitoring there is a wide range of possible approaches, from intermittent manual checks or visual observations, through to continuous monitoring using sophisticated instrumental techniques with automatic data logging. The level of monitoring complexity for a given discharge will depend on several factors, including the scale of actual or potential effects, and historical aspects such as complaints records or documented non-compliance.

Compliance with emission limits can only be demonstrated if monitoring is sufficiently frequent. Where continuous monitors are installed on the plant, little difficulty is usually encountered (provided such equipment is appropriate for the duty and is properly maintained and calibrated). Most continuous monitors have data-loggers where the information is stored either on chart recorders or computer. Where continuous monitoring is not used, permit conditions should stipulate the frequency, sampling period and process conditions appropriate for compliance monitoring. Often an annual test is sufficient if the process is relatively constant and not subject to large and uncertain variations in emissions, but in some cases weekly testing may be needed to ensure that the emissions are within permit limits.

For example, particulate emissions from a small coal-fired boiler with minimal dust emissions can be monitored daily by visual observation, with an annual particulate test to demonstrate general compliance with an emission limit, if applied. However, if a significant visible particulate emission occurs regularly, there may be justification for more frequent monitoring, such continuous opacity monitoring.

Opacity monitoring is a special case in New Zealand because incorrect guidelines were incorporated into previous legislation (definitions of smoke in the Clean Air Act 1972, as amended in 1986). The purpose of monitoring opacity is to ensure that the appearance of the plume is not objectionable. Further discussion on opacity monitoring is included in Appendix C.

Emission tests for odour, using methods such as olfactometry, are generally used to assist with the prediction of effects or for the design of odour control equipment, although they can be used as a measurement of compliance. Odour monitoring may be appropriate for large scale or proposed operations, and to verify the impact of proposed mitigation measures. Monitoring of community response, appropriate process parameters and ongoing trends, such as raw material quality and equipment degradation, may also be appropriate. As with all monitoring programmes, the requirements must be effects-based. Further information about managing odorous discharges can be found in the Ministry's guide to "Odour Management under the Resource Management Act" (Ministry for the Environment, 1995).

Part 2 of this guide focuses specifically on discharge monitoring and provides more detailed information on emission limit conditions and recommendations on measurement techniques.

#### 2.4.3 Ambient monitoring

Some compliance conditions in discharge consents require contaminants to be below specific concentrations at and beyond a plant boundary. Some require ambient monitoring at the boundary. In most circumstances ambient monitoring should not be used to assess the downwind effect of specific site emissions. This is because it may be difficult to distinguish input from other sources, anthropogenic and natural, neighbouring and distant. Even when the species of interest is unique to an industry, it is difficult to predict where the plume will impinge (maximum ground level concentration) without extensive, detailed, and expensive modelling. Further detailed modelling can only provide probable locations of impingement based on meteorological data.

Ambient monitoring methods are most commonly designed to represent the assessment of an 'air-shed', whereas emission testing involves the sampling of a discrete parcel of gas of known or defined origin. Ambient monitoring provides information on the concentrations of contaminants of interest only at the point of monitoring and under the meteorological conditions prevailing at the time.

Ambient monitoring is more directly related to potential effects, so it is often more attractive to impose ambient limits or monitoring programmes in the discharge conditions. This is also true for bio-monitoring. These techniques are limited, however, in their ability to account for single sources as discussed above, so it is usually better to impose emission limits and relate this value to downwind effects by modelling or other techniques.

Further, ambient monitoring may be limited by the sensitivity of available monitoring techniques. For example, the availability of equipment to measure di-isocyanate species is limited. Because of these difficulties it is generally better to confine compliance monitoring at an individual source to measurements of discharges from that source. Sufficient information should be collected at the time of monitoring to allow dispersion modelling, if required, or to allow input into a regional emissions inventory. Normally this involves at least, measurement or estimation of contaminant concentration and mass emission, measurement of stack gas velocity or an estimate of its volumetric flow from fan

parameters, and measurement of stack gas temperature. Details of any structure on the top of the stack (e.g. rain shields) should also be recorded.

There may be situations, particularly with large industries, that cause significant effects on the environment further afield than the immediate surroundings. In these cases, ambient monitoring programmes in conjunction with emission testing regimes are appropriate for assessing environmental effects and for compliance monitoring. Examples of companies with dual ambient and emission testing compliance monitoring conditions in their consents are ECNZ (Huntly power station), New Zealand Aluminium Smelters (Tiwai Point Refinery) and the superphosphate manufacturing industry.

Scenarios where an ambient air or effects monitoring programme may be appropriate include:

- industries (such as open cast mines) where diffuse, fugitive emissions predominate;
- where the community has complained about the discharge;
- to assess the effectiveness of proposed mitigation measures;
- · where the receiving environment is known to be particularly sensitive; and,
- where the potential effects of collective discharges cannot be easily determined by emission monitoring or other source evaluations.

Ambient air monitoring may be carried out by a network of monitors or gauges which provide direct measurements of the contaminant concerned, such as sulphur dioxide monitors or particulate deposit gauges. The effects of the discharges may also be monitored, for example vegetation surveys for damage from elevated sulphur dioxide or fluoride concentrations, or community complaints registers for nuisance odour effects from facilities such as rendering plants and fellmongeries.

It is important to take into account the nature of the local air environment when developing an ambient monitoring programme. For example, ambient monitoring for fluoride levels downwind of a superphosphate plant may be appropriate if there is a potential for ground level concentrations to approach or exceed air quality guidelines, or where sensitive crops or plants are growing nearby. However if the plant is located near the coast, then the effects of fluoride in salt spray may render such monitoring meaningless. In addition, plants (normally the most sensitive receivers to high fluoride concentrations) which grow in coastal areas tend to be fluoride resistant species.

If an ambient monitoring programme is indicated, then a number of variables need to be established. The objectives of the programme must be clearly defined. An effective ambient monitoring programme should be operating prior to the commissioning of a new industrial process, as the background concentrations are integral to the monitoring programme. The scale of the monitoring programme (such as how many monitors are

needed and for how long), the method to be used, the location of the monitors, and the criteria against which the results will be compared must also be determined.

# 3 Determining Compliance Monitoring Requirements

# 3.1 General approach

A general approach to determining monitoring requirements for an air discharge permit is outlined in the flow diagram in Figure 1. This diagram requires certain information from the environmental effects assessment and directs the user to consider specific matters to help determine appropriate monitoring requirements. The approach outlined is intended to be used as a quick reference guide to highlight matters that should be considered rather than provide a standard framework. Specific examples of how the approach can be further developed for particular discharges are provided in the worksheets in section 3.2.

Monitoring requirements are considered for both normal and abnormal operation of the plant, and may be modified according to historical performance. The maximum ground level concentration expected to result from the discharge is added to typical background concentrations that are likely to occur under similar meteorological conditions and for the same averaging periods. It is assumed that this information has been provided with the consent application as part of the assessment of environmental effects. The sum of these concentrations are then compared to the maximum acceptable ground level concentration for the contaminant of concern. The maximum acceptable value will depend on consent authority policy, requirements in a regional plan and national requirements, if available. The value is likely to have been debated in the decision on whether to grant the consent and it was probably used to determine the potential or actual environmental effects of the discharge. The monitoring requirements are then proposed accordingly. The user is also prompted to consider possible scenarios for accidental emissions and the monitoring requirements of any emissions control equipment. Increased monitoring frequency may be appropriate with a history of non-compliance.

Proposed monitoring should be discussed with both the applicant and submitters (if the application has been notified and submissions received). Effective consultation can avoid delays or appeals arising from monitoring requirements that do not meet the concerns of submitters or are unjustifiably costly in the view of the applicant.

Monitoring requirements must be determined on the basis of the effects of an activity. Use of this general approach will not always be appropriate and the following matters should be considered:

• Monitoring requirements are influenced by the sensitivity of the receiving environment. A highly sensitive receiving environment may require more stringent monitoring, but the same recommendations may be excessive in a less sensitive receiving environment



Figure 1 Quick Reference Guide to Determining Monitoring Requirements

- Monitoring requirements can be reviewed and may change over time
- Some activities will be permitted under Regional Air Plans and will not require monitoring
- Hazardous substances may require special consideration and extensive monitoring programmes (for example, more intensive monitoring to verify assumptions made in effects assessments e.g. ecosystem surveys for heavy metals, surveys to identify bioaccumulation etc).
- The approach may be useful for activities that have not been included in the worksheets provided in section 3.2 (for example, asphalt processes).

### 3.2 Worksheets

The following worksheets have been prepared to show how the general approach can be used to determine specific compliance monitoring requirements for particular activities. These worksheets provide a systematic, logical procedure, which prompts users to take into account the key issues relating to compliance monitoring.

As the worksheets cannot be designed to cover every type of emission source, they have been developed to be as applicable as possible for a range of common discharges in New Zealand. Five different worksheets are provided; four combustion source worksheets (for gas, oil, coal and wood fuels) and one non-combustion source worksheet which is intended to be sufficiently flexible to encompass most other emission types.

The combustion source worksheets have been split into the various fuel types, as the key issues relating to the air discharges depend on the fuel used, and each can be kept as simple and concise as possible. In addition, the process and air quality issues for a given fuel type are generally well understood and relatively consistent from site to site. Consequently the forms can be more specific. The recommended monitoring requirements for combustion sources greater than 50 MW should be seen as a starting point, as sources of this size will require relatively complex equipment and process monitoring. Additional requirements will need to be determined through detailed discussion with the applicant and (if appropriate) the manufacturer.

The five worksheets follow a similar structure to the general approach shown in Figure 1. Where appropriate, blank spaces have been included to increase flexibility in the use of the worksheets and allow the user to account for site-specific emission and monitoring requirements not already covered. Each worksheet also contains a set of notes to assist the user in working through the form.

Once the form has been completed, the user is left with a list of general recommendations for minimum monitoring requirements. Additional contaminants can be addressed at this stage where appropriate. Further input may be required to determine the specifics of each requirement, such as exactly where and how to monitor.

Completed worksheets are included in Appendix B for a selected group of industrial discharges identified as being of interest to consent authorities. These example worksheets include the main emissions from;

- superphosphate fertiliser works;
- abrasive (sand/grit) blasting operations;
- spray painting operations; and,
- hot dip galvanising operations.

# WORKSHEET: GAS FIRED COMBUSTION SOURCES

	DETAILS				
	SITE:		SOURCE:		
	PROCESS DESCRIPTION:				
	LOCAL ENVIRONMENT:				
1.	SIZE				
	HEAT RELEASE AT MAXIMUM CO	NTINUOUS RATING:		MW (gross)	
	MAXIMUM FUEL BURNING RATE			kg/hr	
	IF <5 MW	Monitoring requirements $\Rightarrow$	5B, 5C, 5T	GO TO 2	
	IF >5 MW AND <50 MW IF >50 MW	Monitoring requirements $\Rightarrow$ Monitoring requirements $\Rightarrow$	5B, 5C, 5T 5L 5K, 5N, 5T	GO TO 2 GO TO 2	
		inenitering requirementer 🤿			
2.	POTENTIAL EFFECTS				
			NO <sub>2</sub>	CO	
			(µg/m²)	(µg/m <sup>+</sup> )	
	MAXIMUM PREDICTED GLC FOR	$\frac{1}{1}$		(d)	
	BACKGROUND CONCENTRATION	(b) _		(e)	
	TOTAL MAXIMUM GLC	(a) + (b) _		(d) + (e)	
	MAXIMUM ALLOWABLE GLC <sup>o</sup> :	(c)		(f)	
	IS (a+b)<0.5(c)? IS (a+b)>0.5(c)	$\begin{array}{ll} \textit{Monitoring requirements} & \Rightarrow \\ \textit{Monitoring requirements}^{D} \Rightarrow \end{array}$	5E, 5CC 5E, 5EE		
	IS (d+e)<0.5(f)?	Monitoring requirements $\Rightarrow$	5D, 5CC		
	IS (d+e)>0.5(f)	Monitoring requirements <sup>D</sup> $\Rightarrow$	5D, 5DD		
3.	EMISSION CONTROL S	(STEMS			
	ARE THE EMISSIONS CONTROLL	ED USING AIR POLLUTION CO		ENT?	
	YES (specify:				<u>)</u>
	NO				
IF	YES, AND A FAILURE OF THE CON	TROL EQUIPMENT COULD RE	ESULT IN SIGNIFI	CANT ADVERSE EFFECTS,	
Τh	EN CONSIDERATION SHOULD BE	GIVEN TO ADDITIONAL EMIS	SION OR PROCES	S MONITORING REQUIREME	NTS
тс	WARN OF CONTROL EQUIPMENT	FAILURE.			
4.	HISTORICAL PERFORMAN	CE			
FC	R NEW SOURCES, SKIP THIS SEC	TION			
	IN THERE A HISTORY OF NOV				
	EXISTING CO EMISSION I IMIT	$\frac{1}{3} \Rightarrow 5D (consider ar)$	reater frequency) o	r 5J	
	EXISTING NO <sub>2</sub> EMISSION LIMI	TS? $\Rightarrow$ 5E (consider gr	eater frequency) of		
	EXISTING OPACITY EMISSION	I LIMITS? $\Rightarrow 5N$	,		

### 5. RECOMMENDED MONITORING REQUIREMENTS<sup>E</sup> (ALL COMBUSTION SOURCE WORKSHEETS)

Emissions Monitoring			FREQUENCY
	5A	No emissions monitoring required	
	5B	Intermittent visual inspection of plume (e.g. daily)	
	5C	Intermittent monitoring for $O_2$ or $CO_2$ (e.g. annual or 6-monthly)	
	5D	Intermittent monitoring for CO (e.g. annual or 6-monthly)	
	5E	Intermittent monitoring for NO <sub>2</sub> (e.g. annual or 6-monthly)	
	5F	Intermittent monitoring for SO <sub>2</sub> (e.g. annual or 6-monthly)	
	5G	Intermittent monitoring for particulate (e.g. annual or 6-monthly)	
	5H	Intermittent monitoring (species:)	
	51	Continuous monitoring for CO <sub>2</sub> or O <sub>2</sub>	
	5J	Continuous monitoring for CO	
	5K	Continuous monitoring for NO <sub>2</sub>	
	5L	Continuous monitoring for SO <sub>2</sub>	
	5M	Continuous monitoring for particulate	
	5N	Continuous opacity/obscuration monitoring	
	50	Continuous humidity monitoring	
	5P	Continuous monitoring (species:)	
	5Q		
Pr	ocess	Monitoring	
	5R	No process monitoring required	
	5S	Intermittent fuel analysis (e.g. monthly)	
	5T	Continuous monitoring for temperature	
	5U	Continuous monitoring for pressure drop across control equipment	
	5V	Continuous monitoring of inlet/outlet flow rates	
	5W	Continuous voltage monitoring	
	5X	Continuous current monitoring	
	5Y	Continuous spark over monitoring	
	5Z	Intermittent visual inspection	
	5AA		
	5BB		
Ambi	ent Mo	onitoring	
	5CC	No ambient monitoring required	
	5DD	CO monitoring	
	5EE	NO <sub>2</sub> monitoring	
	5FF	SO <sub>2</sub> monitoring	
	5GG	TSP monitoring	
	5HH	Deposited particulate monitoring	
	511	Monitoring (species:)	
	5JJ	Biological monitoring (specify:)	
	5KK		

#### **ADDITIONAL NOTES**

#### NOTES

- A Maximum ground level concentrations (GLCs) should be provided by the applicant as part of the assessment of environmental effects required under Section 88 (4b) of the Resource Management Act (1991). These may either be predicted downwind concentrations determined from an approved atmospheric dispersion model, or from ambient monitoring programmes. If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate maximum allowable concentration (MAC). Averaging times must be consistent for the predicted, allowable and background concentrations.
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- E Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

# WORKSHEET: OIL FIRED COMBUSTION SOURCES

DETAILS						
		SOURCE				
		300RCE.				
PROCESS DESCRIPTION:						
LOCAL ENVIRONMENT:					<u> </u>	
1. SIZE						
HEAT RELEASE AT MAXIMUM (	CONTINUOUS RATING:		MW (gross)			
MAXIMUM FUEL BURNING RAT	E:		L/hr			
IF <5 MW	Monitoring requirements $\Rightarrow$	5B, 5C, 5S, 5T	GO TO 2			
IF >5 MW AND <50 MW	Monitoring requirements $\Rightarrow$	51, 51N, 55, 51	GO TO 2			
IF >30 IVIVV	Monitoring requirements $\Rightarrow$	51, 5L, 5IV, 5S, 51	GO 102			
2. POTENTIAL EFFECTS						
	S	O <sub>2</sub>	NO <sub>2</sub>		со	
	(µg	- /m <sup>3</sup> )	(µg/m <sup>3</sup> )		(µg/m³)	
MAXIMUM PREDICTED GLC FO	R THIS SOURCE <sup>A</sup> : (a)	(d)		(q)		
BACKGROUND CONCENTRATIO	ΟΝ <sup>Β.</sup> (b)	(e)		(b)		
	(a) (b)	(d) ( (o)		(a) (b)		
	(a) + (b)	(u) + (e)		(g) + (ll)		
MAXIMUM ALLOWABLE GLC°:	(C)	(f)		(1)		
IS (a+b)<0.5(c)?	Monitoring requirements $\Rightarrow$	5F				
IS (a+b)>0.5(c)	Monitoring requirements $^{D} \Rightarrow$	5L, 5FF				
IS (d+e)<0.5(f)?	Monitorina requirements $\Rightarrow$	5E				
IS (d+e)>0.5(f)	Monitoring requirements $^{D} \Rightarrow$	5K, 5EE				
IS (g+h) < 0.5(i)?	Monitoring requirements $\Rightarrow$	5D				
13 (g+1)>0.3(i)		<i>33, 300</i>				
	eveteme					
5. EMISSION CONTROL	STOTEWS					
ARE THE EMISSIONS CONTROL	LLED USING AIR POLLUTION CON	ITROL EQUIPMENT	?		,	
YES (specify:					<u>)</u>	
IF YES, AND A FAILURE OF THE CO	F YES, AND A FAILURE OF THE CONTROL EQUIPMENT COULD RESULT IN SIGNIFICANT ADVERSE EFFECTS,					
THEN CONSIDERATION SHOULD B	E GIVEN TO ADDITIONAL EMISSI	ON OR PROCESS M	ONITORING RE	EQUIREMEI	VTS	
TO WARN OF CONTROL EQUIPME	NT FAILURE.					

4.	HIST	ORICAL PERFORMNCE	
FOR	NEW SO	URCES, SKIP THIS SECTION	
FOR E	EXISTIN	G SOURCES, COMPLETE SECTION BELOW	
IS	THERE	A HISTORY OF NON-COMPLIANCE WITH:	
	EXIST	ING CO EMISSION LIMITS? $\Rightarrow$ 5D (consider greater frequency) or 5I	
	EXIST	ING NO <sub>2</sub> EMISSION LIMITS? $\Rightarrow$ 5E (consider greater frequency) or 5J	
	EXIST	ING SO <sub>2</sub> EMISSION LIMITS? $\Rightarrow$ 5F (consider greater frequency) or 5K	
	EXIST	ING OPACITY EMISSION LIMITS? $\Rightarrow$ 5L	
5. R	ЕСОМ	MENDED MONITORING REQUIREMENTS <sup>E</sup> (ALL WORKSHEETS)	
Emis	sions	Monitoring	FREQUENCY
	5A	No emissions monitoring required	
	5B	Intermittent visual inspection of plume (e.g. daily)	
	5C	Intermittent monitoring for $O_2$ or $CO_2$ (e.g. annual or 6-monthly)	
	5D 5E	Intermittent monitoring for CO (e.g. annual or 6-monthly)	
	5E 5E	Intermittent monitoring for $NO_2$ (e.g. annual of 6-monthly)	
	56	Intermittent monitoring for $OO_2$ (e.g. annual of o-monthly)	
	5H	Intermittent monitoring (species:	
	51	Continuous monitoring for $CO_2$ or $O_2$	
	5J	Continuous monitoring for CO	
	5K	Continuous monitoring for NO <sub>2</sub>	
	5L	Continuous monitoring for SO <sub>2</sub>	
	5M	Continuous monitoring for particulate	
	5N	Continuous opacity/obscuration monitoring	
	50	Continuous humidity monitoring	
	5P	Continuous monitoring (species:)	
Б	5Q 700000	Monitoring	
	5R	No process monitoring required	
	55	Intermittent fuel analysis (e.g. monthly)	
	5T	Continuous monitoring for temperature	
	5U	Continuous monitoring for pressure drop across control equipment	
	5V	Continuous monitoring of inlet/outlet flow rates	
	5W	Continuous voltage monitoring	
	5X	Continuous current monitoring	
	5Y	Continuous spark over monitoring	
	5Z	Intermittent visual inspection	
	5AA		
	5BB	·····	
Amb		onitoring	
		CO monitoring required	
	500		
	5EE	SO <sub>2</sub> monitoring	
	566	TSP monitoring	
	5HH	Deposited particulate monitoring	
	511	Monitoring (species: )	
	5JJ	Biological monitoring (specify:	
	5KK		
1			

#### NOTES

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- E Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

# WORKSHEET: COAL FIRED COMBUSTION SOURCES

DETAILS			
SITE:		SOURCE:	
PROCESS DESCRIPTION:			
			_
1. SIZE			
HEAT RELEASE AT MAXIMUM C	CONTINUOUS RATING:	MW (g	ross)
MAXIMUM FUEL BURNING RATI	E:	kg/hr	
			00 70 0
IF >5 MW AND <50 MW	Monitoring requirements $\Rightarrow$ Monitoring requirements $\Rightarrow$	5B, 5C, 5G, 5S, 5T 5B or 5N, 5G, 5L 5S, 5T	GO TO 2 GO TO 2
IF >50 MW	Monitoring requirements $\Rightarrow$	5B, 5G, 5I, 5L, 5N, 5S, 5T	GO TO 3
2. POTENTIAL EFFECTS			
		00 N/	
		$SO_2$ NC	$D_2$ ISP
		(µg/m) (µg/	m) (μg/m)
MAXIMUM PREDICTED GLC FOI	R THIS SOURCE $(a)$	(d)	(g)
BACKGROUND CONCENTRATIO	DN <sup>B</sup> : (b)	(e)	(h)
TOTAL MAXIMUM GLC	(a) + (b)	(d) + (e)	(g) + (h)
MAXIMUM ALLOWABLE GLC <sup>C</sup> :	(c)	(f)	(i)
IS (a+b)<0.5(c)?	Monitoring requirements $\Rightarrow$	5F. 5S	
IS (a+b)>0.5(c)	Monitoring requirements $^{D} \Rightarrow$	5F, 5S, 5FF	
10 (1 -) 0 5(00			
1S(d+e) < 0.5(f)?	Monitoring requirements $\Rightarrow$	5E 5E 5EE	
13 (u+e)>0.3(1)	wormoning requirements $\rightarrow$	JL, JLL	
IS (g+h)<0.5(i)?	Monitoring requirements $\Rightarrow$	5G	
IS (g+h)>0.5(i)	Monitoring requirements $^{D} \Rightarrow$	5G, 5GG	
3. EMISSION CONTROL SYS	STEMS		
ARE THE EMISSIONS CONTROL	LED USING AIR POLLUTION CO	NTROL EQUIPMENT?	YES NO
SECTION BELOW	NTROE EQUIPMENT COULD RE	SOLT IN SIGNIFICANT ADVE	NGE EFFECTS, COMFEETE
SECTION BELOW			
SCRUBBER	Monitoring requirement	ents $\Rightarrow$ 5T, 5U, 5V	
	Monitoring requirement	$\begin{array}{llllllllllllllllllllllllllllllllllll$	
		$\exists IIIS \Rightarrow \exists V, \exists Z$	57 57
OTHER (	) Monitorina requirem	$\Rightarrow \qquad \qquad$	
	,		

4. HISTOR	ICAL PERFORMANCE	
For new so	urces go to 5	
For existing	sources complete section below	
lo the	re a history of non-compliance with evicting TCD emission limite?	
Is the	are a history of non-compliance with existing SO <sub>2</sub> emission limits? $\Rightarrow$ 5	G, consider greater frequency
	$\rightarrow$ of the compliance that existing $ee_2$ emission matrices $\rightarrow$ of	, conclude groater noquelley
5. RECOM	MENDED MONITORING REQUIREMENTS <sup>E</sup> (ALL WORKSHEETS)	
Emissions	Monitoring	FREQUENCY
5A	No emissions monitoring required	
5B	Intermittent visual inspection of plume (e.g. daily)	
5C	Intermittent monitoring for $O_2$ or $CO_2$ (e.g. annual or 6-monthly)	
5D	Intermittent monitoring for CO (e.g. annual or 6-monthly)	
5E	Intermittent monitoring for $NO_2$ (e.g. annual or 6-monthly)	
5F	Intermittent monitoring for $SO_2$ (e.g. annual or 6-monthly)	
5G	Intermittent monitoring for particulate (e.g. annual or 6-monthly)	
5H	Intermittent monitoring (species:)	
51	Continuous monitoring for CO <sub>2</sub> or O <sub>2</sub>	
5J	Continuous monitoring for CO	
5K	Continuous monitoring for NO <sub>2</sub>	
5L	Continuous monitoring for SO <sub>2</sub>	
5M	Continuous monitoring for particulate	
5N	Continuous opacity/obscuration monitoring	
50	Continuous humidity monitoring	
5P	Continuous monitoring (species:)	
5Q		
Process	s Monitoring	
5R	No process monitoring required	
55	Intermittent fuel analysis (e.g. monthly)	
51	Continuous monitoring for temperature	
50	Continuous monitoring for pressure drop across control equipment	
5V	Continuous monitoring of iniet/outlet flow rates	
500	Continuous voltage monitoring	
	Continuous current monitoring	
51	Latermittent vieuel increation	
5PR		
Ambient M	onitoring	
	No ambient monitoring required	
500	CO monitoring	
555	$NO_{\circ}$ monitoring	
555	$SO_2$ monitoring	
566	TSP monitoring	
500	Deposited particulate monitoring	
511	Monitoring (species:	
5.1.1	Biological monitoring (specify:	
5KK		

#### NOTES

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- E Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

# WORKSHEET: WOOD FIRED COMBUSTION SOURCES

Page 1 of 3

DETAILS				
SITE:		SOURCE:		
PROCESS DESCRIPTION:				
LOCAL ENVIRONMENT:				
1. SIZE				
HEAT RELEASE AT MAXIMUM CO	NTINUOUS RATING:	I	MW (gross)	
MAXIMUM FUEL BURNING RATE :		I	kg/hr	
IF <5 MW	Monitoring requirements $\Rightarrow$	5B, 5C, 5G, 5T	GO TO 2	
IF >5 MW AND <50 MW	Monitoring requirements $\Rightarrow$	5B, 5N, 5G, 5I, 5T	GO TO 2	
IF >50 MW	Monitoring requirements $\Rightarrow$	5B, 5G, 5I, 5N, 5T	GO TO 2	
2. POTENTIAL EFFECTS				
	I	NO <sub>2</sub>	со	TSP
	()	g/m <sup>3</sup> )	(µg/m³)	(µg/m <sup>3</sup> )
MAXIMUM PREDICTED GLC FOR	THIS SOURCE <sup>A</sup> : (a)	(d)	(g)	
BACKGROUND CONCENTRATION	<sup>в</sup> : (b)	(e)	(h)	
TOTAL MAXIMUM GLC	(a) + (b)	(d) + (e)	(g) + (h	n)
MAXIMUM ALLOWABLE GLC <sup>C</sup> :	(c)	(f)	(i)	
$15(2+b) = 0.5(2)^2$	Monitoring requirements	55		
IS (a+b)>0.5(c)	Monitoring requirements $\supseteq$	5E. 5EE		
IS (d+e)<0.5(f)?	Monitoring requirements $\Rightarrow$	5J 5DD		
13 (0+6)20.3(1)		300		
IS (g+h)<0.5(i)?	Monitoring requirements $\Rightarrow$	5G		
IS (g+h)>0.5(I)	Monitoring requirements $\degree \Rightarrow$	5G, 5GG		
3. EMISSION CONTROL SYST	EMS			
ARE THE EMISSIONS CONTROLLI	ED USING AIR POLLUTION CON	TROL EQUIPMENT?	YES	NO
IF YES, AND A FAILURE OF THE CON	TROL EQUIPMENT COULD RES	ULT IN SIGNIFICANT	ADVERSE EFFECTS,	COMPLETE
SECTION BELOW				
SCRUBBER	Monitoring requirement	nts $\Rightarrow$ 5T, 5U, 5	/	
BAGHOUSE	Monitoring requirement	nts $\Rightarrow$ 5T, 5U, 52	Z	
CYCLONE/MULTICYCLONE	Monitoring requirement	$\Rightarrow 5V, 5Z$		
	OR Monitoring requirement	$\begin{array}{llllllllllllllllllllllllllllllllllll$	r, 5W, 5X, 5Y	
Г

4. HISTOR	4. HISTORICAL PERFORMANCE				
For new sou For existing	urces go to 5 sources complete section below				
Is there a history of non-compliance with existing TSP emission limits? $\Rightarrow$ 5G, consider greater frequency Is there a history of non-compliance with existing SO <sub>2</sub> emission limits? $\Rightarrow$ 5F, consider greater frequency Is there a history of non-compliance with existing NO <sub>2</sub> emission limits? $\Rightarrow$ 5E, consider greater frequency					
5. RECOMMENDED MONITORING REQUIREMENTS <sup>E</sup> (ALL WORKSHEETS)					
Emissions	Monitoring	FREQUENCY			
5A	No emissions monitoring required				
5B	Intermittent visual inspection of plume (e.g. daily)				
50	Intermittent monitoring for $\Omega_0$ or $\Omega_0$ (e.g. addit)				
5D	Intermittent monitoring for $CO$ (e.g. annual or 6-monthly)				
55	Intermittent monitoring for $NO_{1}$ (e.g. annual or 6-monthly)				
55	Intermittent monitoring for $NO_2$ (e.g. annual of 6-monthly)				
50	Intermittent monitoring for SO <sub>2</sub> (e.g. annual of 6-monthly)				
50	Intermittent monitoring (choosies:				
51	Continuous monitoring for CO, or O				
51	Continuous monitoring for $CO_2$ of $O_2$				
55	Continuous monitoring for CO				
51	Continuous monitoring for $SO$				
5L 5M	Continuous monitoring for particulate				
5N	Continuous monitoring for particulate				
50					
5D	Continuous monitoring (species:				
50					
Brocoss	Monitoring				
FIOCESS 5D	No process monitoring required				
58	Intermittent fuel analysis (o.g. monthly)				
55	Continuous monitoring for temperature				
51	Continuous monitoring for prossure drep across control equipment				
50	Continuous monitoring of inlet/outlet flow rates				
51	Continuous voltage monitoring				
57	Continuous voltage monitoring				
57	Continuous current monitoring				
57	Intermittent visual inspection				
544	internitient visual inspection				
588					
Ambient M	onitoring				
	No ambient monitoring required				
500	CO monitoring				
566	$NO_{\circ}$ monitoring				
566	SO <sub>2</sub> monitoring				
566	TSP monitoring				
500	Denosited particulate monitoring				
511	Monitoring (species:				
5.11	Biological monitoring (specify:				
5KK					

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## WORKSHEET: NON-COMBUSTION SOURCES

#### DETAILS SITE: SOURCE: SPECIES NAME: PROCESS DESCRIPTION: LOCAL ENVIRONMENT: POTENTIAL EFFECTS: ODOUR VEGETATION HEALTH VISIBILITY OTHER ( DEPOSITION ) **EFFECTS UNDER NORMAL OPERATING CONDITIONS** 1. EMISSION CONCENTRATION: mg/m<sup>3</sup> EMISSION RATE: g/s SPECIES ..... MAXIMUM PREDICTED GLC FOR THIS SOURCE<sup>A</sup>: (a) µg/m³ g/m<sup>2</sup>/30days \_\_\_\_\_ BACKGROUND CONCENTRATION<sup>B</sup>: (b) µg/m³ g/m<sup>2</sup>/30days TOTAL MAXIMUM GLC µg/m³ g/m<sup>2</sup>/30days (a) + (b) MAXIMUM ALLOWABLE GLC<sup>C</sup>: g/m<sup>2</sup>/30days (c) µg/m<sup>3</sup> IS (a+b)<0.5(c)? Monitoring requirements $\Rightarrow$ 5H GO TO 2 5H consider greater frequency IS (a+b)>0.5(c)? Monitoring requirements $\Rightarrow$ GO TO 2 or continuous monitoring, and ambient monitoring 2. **EFFECTS UNDER ACCIDENTAL RELEASE CONDITIONS** IS THERE POTENTIAL FOR A MAJOR ACCIDENTAL RELEASE?<sup>E</sup> YES NO IF NO, GO TO 3 IF YES, COMPLETE SECTION BELOW THEN GO TO 3 RUN-AWAY REACTION Monitoring requirements $\Rightarrow$ 5T, 5U, 5V PRESSURE VESSEL FAILURE Monitoring requirements $\Rightarrow$ 5T, 5U, 5V Monitoring requirements $\Rightarrow$ 5V SPILLAGE FIRE/EXPLOSION Monitoring requirements $\Rightarrow$ 5T, 5U, 5V INCOMPLETE REACTION Monitoring requirements $\Rightarrow$ 5T, 5U, 5V OTHER ( \_\_\_\_\_\_) Monitoring requirements $\Rightarrow$ specify:

## WORKSHEET: NON-COMBUSTION SOURCES

3. EN	MISSION CONTROL SYSTEMS	;					
ARE T	THE EMISSIONS CONTROLLED USING	AIR POLLUTION CONTROL EQUIP	PMENT?	YES NO			
IF YES, C	IF YES, COMPLETE SECTION BELOW						
SC		Monitoring requirements $\Rightarrow$	B, 51, 50, 5V				
BA		Monitoring requirements ⇒	)B, 51, 50, 52				
AF		Monitoring requirements $\Rightarrow$	51, 51N, 51				
CY		Monitoring requirements $\Rightarrow$ 8	)B, 5N, 5V, 5Z				
EL		Monitoring requirements $\Rightarrow$ 8	>B, 5N, 5O, 51, 5\ 	V, 5W, 5X, 5Y, 5Z			
BIC	OFILTER	Monitoring requirements $\Rightarrow$ 8	5U, 5T, 5Z				
OT	[HER ()	Monitoring requirements $\Rightarrow$					
4. HI	ISTORICAL PERFORMANCE						
FOR NEW FOR EXIS	/ SOURCES GO TO 5 TING SOURCES COMPLETE SECTIOI	NBELOW					
IS THE	ERE A HISTORY OF NON-COMPLIANC	E WITH EXISTING EMISSION LIMI	TS OR ACCIDEN	TAL RELEASES?			
YE	S (specify:			)			
NC	D						
IE VES TH							
PARAI	METER MONITORING. THIS MAY INC	LUDE CONTINUOUS MONITORING	REQUIREMENT	S.			
5. RECO	OMMENDED MONITORING RE		(SHEETS)				
Emissio	ns Monitoring <sup>⊬</sup>			FREQUENCY			
5A	A No emissions monitoring re	quired					
55	3 Intermittent visual inspectio	Intermittent visual inspection of plume (e.g. daily)					
50	D Intermittent monitoring for C	Intermittent monitoring for $O_2$ or $OO_2$ (e.g. annual or 6-monthly)					
5E	E Intermittent monitoring for N	Intermittent monitoring for NO <sub>2</sub> (e.g. annual or 6-monthly)					
5F	Intermittent monitoring for S	Intermittent monitoring for SO <sub>2</sub> (e.g. annual or 6-monthly)					
50	G Intermittent monitoring for p	Intermittent monitoring for particulate (e.g. annual or 6-monthly)					
5H	H Intermittent monitoring (spe	Intermittent monitoring (species:					
51	Continuous monitoring for $CO_2$ or $O_2$						
5J	J Continuous monitoring for C	Continuous monitoring for CO					
54	Continuous monitoring for N	Continuous monitoring for NO <sub>2</sub>					
51	<ul> <li>Continuous monitoring for a</li> <li>Continuous monitoring for a</li> </ul>	Continuous monitoring for SO <sub>2</sub>					
51	Continuous opacity/obscura	Continuous opacity/obscuration monitoring					
50	D Continuous humidity monito	Continuous humidity monitoring					
5F	Continuous monitoring (spe	cies:	)				
50	ביי <u></u> ב						
Proce	ess Monitoring <sup>⊬</sup>						
56	R No process monitoring requ	ired					
55	5 Intermittent fuel analysis (e.	g. monthly)	-				
51	Continuous monitoring for te	emperature	auinmont				
51	<ul> <li>Continuous monitoring for p</li> <li>Continuous monitoring of in</li> </ul>	let/outlet flow rates (or surroa	ate)				
51	N Continuous voltage monitor	ina					
5×	Continuous current monitor	ng					
5Y	Continuous spark over mon	itoring					

	5Z	Intermittent visual inspection (specify:)	
	5AA		
	5BB		
Ambi	ent Mo	onitoring	
	5CC	No ambient monitoring required	
	5DD	CO monitoring	
	5EE	NO <sub>2</sub> monitoring	
	5FF	SO <sub>2</sub> monitoring	
	5GG	TSP monitoring	
	5HH	Deposited particulate monitoring	
	511	Monitoring (species:	
	5JJ	Biological monitoring (specify:	
	5KK		
	0.11		

#### **ADDITIONAL NOTES**

#### NOTES

- A Maximum ground level concentrations (GLCs) should be provided by the applicant as part of the assessment of environmental effects required under Section 88 (4b) of the Resource Management Act (1991). These may either be predicted downwind concentrations determined from an approved atmospheric dispersion model, or from ambient monitoring programmes. If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate maximum allowable concentration (MAC). Averaging times must be consistent for the predicted, allowable and background concentrations.
- B If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate MAC. If they have been determined from dispersion modelling and there are other significant sources close by, cumulative effects need to be included when considering background levels. Averaging times must be consistent for the predicted, allowable and background concentrations.
- C The maximum allowable ground level concentration (MAC) will depend on consent authority policy. Commonly used sources of ambient air quality guidelines include the MfE guidelines, State of Victoria DGLCs, and WHO Air Quality Guidelines. Averaging times must be consistent for the predicted, allowable, and background concentrations.
- D Contaminant concentrations exceeding the criteria specified in the worksheet indicates inadequate mitigation. In such cases it is recommended that consideration be given to what steps can be taken to reduce downwind concentrations.
- E A major accidental release is defined as one which has the potential to result in significant ad verse effects or an exceedance of a Design Ground Level Concentration (DGLC, Threshold Limit value (TLV) or other Maximum Allowable Concentration (MAC) for any time period. Consent authority will determine which system is appropriate.
- F Not all parameters will need to be monitored for all processes. The exact requirements will be dependent upon the specific application and should be discussed with the applicant and equipment manufacturer.
- G These are the recommended monitoring requirements. Other site-specific circumstances may dictate that additional or alternative requirements may be appropriate.
- H Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

Part 2 Emission Testing

## 4 Establishing Emission Limits and Emission Testing Requirements

## 4.1 Introduction

Part two is divided into eight Chapters, starting with Chapter four. Chapter four raises some of the issues that should be considered when setting a consent condition or emission limit and the issues that might influence methods used for emissions testing. Chapter five provides a general introduction to principles of emission testing common to virtually all measurement of contaminants. Chapters six to ten provide information and recommendations for measurement of specific contaminants, namely: oxides of nitrogen, sulphur dioxide, solvents, particulate and reduced sulphur compounds. Chapter 11 outlines the correction factors that should be applied to in-stack measurements so they can be compared with emission limits and finally Chapter 12 discusses the difficult task of monitoring visible emissions.

# 4.2 Writing consent conditions and emission limits

Setting consent conditions and discharge limits is part of the consultative process of issuing a discharge consent. It involves participation from the regional council, the applicant and in some cases members of the public who have made submissions.

Discharge limits are also commonly used in conjunction with a number of other conditions, such as prescriptive requirements that may relate to the best practicable option (BPO). This guide concentrates on discharge limits in relation to environmental effects, but their relationship to other conditions should not be forgotten.

In setting limits for specific emitted species, a regional council will need to consider:

- evidence presented in the consent application as part of the assessment of environmental effects for the process, or the results from deliberation in a pre-hearing, council hearing or the Environment Court
- national environmental standards or guidelines specifying discharge limits, if applicable
- applicable performance standards for control technology if a best practicable option or a technology-based approach is being followed
- regional air quality policies, particularly for species with cumulative effects
- the scale and significance of the environmental effects of the operation.

Some of the issues that have to be considered when composing the details of the condition are discussed in Part 1 of this guide. However, the following points are relevant to the setting of all air discharge limits.

Limits based on mass emission rates are directly linked to downwind effects on the environment. The mass emission rate measures the source's contribution of the contaminant to the environment. Concentration limits may be more directly applied in relation to national emission standards (if applicable) or to the performance that might be expected from emission control technology.

- 1. If concentration limits are specified, the limit expressed in mass emission per unit time, should also be included.
- 2. In certain cases, for example combustion processes, it may be acceptable to impose a limit based on emitted species' concentration only, corrected to a specified combustion gas parameter concentration e.g 11% oxygen or 12% carbon dioxide. If the concentration limit is expressed in parts per million by volume, no further correction is required. If the concentration is expressed as mass per unit volume e.g. mg/m<sup>3</sup>, the volume term should be corrected to standard conditions—that is dry gas, 0°C and 101.3 kPa atmospheric pressure. (Where a concentration limit is applied without a requirement to correct to a fixed parameter, it is possible that dilution air introduced into the process may reduce the concentration of species emitted without affecting the rate of discharge of the species.)
- 3. Species which are to be considered in a discharge limit should be expressed succinctly and unambiguously. Ideally reference should be made to individual compounds designated by their chemical and common names rather than vague classes of species such as the terms "volatile organic compounds" or "reduced sulphur compounds".
- 4. It is necessary to state unambiguously how compliance can be demonstrated. This will involve specifying the following:
  - frequency of emission testing throughout a year
  - the location where samples will be taken
  - the number of samples that must be taken (and any details regarding averaging times for these samples)
  - the sampling and analysis methods to be adopted
  - stack gas parameters to be noted in conjunction with sampling
  - the process conditions required at the time of testing and any requirement for verification of these (e.g. 75% of maximum operating capacity for a boiler)
  - how the results of testing will be compared to the discharge limit, e.g. comparison with maximum recorded result, average, mean, median, 99th percentile etc.

# 4.3 Factors affecting emission limits and compliance conditions

This section raises some of the issues and difficulties associated with emission testing to assist regional councils in setting informed and appropriate compliance conditions.

For any emission monitoring activity there are three principal sources of variability:

- 1. The emission process itself
- 2. The design of sampling procedure
- 3. Sample acquisition, analysis and interpretation

#### 4.3.1 Variability in emission rate for the process

It is unlikely that a process will emit a contaminant at identical rates over time. Consequently decisions will have to be made as to whether compliance refers to the maximum single result recorded over the monitoring period or whether it refers to a function such as the mean, median or higher percentile result.

Like most distributions related to anthropogenic activities, emissions of contaminants from a source over any fixed period when a process is operating can be expected to follow a geometric rather than normal distribution. Because of this, where sufficient samples are taken —continuous monitoring combined with data logging, for example—the data should be assessed on a percentile basis (such as the 95th, 99th or 99.9th) to avoid rare high numbers distorting the assessment. Continuous monitoring over long time periods also allows assessment during possible process changes. For these reasons, where the significance of the emission dictates, continuous monitoring should be built into compliance conditions. This approach has recently been applied to reduced sulphur emission monitoring from significant sources at the Tasman Pulp and Paper Ltd Kawerau kraft pulp mill.

For small to medium sources, and where continuous monitoring strategies are not applicable, the cost of alternative sampling and analysis, often combined with sampling time requirements, may preclude the taking of sufficient samples to allow useful percentile ranking or statistical analysis. This will require the calculation of confidence limits. At least two samples should be taken during any one sampling visit, as this permits a measure of the overall precision of the sampling process. Many regional councils require three samples. Six or more samples are required to allow the calculation of confidence intervals that are not unrealistically large. However, this could be prohibitively expensive for the industries concerned.

The discussion above also raises the question of which process or processes should be sampled if variation occurs. The assessment of environmental effects presented to the council with the discharge consent application should have specified the process which would lead to the maximum discharge of contaminants, and identified the effects on the environment caused by this maximum discharge. This process should be nominated in the compliance conditions. If no process is specified, testing staff should be instructed to test the process anticipated to give highest emissions. This requires some knowledge of the process itself and the current operating practices of the firm. It may be necessary, however, to establish whether specific processes or operating practices were specified in the consent application as atypical or of short duration (e.g. boiler soot blowing). Emissions testing during these processes may not be appropriate. The potential effects of atypical activities should be assessed as part of the resource consent application process.

#### 4.3.2 Design of sampling procedure

Sampling procedure design refers to the overall approach that is used to obtain an estimate of the quantity of emissions of a particular contaminant.

Factors that introduce variability include:

- the choice of sampling method
- compromises made in testing procedure
- sample method averaging times in relation to downwind effect.

The cost of sampling will be one of the principal factors in selecting a suitable testing method. Data quality, however, is equally important, especially in cases likely to involve enforcement action. Even when it is decided or required to test using standard methods, there may be a choice of sampling strategy and corresponding cost. The difference is most marked when continuous monitoring methods are compared with simpler batch averaging techniques. The advantages and limitations of each method must be considered to arrive at an appropriate cost-effective method.

Compromise may be needed again when the chosen method is applied. A recurring problem with emission sampling in New Zealand is poorly designed, or even non-existent, sampling points. As discussed later in this document, many of the standard methods require the sample probe to traverse a number of points along the horizontal profile of the stack to avoid particle size discrimination. Often lack of room on the sampling platform or obstructions, both outside and inside the stack prevent proper traversing. In some situations, particularly involving small sources, stack construction is too light to mount the sampling equipment. Often for reasons of safe access, the sampling point will not conform to the upstream disturbance requirements and the measured sample may not be an accurate representation of emissions.

Although regional councils should require companies to install sampling locations on their stacks which allow the proper application of testing methods, it is likely that emission testers will need to compromise some part of the testing method. Wherever non-ideal situations require deviation from a method's requirements, it is important that details of the approach adopted are documented. Ideally, such documentation should be done before sampling takes place and be agreed amongst all parties involved—regulators, consent holders and testers. It may be necessary to obtain a second opinion on the validity of an

approach and this role could be filled by experienced emission testing personnel in an auditing role.

The issue of sample-averaging time in relation to compliance limits must be considered. The following matters should be taken into account.

- The nature of the downwind effect should be evaluated. Is the effect characterised by short-term attributes such as odour or eye irritation which will occur in three minutes or less, or is the effect related to more long-term exposure such as heavy metal accumulation or effects on vegetation, for which periods of hours or days are more appropriate?
- The sensitivity of the chosen methodology may be a limiting factor. It may not be possible to collect sufficient material in three minutes to exceed a desired analytical detection limit.
- A sampling method may stipulate that sampling should occur for a specified time period. The time period may be influenced by the regulatory practices of the country that developed the method and may not be appropriate for local conditions.

### 4.3.3 Sample acquisition, analysis and data interpretation

Unlike the variability of process emissions and sampling procedure design, the variability associated with sample acquisition and analysis can be quantified to various extents. The tools available for this are discussed in Appendices 1 and 2. Data quality parameters such as precision and accuracy, and statistical concepts such as confidence intervals can only apply to these stages of the source assessment.

Conversion of raw analytical results into their final reported form may require careful application of the details appearing at the end of many standard methods. In particular, care should be taken with correction of sample volumes to standard conditions (0°C and 101.3 kPa—see Appendix 3 of *Ambient Air Quality Guidelines*, Ministry for the Environment, 1994) and correction of concentrations to a standard oxygen or carbon dioxide level. A common source of error is the assumption that the correction factor for oxygen is linear like the carbon dioxide factor. Correction factors are discussed more fully in Chapter 11.

#### Summary of main points from recommendations in Chapter 4

1. Careful consideration is needed before setting ambient monitoring compliance conditions in a discharge consent. In general, stack-based discharge limits are the most appropriate form of testing compliance.

2. Discharge limits should define unambiguously the species to be monitored, testing method to be followed, averaging time, monitoring frequency, correction conditions for concentration (e.g. standard conditions), any special process requirements at the time of testing and a clear statement of how compliance can be demonstrated from the results of testing.

3. Regional councils should recognise that emission testing locations are unlikely to be ideal in all situations. Three-way dialogue between consent holder, regional council and emission testing staff should be encouraged to ensure that workable compromises are reached.

4. The benefits versus costs of continuous monitoring methods should be compared with batch averaging methods for appropriate contaminants to decide which is most suitable for compliance monitoring.

## **5** Principles of Emission Sampling

## 5.1 Introduction

There are many emission testing methods that could be used to measure emissions. Their suitability for compliance monitoring or enforcement purposes must be judged primarily on data quality. For reliable compliance decisions to be made, the quality of data must be of known. Decision making may not necessarily require data of the best possible quality, but where data quality is unknown or undefined the information is of little value.

For this reason, only methods which have been carefully developed and tested are recommended for compliance monitoring in the following chapters. The method of first choice, where available, should be the appropriate International Standard Organisation (ISO) standard. Generally the ISO standards are more performance-based and less prescriptive than many other national standards and thus offer an element of flexibility. In many cases alternative national standards will conform to the requirements set out by the ISO standard. Many New Zealand firms aspire to, or have achieved, quality and environmental management certification under ISO 9000 and 14000 systems, hence it is also desirable to ensure that the methods used will conform to the requirements of these systems.

Where an ISO emission testing method is not available for a specific contaminant, the appropriate United States Environmental Protection Agency (USEPA) or American Society of Testing and Materials (ASTM) method should be the second choice. USEPA and ASTM methods have a history of validation and in most cases have an inherent quality assurance structure allowing data quality evaluation. There are a significant number of USEPA methods available, often with several sampling options for a specific contaminant.

A limited number of Australian standard methods are also available. To date these standards have drawn heavily on the relevant ISO standards for their construction, although they are not absolutely equivalent with adjustments and alterations to cater for some predicted differences in Australian emission testing conditions and testing apparatus. These methods should also be seen as second choice behind ISO methodology.

ISO standards discussed in the following chapters are available from the International Organisation for Standardisation, Case postale 56, CH-1211 Geneva 20, Switzerland. ISO catalogue information is available at Website **http://www.iso.ch**. Similarly, the USEPA methods discussed can be accessed from the Code of Federal Regulations, Title 40, Part 60 Appendix A, available on microfiche from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, USA. The methods can also be searched from the Internet at Website **http://www.epa.gov/oar/oaqps/emc/tmethods.htm**. Volume 11.03 (Atmospheric Analysis; Occupational Health and Safety) of the Annual Book of ASTM Standards, available from ASTM 1916 Race Street, Philadelphia PA 19103-1187, USA, contains the ASTM methods mentioned in this document. Information

can also be accessed from Website **http://www.astm.org**/. Australian Standard Methods are published by Standards Australia.

The above recommendations are not intended to exclude alternative methods which are able to deliver data of similar quality. This comment applies in particular to the development of new sampling and analysis technologies which, through recent advances in electronics, are increasingly prevalent. However, there is a need to confirm the quality performance of the methods by comparison with the methods of choice listed above. USEPA Method 301, "Field Validation of Pollutant Measurement Methods from Various Waste Media" provides a mechanism for this comparison. The alternative method's performance should be compared with the ISO standard method or alternatively the appropriate USEPA or ASTM method in the comparison exercise. Data may already be available from overseas studies on a similar comparison, in which case a New Zealand study would not be necessary.

In addition to details of recommended compliance monitoring methods, the following chapters also mention "screening methods". Screening methods are able to provide approximate estimations of contaminant concentration, often more rapidly and at lower cost than the recommended compliance monitoring methods. Because the data quality of these methods is either inferior, poorly defined or undefined for a emission testing application, they should not be used for compliance monitoring. Screening methods may have a role in providing preliminary information in an emissions assessment, particularly in situations where the discharge is not expected to be significant and the potential bias (inaccuracy) of the method is known for the circumstances in which it is used.

A common approach has been taken in presenting information in Chapters six to ten. This includes a discussion of likely sources of the contaminant followed by a brief mention of available screening methods. A discussion of recommended compliance monitoring methods then follows.

## 5.2 General sampling principles

The evaluation of emissions from any source usually follows a similar pattern.

- Selection of a suitable sampling point in the stack or duct, or confirmation that existing sampling points conform to requirements.
- Measurement of the velocity, temperature, static pressure and bulk gas properties (moisture, carbon dioxide and oxygen content) of the stack gas.
- Calculation of equal area sampling positions and/or isokinetic sampling rates if the species of interest has particulate or droplet characteristics, or is likely to be stratified in the gas stream. (Temperature and pressure at the gas meter must also be determined to calculate isokinetic sampling rates.)
- Measurement of the concentration of the species of interest in the stack gas in terms of mass per unit volume at known temperature, moisture content and pressure.

These steps are discussed in more detail below and reference made to appropriate published methods.

#### 5.2.1 Selection of a suitable in-stack sampling point

ISO Method 9096: 1992(E) (Stationary source emissions - Determination of concentration and mass flow rate of particulate material in gas-carrying ducts - Manual gravimetric method), ISO 10780: 1994(E) (Stationary source emissions - Measurement of velocity and volume flow rate of gas streams in ducts), USEPA Method 1 (Sample and Velocity Traverses for Stationary Sources) and Australian Standard AS 4323.1 1995 (Stationary Source Emissions, Method 1 - Selection of Sampling Positions) give appropriate guidance in the selection of sampling points. The four methods have some differences. Although these are generally minor, future work should be directed to resolve the approach to be adopted uniformly in New Zealand, since this is a fundamental part of emission testing.

General recommendations are that sampling should take place in a length of straight duct, preferably vertical, having a consistent cross-sectional shape and area. The sampling point should ideally be eight stack diameters downstream of a flow disturbance and four diameters upstream, as stack gas flow is more likely to be uniform if these requirements are met.

The minimum requirements specified to achieve results within  $\pm$  10 percent accuracy of the ISO 9096: 1992(E) method are a straight duct at least seven stack diameters long, with the sampling point five diameters from the inlet. In the case of monitoring from a chimney discharging to open air, the distance to the chimney top from the sample point should also be five diameters, necessitating use of a total duct length of 10 diameters.

In practice this can be very difficult to achieve. Plant designers rarely allow for straight lengths of duct for sampling purposes, so some compromise positioning must be sought. ISO 9096:1992E recognises this and allows for relaxation of the above conditions under the rider that results may be less accurate than  $\pm$  10 percent and that the deviation must be mentioned in the written report. (The method stipulates that sampling conditions are unfavourable when the sampling point is located within one stack diameter of a duct bend, within one diameter of the junction of two ducts, within three diameters of partly closed louvres and within four diameters on the discharge side of a fan). In addition the following gas condition requirements must be satisfied:

- 1. angle of gas flow  $<15^{\circ}$  to duct axis
- 2. no local negative gas flow
- 3. minimum velocity depending on the method used (for pitot tubes a differential pressure >5Pa)
- 4. ratio of the highest to lowest local gas velocities < 3:1
- 5. temperature (in °K) at any point  $< \pm 5$  percent from the mean temperature.

If these conditions cannot be satisfied, an alternative sampling point must be sought at a new location in the stack.

The minimum requirements for USEPA Method 1 are two diameters downstream of a flow disturbance and 0.5 diameters upstream, however the method requires the use of an increased number of points across the sampling plane of the stack when measuring velocity or carrying out equal area sampling.

AS 4323.1 does not set minimum criteria for sampling locations, but where the sampling position is not ideal it similarly requires an increased number of sampling points across the sampling plane.

ISO 9096:1992(E) and ISO 10780: 1994 (E) do not permit the sampling of a gas stream with cyclonic flow.

AS 4323.1 requires the use of temporary additional test sections incorporating straightening vanes for sampling cyclonic flow in vertical profile or an elbow to a length of horizontal section as an alternative. USEPA Method 1 requires the calculation of at least 40 pitch and yaw angles across the stack profile for stacks with cyclonic flow. Either approach is recommended where there is no other suitable sampling point.

### 5.2.2 Velocity measurements and associated bulk stack gas properties

Measurement of velocity and related stack gas properties is covered in ISO 9096:1992(E), USEPA Method 2 - "Determination of stack gas velocity and volumetric flow rate (Type S pitot tube), USEPA Method 3 - "Gas analysis for carbon dioxide, oxygen, excess air and dry molecular weight" and USEPA Method 4 - "Determination of moisture content in-stack gases". Stack gas velocity measurement is also covered in ISO 10780:1994(E) and ASTM D3154-91 - "Average velocity in a duct (Pitot Method)".

Velocity in ducts is measured using use pitot tubes. A pitot tube is a device that measures the pressure resulting from the momentum of moving gases. There are two common types of pitot, the British Standard pitot and the 'S' type pitot. The most obvious difference between the two is that the BS pitot is L-shaped and the 'S' type is straight. In many instances, the 'L' shaped pitot cannot be inserted into the duct because of its shape. For this reason, and the fact that they are less inclined to block under a high dust loading, 'S' type pitots are more commonly used.

The pitot tube is connected to a sensitive pressure measuring device such as an inclined manometer, a differential pressure gauge or an electronic micromanometer. The velocity in the duct is calculated using a formula that requires the following inputs:

- pitot pressure difference
- gas temperature
- static pressure in the duct
- molecular weight of the gas
- calibration factor of the pitot tube.

Velocity measurements are important for calculating isokinetic flow rates for sampling (see below) and the volumetric flow rate in the duct. The product of the volumetric flow rate and the contaminant concentration in the duct gives the mass flow of the contaminant. If this mass flow is part of the discharge consent conditions, the assessment of velocity in the duct is crucial.

The number of velocity measurements that must be taken across the sampling plane is controlled by the principle of equal areas discussed in Section 5.2.4.

Both ISO 9096:1992E, ISO 10780:1994(E) and USEPA Method 2 require that all velocity measuring devices be calibrated, preferably to a traceable standard. This includes pressure measuring devices in the case of pitot tube measurements.

#### 5.2.3 Calculation of isokinetic sampling rates

When sampling particles in a gas stream it is normal practice to sample isokinetically. This means that the velocity of the gases entering the sample nozzles is the same as that in the duct. When these two velocities are equal, the flow lines of the gas stream are undisturbed and the solids in the stream are not deviated from their paths. Failure to achieve this condition can result in sampling errors. This error will be insignificant, however, if the particles in the stream are small enough to act as a gas (say  $<5 \mu m$ ). Note that when sampling gases, isokinetic conditions are generally not required. ISO 9096:1992(E), USEPA Method 5 "Determination of particulate emissions from stationary sources" and ASTM Method D3154 provide details on calculation of isokinetic flow rates.

# 5.2.4 Equal areas and number of points sampled across the sampling plane

Contaminants in a gas stream may not be distributed evenly. For instance, it is common for dust particles to be concentrated against one side of the duct according to flow direction changes. To overcome this and obtain a representative sample, it is necessary to divide the duct into a number of equal areas and sample for an equal time at the centre of each area. The minimum number of sampling points is dictated by the dimensions of the sampling plane. This number generally increases with the size of the duct and is discussed in ISO 9096: 1992(E), USEPA Method 1 and AS 4323.1-1995. Details for calculating the position of the sampling points and their number can be found in the appropriate methods and will not be detailed here. The sampling nozzle is positioned at each point in turn for a equal time during the acquisition of the sample. Sampling points in circular ducts can be reached using two sample ports at right angles and those in rectangular ducts may require several ports along one of the sides.

#### 5.2.5 Measurement of the concentration of species of interest

The concentration of the species of interest is measured using a combination of a sampling train designed to collect the species from a known volume of stack gas, and an appropriate analytical method for determining the amount of species trapped. Methods for a number of contaminant species are discussed in Chapters six to ten.

Species concentration is calculated by dividing the amount collected in the sampling train by the volume of stack gas sampled. The volume sampled may be corrected to standard conditions (see Chapter 11).

#### 5.2.6 Measurement of species mass emission

Mass emission is calculated from the product of species concentration and stack gas volumetric flow rate. The latter is the product of stack cross sectional area and stack velocity. It is important that any corrections applied to the concentration term (such as correction to  $0^{\circ}$ C, 101.3 kPa, dry gas basis and standard oxygen concentration) are also made to the volumetric flow rate term.

## 6 Oxides of Nitrogen

## 6.1 Introduction

Nitrogen oxides exist in the atmosphere as a variety of chemical species but the principal species of concern as a risk to human health is nitrogen dioxide (NO<sub>2</sub>). With a boiling point of 21.2°C, nitrogen dioxide is present in the atmosphere as a reddish-brown gas that is readily soluble in water and is a strong oxidant.

Other oxides of nitrogen are nitric oxide (NO) and nitrous oxide ( $N_2O$ ). Both of these colourless gases are much less toxic although nitric oxide is rapidly transformed to nitrogen dioxide in the atmosphere. Because of this, nitrogen dioxide and nitric oxide are often referred to together as total nitrogen oxides ( $NO_x$ ). Measurements of ambient levels are reported as either nitrogen dioxide or total oxides of nitrogen and it is important to be clear which is being referred to.

Nitrogen oxides are emitted from all combustion processes and from many chemical processes using nitric acid. The most common source is motor vehicles which contribute the majority of  $NO_x$  in the urban environment. For compliance monitoring, large combustion sources (power stations, large boiler systems) and some chemical processes may require measurements. For small sources of  $NO_x$ , add-on measures to control  $NO_x$  emissions are expensive. For equipment such as co-generation systems (commonly gas turbines with heat recovery boilers), low  $NO_x$  configurations are available for new plant.

## 6.2 Screening methods

A relatively simple instrumental technique is available for the measurement of NO and  $NO_2$ . It uses an electrochemical cell and is found in instruments used for occupational measurements as well as on several brands of portable flue gas analyser systems. Reaction of the gas in question in the cell produces a current flow that is related to the concentration. This is displayed on the scale on the instrument and read directly as a single result. The instrument can be considered as semi-continuous since zero errors can be significant when it is used continuously, particularly when measuring stack concentrations. Manufacturers claim that the interferences from other gases are negligible, but experience does not support this. Caution should be exercised, particularly when SO<sub>2</sub> is present.

This technique can be quite reliable for assessing NO in-stack, and it may be used to assess NO from all small combustion sources (say <50 MW) where the majority of NO<sub>x</sub> is NO. When measuring NO<sub>2</sub>, however, considerable care must be taken to remove water from the gases to avoid losing the NO<sub>2</sub> before the analyser. The only practical ways of removing the water are by dilution or semi-permeable membrane. An electrochemical technique should not be used as a screening method to measure NO<sub>2</sub>.

Draeger, Gastec or other indicating tube devices are not recommended as screening methods. (See Appendix F).

## 6.3 Compliance monitoring methods

#### 6.3.1 Instrumental methods

The most widely used method uses real-time instruments that detect the chemiluminescence effect of reacting NO and ozone. The reaction oxidises NO to NO<sub>2</sub> and in the process emits light that is proportional to the concentration of NO in the sample. NO<sub>2</sub> can also be analysed by this technique if it is first converted to NO by reaction with a molybdenum catalyst. Instruments can be designed to detect either ambient or stack concentrations of NO<sub>x</sub> (that is the sum of individual NO and NO<sub>2</sub> concentrations) and NO by directing the sample gas stream alternatively through the catalyst and then by-passing it. Instruments designed to detect stack concentrations directly can have problems with the chemiluminescence effect being quenched in the presence of CO<sub>2</sub> (commonly present in stack gases). For this reason, a preferred method is to use a dilution technique and ambient analysers to measure stack concentrations of NO<sub>x</sub>.

 $NO_2$  is extremely soluble in water and considerable care is needed in sample conditioning to ensure that  $NO_2$ , an important component of  $NO_x$ , is not lost before it reaches the analyser. The comments above regarding sample conditioning techniques apply equally to this. One method is to dilute the sample using dry air that has been passed through activated charcoal to remove  $NO_x$ . The air is mixed with the stack gas sample at a constant ratio is then passed to an ambient level analyser for measurement. The level measured by the analyser is then adjusted by the dilution factor to arrive at the concentration of  $NO_x$  in the stack. To preserve the  $NO_2$  in the stack gas sample, the sample must be maintained at above the condensation temperature for water. Following dilution, the dew point of the resultant gas mixture will be below ambient temperature and  $NO_2$  will not therefore be lost. Most chemiluminescence analysers will measure concentrations of  $NO_x$ , NO and  $NO_2$ .

ISO 10396:1993(E) - "Stationary source emissions - Sampling for the automated determination of gas concentrations" provides general guidance on operating continuous gas analysers including those for NO and NO<sub>2</sub>, and comments on the use of dilution apparatus and permeation drying systems.

USEPA Method 7E - "Determination of nitrogen oxide emissions from stationary sources (Instrumental Analyser Procedure)" - describes the use of a direct reading (no sample dilution) chemiluminescence analyser. The method stipulates practices for standard gas calibration, interference response testing, and sample system bias.

#### 6.3.2 Non-instrumental technique

There are four non-instrumental USEPA methods for determining  $NO_x$  concentrations which are described briefly as follows:

- Method 7 "Determination of nitrogen oxide emissions from stationary sources"- a grab sample is inspirated into a flask containing a quantity of dilute sulphuric acid/hydrogen peroxide mixture and NO is allowed to oxidise to NO<sub>2</sub>. Oxygen is introduced if the sample has a low oxygen content. NO<sub>x</sub> is measured colorimetrically.
- **Method 7A** -Ibid. "Ion chromatographic method" as for Method 7 but analysed by ion chromatography.
- **Method 7B** Ibid. "Ultraviolet spectrophotometry" as for Method 7 but analysed by ultra violet absorption. This method was developed for nitric acid plants.
- Method 7C -Ibid. "Alkaline permanganate/colorimetric method". A sample is extracted from the stack and passed through alkaline potassium permanganate solution in three Greenburg Smith impingers.  $NO_x$  is oxidised to  $NO_2$  and  $NO_3$ . The  $NO_3$  is then reduced to  $NO_2$  with cadmium. The  $NO_2$  is then analysed colorimetrically.
- **Method 7D** Ibid. "Alkaline permanganate/ion chromatographic method" as for Method 7C but analysed by ion chromatography.

# 6.4 Recommendations and interpretation of results

For significant emissions of  $NO_x$ , continuous analysis by a chemiluminescence technique should be used. (ISO 10396:1993 (E) or USEPA Method 7E)

NO<sub>x</sub> emissions are commonly expressed in the following terms:

- **ppm** (parts per million). This is normally in volume terms and can be written as ppmv.
- mg/m<sup>3</sup> (at [conditions]) e.g. mg/m<sup>3</sup> (at 0°C, 1 atm, dry gas basis). Note that if the units include m<sup>3</sup> some statement should be made about conditions (i.e. temperature, pressure, wet or dry).
- mg/m<sup>3</sup> as NO<sub>2</sub> (at [conditions]). This requires that all species of NO<sub>x</sub> be converted into NO<sub>2</sub>. This is a fairly common way of specifying NO<sub>x</sub>. Since NO<sub>2</sub> is the species of concern and that NO tends to oxidise to NO<sub>2</sub>, this is an assumed worst case way of expressing NO<sub>x</sub> emissions. In practice, NO<sub>2</sub> is often only 5 percent of total NO<sub>x</sub> (particularly for combustion sources) so this method of expressing NO<sub>x</sub> can be misleading.

## 7 Sulphur Dioxide

## 7.1 Introduction

Sulphur dioxide is a colourless gas that is highly reactive with surfaces, other gases, etc. It is readily soluble in water and can be oxidised within airborne water droplets.

Sulphur dioxide results from the combustion of any sulphur-containing substrate, typically fossil fuels. All coal- or oil-fired boilers will emit sulphur dioxide. The amount will depend on the sulphur content of the fuel. The following sulphur contents are typical.

Light fuel oil	1.9 %
Diesel	0.3 %
Huntly coal	0.2 to 0.5 %
High sulphur coal	2 to 3 %
(e.g. Pirongia)	

The emission of sulphur can be assessed by assuming that all sulphur burnt in the combustion chamber will be emitted as sulphur dioxide. In practice, some sulphur will be retained in ash (coal fired boilers) and some (approximately 5 percent) will be emitted as sulphuric acid mist formed from sulphur trioxide rather than sulphur dioxide.

Sulphuric acid production involving the formation and catalytic conversion of sulphur dioxide to sulphur trioxide, and Kraft recovery furnaces where spent wood chip digestion liquor is combusted, are also producers of sulphur dioxide.

## 7.2 Screening methods

As for nitric oxide, instruments incorporating electrochemical cell detection are available for the assessment of sulphur dioxide emissions.

Draeger, Gastec or other indicating tube devices are not recommended as screening methods (see Appendix F).

# 7.3 Compliance monitoring methods for sulphur dioxide

### 7.3.1 Instrumental techniques

ISO 7935:1992(E) Stationary source emissions: Determination of the mass concentration of sulphur dioxide. Performance characteristics of automated measuring methods

This method describes two generic approaches to the continuous measurement of sulphur dioxide emissions. The extractive approach withdraws a sample of stack gas, conditions it

and analyses the sulphur dioxide content by a variety of instrumental techniques including infrared or ultraviolet absorption, ultraviolet fluorescence, interferometry and conductimetry. The non-extractive approach involving in-situ or cross-duct methods, performs the analysis in-stack usually using an absorption approach.

The approaches are not prescribed in detail. Instead, any sampling apparatus used must be able to conform to a set of four performance characteristics involving detection limit, effect of interfering substances, response time and integral performance. The numerical tolerances for these characteristics and the means of determining compliance are discussed.

## ISO 10396:1993(E) Stationary source emissions. Sampling for the automated determination of gas concentrations

This method describes procedures and equipment that will permit automated determination of sulphur dioxide in addition to a number of other species. A specific approach that of diluting stack gas to below its dew point and down to a concentration range which can be measured by continuously recording ambient instrumentation has proved generally successful. A "dilution probe" system that extracts gas into a heated chamber and dilutes it with high ratios of purified ambient air to lower the stack gas dew point temperature is required.

### <u>USEPA Method 6C Determination of sulphur dioxide emissions from stationary sources</u> (Instrumental Analyser Procedure)

This method involves continuous gas sample extraction from the stack. A portion of the sample is conveyed to an instrumental analyser for determination of  $SO_2$  gas concentration using an ultraviolet, non-dispersive infrared (NDIR) or fluorescence analyser.

The important non-instrumental components are:

- a heated probe and in-stack or heated out-of-stack particulate filter system
- a heated sample line to a moisture removal system
- a moisture removal system such as a refrigerator type condenser or permeable membrane system that minimises contact between condensate and sample gas
- three-way calibration valve assembly to allow introduction of calibration gases to the measurement system
- a leak-free sample pump constructed of any material that is non-reactive to the gas being sampled.

The method requires high, mid-range and zero calibration gas mixtures in conjunction with some strict measurement system performance specifications to ensure reliable data are collected. A parallel wet chemical Method 6 train analysis is also used to check for analytical interferences and excessive instrumental biases.

### 7.3.2 Non-instrumental techniques

## ISO 7934:1989(E) Stationary source emissions. Determination of the mass concentration of sulphur dioxide. Hydrogen peroxide/barium perchlorate/thorin method

In this method, stack gas is extracted through a heated probe and passed through a glass wool filter encased in a heating jacket. Sulphur dioxide is collected in hydrogen peroxide solution contained in two Dreschel bottles equipped with sintered frit bubblers. After sample collection, trapped sulphur dioxide (in sulphate ion form) is determined by titration with barium nitrate following pH adjustment.

Sulphur trioxide (sulphuric acid mist) is an acknowledged interference with this method but is considered insignificant. Other potential interferences are anions absorbed by the absorption solution that also form sparingly soluble salts with barium ions at pH 3.5.

#### USEPA Method 6 - Determination of sulphur dioxide emissions from stationary sources

In this method a gas sample is extracted from a sampling point in the stack Sulphuric acid mist (including sulphur trioxide) is separated from sulphur dioxide using a glass wool filter and an isopropanol bubbler. The sulphur dioxide is then trapped in peroxide solution in bubblers and later analysed by titration with barium salts using thorin as an end-point detector.

The following points are important:

- SO<sub>2</sub> is a gas therefore there is no requirement for isokinetic sampling.
- Method 6 employs midget impingers and a relatively low sampling rate (1 litre per minute). The midget impinger system can be scaled up to a Greenburg-Smith impinger system (as in USEPA Method 8 with corresponding increase in flow rates), however a heated filter must be incorporated between the probe and isopropanol impinger.
- Free ammonia may interfere with the collection and analysis process. Water soluble cations and fluoride also interfere, but are removed by the filter and isopropanol solution.
- The oxidising power of the isopropanol solution must be shown to be below a specified threshold before use in the field.

### <u>USEPA Method 8 Determination of sulphuric acid mist and sulphur dioxide emissions from</u> <u>stationary sources</u>

In this method a gas sample is extracted isokinetically from the stack. Sulphuric acid mist (including sulphur trioxide) is trapped in isopropanol in the first of three impingers. Sulphur dioxide is trapped in 3 percent peroxide in the second and third impingers in the train. Both species are separately determined later by the barium thorin titration method.

The following are important points

- A heated probe is used to prevent condensation of stack gases.
- As with USEPA Method 6, the oxidising power of the isopropanol solution must be checked to ensure it is within acceptable limits.
- The filter unit may be important in trapping fine mists of sulphuric acid which may not be quantitatively trapped in the isopropanol impinger. It is important that these filters match the required performance specifications.
- Fluorides, free ammonia and dimethyl aniline may cause serious interferences with the process if present in the stack gas in significant quantities.

# 7.4 Recommendations and interpretation of results

Compliance testing of large sources capable of making a significant regional impact should be based on continuous monitoring instrumental techniques. Sulphur dioxide emissions from small to medium sources are more cost-effectively assessed using wet chemical methods such as ISO 7934:1989 (E), USEPA Method 6 and Method 8. The latter method has the advantage of providing additional information on sulphuric acid mist emissions. However sample collection must be isokinetic.

## 8 Solvents

## 8.1 Introduction

For the purposes of this guide, the term "solvents" refers to the group of volatile organic compounds, with boiling points of about 140°C or less, that are used as a matrix to dissolve solid materials. On evaporation of the solvent, a film of the solid is formed over a surface. Solvents are also used as cleaning materials because of their powers in grease cutting. A variety of solvents are used in many New Zealand industries.

Industrial processes employing solvents include paint spraying, printing, dry cleaning, adhesive tape production and sand paper production.

Occasionally the solvent will consist of a single chemical such as ethanol. More commonly the solvent will be composed of a number of different species. Manufacturers may declare the composition of solvent species in the material safety data sheet for the product. In many cases, however, a generic class such as "petroleum hydrocarbons" or "mineral turpentine" is indicated which generally means that complex mixtures of organic species are present.

Discharges of individual solvent species should be investigated where the potential exists for them to cause a downwind health effect. Typical solvent compounds in this category include benzene, toluene, xylene, n-hexane, ethyl acrylate and chlorinated solvents such as dichloromethane and perchloroethylene. Aspects of nuisance odours associated with solvent discharges are being considered in a Sustainable Management Fund (SMF) project.

The methods described here are largely restricted to non-polar, non-reactive compounds with low water solubility which are retained well on activated carbon absorbent. Reactive, polar solvents require more specialised sampling methods which are often specific to a chemical class, for example USEPA Method 0011 for aldehydes and ketones. In many cases reliable sampling methods for reactive compounds are still being developed.

## 8.2 Screening methods

No screening methods are currently available. Draeger, Gastec or other indicating tube devices are not recommended as screening methods (see Appendix F)

## 8.3 Standard sampling methods

#### USEPA Method 0030 - Volatile organic sampling train (VOST)

This method is applicable to solvent compounds with boiling points in the range 30°C to about 120°C. A 20-litre sample of stack gas is extracted from the source at a sampling rate of one litre per minute, and is cooled to 20°C by passage through a water cooled condenser. Organic species are collected on a Tenax solid phase sorbent trap. A back-up condenser and sorbent trap system provide a quality assurance check on sample breakthrough. Trapped material is analysed by thermal desorption purge and trap GC/MS.

The following points are significant:

- Thermal desorption removes all absorbed species for analysis at one go. Although this confers high sensitivity where emissions are low, it is also possible to saturate detector signals if emission levels are high. The one-shot aspect of this form of analysis can easily lead to total sample loss. The VOST method was originally developed to demonstrate that high destruction efficiencies (>99.99%) could be achieved in appropriate technologies, hence its requirement for high sensitivity.
- The VOST process requires that six separate 20 minute samples are collected over a two hour sampling period. The first set of traps is often analysed as a range finder. If an adequate amount of the compounds of interest is found, then the other five sets of traps can be analysed in the same manner. If the first analysis detects no compounds of interest, the other five pairs are desorbed and collected onto a single analytical trap, allowing a five-fold increase in the detection limit.

### <u>USEPA Method 18 - Measurement of gaseous organic compound emissions by gas</u> <u>chromatography</u>

USEPA Method 18 is a generic method for measuring volatile organic compounds in stack gases. Sample analysis is by gas chromatography with a suitable detector. There are three principal methods suggested for sample acquisition: direct interface from the stack to the chromatographic system, collection in a container (e.g. Tedlar bag ) or collection on an adsorption tube (e.g. activated charcoal).

The method is applicable to species present in the stack gas at concentrations of one part per million or greater. The method specifies procedures that define performance and partially validate the method each time it is applied.

## 8.4 Recommendations

USEPA Method 18 is probably the most appropriate method for New Zealand's current monitoring needs for this class of compounds. Care must be taken when sampling from moisture laden or high temperature emissions, as these conditions can lead to losses from the absorbent. USEPA Draft Method 40 provides guidance on preparing Tedlar bag samples from such sources, and the sampling train described there can be also be applied to the absorbent tube procedure. Alternatively, using a moisture removal device such as a Permapure drier could be considered provided it has been shown that the system does not cause preferential losses of the species of interest.

USEPA Method 0030, with its high sensitivity leading to potential overload of analytical systems, is unsuitable for compliance monitoring in most New Zealand situations. It may be suitable, however, where it is necessary to show a high destruction removal efficiency in a piece of emissions control equipment. At the time this guide was published, there was no

analytical facility in New Zealand which can analyse the large thermal desorption tubes used in the sampling train.

## 9 Particulate

## 9.1 Introduction

Common sources of particulate from industrial processes are:

- solid fuel fired boilers
- quarrying operations

Common sources of particulate from industrial processes are:

• wood processing plants.

Fugitive emissions from processes such as quarrying operations are not considered in the document. The methods here are only appropriate for particulate emitted from ducts or stacks.

## 9.2 Screening methods

No screening methods are currently recommended.

## 9.3 Compliance monitoring methods

Particulate testing methods generally fall into two categories filtration in-stack and filtration out-of-stack. For the sake of clarity the following sections are separated by this distinction even though individual listed methods may include both conformations.

Both techniques use a pre-weighed filter to collect particulate material. With in-stack methods the filter is placed into the stack or vent in a specially designed holder to allow a sample of the gas stream to be collected isokinetically and passed through it. Out-of-stack methods use a heated probe and an external heated filter holder chamber but still sample at isokinetic rates. Following the test, the filter is dried and re-weighed, and the increase in weight and the sample volume used to calculate the particulate concentration in the stack or vent.

The following comments are relevant for both types of sampling.

Although isokinetic particulate sampling is one of the most common tests, it can be difficult to sample representatively and the method is very sensitive to variations in stack conditions. "Isokinetic" means that the gas sample is drawn from the stack so that the velocity of the sample gas at the nozzle tip is identical to the flue gas velocity at that point. Because of this, it is essential to sample in an area of stable flow and have the stack gases well characterised. If this is not the case, erroneous and misleading results may be obtained. Guidance on the location of suitable sampling points was provided in Section 5.2.1 and on isokinetic sampling in Section 5.2.3.

Measurement of velocity (usually using a pitot tube) is important as this determines the isokinetic sampling rate and the eventual mass emission rate for the process. The sample train also provides a measurement of moisture content for the gases which is used to correct the sample volume to 0  $^{\circ}$ C. Velocity measurement was discussed in Section 5.2.2.

If the process is based on combustion, determination of  $CO_2$ ,  $O_2$  and moisture is required in order to obtain the average molecular weight of the gas stream. In addition,  $CO_2$  concentrations may be used in calculations if the final result is to be corrected to a standard excess air.

For in-stack sampling methods, if the gases to be sampled are at high temperature (say above 150°C), the filter must be conditioned in an oven at the expected gas temperature to ensure that binder from the filter is not lost during sampling at the high temperature. Failure to do this can result in significantly underestimating the result.

#### 9.3.1 In-stack filter methods

### ISO 9096: 1992 (E) "Stationary source emissions. Determination of concentration and mass flow rate of particulate material in gas-carrying ducts - manual gravimetric method" and Equivalent Methods

ISO 9096:1992 (E) provides a generic description of the fundamental requirements of a particulate measuring system namely: a sampling probe tube with entry nozzle, a particle separator (in-stack or external) a gas metering system (in-stack or external) and a suction system. Two general conformations of equipment are described, one employing gas flow measurement via an orifice plate where the stack gas water vapour is maintained and the other dependent on gas volume measurement where water vapour must be removed before it enters a dry gas meter. The latter system is the one most commonly used in New Zealand. Performance specifications for individual equipment parts are listed in the method.

ASTM Method D 3685-78 "Standard test method for particulates independently or for particulates and collected residue simultaneously in stack gases" and USEPA Method 17 "Determination of particulate emissions from stationary sources (in-stack filtration method)" can be regarded as equivalent to ISO 9096: 1992 (E). Similarly sampling configurations outlined in Australian Standard AS 4323.2-1995 "Stationary Source Emissions Method 2: Determination of total particulate matter - isokinetic manual sampling - gravimetric method" which conform to the ISO schematic diagram can be regarded as equivalent methods also.

The British Coal Utilisation Research Association (BCURA) cyclone probe sampling train conforms to the orifice plate conformation of the ISO method and can be regarded as an equivalent method provided operating characteristics allow a  $\pm 10$  percent method accuracy and a filtration system with an efficiency of >98.0 percent for particles of 0.3 µm is used.

#### 9.3.2 Out-of-stack filter method

Out-of-stack filter methods are generally more cumbersome than their in-stack counterparts and have been less widely used in New Zealand. The out-of-stack method is particularly useful in circumstances when the stack gases are very wet (downstream of a wet scrubber) or very hot (exit of an incinerator). ISO 9096: 1992 (E) described in Section 9.3.1 above allows for an out-of-stack filter configuration with equivalent equipment tolerances as for the in-stack method. USEPA Method 5 "Determination of particulate emissions from stationary sources" conforms to the requirements of the ISO standard.

# 9.4 Recommendations and interpretation of results

For routine measurement of particulate in ducts, in-stack measurements conforming to the standards of ISO 9096: 1992 (E) such as ASTM method D3685-78 or USEPA Method 17 should be used. In our opinion the ASTM method is effective with conventional glass fibre thimbles up to gas temperatures of about 300 °C. If temperatures are substantially higher than this or the stream is very wet, an out-of-stack ISO 9096-compatible method such as USEPA Method 5 should be used, or alternatively alundum thimbles can be employed. Wet stacks can be measured using the in-stack method, but thimbles can often burst. Special heated probes can be used to overcome this problem.

Results should always be expressed at 0 °C, atmospheric pressure and a dry gas basis. For combustion processes such as boilers, an oxygen or  $CO_2$  correction should be applied to standardise at a constant excess air factor. Asphalt plants are not normally corrected for excess air although they do have a combustion component.
# **10 Reduced Sulphur Compounds**

## 10.1 Introduction

Although in theory the term "reduced sulphur compounds" could apply to hydrogen sulphide and all organic compounds in which sulphur has a formal oxidation state of zero or lower, in practice the term is usually applied to the four principal gases emitted from the kraft pulp process: hydrogen sulphide, methyl mercaptan, dimethyl sulphide and dimethyl disulphide. These are highly odorous compounds with some of the lowest reported odour thresholds in the literature.

There are many processes, both man-made and natural, where hydrogen sulphide is by far the predominant reduced sulphur species emitted. Natural sources include geothermal emissions and the emissions from bacterial anaerobic digestion in a sulphur-rich matrix, characterised familiarly by rotten eggs.

Man-made processes which release hydrogen sulphide are also chiefly associated indirectly with anaerobic digestion, including the by-products of wool scouring, fellmongery and sewage treatment. Several stages of chemical pulp production and the oil refining industry can produce hydrogen sulphide as well.

Of the other reduced sulphur compounds, dimethyl sulphide is produced in surprisingly large amounts by marine organisms and it has been postulated that the chemical may have a role in seeding rain clouds.

Human related emissions of other reduced sulphur compounds emanate from chemical pulp production, the dissolution of phosphate rock in the production of superphosphate, and in sewage treatment.

#### 10.1.1 General method description

Source testing methods for reduced sulphur species generally fall into two categories. In one category reduced sulphur compounds are determined individually from a sample of stack gas using a chromatographic separation process combined with an appropriate sulphur specific detector. In the other category the reduced sulphur species in the stack gas sample are oxidised to sulphur dioxide, which is then analysed by traditional methods.

Both approaches have advantages and disadvantages. The methods based on individual species determination obviously provide much more information than does conversion to sulphur dioxide. The ability to distinguish individual species may be significant where the more odorous compounds hydrogen sulphide and methyl mercaptan are present in either significantly larger or significantly smaller amounts compared to dimethyl disulphide and dimethyl disulphide. The information provided by emission monitoring can be used in conjunction with plume dispersion modelling to predict worst-case downwind

concentrations. Consequently the ability to assess the concentrations will ensure that reduced sulphur compound impact is neither over- nor under-estimated.

The major disadvantages associated with the species-specific approaches include the need for relatively complex chromatographic and sulphur detection instrumentation, relatively expensive calibration gas mixtures and the need for the samples to be analysed within one hour of acquisition.

The major advantages of conversion to sulphur dioxide include the relative simplicity of the analytical stage, the long-term stability of the samples, once acquired, and less expensive calibration requirements.

The conversion to sulphur dioxide approach cannot discriminate between individual species. This drawback may become less significant, however, in situations where one reduced sulphur species (such as hydrogen sulphide) is clearly predominant, or the relative distribution of reduced sulphur compounds has been established and can be assumed to be reasonably stable. Sampling times can be significantly longer than the chromatographic process, however it is possible, albeit at some expense, to use a continuous analytical system where short-term fluctuations make shorter averaging times important.

Given the prevalence of hydrogen sulphide emissions, there are some specific emission testing methods available which allow its individual determination. Similarly, because dimethyl sulphide and dimethyl disulphide are essentially volatile organic compounds, emission testing methods for this class may also be appropriate for individual determination of these compounds

## 10.2 Screening methods

No screening methods are currently recommended.

# 10.3 Compliance monitoring methods

#### 10.3.1 Individual species determination

#### USEPA Method 16

The principle of the method is that a gas sample is extracted from the emission source and diluted with clean dry air. An aliquot of the diluted sample is then analysed for the four reduced sulphur gas species by gas chromatographic separation and flame photometric detection.

This method requires that set criteria are adhered to, but does not require that a fixed sampling and analysis methodology be followed.

The following are important points associated with the system:

- Moisture condensation in sampling components must be avoided by heating or conditioning the sample with dry dilution air below its dew point.
- It may be necessary to introduce sulphur dioxide scrubbing apparatus if this species causes an interference.
- Sampling componentry in contact with the sample must be made of inert materials such as Teflon or stainless steel.
- There are rigorous requirements to establish dilution rate and calibration of the analytical system.
- A sample run is composed of 16 individual analyses (injects) performed over a period of not less than three hours or more than six hours.

Environment Canada Reference Method EPS 1/RM/6 : Reference method for source testing: measurement of releases of total reduced sulphur compounds from pulp and paper operations

This method is considerably simpler than USEPA Method 16. A gas sample is extracted from the stack through a heated teflon sample line, drawn through an impinger containing concentrated phosphoric acid to remove water vapour and collected in a Teflon or Tedlar bag or bottle. It is then analysed by gas chromatography with flame photometric detection.

The following are significant points:

- Analysis must begin *within one hour* of taking the sample.
- The gas chromatograph is calibrated by reference to a certified four-component calibration gas mixture. At least two dilutions of the gas mixture in the instrumental working range should be made.
- Although not specifically mentioned in the method, sulphur dioxide may interfere with determination of certain species and it may be necessary to introduce a scrubbing system as described in USEPA Method 16.

# <u>USEPA Method 11</u> Determination of hydrogen sulphide content of fuel gas streams in petroleum refineries

Although the title of this method implies fairly restrictive application, in theory it should be applicable to determination of hydrogen sulphide in a wider range of source types, provided proper attention is paid to potential interfering species. The sampling train is essentially similar to that described in the scaled-up ambient methods for hydrogen sulphide described below, although it employs midget impingers and a hydrogen peroxide scrubbing system to remove sulphur dioxide. Cadmium sulphate is used as the absorbing medium and final determination is by iodometric titration.

#### Hydrogen sulphide by scaled up ambient methodology

Some success has been achieved using a scaled-up version of ambient sampling Method 701 in *Methods of Air Sampling and Analysis*, (ed J P Lodge). The midget impinger is replaced by Greenburg Smith impingers and the volume of absorbent increased to 100 ml. The cadmium sulphate solution of the original method is replaced by zinc acetate, which is significantly less toxic. Although final analysis can be by conventional iodometric titrimetry, methylene blue derivitisation and colorimetric determination is more sensitive and specific, although special precautions are necessary if significant sulphite concentration from dissolved sulphur dioxide is present. This method must undergo side-by-side trials according to USEPA Method 301 before it can be adopted as a recommended compliance monitoring method.

#### Methyl mercaptan by scaled-up ambient methodology

Similarly, methyl mercaptan can be sampled by scaling up Method 118 in *Methods of Air Sampling and Analysis*, (ed J P Lodge). Again the midget impinger absorbent system is replaced by two Greenburg Smith impingers, each containing 100 ml of mercuric acetate absorbing solution. Derivitisation with methylene blue is followed by colorimetric determination as described in the original method. As with the previous method, this process must be validated using USEPA Method 301.

# 10.3.2 Determination of reduced sulphur compounds as sulphur dioxide

USEPA Method 16A Determination of total reduced sulphur emissions from stationary sources (impinger technique)

In this method a gas sample is extracted from the source, and sulphur dioxide is removed from the sample using a citrate buffer solution. Reduced sulphur compounds are then thermally oxidised to sulphur dioxide, collected in hydrogen peroxide as sulphate and analysed by titration with barium salts using thorin as an end point indicator.

Important aspects associated with the sampling train are:

- Reduced sulphur compounds other than the four principal components (e.g. carbonyl sulphide) will also be oxidised to sulphur dioxide.
- Train components minimise initial moisture condensation and interaction with reduced sulphur species.
- Calcium carbonate particulate matter can cause significant positive interferences, hence the requirement for an efficient particulate removal system early in the train.
- The tube furnace providing thermal oxidation must operate at 800°C.
- A sampling event comprises three one-hour sampling runs or a single three-hour run.
- System performance must be checked after each sampling. This involves sampling a known quantity of hydrogen sulphide gas and demonstrating efficient recovery.

• Excess oxygen must be present to ensure complete thermal oxidation of the reduced sulphur species.

#### USEPA Method 16B- Determination of reduced sulphur emissions from stationary sources

This method is similar to USEPA Method 16A except that after oxidation, the sulphur dioxide gas is diluted and transferred to a gas chromatograph with flame photometric detector for final determination.

## 10.4 Recommendations

#### 10.4.1 Species-specific methods

Environment Canada Reference Method EPS 1/RM/6 is routinely used at both of New Zealand's kraft pulp production plants for individual reduced sulphur species determination. It has proved to be a relatively simple method for sample acquisition. Both it and USEPA Method 16, however, require sophisticated sulphur analysis equipment on-site at the time of sampling, and this may prove a limitation for their widespread use.

The modified ambient procedures (impinger techniques) for hydrogen sulphide and methyl mercaptan are simple, sensitive methods for a variety of emission sources, but require validation.

### 10.4.2 Conversion of reduced sulphur species to sulphur dioxide methods

USEPA Method 16A has the advantage of producing stable samples which do not require immediate analysis. Sampling trains for this method are now available commercially. Tasman Pulp and Paper Ltd operate a continuous analysis system on the lines of USEPA Method 16B on their principal stacks as part of their compliance monitoring system and this approach is to be encouraged for major sources.

Care must be taken in expressing the results of analysis. Individual species determination is relatively straightforward, with concentration results expressed as ppmv or  $mg/m^3$  at standard temperature, pressure and on a dry gas basis, with correction to a fixed oxygen or carbon dioxide stack gas concentration if appropriate. When dilution systems are used, as in continuous monitoring systems, it will be necessary to incorporate an additional correction to account for the fact that analysis has been conducted on a wet gas basis.

# 11 Corrections (CO<sub>2</sub> etc)

## 11.1 Introduction

Since gas volumes are affected by pressure and temperature, careful specification of these parameters is required when expressing concentration of contaminants (e.g. particulate 250 mg/m<sup>3</sup>). Any emission limit having a m<sup>3</sup> term must have a qualifier for its conditions. The one most commonly used is 0°C, 1 atmosphere pressure and dry. In addition to these, combustion processes often have qualifications to correct the volume for a given oxygen or carbon dioxide content in the flue gases. The most common of these would be a correction to 12% CO<sub>2</sub> applied to most boiler systems.

The purpose of the  $CO_2$  or  $O_2$  correction is effectively to add or remove dilution air to a set condition. This allows fair comparison of emission limits between companies and prevents companies from achieving consent conditions by adding dilution air to the combustion process.

This Chapter will explain the corrections and detail how they are calculated.

# 11.2 Correcting for carbon dioxide (CO<sub>2</sub>)

In general this correction applies only for combustion processes. Some processes are combustion related but are not considered appropriate for a  $CO_2$  correction. Examples of these are asphalt plants and cement works.

The  $CO_2$  figure used as a reference point is normally 12 percent. This figure has been used in the past because it represents a typical  $CO_2$  concentration found in boilers running under approximately optimum conditions. The correction is very simple to apply and is calculated by the following:

Corrected emission = measured emission X 12% / (measured  $CO_2$ )%

# 11.3 Correcting for oxygen (O<sub>2</sub>)

This is an alternative correction to the  $CO_2$  approach above. The reasoning is identical and the correction is calculated as follows:

Corrected emission = measured emission X (21 - reference  $O_2$ )% / (21 - measured  $O_2$ )%

It is sometimes difficult to remember which way up the equation is used. It is helpful to remember that when correcting an emission from a low  $CO_2$  to a higher  $CO_2$ , the answer will be a higher emission because excess air is removed. When correcting a high  $O_2$  to a lower  $O_2$  the corrected emission will again be higher because, as before, excess air is removed. In the absence of combustion,  $CO_2$  can be considered to be zero and oxygen can be considered to 21 percent.

For incineration processes a correction to 11 percent oxygen is common both in New Zealand and overseas. The most common correction used in the past is for boiler systems which have traditionally been corrected to  $12 \% CO_2$ .

# 12 Visible Emissions

Measurement of visible emissions can be of considerable assistance to councils and process operators. Results from opacity monitors can be sent to councils routinely to show compliance.

## 12.1 Opacity

Opacity monitors range in cost from a few thousand dollars to many tens of thousands. The simple systems consist of a light source one side of a stack and a detector at the other. Obstructions between the two (e.g. smoke) will result in less light falling on the detector. A signal is then received on the instrument and is normally recorded as percent obscuration. The system can be calibrated using neutral density filters which are placed in the path to simulate opacity readings.

The higher cost instruments normally claim to measure particles by a light scattering technique. It is often claimed that particulate concentration can be measured in this way. Each installation must be calibrated using gravimetric particulate sampling methods as outlined above. If this is done, continuous approximate measurements of particulate are possible.

## 12.2 Ringelmann numbers

The assessment of smoke density using Ringelmann numbers is largely outdated. Ringelmann charts are made up of black lines of differing thickness on white card. The black lines are organised to obscure the white card by 0, 20, 40, 60, 80 and 100 percent. These then represent Ringelmann 0, 1, 2, 3, 4 and 5 respectively. Thus R0 is a clear stack and R5 is 100 percent obscured. The system was devised by Professor Ringelmann of Paris towards the end of the nineteenth century to assess visible emissions from stacks emitting **black** smoke. This method cannot be used for measuring emissions of white smoke. The charts must be viewed from a distance so that the black lines on the white card appear as shades of grey. The system was adopted as a British Standard in 1958 and now includes a miniature Ringelmann chart (1969) printed in shades of grey and designed to be held 1.5 m away from the observer's eye or, in practice, at arms length. To make the measurement, the chart is held against the top of the stack and a comparison made between the greyness of the smoke and the shades of grey on the chart.

In 1972 an Addendum was written to cover the relationship between Ringelmann numbers and in-stack optical monitors. For example Ringelmann 1 is in most cases equivalent to 5 percent obscuration.

## 12.3 Visual assessments

USEPA Method 9 allows for the visual measurement of smoke densities from stationary sources. The method requires that observers be trained to recognise plume opacities. Once this has been done, a trained observer will read the smoke plume over a test period and report the results.

This method is currently not available in New Zealand since we do not have access to a smoke generator capable of producing plumes of any required opacity.

# 12.4 Recommendations

USEPA Method 9 is recommended for the assessment of smoke density, although the method cannot be followed until suitable training facilities are available in New Zealand

USEPA Method 9 is preferred over the Ringelmann method. In cases where the Ringelmann method is used, it should be applied for the assessment of black smoke only.

A more detailed discussion of the use of the Ringelmann method, opacity and obscuration values is provided in a paper by Ron Pilgrim in Appendix C.

#### Main Points and Recommendations from Chapters 4 to 12

- ISO Method 9096: 1992(E), ISO Method 10780: 1994 (E), USEPA Method 1 or AS 4323.1 1995 are recommended methods for in-stack sample point selection.
- 2. ISO 9096: 1992(E), ISO Method 10780: 1994 (E), USEPA Methods 3 and 4 are recommended for stack velocity and bulk stack gas property determination.
- 3. Electrochemical cell devices are seen as suitable screening techniques for in-stack  $NO_x$  and  $SO_2$  determination
- 4. A continuous chemiluminescent analysis technique such as ISO 10396:1993(E) or USEPA Method 7E is recommended as the standard NO<sub>x</sub> sampling method for significant sources.
- 5. For small to medium sources ISO Method 7934:1989(E), or USEPA Methods 6 or 8 are recommended for sulphur dioxide or sulphur oxides determination.
- 6. USEPA Method 18 is recommended for solvent monitoring under appropriate conditions.
- Methods compatible with the requirements of ISO 9096: 1992(E) such as ASTM Method D3685-78, AS 4323.2-1995 or USEPA Methods 5 and 17 and the BCURA cyclone probe sampling train are methods recommended depending on source conditions.
- 8. For species specific reduced sulphur compound determination, Environment Canada Reference Method EPS 1/RM/6 and USEPA Method 16 are recommended compliance monitoring methods. Wet chemical impinger techniques based on ambient monitoring principles may be suitable for individual determination of hydrogen sulphide and methyl mercaptan provided suitable validation is carried out. USEPA Method 16A and the continuous monitoring system principles of USEPA Method 16B are recommended for total reduced sulphur determination.
- 9. USEPA Method 9 is recommended for the assessment of smoke density. The Ringelmann system for assessing smoke density is applicable to sources emitting black smoke only.
- 10. Only a few reliable screening methods have been considered in this document. Effort should be directed to developing simple, inexpensive screening technologies that are able to conform to acceptable accuracy and precision parameters and assessing the viability of any current industry screening practices.

# Appendix A: Sections 88 and 108 of the Resource Management Act (1991)

#### **Application for Resource Consent**

88. Making an application-

(1) Any person may, in the manner set out in subsection (4), apply to the relevant local authority for a resource consent.

(2) No application shall be made for a resource consent—

(a) For a prohibited activity; or

(b) For any activity described as a prohibited activity by a proposed plan once the time for making or lodging submissions or appeals against the proposed rule has expired and—

(i) No such submissions or appeals have been made or lodged; or

(ii) All such submissions and appeals have been withdrawn or dismissed.

(3) An application may be made for a resource consent—

(a) For a controlled activity or a discretionary activity or a non-complying activity, under a plan or proposed plan; or

(b) Where there is no plan or proposed plan, for an activity for which a consent is required under Part III.

(4) [Subject to subsection (5), an] application for a resource consent ... shall be in the prescribed form and shall include—

(a) A description of the activity for which consent is sought, and its location; and

(b) An assessment of any actual or potential effects that the activity may have on the environment, and the ways in which any adverse effects may be mitigated; and

(c) Any information required to be included in the application by a plan or regulations; and

(d) A statement specifying all other resource consents that the applicant may require from any consent authority in respect of the activity to which the application relates, and whether or not the applicant has applied for such consents; and

(e) Where the application is for a subdivision consent, the information specified in section 219.

[(5) The assessment required under subsection (4)(b) in an application for a resource consent relating to a controlled activity, or a discretionary activity over which the local

authority has restricted the exercise of its discretion, shall only address those matters specified in a plan or proposed plan over which the local authority has retained control, or to which the local authority has restricted the right to exercise its discretion, as the case may be.]

(6) Any assessment required under subsection (4)(b) or subsection (5)—

(a) Shall be in such detail as corresponds with the scale and significance of the actual or potential effects that the activity may have on the environment; and

(b) Shall be prepared in accordance with the Fourth Schedule.

(7) Without limiting subsection (4) or section 92, an application for a resource consent for reclamation shall be accompanied by adequate information to accurately show the area proposed to be reclaimed, including its size and location, and the portion of that area (if any) to be set apart as an esplanade reserve under section 246(3).

#### Section 108. Conditions of resource consents

[(1) Except as expressly provided in this section and subject to any regulations, a resource consent may be granted on any condition that the consent authority considers appropriate, including any condition of a kind referred to in subsection (2).

[(2) A resource consent may include any one or more of the following conditions:

(a) Subject to subsection (10), a condition requiring that a financial contribution be made:

(b) A condition requiring that a bond be given in respect of the performance of any one or more conditions of the consent, including any condition relating to the alteration or the removal of structures on the expiry of the consent:

(c) A condition requiring that services or works, including (but without limitation) the protection, planting, or replanting of any tree or other vegetation or the protection, restoration, or enhancement of any natural or physical resource, be provided:

(d) In respect of any resource consent (other than a subdivision consent), a condition requiring that a covenant be entered into, in favour of the consent authority, in respect of the performance of any condition of the resource consent (being a condition which relates to the use of land to which the consent relates):

(e) Subject to subsection (8), in respect of a discharge permit or a coastal permit to do something that would otherwise contravene section 15 (relating to the discharge of contaminants) or section 15B, a condition requiring the holder to adopt the best practicable option to prevent or minimise any actual or likely adverse effect on the environment of the discharge and other discharges (if any) made by the person from the same site or source:

(f) In respect of a subdivision consent, any condition described in section 220 (notwithstanding any limitation on the imposition of conditions provided for by section 105(1)(a) or (b)):

(g) In respect of any resource consent for reclamation granted by the relevant consent authority, a condition requiring an esplanade reserve or esplanade strip of any specified width to be set aside or created under Part X:

(h) In respect of any coastal permit to occupy any part of the coastal marine area (relating to land of the Crown in the coastal marine area or land in the coastal marine area vested in the regional council), a condition—

(i) Detailing the extent of the exclusion of other persons:

(ii) Specifying any coastal occupation charge.]

[(3) A consent authority may include as a condition of a resource consent a requirement that the holder of a resource consent supply to the consent authority information relating to the exercise of the resource consent. [(4) Without limiting subsection (3), a condition made under that subsection may require the holder of the resource consent to do one or more of the following:

(a) To make and record measurements:

(b) To take and supply samples:

(c) To carry out analyses, surveys, investigations, inspections, or other specified tests:

(d) To carry out measurements, samples, analyses, surveys, investigations, inspections, or other specified tests in a specified manner:

(e) To provide information to the consent authority at a specified time or times:

(f) To provide information to the consent authority in a specified manner:

(g) To comply with the condition at the holder of the resource consent's expense.

[(5) Any conditions of a kind referred to in subsection (3) that were made before the commencement of this subsection, and any action taken or decision made as a result of such a condition, are hereby declared to be, and to have always been, as valid as they would have been if subsections (3) and (4) had been included in this Act when the conditions were made, or the action was taken, or the decision was made.]

(6) Any condition under subsection [(2)(b)] may, among other things,—

(a) Require that the bond be given before the consent may be exercised or at any other time:

(b) Require that section 109(1) apply to the bond except in the case of a land use consent or a subdivision consent:

(c) Provide that the holder of the resource consent remains liable under this Act for any breach of conditions of the consent which occur before the expiry of the consent and for any adverse effects on the environment which become apparent during or after the expiry of the consent:

(d) Require the holder of the resource consent to provide such security as the consent authority thinks fit for the performance of any condition of the bond:

(e) Without limiting paragraph (d), require the holder of the resource consent to provide a guarantor (acceptable to the consent authority) to bind itself to pay for the carrying out and completion of any condition in the event of any default of the holder or any occurrence of any adverse environmental effect requiring remedy:

(f) Provide that the bond may be varied or cancelled or renewed at any time by agreement between the holder and the consent authority.

(7) Any condition under subsection [(2)(d)] may, among other things, provide that the covenant may be varied or cancelled or renewed at any time by agreement between the consent holder and the consent authority.

(8) Before deciding to grant a discharge permit or a coastal permit to do something that would otherwise contravene section 15 (relating to the discharge of contaminants) subject to a condition described in subsection [(2)(e)], the consent authority shall be satisfied that, in the particular circumstances and having regard to—

(a) The nature of the discharge and the receiving environment; and

(b) Other alternatives, including any condition requiring the observance of minimum standards of quality of the receiving environment—

the inclusion of that condition is the most efficient and effective means of preventing or minimising any actual or likely adverse effect on the environment.

[(9) In this section, "financial contribution" means a contribution of-

(a) Money; or

(b) Land, including an esplanade reserve or esplanade strip (other than in relation to a subdivision consent), but excluding Maori land within the meaning of the Maori Land Act 1993 unless that Act provides otherwise; or

(c) A combination of money and land.

[(10) A consent authority must not include a condition in a resource consent requiring a financial contribution unless—

(a) The condition is imposed in accordance with the purposes specified in the plan (including the purpose of ensuring positive effects on the environment to offset any adverse effect); and

(b) The level of contribution is determined in the manner described in the plan.]

# Appendix B: Example Worksheets

## B1 Superphosphate Fertiliser Works

The application is for an existing operation consisting of a 250 tonne per day sulphuric acid plant and a superphosphate acidulation plant.

The acid plant is single absorption with a guaranteed conversion efficiency of sulphur to sulphuric acid of 98 percent. The equates to a sulphur dioxide emission of about 30 g/s, and about 1.7 g/s of sulphur trioxide or acid mist.

Discharges from the superphosphate plant include fluoride and reduced sulphur compounds expressed as hydrogen sulphide. Fluoride discharges applied for in the application are 0.5 g/s , and hydrogen sulphide at 1 g/s.

Other minor discharges include hydrogen sulphide from the sulphur melters, dust from the granulators and conveyors, and dust from the rock grinders.

#### B1.1 Acid Plant Discharges

Dispersion modelling of the sulphuric acid plant shows a maximum 10-minute average of 300  $\mu$ g/m<sup>3</sup> at a distance of about 300 metres from the plant. Other modelling shows maximum one hour averages of about 100  $\mu$ g/m<sup>3</sup> and about 30  $\mu$ g/m<sup>3</sup> for 24-hour averages. The maximum 10-minute average occurs under slightly unstable meteorological conditions when the background is low.

Relevant ambient air quality guidelines are the Ministry for the Environment Ambient Air Quality Guidelines for sulphur dioxide, namely 500  $\mu$ g/m<sup>3</sup> for a 10-minute average, 350  $\mu$ g/m<sup>3</sup> for a one hour average and 125  $\mu$ g/m<sup>3</sup> for a 24-hour average.

In this application the predicted concentrations are greater than 50 percent of the guideline value under normal conditions and a minimum requirement is intermittent monitoring of sulphur dioxide. This should be carried out at a minimum of once per month. However, because the predicted ambient concentrations are sufficiently close to the guideline, ambient monitoring is advised, and continuous emission monitoring is suggested. The plant has a continuous sulphur dioxide monitor installed in the acid plant stack.

Accidental release conditions include absorber failure or loss of catalyst bed temperature both of which are best described as incomplete reaction. This implies continuous monitoring for catalyst temperature, and acid flow rate. Pressure drop is not normally monitored.

The emission control system comprises the acid absorber and fibreglass mist eliminators. There are no parameters monitored on the mist eliminators, but failure will invariably result in a visible acid mist plume. Monitoring requirements indicated therefore include;

- Visual inspection of the plume
- Acid temperature
- Acid flow

Although monitoring of pressure drop is indicated on the worksheet, this would not usually be necessary for this operation.

#### B1.2 Superphosphate Plant Discharges

The three main discharges to be considered for this plant are fluoride, odour (as hydrogen sulphide) and dust from the rock and product grinding processes.

#### B1.2.1 Fluoride

Fluoride emissions are controlled in a series of three countercurrent water scrubbers. Maximum predicted off-site ground level concentrations (MGLC's) for fluoride are summarised in the following table together with the relevant MfE guidelines

Averaging Time	Guideline ( $\mu g/m^3$ )	MGLC ( $\mu g/m^3$ )
12 hours	3.7	0.2
24 hours	2.6	1.15
7 days	1.7	0.12
90 days	0.25	0.1

MGLC's are well below the guideline values, and only intermittent emission monitoring is required. Ambient monitoring for fluoride is not indicated, but the company has agreed to carry out monitoring for a two-year period to verify the modelling predictions.

There is no potential for a major accidental release other than from an air pollution control system failure. This is covered in Part 3 of the worksheet. The three stage scrubber includes high pressure pumps for scrubbing liquor recycle, and parameters to be monitored include scrubber liquor flow rate, pump pressure, and liquor temperature. Visual inspection of the plume is also indicated for this plant, but will only serve to show that the scrubber is operating at normal temperature and liquor flow rates. This requirement can be optionally deleted.

Emission monitoring records show that even though the permit application is for a discharge concentration of 50 mg/m<sup>3</sup> in the stack gases, normal levels are below 30 mg/m<sup>3</sup>. There is no history of non-compliance.

#### B1.2.2 Odour

The odour is a complex mixture of a large number of reduced sulphur compounds, released in the scrubber exhaust. There is no potential for an accidental release other than a scrubber failure. Monitoring of scrubber performance is recommended. Additional odour monitoring requirements are outside the scope of this document. For further information about odour, consult "Odour Management under the Resource Management Act" produced by the Ministry for the Environment (1995).

#### B1.2.3 Particulate

All particulate discharges from the rock and product grinding operations are controlled with fabric filters. Only one example is provided in this instance. Maximum predicted particulate deposition has been modelled by the applicant with all sources contributing. The maximum rate of deposition is predicted to be about 2 g per square metre per 30 days. There is no guideline value for deposition, but commonly used guidelines include those from the State of Victoria (4 g/m<sup>2</sup> per 30 days) and in the United States (5 g/m<sup>2</sup> per 30 days). In this instance the Victorian guideline is considered appropriate.

The predicted levels are about half of the guideline at one or two locations, but well below it for most locations around the plant. Therefore a decision to treat it as less than half has been made. Emission monitoring is indicated as intermittent only. There is no potential for a major release.

The emission control system comprises a reverse pulse fabric filter. Intermittent visual inspection of the plume is indicated. However this need only be carried out if there is a problem with visible emissions. Temperature monitoring is indicated, but not required in this application, as the gas stream is only about 40°C and does not vary. Pressure drop across the bag filter is required to warn of potential failure. This is checked on a weekly basis as part of the maintenance program.

There is no history of non-compliance with particulate discharges.

DETAILS							
SITE:ABC Fertiliser	<u>Co.</u>	SOURCE:	Aci	id Plant			
SPECIES NAME:	Sulphur dioxide,_	<u>    10 r</u>	nin. averag	<u>es</u>			
PROCESS DESCRIPTION:	Sulphuric acid ma	anufacture_					
	Single absorption contact plant						
LOCAL ENVIRONMENT:	Industrial with son	ne residenti	al				
POTENTIAL EFFECTS:	HEALTH ODOUR DEPOSITION OTHER (_	VEG	GETATION	VISIBILITY )			
1. EFFECTS UNDER NORM	IAL OPERATING COND	TIONS					
EMISSION CONCENTRATION:	0.18% mg/m <sup>3</sup>	3 EMISSION	NRATE:	<u>30</u> g/s			
SPECIES		<b>S0</b> <sub>2</sub>	$\cap$				
MAXIMUM PREDICTED GLC FOR	THIS SOURCE <sup>A</sup> : (a)	<u>300</u>	µg/m³	g/m²/30days			
BACKGROUND CONCENTRATION	<sup>в</sup> . (b)		µg/m³	g/m²/30days			
TOTAL MAXIMUM GLC	(a) + (b)	300	µg/m³	g/m²/30days			
MAXIMUM ALLOWABLE GLC <sup>C</sup> :	(c)	500	ug/m <sup>3</sup>	g/m²/30days			
IS (a+b)<0.5(c)? Mon	itorina requirements $\Rightarrow$	5H		G0 T0 2			
IS (a+b)>0.5(c)? ✔ Mon	itoring requirements $\Rightarrow$	5H consider gre	ater frequency	GO TO 2			
		or continuous m	onitoring, and a	ambient monitoring			
2. EFFECTS UNDER ACCIE	DENTAL RELEASE CON	DITIONS					
IS THERE POTENTIAL FOR A MAJ	OR ACCIDENTAL RELEASE? <sup>E</sup>	🗸 Yes	i	NO			
IF NO, GO TO 3							
IF YES, COMPLETE SECTION BEL	OW THEN GO TO 3						
RUN-AWAY REACTION	Monitoring requirem	ents $\Rightarrow$ 5T,	5U, 5V				
PRESSURE VESSEL FAILURE	Monitoring requirem	ents $\Rightarrow$ 5T,	5U, 5V				
	Monitoring requirem	ents ⇒ 5V					
	Monitoring requirem	$ents \Rightarrow 51,$	50, 5V				
OTHER (	) Monitoring requirem	ents ⇒ snei	cify:				
	,	<b>-</b> • • • • • • • • • • • • • • • • • • •	··· <i>y</i> ·				

3. EMIS	SION CONTROL SYSTEMS				
ARE THE	EMISSIONS CONTROLLED USING	AIR POLLUTION CONTROL	EQUIPMENT?	🖌 YES	NO
IF YES, COM	PLETE SECTION BELOW <sup>F</sup>				
🗸 SCRU	BBER	Monitoring requirements $\Rightarrow$	5B, 5T, 5U, 5	5V	
BAGH	OUSE	Monitoring requirements $\Rightarrow$	5B, 5T, 5U, 5	ōΖ	
AFTER	RBURNER	Monitoring requirements $\Rightarrow$	51, 5N, 5T		
CYCL	ONE/MULTICYCLONE	Monitoring requirements $\Rightarrow$	5B, 5N, 5V, 5	5Z	
ELEC	TROSTATIC PRECIPITATOR	Monitoring requirements $\Rightarrow$	5B, 5N, 5O,	5T, 5V, 5W, 5X,	5Y, 5Z
BIOFIL	TER	Monitoring requirements $\Rightarrow$	5U, 5T, 5Z		
✓ OTHE	R ( <u>Absorber</u> )	Monitoring requirements $\Rightarrow$	·	_5_L	
4. HIST	ORICAL PERFORMANCE				
FOR NEW SO	URCES GO TO 5				
FOR EXISTIN	G SOURCES COMPLETE SECTION	IBELOW			
IS THERE A H	IISTORY OF NON-COMPLIANCE W	ITH EXISTING EMISSION LIN	MITS OR ACCIDE	NTAL RELEASE	S?
YES	(specify:				<u>)</u>
✓ <sub>NO</sub>					
IF YES, THEN	I CONSIDERATION SHOULD BE G	VEN TO INCREASED FREQU	UENCY OF EMISS	SION MONITOR	ING, AND PROCESS
PARAMET	ER MONITORING. THIS MAY INC	LUDE CONTINUOUS MONITO	ORING REQUIREI	MENTS.	
5. RECOM	MENDED MONITORING RE	QUIREMENTS <sup>G</sup> (ALL W	ORKSHEETS	)	
Emissions	Monitoring <sup>⊬</sup>			FREQ	UENCY
5A	No emissions monitoring re-	quired			
🖌 5B	Intermittent visual inspection	n of plume (e.g. daily)			
5C	Intermittent monitoring for C	$P_2$ or CO <sub>2</sub> (e.g. annual or	6-monthly)		
5D	Intermittent monitoring for C	O (e.g. annual or 6-mon	nthly)		
5E	Intermittent monitoring for N	O2 (e.g. annual or 6-moi	nthly)		
🖌 5F	Intermittent monitoring for S	O <sub>2</sub> (e.g. annual or 6-mor	nthly)	Mont	hly
5G	Intermittent monitoring for p	articulate (e.g. annual or	r 6-monthly)		
✓ 5H	Intermittent monitoring (spe	cies:S <u>0</u> 2	)	Mont	hly
51	Continuous monitoring for C	$O_2$ or $O_2$			
5J	Continuous monitoring for C	0			
5K	Continuous monitoring for N	O <sub>2</sub>			
✓ 5L	Continuous monitoring for S	O <sub>2</sub>			
5M	Continuous monitoring for p	articulate			
5N	Continuous opacity/obscura	tion monitoring			
50	Continuous humidity monito	ring			
5P	Continuous monitoring (spe	cies:	)		
5Q					
Process	s Monitoring <sup>⊬</sup>				
5R	No process monitoring requ	ired			
_5S	Intermittent fuel analysis (e.	g. monthly)			
<b>√</b> 5⊤	Continuous monitoring for te	emperature		Absorbe	r & Catalyst
5U	Continuous monitoring for p	ressure drop across con	ntrol equipment	Absorbe	r acid
✓ 5V	Continuous monitoring of in	et/outlet flow rates (or su	urrogate)	Absorbe	r acid
5W	Continuous voltage monitor	ng			
5X	Continuous current monitori	ng			
5Y	Continuous spark over mon	itorina			

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	5Z	Intermittent visual inspection (specify:)	
	5AA		
	5BB		
Ambi	ent Mo	onitoring	
	5CC	No ambient monitoring required	
	5DD	CO monitoring	
	5EE	NO <sub>2</sub> monitoring	
$\checkmark$	5FF	SO <sub>2</sub> monitoring	One year programme
	5GG	TSP monitoring	
	5HH	Deposited particulate monitoring	
	511	Monitoring (species:)	
	5JJ	Biological monitoring (specify:)	
	5KK		

#### **ADDITIONAL NOTES**

#### NOTES

- A Maximum ground level concentrations (GLCs) should be provided by the applicant as part of the assessment of environmental effects required under Section 88 (4b) of the Resource Management Act (1991). These may either be predicted downwind concentrations determined from an approved atmospheric dispersion model, or from ambient monitoring programmes. If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate maximum allowable concentration (MAC). Averaging times must be consistent for the predicted, allowable and background concentrations.
- B If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate MAC. If they have been determined from dispersion modelling and there are other significant sources close by, cumulative effects need to be included when considering background levels. Averaging times must be consistent for the predicted, allowable and background concentrations.
- C The maximum allowable ground level concentration (MAC) will depend on consent authority policy. Commonly used sources of ambient air quality guidelines include the MfE guidelines, State of Victoria DGLCs, and WHO Air Quality Guidelines. Averaging times must be consistent for the predicted, allowable, and background concentrations.
- D Contaminant concentrations exceeding the criteria specified in the worksheet indicates inadequate mitigation. In such cases it is recommended that consideration be given to what steps can be taken to reduce downwind concentrations.
- E A major accidental release is defined as one which has the potential to result in significant ad verse effects or an exceedance of a Design Ground Level Concentration (DGLC, Threshold Limit value (TLV) or other Maximum Allowable Concentration (MAC) for any time period. Consent authority will determine which system is appropriate.
- F Not all parameters will need to be monitored for all processes. The exact requirements will be dependent upon the specific application and should be discussed with the applicant and equipment manufacturer.
- G These are the recommended monitoring requirements. Other site-specific circumstances may dictate that additional or alternative requirements may be appropriate.
- H Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

DETAILS					
SITE:ABC Fer	tiliser Plant	SOUR	ce: <u>Su</u>	olant	
SPECIES NAME:	Fluoride				
PROCESS DESCRIPTION:	<u>Acidifica</u>	ation of phose	hate rock		
LOCAL ENVIRONMENT:	Industria	al with some	residential		
POTENTIAL EFFECTS:	HEALTH	ODOUR	✓ VEGETATIO	N VI	SIBILITY
	DEPOSITION	OTHER (		)	
1. EFFECTS UNDER I	NORMAL OPERATIN		IS		
EMISSION CONCENTRATION:	<u>50</u>	mg/m <sup>3</sup>	EMISSION RATE	E: <u>0'</u> 2	25g/s
SPECIES			F⁻		
MAXIMUM PREDICTED GLC	C FOR THIS SOURCE <sup>A</sup> :	(a)	0.2	µg/m³ g/m²	/30days
BACKGROUND CONCENTR	ATION <sup>B</sup> :	(b)	<u>0</u>	µg/m³ g/m²	/30days
TOTAL MAXIMUM GLC		(a) + (b)	0.2	µg/m³ g/m²	/30days
MAXIMUM ALLOWABLE GL	C <sup>c</sup> :	(c)	3.7	µg/m³ g/m²	/30days
IS (a+b)<0.5(c)?	Monitoring requirements	⇒ 5H		GO TO .	2
IS (a+b)>0.5(c)?	Monitoring requirements	$\Rightarrow$ 5H col	nsider greater freq	uency GO TO	2
		or con	tinuous monitoring	ı, and ambient moni	toring
2. EFFECTS UNDER /	ACCIDENTAL RELEA	SE CONDITIO	DNS		
IS THERE POTENTIAL FOR	A MAJOR ACCIDENTAL R	ELEASE? <sup>E</sup>	YES	✓ <sub>NO</sub>	
IF NO, GO TO 3					
IF YES, COMPLETE SECTIO	ON BELOW THEN GO TO 3	}			
RUN-AWAY REACTION	Monitorii	ng requirements	$\Rightarrow 5T, 5U, 5V$		
	ILURE Monitorii Monitorii	ng requirements	$\Rightarrow 51, 50, 5V$		
	Monitori	ng requirements	$\rightarrow$ 5V $\rightarrow$ 5T 5U 5V		
	N Monitori	na requiremente	$\rightarrow 57.511.5V$		
OTHER (	) Monitorii	ng requirements	$\Rightarrow specify: \$		
		- ,			

3. EMI	SSION CONTROL SYSTEMS	5	
ARE THE	E EMISSIONS CONTROLLED USING	AIR POLLUTION CONTROL EQUIPMENT?	YES NO
IF YES, CO	MPLETE SECTION BELOW <sup>F</sup>		
✓ <sub>SCR</sub>	UBBER	Monitoring requirements $\Rightarrow$ 5B, 5T, 5	iU, 5V
BAG	HOUSE	Monitoring requirements $\Rightarrow$ 5B, 5T, 5	5U, 5Z
AFTE	ERBURNER	Monitoring requirements $\Rightarrow$ 51, 5N, 5	Τ
CYC	LONE/MULTICYCLONE	Monitoring requirements $\Rightarrow$ 5B, 5N, 5	5V, 5Z
ELEC	CTROSTATIC PRECIPITATOR	Monitoring requirements $\Rightarrow$ 5B, 5N, 5	50, 5T, 5V, 5W, 5X, 5Y, 5Z
BIOF	FILTER	Monitoring requirements $\Rightarrow$ 5U, 5T, 5	Z
ОТН	ER ()	Monitoring requirements $\Rightarrow$	
4. HIS	TORICAL PERFORMANCE		
FOR NEW S	OURCES GO TO 5		
FOR EXISTI	NG SOURCES COMPLETE SECTIO	N BELOW	
IS THER	E A HISTORY OF NON-COMPLIANC	E WITH EXISTING EMISSION LIMITS OR A	CCIDENTAL RELEASES?
YES	(specify:		<u>)</u>
♥ NO			
IF YES, THE	N CONSIDERATION SHOULD BE G	IVEN TO INCREASED FREQUENCY OF EN	IISSION MONITORING, AND PROCES
PARAME	ETER MONITORING. THIS MAY INC	LUDE CONTINUOUS MONITORING REQUI	REMENTS.
5. RECO	MMENDED MONITORING RE	QUIREMENTS <sup>®</sup> (ALL WORKSHEE	TS)
Emission	s Monitoring <sup>⊩</sup>		FREQUENCY
5A	No emissions monitoring re	quired	
✓ 5B	Intermittent visual inspectio	n of plume (e.g. daily)	
5C	Intermittent monitoring for C	$D_2$ or $CO_2$ (e.g. annual or 6-monthly)	
5D	Intermittent monitoring for C	CO (e.g. annual or 6-monthly)	
5E	Intermittent monitoring for N	$IO_2$ (e.g. annual or 6-monthly)	
5F	Intermittent monitoring for S	$SO_2$ (e.g. annual or 6-monthly)	
5G	Intermittent monitoring for p	articulate (e.g. annual or 6-monthly)	
✓ 5H	Intermittent monitoring (spe	cies:H <u>F</u> )	Monthly
51	Continuous monitoring for (	$CO_2 \text{ or } O_2$	
5J	Continuous monitoring for (	20	
5K	Continuous monitoring for N		
5L	Continuous monitoring for S	50 <sub>2</sub>	
5M	Continuous monitoring for p		
5N	Continuous opacity/obscura	ation monitoring	
50		pring	
59	Continuous monitoring (spe	cies:)	
5Q	Manitarina <sup>H</sup>		
Proces	S Monitoring	ired	
	Intermittent fuel enclusio (e	a monthly)	Corubbor liquor
50 √ ⊑⊤	Continuous monitoring for t	g. monuny)	Sci ubbei Ilyuul
	Continuous monitoring for t	emperature	ont Scrubbor liquor
		let/outlet flow rates (or surragets)	ent Schubbel liquoi
51	Continuous monitoring of In	ing	
57	Continuous voltage monitor	ing	
AC EV		itoring	
10	Continuous spark over mor	moning	

## Page 2 of 3

	5Z	Intermittent visual inspection (specify:)	
	5AA		
	5BB		
Ambi	ent Mo	onitoring	
	5CC	No ambient monitoring required	
	5DD	CO monitoring	
	5EE	NO <sub>2</sub> monitoring	
	5FF	SO <sub>2</sub> monitoring	
	5GG	TSP monitoring	
	5HH	Deposited particulate monitoring	
	511	Monitoring (species:)	
	5JJ	Biological monitoring (specify:)	
	5KK		

#### **ADDITIONAL NOTES**

#### NOTES

- A Maximum ground level concentrations (GLCs) should be provided by the applicant as part of the assessment of environmental effects required under Section 88 (4b) of the Resource Management Act (1991). These may either be predicted downwind concentrations determined from an approved atmospheric dispersion model, or from ambient monitoring programmes. If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate maximum allowable concentration (MAC). Averaging times must be consistent for the predicted, allowable and background concentrations.
- B If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate MAC. If they have been determined from dispersion modelling and there are other significant sources close by, cumulative effects need to be included when considering background levels. Averaging times must be consistent for the predicted, allowable and background concentrations.
- C The maximum allowable ground level concentration (MAC) will depend on consent authority policy. Commonly used sources of ambient air quality guidelines include the MfE guidelines, State of Victoria DGLCs, and WHO Air Quality Guidelines. Averaging times must be consistent for the predicted, allowable, and background concentrations.
- D Contaminant concentrations exceeding the criteria specified in the worksheet indicates inadequate mitigation. In such cases it is recommended that consideration be given to what steps can be taken to reduce downwind concentrations.
- E A major accidental release is defined as one which has the potential to result in significant ad verse effects or an exceedance of a Design Ground Level Concentration (DGLC, Threshold Limit value (TLV) or other Maximum Allowable Concentration (MAC) for any time period. Consent authority will determine which system is appropriate.
- F Not all parameters will need to be monitored for all processes. The exact requirements will be dependent upon the specific application and should be discussed with the applicant and equipment manufacturer.
- G These are the recommended monitoring requirements. Other site-specific circumstances may dictate that additional or alternative requirements may be appropriate.
- H Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

DETAILS					
SITE:ABC Fer	tiliser Plant	SOU	RCE:	<u>Granulator</u>	
SPECIES NAME:	Particu	ulate			
PROCESS DESCRIPTION:	Granul	ation of produ	<u>ct</u>		
LOCAL ENVIRONMENT:	Indust	rial with some	residentia	<u> </u>	
POTENTIAL EFFECTS:	HEALTH	ODOUR	VEGET	ATION	VISIBILITY
		OTHER (			_)
1. EFFECTS UNDER	NORMAL OPERAT	ING CONDITIO	NS		
EMISSION CONCENTRATION:	<u>50</u> _	mg/m <sup>3</sup>	EMISSION I	RATE: _	<u>0`25</u> g/s
SPECIES					
MAXIMUM PREDICTED GLO	FOR THIS SOURCE <sup>A</sup> :	(a)	<u>     2                               </u>	μg/m³	g/m²/30days
BACKGROUND CONCENTR	RATION <sup>B</sup> :	(b)	<u>3</u>	μg/m <sup>3</sup>	g/m²/30days
TOTAL MAXIMUM GLC		(a) + (b)	<u>    5                                </u>	μg/m <sup>3</sup>	g/m²/30days
MAXIMUM ALLOWABLE GL	C <sup>c</sup> :	(c)	<u>     4                               </u>	μg/m³	g/m²/30days
IS (a+b)<0.5(c)?	Monitoring requirement	$nts \Rightarrow 5H$		G	O TO 2
IS (a+b)>0.5(c)?	Monitoring requirement	$nts \Rightarrow 5Hco$	onsider greater	frequency G	i0 TO 2
		OF CO	ntinuous monite	oring, and ambien	it monitoring
2. EFFECTS UNDER	ACCIDENTAL REL	EASE CONDIT	IONS		
				,	
IS THERE POTENTIAL FOR	A MAJOR ACCIDENTAI	_ RELEASE? <sup>E</sup>	YES	✓ <sub>NO</sub>	
IF NO, GO TO 3					
IF YES, COMPLETE SECTIO	ON BELOW THEN GO T	03			
RUN-AWAY REACTION	Monit	oring requirements	$\Rightarrow$ 5T, 5U,	5V	
PRESSURE VESSEL FA	ILURE Monit	oring requirements	$\Rightarrow$ 5T, 5U,	5V	
	Monit	oring requirements	⇒ 5V → 5T 5U	51/	
	N Monit	orina requirements	$\rightarrow$ 51, 50, $\Rightarrow$ 5T 511	5V	
OTHER (		oring requirements	$\Rightarrow$ specify:		
``					

3. EMIS	SSION CONTROL SYSTEMS	;			
ARE THE	EMISSIONS CONTROLLED USING	AIR POLLUTION CONTROL	EQUIPMENT?	🖌 YES	NO
IF YES, CON	IPLETE SECTION BELOW <sup>F</sup>				
SCRL	BBER	Monitoring requirements $\Rightarrow$	5B, 5T, 5U,	5V	
✓ BAGH	OUSE	Monitoring requirements $\Rightarrow$	5B, 5T, 5U,	5Z	
AFTE	RBURNER	Monitoring requirements $\Rightarrow$	5I, 5N, 5T		
CYCL	ONE/MULTICYCLONE	Monitoring requirements $\Rightarrow$	5B, 5N, 5V,	5Z	
ELEC	TROSTATIC PRECIPITATOR	Monitoring requirements $\Rightarrow$	5B, 5N, 5O,	5T, 5V, 5W, 5X	, 5Y, 5Z
BIOFI	LTER	Monitoring requirements $\Rightarrow$	5U, 5T, 5Z		
OTHE	R ()	Monitoring requirements $\Rightarrow$			
4. HIST	ORICAL PERFORMANCE				
FOR NEW SC	OURCES GO TO 5				
FOR EXISTIN	IG SOURCES COMPLETE SECTIOI	N BELOW			
IS THERE	A HISTORY OF NON-COMPLIANC	E WITH EXISTING EMISSION	I LIMITS OR ACC	DENTAL RELE	EASES?
YES	(specify:				<u>)</u>
✓ <sub>NO</sub>					
IF YES, THEN	I CONSIDERATION SHOULD BE G	IVEN TO INCREASED FREQU	JENCY OF EMIS	SION MONITOF	RING, AND PROCESS
PARAME	TER MONITORING. THIS MAY INC	LUDE CONTINUOUS MONITO	ORING REQUIRE	MENTS.	
5. RECON	IMENDED MONITORING RE	QUIREMENTS <sup>G</sup> (ALL W	ORKSHEET	5)	
Emissions	Monitoring <sup>⊬</sup>	-		FREG	QUENCY
5A	No emissions monitoring re	quired			
✓ 5B	Intermittent visual inspection	n of plume (e.g. daily)			
5C	Intermittent monitoring for C	$O_2$ or $CO_2$ (e.g. annual or	6-monthly)		
	•		• •		
5D	Intermittent monitoring for C	O (e.g. annual or 6-mon	thly)		
5D 5E	Intermittent monitoring for C Intermittent monitoring for N	$O$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mo	thly) nthly)		
5D 5E 5F	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor $IO_2$ (e.g. annual or 6-mor	thly) nthly) nthly)		
5D 5E 5F 5G	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or	thly) nthly) nthly) <sup>.</sup> 6-monthly)		
5D 5E 5F 5G ✔ 5H	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe	O (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies:	thly) nthly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C	O (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mon articulate (e.g. annual or cies: $O_2$ or $O_2$	thly) nthly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C Continuous monitoring for C	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ CO	thly) nthly) nthly) · 6-monthly) )		
5D 5E 5G ✓ 5H 5I 5J 5K	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C Continuous monitoring for C	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$	thly) nthly) nthly) 6-monthly)		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ $IO_2$ $IO_2$ $IO_2$	thly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for S	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ $IO_2$ $IO_2$ $IO_2$ $IO_2$ articulate	thly) nthly) • 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous monitoring for p	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ $IO_2$ articulate tion monitoring	thly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5O	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p	CO (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $CO_2$ or $O_2$ $CO_2$ $O_2$ $O_2$ articulate tion monitoring bring	thly) nthly) • 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5O 5P	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring for Q Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ $IO_2$ articulate tion monitoring oring cies:	thly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5N 5N 5O 5P 5Q	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous monitoring for p	CO (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $CO_2$ or $O_2$ $CO_2$ or $O_2$ $CO_2$ $CO_2$ articulate tion monitoring oring cies:	thly) nthly) • 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5O 5P 5Q <b>Process</b>	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous opacity/obscura Continuous humidity monitor Continuous monitoring (spe	C (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $O_2$ or $O_2$ $O_2$ $O_2$ articulate tion monitoring oring cies: 	thly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 50 5P 5Q <b>Process</b> 5R	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous monitoring for p	CO (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mon $O_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $O_2$ or $O_2$ $O_2$ or $O_2$ $O_2$ $O_2$ articulate tion monitoring oring cies: 	thly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5O 5P 5Q <b>Process</b> 5R 5S	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring (spe Continuous monitoring for C Continuous monitoring for C Continuous monitoring for S Continuous monitoring for S Continuous monitoring for p Continuous opacity/obscura Continuous humidity monito Continuous monitoring (spe 	C (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ $IO_2$ articulate tion monitoring oring cies: $IO_2$	thly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5O 5P 5Q Process 5R 5S 5T	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for S Continuous monitoring for p Continuous monitoring (spe	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ $IO_2$ $IO_2$ $IO_2$ $IO_2$ articulate tion monitoring oring cies: $IO_2$	thly) nthly) · 6-monthly) )		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5O 5P 5Q <b>Process</b> 5R 5S 5T 5U	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring for p Continuous monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous opacity/obscura Continuous humidity monito Continuous monitoring (spe	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ IO	thly) nthly) · 6-monthly) )	 	
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5N 5O 5P 5Q <b>Process</b> 5R 5S 5T 5U 5V	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous humidity monito Continuous monitoring (spe Monitoring <sup>H</sup> No process monitoring requ Intermittent fuel analysis (e. Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ $IO_2$ $IO_2$ $IO_2$ articulate tion monitoring cies: $IO_2$ ired g. monthly) emperature ressure drop across con let/outlet flow rates (or su	thly) nthly) · 6-monthly) ) ) 	 	
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5O 5P 5Q Process 5R 5S 5T ✓ 5U 5V 5W	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring for C Continuous monitoring for C Continuous monitoring for C Continuous monitoring for S Continuous monitoring for S Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous humidity monitor Continuous monitoring (spe Monitoring <sup>H</sup> No process monitoring requi Intermittent fuel analysis (e. Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ IO	thly) nthly) · 6-monthly) ) ) ) 		
5D 5E 5F 5G ✓ 5H 5I 5J 5K 5L 5M 5N 5N 5O 5P 5Q <b>Process</b> 5R 5S 5T 5U 5V 5V 5W 5X	Intermittent monitoring for C Intermittent monitoring for N Intermittent monitoring for S Intermittent monitoring for p Intermittent monitoring for C Continuous monitoring for C Continuous monitoring for N Continuous monitoring for S Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous humidity monito Continuous humidity monito Continuous monitoring (spe Monitoring <sup>H</sup> No process monitoring requ Intermittent fuel analysis (e. Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous monitoring for p Continuous monitoring of in Continuous voltage monitor	CO (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mon $IO_2$ (e.g. annual or 6-mor articulate (e.g. annual or cies: $IO_2$ or $O_2$ $IO_2$ IO	thly) nthly) · 6-monthly) ) ) ) 	 	

Page 2 of 3

	5Z	Intermittent visual inspection (specify:)	
	5AA		
	5BB		
Ambi	ent Mo	onitoring	
	5CC	No ambient monitoring required	
	5DD	CO monitoring	
	5EE	NO <sub>2</sub> monitoring	
	5FF	SO <sub>2</sub> monitoring	
	5GG	TSP monitoring	
	5HH	Deposited particulate monitoring	
	511	Monitoring (species:)	
	5JJ	Biological monitoring (specify:)	
	5KK		

#### **ADDITIONAL NOTES**

#### NOTES

- A Maximum ground level concentrations (GLCs) should be provided by the applicant as part of the assessment of environmental effects required under Section 88 (4b) of the Resource Management Act (1991). These may either be predicted downwind concentrations determined from an approved atmospheric dispersion model, or from ambient monitoring programmes. If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate maximum allowable concentration (MAC). Averaging times must be consistent for the predicted, allowable and background concentrations.
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- C The maximum allowable ground level concentration (MAC) will depend on consent authority policy. Commonly used sources of ambient air quality guidelines include the MfE guidelines, State of Victoria DGLCs, and WHO Air Quality Guidelines. Averaging times must be consistent for the predicted, allowable, and background concentrations.
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- E A major accidental release is defined as one which has the potential to result in significant ad verse effects or an exceedance of a Design Ground Level Concentration (DGLC, Threshold Limit value (TLV) or other Maximum Allowable Concentration (MAC) for any time period. Consent authority will determine which system is appropriate.
- F Not all parameters will need to be monitored for all processes. The exact requirements will be dependent upon the specific application and should be discussed with the applicant and equipment manufacturer.
- G These are the recommended monitoring requirements. Other site-specific circumstances may dictate that additional or alternative requirements may be appropriate.
- H Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

## **B2** Abrasive Blasting

The application is for a new abrasive blasting plant with a fully enclosed blasting booth. The applicant wishes to discharge up to 5 m<sup>3</sup>/s (corrected to 0°C) of cleaned ventilation air from the booth. The air handling system includes a grit recycle cyclone, ducting, a reverse pulse-jet fabric filter, and an induced draught fan discharging through a 10 meter high stack.

Information provided in the application quotes the supplier of the fabric filter as guaranteeing a particulate discharge of less than 25 mg/m<sup>3</sup>. Only steel grit is proposed as the abrasive medium. No monitoring has been proposed in the application. Information provided in the assessment of effects shows that the operation will be located in an industrial zone with heavy industry generally dominating the area.

#### B2.1 Normal Operating Conditions

The applicant has indicated that the plant will operate with less than 25 mg/m<sup>3</sup> (corrected to 0°C) in the stack exit. This equates to 0.125 g/s. Of this, only 20 percent is expected to be  $PM_{10}$  material (inhalable particulate matter less than 10µm in diameter).

Dispersion modelling provided in the application shows that the maximum downwind total suspended particulate (TSP) concentration for a three minute average is  $36 \ \mu g/m^3$  for all meteorological conditions and of this,  $7 \ \mu g/m^3$  is PM<sub>10</sub>. This occurs about 20 m from the stack but not off the site. The maximum off-site three-minute average TSP concentration is  $20 \ \mu g/m^3$  ( $4 \ \mu g/m^3 \ PM_{10}$ ). Modelling predictions provided with the application indicate that the maximum 24 hour average TSP will be between 20 and  $30 \ \mu g/m^3$  including background.

Maximum allowable GLC's include EPA Victoria's TSP standard of 330  $\mu$ g/m<sup>3</sup> (3-minute average), and the Ontario standard of 100  $\mu$ g/m<sup>3</sup> (30-minute point of impingement limit) for particulate matter less than 44  $\mu$ m aerodynamic diameter. The Ministry for the Environment Guideline is 120  $\mu$ g/m<sup>3</sup> for a 24-hour average for PM<sub>10</sub>.

It is Council policy to use the State of Victoria DGLC's and the MfE guidelines. Background TSP concentrations in the area range between 10 -  $15 \,\mu g/m^3$ .

For this application, both the TSP and  $PM_{10}$  maximum ground level concentrations are less than 0.5 of the maximum allowable concentrations (refer to attached worksheet). Monitoring requirements are therefore indicated as 5B, namely intermittent monitoring for particulate. For a bag filter unit, emissions do not normally change dramatically with time, unless there is a major bag failure, and a life of about 5 years would be expected from the bags before replacement is required. Particulate monitoring at commissioning is advised, and thereafter every two years.

#### B2.2 Accidental Release Conditions

There are no major release scenarios in this category which could occur from the site. However a bag failure will result in a discharge and is considered in the next section.

## B2.3 Emission Control Systems

The discharges are controlled by a bag filter system and therefore the following additional monitoring requirements are recommended:

- Daily inspection of the discharge
- Continuous monitoring for pressure drop across the baghouse to warn of broken bags
- Weekly visual inspection of the bags for wear and tear, or breaks.

DETAILS				
SITE:Nitty Gri	ty Blasting Co.	SOURCE	E:Blast b	booth
SPECIES NAME:	Particulate	(grit)		
PROCESS DESCRIPTION:	Abrasive b	lasting; ste	eel grit	
	Bag filter			
LOCAL ENVIRONMENT:		ndustrial		
POTENTIAL EFFECTS:	HEALTH C	DOUR	VEGETATION	VISIBILITY
▼	DEPOSITION C	THER (		)
1. EFFECTS UNDER NOF	MAL OPERATING	CONDITIONS	5	
EMISSION CONCENTRATION:	<u>    25    </u>	ng/m <sup>3</sup> E	EMISSION RATE:	<mark>0.125</mark> g/s
SPECIES			PM <sub>10</sub>	
MAXIMUM PREDICTED GLC FO	R THIS SOURCE <sup>A</sup> :	(a)	µg/m³	g/m²/30days
BACKGROUND CONCENTRATIO	ON <sup>B</sup> :	(b)	μg/m³	g/m²/30days
TOTAL MAXIMUM GLC		(a) + (b)	20 - 30 µg/m³	g/m²/30days
MAXIMUM ALLOWABLE GLC <sup>C</sup> :		(c)	120 µg/m <sup>3</sup>	g/m <sup>2</sup> /30days
		()		5 <i>,</i>
IS (a+b)<0.5(c)? ✓ M	onitoring requirements =	⇒ 5H		GO TO 2
IS (a+b)>0.5(c)? M	onitoring requirements =	⇒ 5H consi	ider greater frequency	GO TO 2
		or contin	uous monitoring, and ar	nbient monitoring
2. EFFECTS UNDER ACC	IDENTAL RELEAS	E CONDITION	NS	
		FACESE		
IS THERE POTENTIAL FOR A M	AJOR ACCIDENTAL REL	EASE?	YES I	NO
IF NO, GO TO 3				
IF YES, COMPLETE SECTION B	ELOW THEN GO TO 3			
RUN-AWAY REACTION	Monitorina	requirements $\Rightarrow$	5T. 5U. 5V	
PRESSURE VESSEL FAILUF	RE Monitoring	requirements $\Rightarrow$	5T, 5U, 5V	
SPILLAGE	Monitoring	requirements $\Rightarrow$	5V	
FIRE/EXPLOSION	Monitoring	requirements $\Rightarrow$	5T, 5U, 5V	
INCOMPLETE REACTION	Monitoring	requirements $\Rightarrow$	5T, 5U, 5V	
OTHER (	) Monitoring	requirements $\Rightarrow$	specify:	

3. EMIS	SSION CONTROL SYSTEMS	;				
ARE THE	EMISSIONS CONTROLLED USING		OL EC	UIPMENT?	🖌 YES	NO
IF YES, CON	IPLETE SECTION BELOW <sup>F</sup>					
SCRL	IBBER	Monitoring requirements	⇒	5B, 5T, 5U,	5V	
BAGH	IOUSE	Monitoring requirements	⇒	5B, 5T, 5U,	5Z	
AFTE	RBURNER	Monitoring requirements	⇒	5I, 5N, 5T		
CYCL	ONE/MULTICYCLONE	Monitoring requirements	⇒	5B, 5N, 5V,	5Z	
ELEC	TROSTATIC PRECIPITATOR	Monitoring requirements	⇒	5B, 5N, 50	, 5T, 5V, 5W,	5X, 5Y, 5Z
BIOFI	LTER	Monitoring requirements	$\Rightarrow$	5U, 5T, 5Z		
OTHE	R ()	Monitoring requirements	⇒			
4. HIST	ORICAL PERFORMANCE					
FOR NEW SC	OURCES GO TO 5					
FOR EXISTIN	IG SOURCES COMPLETE SECTIOI	V BELOW				
IS THERE	A HISTORY OF NON-COMPLIANC	E WITH EXISTING EMISS	ION LI	MITS OR AC	CIDENTAL RE	ELEASES?
YES	(specify:					<u>)</u>
NO						
IF YES,	THEN CONSIDERATION SHOULD	BE GIVEN TO INCREA	SED I	REQUENCY	OF EMISSIO	ON MONITORING, AND
PROCES	S PARAMETER MONITORING. THI	S MAY INCLUDE CONTIN	uous	MONITORIN	G REQUIREN	IENTS.
5. RECON	IMENDED MONITORING RE		. wo	RKSHEET	S)	
Emissions	Monitoring <sup>⊬</sup>				FR	EQUENCY
5A	No emissions monitoring re	quired				
✓ 5B	Intermittent visual inspection	n of plume (e.g. daily)				
5C	Intermittent monitoring for C	$O_2$ or $CO_2$ (e.g. annual	or 6-	monthly)		
5D	Intermittent monitoring for C	O (e.g. annual or 6-m	onth	ly)		
5E	Intermittent monitoring for N	IO <sub>2</sub> (e.g. annual or 6-r	nonth	nly)		
5F	Intermittent monitoring for S	O <sub>2</sub> (e.g. annual or 6-n	nonth	nly)		
5G	Intermittent monitoring for p	articulate (e.g. annual	or 6	-monthly)		
✓ 5H	Intermittent monitoring (spe	cies: T.S.P.)			T۱	<i>N</i> o yearly
51	Continuous monitoring for C	$O_2$ or $O_2$				
5J	Continuous monitoring for C	0				
5K	Continuous monitoring for N	1O <sub>2</sub>				
5L	Continuous monitoring for S	SO <sub>2</sub>				
5M	Continuous monitoring for p	articulate				
5N	Continuous opacity/obscura	ation monitoring				
50	Continuous humidity monito	oring				
5P	Continuous monitoring (spe	cies:		)		
5Q						
Process	s Monitoring <sup>⊬</sup>					
5R	No process monitoring requ	iired				
5S	Intermittent fuel analysis (e.	g. monthly)				
✓ <sup>5T</sup>	Continuous monitoring for te	emperature				
5U	Continuous monitoring for p	ressure drop across c	contro	ol equipmer	nt	
5V	Continuous monitoring of in	let/outlet flow rates (o	r surr	ogate)		
5W	Continuous voltage monitor	ing				
5X	Continuous current monitor	ing				

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✓ 5Z	Intermittent visual inspection (specify:	Bags)	Weekly
5AA			
5BB			
Ambient Monitoring			
5CC	No ambient monitoring required		
5DD	CO monitoring		
5EE	NO <sub>2</sub> monitoring		
5FF	SO <sub>2</sub> monitoring		
5GG	TSP monitoring		
5HH	Deposited particulate monitoring		
511	Monitoring (species:	)	
5JJ	Biological monitoring (specify:	)	
5KK			

#### ADDITIONAL NOTES

#### NOTES

- A Maximum ground level concentrations (GLCs) should be provided by the applicant as part of the assessment of environmental effects required under Section 88 (4b) of the Resource Management Act (1991). These may either be predicted downwind concentrations determined from an approved atmospheric dispersion model, or from ambient monitoring programmes. If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate maximum allowable concentration (MAC). Averaging times must be consistent for the predicted, allowable and background concentrations.
- B If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate MAC. If they have been determined from dispersion modelling and there are other significant sources close by, cumulative effects need to be included when considering background levels. Averaging times must be consistent for the predicted, allowable and background concentrations.
- C The maximum allowable ground level concentration (MAC) will depend on consent authority policy. Commonly used sources of ambient air quality guidelines include the MfE guidelines, State of Victoria DGLCs, and WHO Air Quality Guidelines. Averaging times must be consistent for the predicted, allowable, and background concentrations.
- D Contaminant concentrations exceeding the criteria specified in the worksheet indicates inadequate mitigation. In such cases it is recommended that consideration be given to what steps can be taken to reduce downwind concentrations.
- E A major accidental release is defined as one which has the potential to result in significant ad verse effects or an exceedance of a Design Ground Level Concentration (DGLC, Threshold Limit value (TLV) or other Maximum Allowable Concentration (MAC) for any time period. Consent authority will determine which system is appropriate.
- F Not all parameters will need to be monitored for all processes. The exact requirements will be dependent upon the specific application and should be discussed with the applicant and equipment manufacturer.
- G These are the recommended monitoring requirements. Other site-specific circumstances may dictate that additional or alternative requirements may be appropriate.
- H Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

# **B3** Spray Painting

This application is for an existing small spray painting booth. The process involves only solvent-based paints with no iso-cyanates. Emissions include a wide variety of solvents including toluene, xylene, MEK, cyclohexanone, and some glycol ethers. The booth is extracted through a water curtain type overspray eliminator at a rate of 5  $\text{m}^3$ /s. Estimates of the solvent emissions have been based on the fact that about 70 percent of the solvent is released at the spray gun, and the remaining discharge occurs over an extended time as the paint dries.

The applicant has modelled the solvent emissions as total solvent, with maximum predicted off site concentrations of about  $10 \text{ mg/m}^3$  for 3 minute averages and the individual compounds have been pro-rated to their stack concentration. There are no ambient air quality guidelines for these compounds, so the predicted concentrations have been compared to the State of Victoria MGLC's. Only xylene has a maximum concentration close to the MGLC of  $10 \text{ mg/m}^3$ , and the maximum predicted concentration is 5 mg/m<sup>3</sup>. Of note is that the Victorian guideline is based on the odour of xylene, and not on the potential health effects.

For normal operation, some intermittent monitoring is indicated. Since it is not practical nor necessary to monitor for xylene, the requirement is for paint consumption to be recorded on a monthly basis. There is no potential for a major accidental release in this case. The emission control system is a wet wall scrubber which removes in excess of 95 percent of the paint overspray. Monitoring is indicated for plume visibility, temperature, pressure drop, and flow rates. Plume visual inspection is an indicator of the scrubber efficiency. Because the discharge and the gas stream is at ambient temperature, no temperature monitoring is required. Pressure drop across the scrubber is very low at about 2 to 3 inches WG, and monitoring would serve no purpose. However monitoring of the water flow rate is required. In this application, the applicant has agreed to install a pressure sensor on the water supply to the wet wall, as well as a water level alarm in the tank at the bottom of the unit. Both sensors will alarm in the event of water supply failure.
DETAILS						
SITE: <u>XYZ Spi</u>	ray Painters	SOUR	RCE:	<u>Spray</u>	Booth	
SPECIES NAME:		Solvent (xylene	e)			
PROCESS DESCRIPTION:	<u>S</u>	oray painting_				
LOCAL ENVIRONMENT						
POTENTIAL EFFECTS:	HEALTH V	ODOUR	VEGETATIO	DN	VISIBILITY	
	DEPOSITION	OTHER (		)		
1. EFFECTS UNDER	NORMAL OPERATI	NG CONDITIO	NS			
EMISSION CONCENTRATIO	DN: _ <u>1000</u> _	mg/m <sup>3</sup> EMISS	SION RATE:		<b>2</b> g/s	
SPECIES			odour/xyle	ne		
MAXIMUM PREDICTED GLO	FOR THIS SOURCE <sup>A</sup> :	(a)	5000		/m²/30davs	
BACKGROUND CONCENTR	ATION <sup>B</sup>	(b)			$/m^2/30$ days	
		(a) + (b)	5000	µg/m <sup>3</sup>	/m <sup>2</sup> /30days	
	~ <sup>C</sup> .		_ <u></u>	- <sup>µg/m</sup> <sup>g</sup>	/m <sup>2</sup> /20devo	
	<b>G</b> .	(C)	_10,000		/m/souays	
IS (a+b)<0.5(c)?	✓ Monitoring requirement	ts $\Rightarrow$ 5H			GO TO 2	
IS (a+b)>0.5(c)?	Monitoring requirement	ts $\Rightarrow$ 5H co.	nsider greater	frequency	GO TO 2	
or continuous monitoring, and ambient monitoring						
2. EFFECTS UNDER	ACCIDENTAL RELE	EASE CONDITI	IONS			
		_				
IS THERE POTENTIAL FOR A MAJOR ACCIDENTAL RELEASE? <sup>E</sup> YES <b>V</b> NO						
IF NO, GO TO 3						
IF YES, COMPLETE SECTION BELOW THEN GO TO 3						
RUN-AWAY REACTION	Monito	ring requirements	$\Rightarrow$ 5T, 5U,	5V		
PRESSURE VESSEL FA	ILUKE Monito	ring requirements	$\Rightarrow$ 51, 5U, $\Rightarrow$ 5V	ov		
FIRE/EXPLOSION	Monito	ring requirements	$\rightarrow$ 5V $\Rightarrow$ 5T 5U	5V		
INCOMPLETE REACTIO	N Monito	ring requirements	⇒ 5T, 5U.	5V		
OTHER (	) Monito	ring requirements	$\Rightarrow$ specify:			
·				· <b>-</b>		

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3. EMISSION CONTROL SYSTEMS			
ARE THE EMISSIONS CONTROLLED USING	AIR POLLUTION CONTRO	OL EQUIPMENT?	✓ YES NO
IF YES, COMPLETE SECTION BELOW <sup>F</sup>			
✓ SCRUBBER	Monitoring requirements	⇒ 5B, 5T, 5U,	5V
BAGHOUSE	Monitoring requirements	⇒ 5B, 5T, 5U,	5Z
AFTERBURNER	Monitoring requirements	$\Rightarrow$ 51, 5N, 5T	
CYCLONE/MULTICYCLONE	Monitoring requirements	$\Rightarrow$ 5B, 5N, 5V,	5Z
ELECTROSTATIC PRECIPITATOR	Monitoring requirements	$\Rightarrow$ 5B, 5N, 5O,	5V, 5W, 5X, 5Y, 5Z
BIOFILTER	Monitoring requirements	⇒ 5U, 5T, 5Z	
OTHER ()	Monitoring requirements	⇒	
4. HISTORICAL PERFORMANCE			
FOR NEW SOURCES GO TO 5			
FOR EXISTING SOURCES COMPLETE SECTION	BELOW		
IS THERE A HISTORY OF NON-COMPLIANCE	E WITH EXISTING EMISSI	ON LIMITS OR ACC	CIDENTAL RELEASES?
YES (specify:	)		
NO			
IF YES, THEN CONSIDERATION SHOULD BE GI	VEN TO INCREASED FRE		SION MONITORING, AND PROCESS
			MENTS.
5. RECOMMENDED MONITORING REC		WORKSHEETS	
Emissions Monitoring			FREQUENCY
5A No emissions monitoring rec	juired		
5B Intermittent visual inspection	of plume (e.g. dally)		
5C Intermittent monitoring for C	$_2$ of $CO_2$ (e.g. annual $O_2$ (e.g. annual $O_2$ (e.g. annual or 6 m	onthu)	
5E Intermittent monitoring for N	$O_{1}$ (e.g. annual of 6-m	onthly)	
5E Intermittent monitoring for N	$O_2$ (e.g. annual or 6-m	nonthly)	
5G Intermittent monitoring for pa	articulate (e.g. annual	or 6-monthly)	
✓ 5H Intermittent monitoring (spec	cies: Paint consum	ption )	Monthly
5I Continuous monitoring for C	$O_2$ or $O_2$	,	<b>,</b>
5J Continuous monitoring for C	0		
5K Continuous monitoring for N	O <sub>2</sub>		
5L Continuous monitoring for S	O <sub>2</sub>		
5M Continuous monitoring for pa	articulate		
5N Continuous opacity/obscurat	ion monitoring		
50 Continuous humidity monitor	ring		
5P Continuous monitoring (spec	cies:)		
5Q			
Process Monitoring <sup>⊬</sup>			
5R No process monitoring requi	red		
5S Intermittent fuel analysis (e.g	g. monthly)		
5T Continuous monitoring for te	mperature		
5U Continuous monitoring for pr	essure drop across c	ontrol equipmen	it
▼ 5V Continuous monitoring of inl	et/outlet flow rates (or	r surrogate)	Water flow and level
5W Continuous voltage monitori	ng		
5X Continuous current monitori	ng		
5Y Continuous spark over moni	toring		

	5Z	Intermittent visual inspection (specify:	)
	5AA		
	5BB		
Ambi	ent Mo	onitoring	
	5CC	No ambient monitoring required	
	5DD	CO monitoring	
	5EE	NO <sub>2</sub> monitoring	
	5FF	SO <sub>2</sub> monitoring	
	5GG	TSP monitoring	
	5HH	Deposited particulate monitoring	
	511	Monitoring (species:	)
	5JJ	Biological monitoring (specify:	)
	5KK		

#### **ADDITIONAL NOTES**

#### NOTES

- A Maximum ground level concentrations (GLCs) should be provided by the applicant as part of the assessment of environmental effects required under Section 88 (4b) of the Resource Management Act (1991). These may either be predicted downwind concentrations determined from an approved atmospheric dispersion model, or from ambient monitoring programmes. If the GLCs have been obtained from ambient monitoring, then background levels are already accounted for and they should be compared directly with the appropriate maximum allowable concentration (MAC). Averaging times must be consistent for the predicted, allowable and background concentrations.
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- C The maximum allowable ground level concentration (MAC) will depend on consent authority policy. Commonly used sources of ambient air quality guidelines include the MfE guidelines, State of Victoria DGLCs, and WHO Air Quality Guidelines. Averaging times must be consistent for the predicted, allowable, and background concentrations.
- D Contaminant concentrations exceeding the criteria specified in the worksheet indicates inadequate mitigation. In such cases it is recommended that consideration be given to what steps can be taken to reduce downwind concentrations.
- E A major accidental release is defined as one which has the potential to result in significant ad verse effects or an exceedance of a Design Ground Level Concentration (DGLC, Threshold Limit value (TLV) or other Maximum Allowable Concentration (MAC) for any time period. Consent authority will determine which system is appropriate.
- F Not all parameters will need to be monitored for all processes. The exact requirements will be dependent upon the specific application and should be discussed with the applicant and equipment manufacturer.
- G These are the recommended monitoring requirements. Other site-specific circumstances may dictate that additional or alternative requirements may be appropriate.
- H Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

## B4 Hot Dip Galvanising

This application is for an existing hot dip galvanising plant. The process is typical of those found in New Zealand, comprising a caustic bath at 80°C for grease removal, followed by a water wash, and a dilute (11%) hydrochloric acid treatment, and a further water wash prior to "dry" fluxing in a zinc ammonium chloride solution at about 80°C. The articles to be galvanised are then allowed to dry before being immersed into the molten zinc bath. Emissions from the operation are mostly those associated with the immersion into the zinc bath, where a significant cloud of white fume is released. The fume contains mostly ammonium chloride, zinc chloride, zinc oxide and some hydrochloric acid fume.

The plant is naturally ventilated via a long roof monitor running along the length of the building.

The assessment of effects submitted with the application includes some dispersion modelling based on emission rates measured during a recent test program. Emissions were measured over 5 minute periods. Dispersion modelling shows that the maximum predicted off site concentrations, for all species monitored, were less than 10 percent of the relevant guidelines taken from the State of Victoria MGLC's documentation. However there has been a long history of complaint from the neighbours relating to visible emissions of fume. This visible emission is considered to be a nuisance.

Both the acid bath and the caustic bath increase their emissions at elevated temperatures. This means the best practicable minimisation techniques include keeping the bath temperatures low. If organic material such as oils remain on the articles to be galvanised, visible emissions increase dramatically. This means that cleaning must be thorough and that the pH and general cleanliness of the baths should monitored regularly. Weekly is normally often enough.

There is no ground level concentration for comparison with any appropriate guideline, nor is there any potential for a major accidental release. The only emission control is by process parameters. In this case, pickling and cleaning bath temperatures should be monitored, as should their pH. The zinc bath temperature should also be monitored.

As there is a history of complaints relating to visible emissions from this plant, intermittent visibility monitoring is indicated. This is to be included as a plume opacity condition in the permit.

DETAILS						
SITE:Ga	alvo Ltd	SOUI	RCE:	<u>Zir</u>	nc bath	
SPECIES NAME:	<u>Fum</u>	<u>ne</u>				
PROCESS DESCRIPTION:	<u>Hot</u>	dip galvanis	ing			
LOCAL ENVIRONMENT:	<u>l nd</u>	ustrial				
POTENTIAL EFFECTS:	HEALTH	ODOUR	VEGETA	TION	VISIBILI	ΤY
	DEPOSITION	OTHER (			)	
1. EFFECTS UNDER N	NORMAL OPERATIN	G CONDITIO	NS			
EMISSION CONCENTRATION:	500	mg/m <sup>3</sup>	EMISSION R	ATE:	5	g/s
			Fumo		_	-
					a/m <sup>2</sup> /20daya	
	ATION <sup>B</sup>	(a)	<u>N/A</u>	µg/m	g/m/30uays	
BACKGROUND CONCENTR	ATION :	(d)	<u> </u>	µg/m²	g/m /30days	
TOTAL MAXIMUM GLC	- 6	(a) + (b)	<u>N/A</u>	µg/m°	g/m²/30days	
MAXIMUM ALLOWABLE GLO	C <sup>°</sup> :	(c)	<u>N/A</u>	µg/m³	g/m²/30days	
IS (a+b)<0.5(c)?	Monitoring requirements	; ⇒ 5H			GO TO 2	
IS (a+b)>0.5(c)?	Monitoring requirements	$\Rightarrow$ 5H co	onsider greater fi	requency	GO TO 2	
or continuous monitoring, and ambient monitoring						
2. EFFECTS UNDER A	ACCIDENTAL RELEA	ASE CONDITI	ONS			
IS THERE POTENTIAL FOR		RELEASE2 <sup>E</sup>	YES	$\checkmark$	NO	
			120	I		
IF NO, GO TO 3		0				
IF TES, COMFLETE SECTIO	IN BELOW THEN GO TO S	2				
RUN-AWAY REACTION	Monitori	ng requirements	⇒ 5T, 5U, 5	V		
PRESSURE VESSEL FA	ILURE Monitori	ing requirements	⇒ 5T, 5U, 5	V		
SPILLAGE	Monitori	ing requirements	$\Rightarrow$ 5V			
FIRE/EXPLOSION	Monitori	ing requirements	⇒ 5T, 5U, 5	V		
INCOMPLETE REACTION	N Monitori	ing requirements	⇒ 5T, 5U, 5	V		
OTHER (	) Monitori	ing requirements	$\Rightarrow$ specify:			

3.	EMIS	SION CONTROL SYSTEMS				
AF	RE THE E	EMISSIONS CONTROLLED USING	AIR POLLUTION CONTRO	DL EQU	JIPMENT?	YES 🗸 NO
IF YES	S, COM	PLETE SECTION BELOW <sup>F</sup>				
	SCRU	BBER	Monitoring requirements	⇒	5B, 5T, 5U, 5V	
	BAGH	DUSE	Monitoring requirements	⇒	5B, 5T, 5U, 5Z	
	AFTER	BURNER	Monitoring requirements	⇒	5I, 5N, 5T	
	CYCLO	DNE/MULTICYCLONE	Monitoring requirements	⇒	5B, 5N, 5V, 5Z	
	ELECT	ROSTATIC PRECIPITATOR	Monitoring requirements	⇒	5B, 5N, 5O, 5T, 5	iV, 5W, 5X, 5Y, 5Z
	BIOFIL	TER	Monitoring requirements	⇒	5U, 5T, 5Z	
	OTHER	R ()	Monitoring requirements	⇒		
4.	HIST	ORICAL PERFORMANCE				
FORM	IEW SO	URCES GO TO 5				
FOR E	EXISTING	G SOURCES COMPLETE SECTION	IBELOW			
IS	THERE	A HISTORY OF NON-COMPLIANC	E WITH EXISTING EMISSI	ON LIN	ITS OR ACCIDEN	ITAL RELEASES?
<ul> <li>✓</li> </ul>	YES	(specify: Visibility	y complaints 🛛 🗲	5T,	5 <b>AA</b> )	
	NO					
IF	YES, T	HEN CONSIDERATION SHOULD	BE GIVEN TO INCREAS	SED FI	REQUENCY OF E	EMISSION MONITORING, AND
PF	ROCESS	PARAMETER MONITORING. THI	S MAY INCLUDE CONTINU	JOUSI	MONITORING REG	QUIREMENTS.
5. R	ECOM	MENDED MONITORING RE	QUIREMENTS <sup>G</sup> (ALL	WOR	KSHEETS)	
Emis	sions	Monitoring <sup>⊬</sup>				FREQUENCY
	5A	No emissions monitoring rea	quired			
✓	5B	Intermittent visual inspection	of plume (e.g. daily)			Daily
	5C	Intermittent monitoring for C	$_2$ or CO <sub>2</sub> (e.g. annual	or 6-r	nonthly)	-
	5D	Intermittent monitoring for C	O (e.g. annual or 6-m	onthly	/)	
	5E	Intermittent monitoring for N	O <sub>2</sub> (e.g. annual or 6-m	nonthl	y)	
	5F	Intermittent monitoring for SO <sub>2</sub> (e.g. annual or 6-monthly)				
	5G	Intermittent monitoring for particulate (e.g. annual or 6-monthly)				
	5H	Intermittent monitoring (spe	cies:		)	
	51	Continuous monitoring for C	O <sub>2</sub> or O <sub>2</sub>			
	5J	Continuous monitoring for C	0			
	5K	Continuous monitoring for N	O <sub>2</sub>			
	5L	Continuous monitoring for S	O <sub>2</sub>			
	5M	Continuous monitoring for p	articulate			
	5N	Continuous opacity/obscura	tion monitoring			
	50	Continuous humidity monito	ring			
	5P	Continuous monitoring (spe	cies:		)	
	5Q					
Pi	rocess	Monitoring <sup>⊬</sup>				
	5R	No process monitoring requ	ired			
	5S	Intermittent fuel analysis (e.	g. monthly)			Bath temperatures
✓						
	́5Т	Continuous monitoring for te	emperature			
	5T 5U	Continuous monitoring for p	emperature ressure drop across c	ontrol	equipment	
	5T 5U 5V	Continuous monitoring for p Continuous monitoring of in	emperature ressure drop across c et/outlet flow rates (or	ontrol	equipment ogate)	
	5T 5U 5V 5W	Continuous monitoring for te Continuous monitoring of in Continuous voltage monitor	emperature ressure drop across c et/outlet flow rates (or ng	ontrol r surro	equipment ogate)	
	5T 5U 5V 5W 5X	Continuous monitoring for p Continuous monitoring of in Continuous voltage monitor Continuous current monitor	emperature ressure drop across c et/outlet flow rates (or ng ng	ontrol surro	equipment ogate)	

5Z	Intermittent visual inspection (specify:)	
🗸 5AA	Weekly pH measurement of baths	Weekly
5BB		
Ambient M	onitoring	
5CC	No ambient monitoring required	
5DD	CO monitoring	
5EE	NO <sub>2</sub> monitoring	
5FF	SO <sub>2</sub> monitoring	
5GG	TSP monitoring	
5HH	Deposited particulate monitoring	
511	Monitoring (species:)	
5JJ	Biological monitoring (specify:)	
5KK		

#### **ADDITIONAL NOTES**

#### NOTES

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- D Contaminant concentrations exceeding the criteria specified in the worksheet indicates inadequate mitigation. In such cases it is recommended that consideration be given to what steps can be taken to reduce downwind concentrations.
- E A major accidental release is defined as one which has the potential to result in significant ad verse effects or an exceedance of a Design Ground Level Concentration (DGLC, Threshold Limit value (TLV) or other Maximum Allowable Concentration (MAC) for any time period. Consent authority will determine which system is appropriate.
- F Not all parameters will need to be monitored for all processes. The exact requirements will be dependent upon the specific application and should be discussed with the applicant and equipment manufacturer.
- G These are the recommended monitoring requirements. Other site-specific circumstances may dictate that additional or alternative requirements may be appropriate.
- H Continuous monitoring may or may not involve continuous recording of data. The requirements for this depends upon the process, the parameter being monitored and the potential for adverse effects. In general, continuous recording is recommended for the monitoring of pollutant emission levels, while process monitors (temperature, oxygen, scrubber flow rates) should be manually logged regularly.

# Appendix C: Smoke Discharge Requirements

The issue of opacity monitoring has become somewhat of a special case in New Zealand due to incorrect guidelines being incorporated into the definitions of smoke in the now repealed Clean Air Act.

Included in this appendix is a copy of comments regarding the measurement of opacity made by Mr R Pilgrim from Kingston Morrison Limited, which were included as part of a submission to the Northland Regional Council on activity classes for small/medium sized fuel burning equipment.

The original Clean Air Act defined smoke discharges from a chimney according to the Ringelmann Charts. These charts are made up of black lines or black dots on a white or clear background; Ringelmann Shade No.1 is 20 percent of the white or clear background surface obscured, R2 is 40 percent obscured; R3 is 60 percent obscured, etc. In the Clean Air Act, light smoke was defined as lying between Ringelmann Shade No.1 and Ringelmann Shade No.2; dense smoke was defined as being greater than Ringelmann Shade No.2.

In the 1982 amendment these definitions were changed, with Ringelmann Shade No.1 being replaced with 20 percent obscuration, and Ringelmann Shade No.2 being replaced with 40% obscuration. However, while Ringelmann Shade No 1 equates to 20 percent obscuration under ideal conditions, in reality this relationship changes with variations in parameters such as optical path length/chimney exit diameter, and temperature differences.

Studies of the relationship between observed Ringelmann shade numbers and percent obscuration for a typical sky brightness behind dark smoke (corresponding to good conditions for visual observation) showed that Ringelmann Shade No 1 is equivalent to 52 percent obscuration in stack, and Ringelmann Shade No 2 is equivalent to 64 percent obscuration in stack. This is discussed in more detail in the attached document.

Other issues associated with the measurement of plume opacity include the following.

- There are very few practitioners in New Zealand who are qualified to visually assess Ringelmann shades or percent opacity, and there is currently no training programme available within New Zealand.
- The measurement of opacity, whilst primarily providing a means of monitoring the aesthetic impacts of a discharge, can also serve as an indication of good operation of the unit, and the soiling potential of the discharge.
- Use of the Ringelmann Charts is only applicable for black smoke. It cannot be used to assess white smoke discharges.

### ACTIVITY CLASSES FOR SMALL/MEDIUM SIZED FUEL BURNING EQUIPMENT SMOKE DISCHARGE REQUIREMENTS Ron Pilgrim (Kingston Morrison)

#### 1.INTRODUCTION

Since preparing the draft document in May 1994 we have looked further into smoke discharge requirements being imposed on fuel burning equipment by regional councils in new air discharge permits. Most permit conditions aim to prohibit the discharge of "smoke" having an obscuration (opacity) of 20 percent or more either by reference to the point of discharge, by reference to a light extinction meter (smoke obscuration meter) located upstream of the chimney exit, or in some cases without specifying the point or situation that the optical standard applies to.

Presumably 20 percent obscuration is a carry-over of the prohibition of light smoke requirements of the (NZ) Clean Air Act 1972 and similar legislation, and meeting this opacity limit is deemed to be the "best practicable option", and in any case will comply with section 5(2)(c) of the Resource Management Act 1991 ("... avoiding, remedying, or mitigating any adverse effects of activities on the environment."). Imposing 20 percent obscuration, or 40 percent for that matter, does not necessarily reflect the visual impact of smoke discharging from the chimney to atmosphere.

In New Zealand "light smoke" was defined in the Clean Air Act 1972 as:

"Light smoke means smoke which -

(a) If compared in the appropriate manner with New Zealand Standard Specification 1568C 1960 Ringelmann Chart, would appear to be as dark as, or darker than, shade No. 1 thereon but not so dark as dense smoke; or

(b) Is of such opacity as to obscure the observer's view to a degree equal to smoke as dark as, or darker than, the said shade No. 1; or

(c) Is ascertained by a prescribed method to be dense/light smoke within the meaning of regulations ...."

This definition was borrowed from the British Clean Air Act 1956. The definition was amended (added to) by section 2 (3) of the Clean Air Amendment Act 1982 as follows:

"(bb) Causes, when measured by photo-electric means, more than 20% obscuration but not more than 40% obscuration in the chimney or in the duct leading to the chimney;".

"Dense smoke" was defined in a similar manner but with reference to Ringelmann Shade No.2, and more than 40 percent obscuration for the 1982 amendment.

The discharge of "light smoke" (subject to times of observation) from any fuel burning equipment was prohibited in areas designated "clean air zones" although exemptions were available; and "dense smoke" was prohibited from fuel burning equipment on industrial and trade premises over the remainder of the country.

The aims of Councils when administering the Resource Management Act as we see it are:

To impose smoke discharge requirements that are consistent with the purposes of the Act;

To word requirements to ensure they are legally and technically defensible; and

To ensure that requirements are enforceable by the regulatory authority (and if not, the regulatory authority is aware of the limitations and how they can be avoided).

# 2. RELATIONSHIP BETWEEN RINGELMANN NUMBERS, OBSCURATION, OPACITY, AND OPTICAL DENSITY

#### Ringelmann Chart Assessment.

Smoke discharge from a chimney can be observed visually and compared with Ringelmann Charts of one form or another. These charts and elements are made up of black lines or black dots on a white or clear background; Ringelmann Shade No.1 is 20% of the white or clear background surface obscured, R2 is 40% obscured; R3 is 60% obscured, etc. By definition, therefore, R1 is 20% obscuration; R2 is 40% obscuration; R3 is 60% obscuration.

#### Percentage Obscuration and Percentage Opacity.

These terms are equivalent and refer to the percentage of light absorbed when transmitted across a discharge. Conversely percentage transmittance is the amount of light not absorbed in transit (100 - % obscuration or opacity). Ringelmann No.1 (20% obscuration or opacity) is equivalent to 80% light transmittance; R2 is equivalent to 60% light transmittance, etc.

#### Optical Density.

This is the negative of the logarithm of the opacity or obscuration of a discharge. An opacity or zero percent (100% transmittance) is 0% optical density. Ninety percent opacity (10% transmittance) equates to an optical density of 1.0; 99% opacity equates to an optical density of 2.0. Both optical density and percent opacity are determined by most sophisticated photo-electric smoke detectors such as the transmissometer installed by the Company.

#### Ringelmann Shades and Obscuration/Opacity

While Ringelmann Shade No 1, by definition (under ideal conditions) equates to 20 percent obscuration, in reality this relationship changes with changes with circumstances. Variables such as illumination of the plume under observation (angle and direction of sun in relation to smoke discharge and observer, colour of the sky), colour of the smoke, diameter of the discharge, etc, are very important. If the source of light illuminating the smoke plume and the Ringelmann Chart is from the rear of the observer and if the blackness of the smoke particles and ink on the card is similar there can be a reasonable correlation between the Ringelmann shade (and its defined obscuration) and the percentage obscuration (opacity) measured photo-electrically across the discharge chimney. A smoke plume is also seen by an observer through a combination of reflected light and transmitted light, although this depends on the smoke density. Comparison of smoke using a Ringelmann Chart relies on only reflected light from the chart to the observer. The use of a "Telesmoke" or equivalent relies on observation of the plume through a translucent comparator mounted within a telescope and reflected light from the comparator is excluded.

Comparison of smoke discharge with the Ringelmann Chart or its equivalent is still very useful as it is a visual assessment and it quantifies the aesthetic impact of discharges better than any instrumental measuring method. Smoke of such an opacity to obscure an observer's view to a degree less than smoke equivalent to Ringelmann 1 was, by definition under the Clean Air Act 1972, not regarded as smoke. ("Light smoke" was equal to or greater than R1 and up to but not including R2.) Such a discharge could not be regarded as objectionable.

As indicated above, visual assessment of smoke discharges not only depends on the optical density of the discharge but is also a function of the brightness and colour of the sky immediately behind the chimney and other factors such as colour of the discharge. In Addendum Number 1 1972 to BS2742:1969 Ringelmann Chart (attached as Appendix 1) the British Standards Institution recognised that since instrumental measurement was increasingly being used to enforce smoke discharge standards, interpretation of instrumental results in terms of Ringelmann numbers in an agreed fashion was important. Consequently Ringelmann numbers were re-defined in a way which did not vary with sky brightness and which was less dependent on the colour of the discharge and other influences than did Ringelmann assessments obtained by visual observation. The following relationships between observed Ringelmann shade numbers, obscuration, and optical density, in the chimney for a typical sky brightness behind dark smoke corresponding to good conditions for visual observation are set out below:

Ringelmann Number	% Obscuration	Optical Density
(R(s))	(Opacity)	
1.	52	0.32
2	64	0.44
3	76	0.62
4	88	0.92
5	100	2+

The Addendum also provides a correction for difference in chimney exit diameter and the instrument light path and for difference in temperature between the optical measuring point and the chimney exit. If the instrument optical path and the diameter of the chimney exit are similar, and there is little difference in temperature, the difference between the standard Ringelmann observation equivalent and the percentage obscuration (opacity) derived by the instrument is minimal. This is not the case if instrument path length is substantially different to chimney diameter. The example given on page 3 of the Addendum (a large diameter chimney) illustrates this. The same principles also applies to smaller chimneys and ducts into them.

In late 1983 NECAL evaluated Addendum No.1 with the smoke generator used to train Health Inspectors in smoke observation assessment (NECAL Report 3/83 dated 14/11/1983). The conclusion (page 5) was:

"The results show extremely close agreement between the visually-assessed Ringelmann numbers and those derived from BS 2742: 1969: Addendum No.1 (1972). The standard should therefore be used when comparing Ringelmann numbers with smoke densities measured by optical means in a chimney or duct."

The 1982 amendment to the Clean Air Act was not consistent with the British Addendum in direct relationship with standardised Ringelmann numbers, and failure to recognise the importance of optical path length/chimney exit diameter, and temperature differences. These inconsistencies were discussed within the Air Pollution Control Group. Although the 1982 amendment was not revised, re-training of Inspectors using the standardised Ringelmann/percentage obscuration relationship commenced.

# 3. RELATIONSHIP BETWEEN SMOKE DISCHARGE AND MASS DISCHARGE OF TOTAL PARTICULATE MATTER

Smoke discharge limits are primarily designed to minimise visual impact, and if they achieve that soiling of down wind surfaces by smoke will not occur. Although excessive smoke discharge may on occasions result in increased soiling down wind out of proportion to the mass discharge (due to the very small particle size range of smoke), direct impact such as deposition and soiling primarily relates to mass discharge of total particulate per unit time. It is, therefore, scientifically supportable to have dual limits - visual smoke or opacity limits to prevent loss of visual amenity (and indirectly to ensure that smoke soiling

does not occur), and mass discharge limits to prevent excessive deposition and soiling beyond the boundary of the source premises.

#### 4. DISCUSSION

We believe the BS 2742:1969 Addendum No.1 relationship is still valid and is reflected in current British requirements. We also believe that the Ringelmann Chart approach, which has been accepted by the US District and Supreme Courts for many years, is still used in the USA, but that 40 percent opacity in the chimney (adjusted for path length) is the general standard for existing fuel burning equipment and for new equipment in most areas. For new plant in sensitive areas 20 percent opacity appears to be required. We see the use of an instrumental opacity standard for fuel burning equipment that is equipped (or should be equipped) with a smoke obscuration instrument as being preferable to visual enforcement procedures. Visual procedures may still be necessary for appliances not equipped with smoke opacity detection.

#### Alternatives to "20% Opacity"

If smoke discharged is <u>not</u> of an opacity to obscure the observer's view to a degree equal to smoke as dark as or darker than Ringelmann Shade No.1, <u>and</u> if such a discharge will not cause adverse effects, then it is technically justifiable and consistent with section 5 of the Resource Management Act to include in discharge permits an obscuration limit determined by photo-electrical means of 52 percent (unitary path length/chimney exit ratio). We are reluctant to recommend 52 percent opacity as it gives the appearance of considerable relaxation of standards over that imposed under the Clean Air Act and requirements more recently imposed in RM Act discharge permits.

An alternative consistent with the purposes of the Act would be to set an instrumental opacity limit for each appliance and location which equates to a visual discharge that "average reasonable people" would be expected to accept as not being objectionable. Unfortunately, the opacity limit would vary depending on a variety of factors and such an approach would be impossible to uniformly administer.

Another alternative is to impose 40 percent opacity (unitary path length/chimney exit ratio) determined by photo-electric means. This is more realistic than 20 percent opacity and does not appear to be too lenient. It also appears to be reasonably consistent with reported USA practices, and would probably be accepted by most NZ industry as being consistent with previous requirements. It is not, however, consistent with the British 1972 Addendum in respect to the opacity of smoke equivalent to standardised Ringelmann shade No.1.

Whatever the percent opacity imposed, the importance of optical path length/chimney exit ratio (including temperature difference), and the necessity to exactly specify what the opacity limit refers to, must be recognised when setting rules and discharge permit conditions.

The ability to cost-effectively enforce any requirement set is very important. Enforcement of smoke discharges from equipment burning non-gaseous fuels as "controlled" or "discretionary" activities (as recommended in the draft) is relatively easy because of the requirement to have suitable smoke monitoring and recording equipment. Monitoring of fuel burning equipment not requiring instrumental smoke monitoring is difficult, the most practical method (during daylight conditions) is for smoke to be visually assessed as necessary by trained officers. As well as Councils having to provide for training and refresher courses, rules or permit conditions must provide for visual assessment of smoke. Re-introduction of visual standards such as included in the Clean Air Act would be necessary. Alternatively rules and permit conditions could allow councils to require the installation of a monitoring opacity meter if [in the opinion of an officer, for example] the discharge of smoke appears to exceed the permitted standard.

If a visual assessment standard (Ringelmann Shades) and instrumental opacity requirement are concurrent then they must be consistent. If instrumental opacity limits only are to be required then possible inconsistency is avoided. However, any smoke discharge limit must be consistent with section 5 of the Act. We believe that prohibiting the discharge of "light smoke" as previously defined would (with suitable times of observation) be consistent with the requirements of section 5 of the Resource Management Act. However, setting an instrumental opacity maximum of 20 percent with a unitary instrument path length/chimney exit ratio is not consistent with "light smoke".

#### 5. RECOMMENDED PERMIT CONDITIONS/RULES

For fuel burning equipment that is or should be equipped with an effective combustion gas opacity monitor:

The opacity of any discharge to air (excluding steam) when measured by photo-electric means or by other approved methods in the chimney or duct leading to the chimney shall not exceed, when corrected for path length and temperature as set out in Addendum No.1 (1972) to BS 2742: 1969, 40 percent for more than [two minutes continuous or in aggregate more than four minutes in any period of 60 minutes]. Except that the grantee may exceed this limit for a maximum period of 30 minutes when starting any fuel burning equipment from cold, and for soot blowing, providing that opacity of the discharge and the time the discharge occurs is reduced as far as practicable.

For fuel burning equipment not required to be equipped with combustion gas opacity monitoring equipment:

The opacity of any discharge to air (excluding steam), if compared in the appropriate manner with New Zealand Standard Specification 1568C 1960 Ringelmann Chart, shall not be as dark as or darker than shade No.1 or shall not be of such opacity as to obscure the observer's view to a degree equal to smoke as dark as or darker than shade No. 1, for more than [two minutes continuous or in aggregate more than four minutes in any period of 60 minutes]. Except that the grantee may exceed this limit for a maximum period of 30

minutes when starting any fuel burning equipment from cold, and for soot blowing, providing that opacity of the discharge and the time the discharge occurs is reduced as far as practicable.

# Appendix D: Quality Control Systems for Source Sampling and Analysis

This Appendix focuses on some practical ways of applying aspects of quality control to assist in producing data of known quality. Appendix E provides detailed information on developing quality assurance procedures related to compliance monitoring.

The key points of Appendix E can be paraphrased as follows:

- It is important to define the goal or the purpose of the study at the outset rather than midway or at the end.
- The quality of the information used to make decisions must be known.
- Quality assurance strategies adopted should be appropriate to meet the needs of the points above.

The two quality assurance parameters which are most relevant to data quality evaluation are *precision* (the degree to which results can be repeated) and *bias* (how close results are to the "true" result).

Techniques that can be applied to control and quantify these terms are discussed below. In some cases it is possible to separate the error in the sampling design and sample acquisition phase of the monitoring procedure from those in the sample analysis phase. In other cases only the whole procedure can be evaluated.

## D1 Evaluating Bias

### D.1.1 Use of blank samples

Blank samples can be used to assess the possibility that extraneous material has contaminated the samples and whether the sample matrix affects the sampling and analytical process.

Field blanks are samples of the absorbing reagents and rinse materials used in sample acquisition, which have travelled to the sampling site. Some sampling methods require that the field blank sample be prepared from a duplicate sampling train that is taken into the field and treated in similar manner to the working train except that it is not exposed directly to the source. The field blank measures incidental or accidental sample contamination during the whole sampling and analytical process (sampling, transport to and from the site, storage, sample preparation and analysis)

Laboratory reagent blanks are aliquots of reagent water or quartz sand that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, internal standards and surrogates that are used with other samples. The laboratory reagent blank is used to determine if analytes or other interferences are present in the laboratory environment, or the reagents and apparatus used in the laboratory.

Other blank types may be used to monitor more specific stages in the sampling and analytical process. For instance transport blanks are samples of analyte-free media taken from the laboratory to the sampling site and returned to the laboratory unopened. They are used to measure cross-contamination from the container during transport, field handling and storage. Some methods require absorbent material blanks to be run before sample acquisition, where the level of analyte in an aliquot of unexposed reagent must be shown to be lower than a threshold value.

The zero point calibration check for continuous instrumental analysers can be considered analogous to a blank sample for more conventional sampling techniques.

The number and type of blank samples taken depend on several factors. The cost of acquiring and analysing blank samples will usually be a paramount and limiting consideration. Good practice would require, however, that at least one field blank be taken per sampling exercise and that one laboratory reagent blank be analysed per batch of samples. In a major on-going study, specific blank types such as "transport blanks" can prove useful in pinpointing sources of contamination.

In some situations some blank samples become redundant. For instance if field blank samples show no sign of contamination then there is no point in analysing transport blanks. Similarly if all samples show analyte levels below the limit of detection, or below levels considered significant, there is a lesser requirement to analyse field-related blanks, except field or surrogate spikes. The latter situation becomes important when performing high cost analyses. Field blank samples must always be collected and stored at the time of sample acquisition; the discretion to process a sample or not, applies only to the analytical stage.

Application of the information from blank samples can be a contentious issue. The courses of action to be taken, once results have been established, should have been decided and documented before sampling and analysis has started.

The values from laboratory reagent blanks, which in effect measure contaminant introduction from the laboratory environment, should be subtracted from the gross sample analytical signal or measurement before the sample analyte concentration is calculated. There is, however, a limit to how high this blank subtraction can be before the results become seriously perturbed. The value at which it is decided that the blank can no longer be subtracted is ultimately an arbitrary decision. A limit of 20 percent of the gross analyte signal is recommended. Sets of samples which have laboratory reagent blanks above this cut-off point can still be reported as being less than the gross analytical signal if this is appropriate.

Field blanks can be contaminated not only from the field, but also from the laboratory. Field blank signals should not be subtracted from the gross sample signal. Rather, the field blank signal should be used as an indicator of total sample contamination. Where this contamination exceeds a certain threshold, for instance 30 percent it may be necessary to re-sample.

### D1.2 Use of quality control samples

A "quality control sample" is a sample containing analytes of interest that is regularly analysed to check that a method is reproducible. These samples are more easily introduced at the analytical stage, although field spike samples can also come under this category. Quality control samples can be simply blank sample material to which is added a known amount of analyte. In some situations the use of certified reference materials as quality control samples may be appropriate. These are available from the United States National Bureau of Standards and the European Community Bureau of Reference. The United States Environmental Protection Agency also produces audit samples for a number of its source testing methods.

Quality control samples allow quantitation of the bias parameter:

If X is the measurement value and T the true value then bias is often expressed as per cent accuracy (%A) where:

 $%A = X/T \times 100.$ 

### D1.3 Calibration of sampling equipment

Another source of bias is improperly calibrated sampling equipment. Equipment that requires maintenance and calibration includes pitot tubes, nozzles, manometers, thermometers and thermocouples, flow meters, orifices and dry gas meters. Routine "absolute" calibration should be distinguished from chemical calibration where the relationship between instrument response and concentration is established. Absolute calibration ensures that the perceived response corresponds to the correct physical signal. USEPA methods often require traceability to a primary or secondary measurement standard such as National Bureau of Standards materials.

### D1.4 Leak testing

Where sampling trains are not leak tight to the ambient atmosphere outside the source being investigated, results will have a negative bias. Trains should be assessed for leaks before and after the sampling process. Many sampling methods specify leak testing protocols.

## D2 Evaluating precision

Evaluating the precision of data for source sampling and analysis is more difficult than for samples from other environmental media such as soil and water. For example, combined sampling and analytical precision for a soil sample is estimated by taking two independent samples as close as possible to the same place and time, storing in separate containers and analysing independently. The precision of the analysis can be estimated by analysing duplicate or replicate sub-samples of the individual soil samples.

To perform a similar precision assessment for combined source sampling and analysis requires two sets of sampling apparatus with sufficient personnel to operate them, and ideally co-located sampling probes during the emission testing process. This may not always be possible.

Testing the precision of the analytical stage is much simpler, provided the source samples can be sub-sampled. This is not possible where a surrogate spike has been applied to the sampling apparatus or where there is likely to be inhomogeneous distribution of the sample across the sampling train components, as with solid absorbents (e.g. activated charcoal). Sub-sampling is often a more practicable option with wet chemical trains which lead to a homogeneous liquid sample.

Precision can be expressed in quantitative terms as a range percent using (R%):

$$R\% = (C_1 - C_2) / C_m$$

where:

 $C_1$  = highest value determined

 $C_m$  = mean value of the set

 $C_2 = \mbox{lowest}$  value determined .

## Appendix E: Strategies for the Introduction of Quality Assurance Procedures in Compliance Monitoring

## E1 Introduction

Data of unknown quality is of very little use for any application, and may lead to deduce erroneous conclusions. Rigorous and complete quality assurance practices are essential in producing reliable emission data that is accepted with confidence by all parties.

There are several quality management systems capable of assessing compliance testing. The system that is discussed here, the United States Environmental Protection Agency's Quality Assurance/Quality Control Approach, is not specially endorsed and may not be suitable for direct translation into the New Zealand regulatory situation. However, its framework dovetails into many recommended source testing methods and it is thus an appropriate example. Furthermore, many of the features of this approach, such as the requirement for consultation amongst regulatory, emitting company and field testing staff in the setting of objectives for data quality, are seen as desirable for the improvement of data quality in the New Zealand scene. It is discussed primarily to provoke thought amongst readers.

## E1.1 The USEPA Quality Assurance/Quality Control Approach

Regardless of the size or complexity of a compliance monitoring study, the resulting decisions made must be based on information of known quality. A quality assurance/quality control  $(QA/QC)^1$  programme aims to ensure that data produced from any part of a study designed to evaluate the problem, is sufficient to support the decision-making process. The logic of the decision-making process is as much a part of QA/QC as the more commonly applied definitions of the quality of any single analytical result. Every compliance monitoring evaluation should follow a similar pattern of development to that shown in Table A1:

<sup>1</sup> Quality assurance and quality control are concepts which have some degree of overlap. Quality assurance is seen as a system of activities that assures the producer or user of a product or a service that defined standards of quality with a stated level of confidence are met. Quality control differs in that it is an overall system of activities that controls the quality of a product or service so that it meets the needs of users. Quality control consists of the internal day to day control and assessment of measurement quality, whereas quality assurance is the management system that ensures an effective quality control system is in place and working as intended.

# Table E1: Steps to ensure decisions are based on data of known quality

Define the goal or purpose of the study and how it will be achieved Define the data quality objectives that specify the quality of the data that is acceptable Design a QA programme plan defining overall QA policy Design a QA project plan detailing specific QA and QC requirements for the study Undertake study based on the stipulations established in the previous steps Evaluate data and make decision

Decision-making may not necessarily require information of the best possible quality. For example, a preliminary investigation of a source may use a low cost screening analytical technique. Provided the limitations of this technique are understood, it might properly be used as an assessment tool providing reliable data. This concept will be discussed later.

The individual steps shown in Table A1 are discussed in more detail in the following sections.

# E1.2 Defining the purpose of the study and how it will be achieved

Definition of the study goal or purpose should be the first activity that is carried out. The goal or purpose must be defined concisely but with sufficient detail to ensure it is understood by everyone involved in data collection.

The purpose of the study might be relatively simple, such as confirming that emissions from a source do not exceed concentrations or mass emissions of a species specified in a discharge consent. Alternatively it might be more complex such as in the case of confirming the suitability of a company's own emission testing programmes by an audit.

## E1.3 Defining the data quality objectives

Data Quality Objectives (DQOs) are statements developed by data users to specify the quality of data needed from a particular data collection activity. Once the user has specified the quality of data needed, then the type of quality control procedures necessary to ensure that the data satisfy the user's specifications must be determined. The process of selecting DQOs provides a logical, objective and quantitative framework for finding an appropriate balance between the time and resources that will be used to collect data and the quality of the data needed to make the decision. In many cases funds available dictate the amount and quality of data to be collected.

DQOs may be qualitative or quantitative in nature. Quantitative DQOs contain reference to specific quantitative terms such as standard deviations, percent recovery etc whereas qualitative DQOs are descriptive and may refer to specific actions that would be taken in a particular instance such as re-sampling if a process production rate were to fall below a certain target level during testing.

Consider the following when developing DQOs:

- The decision to be made
- Why testing data are needed and how they will be used
- Time and resource constraints on data collection
- The methodology used to collect the data
- The calculations, statistical or otherwise, that will be performed on the data in order to arrive at a result.

Data quality indicators are key functions in this process, and in every project data quality objectives should be written, as they reflect the magnitude of error associated with acquired data. The USEPA lists five data quality indicators that it considers important: precision, bias, representativeness, completeness and comparability.

*Precision* can be described as "a measure of mutual agreement among individual measurements of the same property". More simply here it can be thought of as a measure of how greatly an analytical result varies on repeated analysis of a sample. For data sets with a small number of points (2 < n < 8) precision can be estimated as range percent (R%):

 $R\% = (C_1 - C_2)/C$ 

where

C1 = highest value determined C2 = lowest value determined Cm = mean value of the set

otherwise it can be expressed as a relative standard deviation (%RSD) where:

%RSD = 100% x standard deviation/mean result.

In source sampling, components associated with sampling design, sample collection and analysis will contribute to the overall estimate of precision. It is not possible to estimate the contribution from sampling design. Combined sampling and analytical precision can be estimated by collection and analysis of duplicate (i.e. co-located) samples. Analytical precision alone can be measured by repeated analysis of laboratory replicated samples.

*Bias* (colloquially called "Accuracy") can be defined as "the degree of agreement of a measurement (or an average of measurements) with an accepted reference or true

value". If "X" is the measurement value and "T" the true value then bias is often expressed as percent accuracy (%A) where:

 $(\% A) = X/T \times 100.$ 

As with precision, the bias parameter in source sampling may contain components from sample design, collection and analysis phases. Again, the contribution from sampling design cannot be estimated, however combined sampling and analytical steps bias can be estimated by using field spike samples. In this process a sample is generated in the field by spiking an appropriate part of unexposed sampling apparatus with a known quantity of the target analyte The sample is recovered and analysed in the normal way. The percent recovery of the spike is calculated.

*Representativeness* expresses the degree to which data accurately, precisely and completely characterise the process conditions. An example where representativeness can be quantified is the requirement for samples to match a percent isokineticity level while performing particulate analysis.

*Completeness* is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions, usually expressed as a percentage.

Use of the completeness parameter acknowledges that data may be lost by a number of different routes including specific sampling points being inaccessible at the time of sample collection, breakage or spilling of sample during handling or shipping, and sample holding time being exceeded before analysis.

When statistical tests are used to assess data, a certain level of completeness is needed, and contingency plans for re-sampling or re-assessing of the sampling site may be in necessary.

*Comparability* expresses the confidence with which one data set can be compared to another.

Comparability between different monitoring exercises can be assessed by considering the method of sample collection, how experimental results are reported (corrected to the same standard conditions e.g. dry weight, standard temperature and pressure etc.) and similarity of data quality measurement steps.

The development of DQOs is a complex, iterative process involving both decisionmakers and technical staff. Both parties are responsible for defining how they intend to use the data and determining the quality needed to support that use. DQOs should be agreed and set before the data is acquired. This prior communication is a particular advantage of this approach. Once DQOs have been developed and a design for the data collection expected to achieve these objectives has been selected, quality assurance and quality control programmes specifically tailored to the data collection programme are designed. These programmes are described in a quality assurance project plan described below.

# E1.4 Designing a QA programme plan defining overall QA policy

The QA programme plan is a document that commits the study overseers to a specific QA policy. The QA plan describes the overall policies, organisation, objectives and functional responsibilities for achieving data quality goals. The USEPA see the following as being the five major functions of a QA programme plan:

- A statement of the purpose and importance of a QA plan.
- A description of the procedures that will be used to carry out the programme.
- A description of the resources committed to perform the QA work.
- Identification of the individual projects or packages of work in a study that require QA project plans.
- A description of how QA implementation will be evaluated.

In general the QA programme plan is a document in which an organisation's quality assurance policy is spelt out in some detail. For an analytical laboratory, it might include sections on laboratory organisation and responsibilities, sample management and chain of custody, analytical methods and associated quality control activities, data handling and reporting, data evaluation and validation. A consulting firm more oriented towards field sampling might have more emphasis on calibration and maintenance of sampling equipment.

# E1.5 Designing a QA project plan detailing specific QA and QC requirements for the study

A QA project plan is a document that describes all of the activities needed to ensure that the data collection programme will produce environmental data of the type and quality required to satisfy the data quality objectives.

The USEPA have identified 16 essential elements for the composition of a QA Project Plan:

- 1. Title page
- 2. Table of contents
- 3. Project description
- 4. Project organisation and responsibility
- 5. QA objectives

- 6. Sampling procedures
- 7. Sample custody
- 8. Calibration procedures and frequency
- 9. Analytical procedures
- 10. Data reduction validation and reporting
- 11. Internal quality control checks
- 12. Performance and systems audits
- 13. Preventative maintenance
- 14. Specific routine measures used to assess data precision, accuracy and completeness
- 15. Corrective action
- 16. Quality assurance reports to management

A QA/QC checklist for the three aspects of emission testing, sampling, analysis and reporting which is helpful in focusing on the tasks necessary to comply with the requirements of the sixteen steps above.

Category	Sampling	Analysis	Reporting
Technical responsibility	Yes	Yes	Yes
QA responsibility	Yes	Yes	Yes
Data Quality Objectives	Yes	Yes	Yes
Quality control procedures			
Equipment calibration	Yes	Yes	No
Sample custody chain	Yes	Yes	No
Measurement traceability	Yes	Yes	No
Blanks	Yes	Yes	No
Control checks	No	Yes	No
Calibration standards	No	Yes	No
Storage time	Yes	Yes	No
Sample spikes	Optional	Yes	No
Internal standards	No	Optional	No
Surrogates	No	Optional	No
Replicates	Optional	Yes	No
Linearity	No	Yes	No
Leak testing	Yes	Yes	No
Data review	Yes	Yes	Yes
Quality Assurance Procedures			
System audits	Optional	Optional	Optional
Performance audits	Optional	Yes	No
Written standard operating	Yes	Yes	Yes
procedures			
Documentation	Yes	Yes	Yes

# Appendix F: Exclusion of Indicating Tubes 127 as Screening Methods for Source Evaluation

Indicating tubes (or detector tubes) marketed by companies such as Draeger, Gastec and Kitagawa have been used in the past as simple, rapid techniques for indicating the concentration of species' emissions from stationary sources. The tubes work on the principle of having a known volume of air passed through their contents and developing a stain or colour on a marked scale, representative of the concentration of the species under investigation.

Indicating tubes have not been recommended as screening techniques for evaluative purposes for the following reasons:

- 1. Indicating tubes are designed to measure the concentration of species of interest in workplace air or in general ambient air situations, where air temperature and humidity fall within fairly well defined ranges. It is possible that the temperature or moisture content of stack gases may fall outside the range which permits the indicating tube reaction to perform correctly and consistently. Another complicating feature of stack gases is the possible presence of chemical species unrelated to the species of interest, but which may act as positive or negative interferences for the tube reaction. Interfering species might include sulphur oxides, nitrogen oxides and halo-acids. The presence of particulate matter in the stack gas may also interfere with the proper functioning of the tube.
- 2. The tube reaction resulting in stain development often lacks specificity for the species of interest. Many practitioners may not be aware of how general the indicating reactions are. In situations involving the emission of a single species in air this will not be a problem. Where mixtures of compounds are emitted, however, positive interferences may result. For instance the reaction involving reduction of chromate or dichromate to chromous ion is the basis for measuring the following compounds or groups of compounds in the Gastec system: acetone, anline, butane, butyl acetate, ethanol, ethyl acetate, ethyl ether, ethylene oxide, gasoline, hexane, isopropanol, LP gas, methanol, methyl ethyl ketone, methyl isobutyl ketone, propane, sulphur dioxide and vinyl chloride. The additional presence of any one of these compounds would give a higher reading. The name of the compound listed on the tube often refers to the calibration scale rather than to a unique chemical reaction of the contents of the tube.

The decision not to recommend indicating tubes for evaluative screening was not intended to discourage their use in appropriate situations. Such situations might include vents drawing dilution air from a process with a single chemical species of interest. Comparison of results from indicator tubes with a recommended compliance monitoring method using USEPA Method 301 can also be used to determine the suitability of an indicator tube for a particular situation.