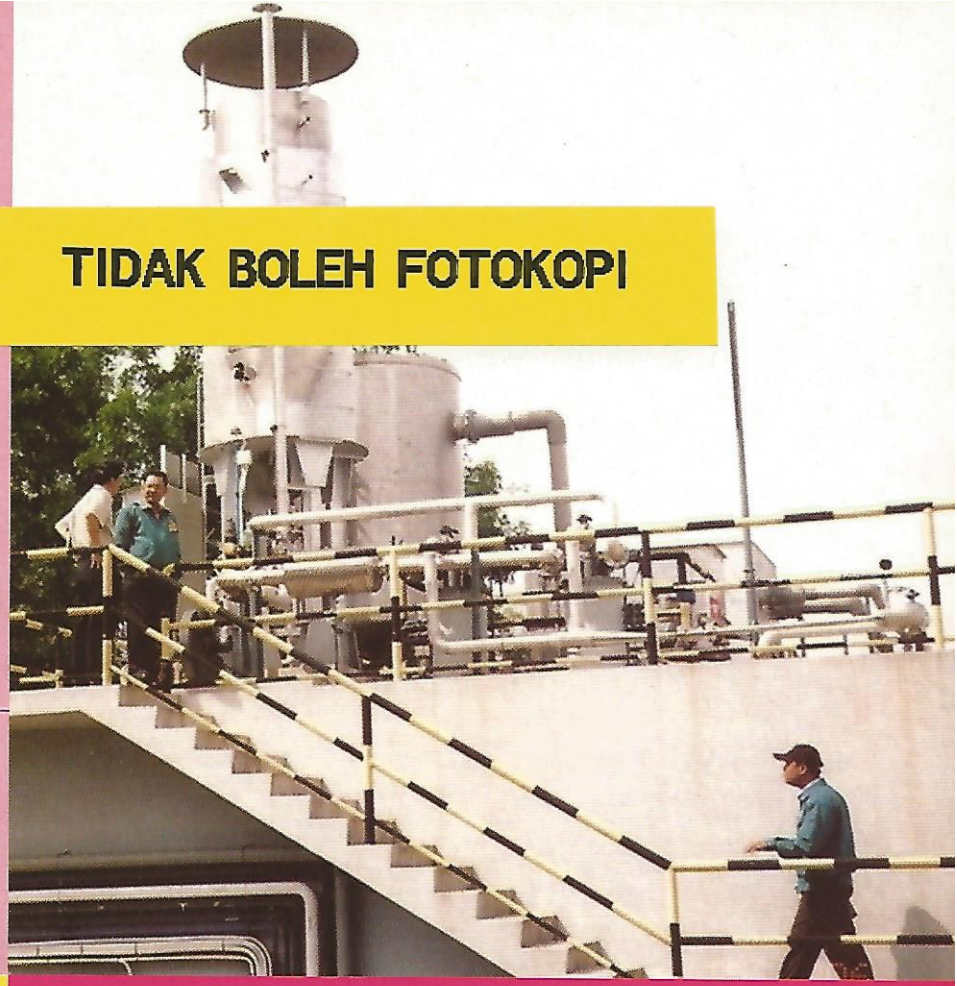
Book 5



Technical Guidance Document Series Number: DOE-APCS-5

NICAL NCE ON PERFORMANCE MONITORING OF AIR POLLUTION CONTROL SYSTEMS

FOR THE USE OF THE INDUSTRIES AND CONSULTANTS

DOE Malaysia
First Edition:
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TECHNICAL GUIDANCE ON PERFORMANCE MONITORING OF AIR POLLUTION CONTROL SYSTEMS

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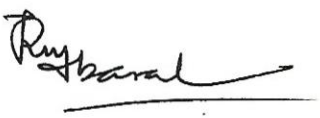
FOREWORD

Industry inspections are an intergral component of the Department of Environment's enforcement action. The aim of the inspections is to ensure that pollution control systems that have been installed in the industries are being operated and maintained in **optimal conditions**, without which the system would not function efficiently as designed. The system inspection underlines the importance of the pollution control systems **performance monitoring** which can be understood to mean **preventive maintenance** and **monitoring activities** systematically conducted on a predetermined schedule. Such **maintenance and monitoring culture** will minimize breakdown of pollution control systems resulting in non compliance to regulatory requirements.

It is our earnest hope that use of this technical guidance document will help improve **regulatory compliance** and consequently achieve a better **environmental quality** for all.



Dato' Hajah Rosnani Ibarahim
Director General of the Environment, Malaysia
21 December, 2006

PERFORMANCE MONITORING OF AIR POLLUTION CONTROL SYSTEMS

1. INTRODUCTION

Preventive maintenance and **performance monitoring** of a pollution control system, be it an effluent treatment system to treat an industrial effluent, or an air pollution control system to abate the release of air contaminants into the atmosphere, is a **prerequisite** for an uninterrupted and efficient operation of the control system. Experience of the officers of the Department of Environment (D.O.E) during **enforcement and site inspections** attests to the undisputable fact that preventive maintenance and performance monitoring of pollution control systems is not given due importance by the industrial operators. With regard to air pollution control systems, broken and rusty ducting, corroded cyclones, broken filter bags, malfunctioned compressed air system, non functioning pressure gages, etc are common observations made during enforcement rounds. This subsequently leads to inefficient operation of the control system which may result in violation of **emission standards** as well as **work place air quality standards**. If performance monitoring had been put in place and strictly adhered to, this unacceptable state of affairs would never happen. Continual and efficient functioning of air pollution control systems is dependent on effective preventive maintenance and performance monitoring program.

2. OBJECTIVE OF THE GUIDANCE DOCUMENT

The objectives of the guidance document are:

(i) To standardize the **performance monitoring procedure** to be conducted by the industries to ensure proper working conditions of air pollution control equipment. Regulation 40 of the Clean Air Regulations. 1978 requires that control system be maintained in **proper working condition**.

(ii) To standardize **performance monitoring requirements** as spelt out in the approval conditions of new installations of air pollution control system. The control system covered in this guideline falls under the broad definition of control equipment as used in the **Environmental Quality Act,** 1974.

3. IMPORTANCE OF PERFORMANCE MONITORING

Performance monitoring typically forms an integral part of **preventive maintenance procedure** adopted in an industry to ensure smooth and uninterrupted operation of air pollution control system. Additionally, preventive maintenance helps detect early onset of deteriorating performance of the control system hence avoids unnecessary **plant shutdowns** and costly **enforcement penalties.** Preventive maintenance procedure can specify action levels at which **corrective actions** are to be initiated.

From the enforcement viewpoint, performance monitoring of air pollution control equipment is an acceptable surrogate to **stack emission testing** to gage compliance with emission standards. As known by air pollution professionals, stack emission testing is not commonly conducted on a routine basis due to cost and other constraints. Data kept in preventive maintenance procedures and performance monitoring is typically used by environmental agencies worldwide as an **additional enforcement** tool apart from actual stack emission testing.

4. PERFORMANCE MONITORING REQUIREMENT

All air pollution control systems must be maintained and operated in such a manner that they are in **good working condition** as required by Regulation 40 of the Clean Air Regulations. In order to ensure compliance with this requirement a set of activities need to be conducted on a **routine basis** typically by the operator of the pollution control system. These activities commonly referred to as **operation** and **maintenance** (O&M) or more appropriately **preventive maintenance and performance monitoring** are routine and primary duties of the operator.

4.1 Written Permission Conditions for New Sources

Approval of new installations of control equipment will invariably incorporate some conditions on **performance monitoring requirements**. These may include **reporting** and **record keeping requirements**. Typical **forms/log sheets** to be used to record the performance data may be prescribed or recommended.

4.2 Existing Sources

Although some existing sources have instituted regular activities to monitor the performance of air pollution control equipment on their premises, by en large most sources are still oblivious to the need to have such regular monitoring. A **directive** may be issued to these sources to instruct them to put in place a **performance monitoring program** and a reasonable time frame of **six months** is recommended for compliance with the directive. Within this time period the industries are expected to be able to undertake the necessary actions such as minor work to install the required **monitoring instruments**, if necessary.

5. PERFORMANCE MONITORING OF CENTRIFUGAL COLLECTORS

Centrifugal collectors/separators are the most widely used **inertial separators** today. Centrifugal collectors are commonly used as **precleaners** to remove coarser particulates and reduce load on more efficient dust collectors. New generation high efficiency axial flow vortex tubes are also used as filters on solid-fuelled burning equipment. The most common types of centrifugal collectors in use today are:

(i) Single-cyclone separators

(ii) Multiple-cyclone separators or multiclones/multicyclones.

Table 1 below summarizes typical preventive maintenance procedure and performance monitoring for single cyclones and multicyclones.

Table 1: Preventive maintenance procedures for cyclones and multicyclones

Type of cyclone	Frequency	Procedure/ task
Single Cyclones	**Daily**	Record **cyclone pressure drops.** Check **stack** (if cyclone is the only collector). Record **fan motor amperage**. Inspect **dust discharge hopper** to assure dust is removed.
	Weekly	Check **fan bearings**. Check gaskets, valves, and other opening for **leakage.**
	Monthly	Check for sign of corrosion and other signs of deterioration. Inspect inlet and outlet for dust-build up.
Multicylones	**Daily**	Same as cyclones.
	Weekly	Same as cyclones.
	Monthly	Same as cyclones

(Source: Adapted from Bureau of Mines, 1987)

5.1 Regulatory Record Keeping Requirements

At the minimum the mandatory performance monitoring data specified in Table 2 must be kept and made available to DOE officers for inspection. Typical forms to record performance data of mechanical separators are given in Appendix I.

Table 2: Records of performance data of cyclones

Parameter	Comments
Pressure drop	Pressure drop indicates if **blockage** has occurred.
Flowrate	Pressure drop information cannot be interpreted properly unless flowrate information is known.
Opacity	Whether a continuous transmissometer/smoke meter/opacity meter is incorporated into the system or not, the output on **opacity/stack observation** should be recorded. The cause of abnormal change in opacity level should be pursued and understood. If operator is not trained to conduct smoke observation, a descriptive statement on the condition of stack emission is sufficient.
Dust	At least one parameter indicating the quantity of dust removed (e.g. weight or volume) from cyclone hopper must be monitored. Significant change in dust quantity may be indicative of cyclone failure or of process changes.

6. PERFORMANCE MONITORING OF BAGFILTERS

Commonly known as baghouses, bagfilters are one of the most efficient and cost effective types of dust collectors available and can achieve a collection efficiency of more than 99% for very fine particulates.

Classified on the basis of cleaning method, four common types of baghouses are:

(i) Mechanical shaker
(ii) Reverse air
(iii) Reverse/Pulse jet
(iv) Sonic cleaning

Table 3 summarizes typical preventive maintenance procedure and performance monitoring for bagfilters.

Table 3: Preventive maintenance procedures for baghouses

Frequency	Procedure
Daily	• Check pressure drop • Observe stack (visually or with opacity meter) • Walk through system, listening for proper operation • Check for unusual occurrences in process • Observe control panel indicators • Check compressed-air pressure • Assure that dust is being removed from system
Weekly	• Inspect screw-conveyor bearings for lubrication • Check packing glands • Operate damper valves • Check compressed-air lines, including line filters and dryers • Check that valves are opening and closing properly in bag-cleaning sequence • Verify accuracy of temperature-indicating equipment • Check pressure-drop-indicating equipment for plugged lines
Monthly	• Check all moving parts in shaker mechanism • Inspect fans for corrosion and material buildup • Check drive belts for wear and tension • Inspect and lubricate appropriate items • Spot-check bag tension • Spot check for bag leaks • Check hoses and clamps • Check accuracy of indicating equipment • Inspect housing for corrosion
Quarterly	• Inspect baffle plate for wear • Inspect bags thoroughly • Check duct for dust buildup • Observe damper valves for proper seating • Check gaskets on doors • Inspect paint, insulation, etc. • Check screw conveyor for wear or abrasion • Check fan belts
Annually	• Check welds • Inspect hopper for wear

(Source: Adapted from Bureau of Mines, 1987)

6.1 Regulatory Record Keeping Requirements

A record keeping program is essential for the smooth operation of the baghouses and may lengthen its useful life and minimize emission. The program should comprise both **operating** and **preventive maintenance records and performance monitoring records**. Record keeping requirements may vary from one industry to another depending on the **type of manufacturing process** being controlled, the **size of operation**, the **size and the location** of the industry. From the regulatory stand point, at the minimum the records specified in Table 4 must be kept and maintained. Typical forms to record performance data on bagfilters are illustrated in Appendix II. This form and other relevant information must be kept in a log and made available to the DOE officers for inspection. The frequency for **manual collection** of the data on pressure drop and opacity observation should be at the minimum **once per day**.

Table 4: Record of performance data of bagfilters

Data	Comments
Pressure drop	Pressure drop across the filter must be monitored as an indication of resistance to flow and **cleaning effectiveness**.
Flowrate	Pressure drop information cannot be interpreted properly unless flowrate information is known. Flowrate record is useful in identifying a developing leak in the ducting or in the baghouse itself.
Opacity	Whether a continuous transmissometer/smoke meter/opacity meter is incorporated into the system or not, the output on **opacity/stack observation** should be recorded. The cause of abnormal change in opacity level should be pursued and understood.
Temperature	In some applications, temperature data are also important to evaluate high **temperature excursion** condensation. At least the inlet gas temperature of the baghouse must be monitored.
Dust	Additionally, at least one parameter indicating the **quantity of dust removed** (e.g. weight or volume) from each compartment of the baghouse must be monitored. Significant change in dust quantity may be indicative of **baghouse failure** or of **process changes**.
Compressed air pressure	Where cleaning is effected by using compressed air, the pressure should be monitored to ensure **effective cleaning operation.**

7. PERFORMANCE MONITORING OF PARTICULATE SCRUBBERS

Commonly known as **wet scrubbers**, these particulate/dust collectors use liquid (usually water) as the scrubbing liquid to remove dust particles from a dust-laden gas stream. Wet scrubbers may be categorized by pressure drop (in inches water gauge) as follows:

- **Low-energy scrubbers** (0.5 to 2.5), e.g. gravity-spray-tower scrubber
- **Low- to medium-energy scrubbers** (2.5 to 6), e.g. wet cyclones
- **Medium- to high-energy scrubbers** (6 to 15), e.g. packed-bed scrubbers
- **High-energy scrubbers** (greater than 15), e.g. venturi scrubbers.

Although there are a variety of commercially available scrubbers hence preventive maintenance procedures may differ slightly from one another, Table 5 summarizes the procedures for typical wet scrubbers for particulates control.

8. PERFORMANCE MONITORING OF GASEOUS SCRUBBERS

The preventive maintenance procedures recommended for gaseous scrubbers are given in Table 6 below.

Table 5: Preventive maintenance procedures for wet particulate scrubbers

Frequency	Procedure
Daily	• Check recycle flow • Check bleed flow • Measure temperature rise across motor • Check fan and pump bearing every 8 hours for grease/oil level, grease/oil color, grease/oil temperature, and vibration • Check scrubber pressure drop • Check pump discharge pressure • Check fan inlet and outlet pressure • Check slurry bleed concentration • Check vibration of fan for buildup or bleeds • Record inlet and saturation temperature of gas stream • Use fan motor current readings to detect flow decreases. Use fan motor current to indicate gas flow.

Weekly	• Check wet/dry line areas for material buildup. Clean, if necessary • Check liquid spray quantity and manifold pressure on mist eliminator automatic wash down • Inspect fans on dirty applications for corrosion, abrasion, and particulate buildup • Check bearings, drive mechanisms, temperature rise, sprocket alignment, sprocket wear, chain tension, oil level, and clarifier rakes • Check ductwork for leakage and excessive flexing. Line or replace as necessary • Clean and dry pneumatic lines associated with monitoring instrumentation.
Semiannually	• Verify accuracy of instruments and calibrate • Inspect orifice plates • Clean electrical equipment, including contacts, transformer insulation, and cooling fans • Check and repair wear zones in scrubbers, valves, piping, and ductwork • Lubricate damper drive mechanisms and bearings. Verify proper operation of dampers and inspect for leakage.

(Source: Bureau of Mines, 1987)

Table 6: Preventive maintenance of gaseous scrubbers

	DAILY INSPECTION
Check point	**What to look for**
1. Pump	a. Leaking b. Increased noise
2. Valves	a. Position b. Leaks
3. Piping	a. Leaks
4. Body	a. Leaks
5. Pressure gage	a. Pressure change from previous day
6. Pressure gage ammeter combination	a. Changes in either or both pressure reading and ampere drawn from last clean system check readings.

Gage Readings	Probable Trouble
1. a. Water pressure same	None
b. Ampere draw same	
2. a. Water pressure decrease	a. Missing nozzles
b. Ampere draw decrease	b. Pump wear or plugging of suction line
3. a. Water pressure same or increase	a. Plugging of nozzles or spray bars
b. Ampere draw decrease	
4. a. Water pressure increase	a. Holes in spray bar or manifold
b. Ampere draw increase	

WEEKLY INSPECTION

Check point	What to look for
1. Spray bars	a. Plug nozzles
	b. Worn or missing nozzles
2. Pipes and manifolds	a. Plugging or leaks
3. Pressure gage	a. Check accuracy
4. Pumps and valves	a. Wear
	b. Valves operation
5. Main body of scrubber	a. Material feed building
	b. Abrasion
	c. Corrosion

(Source: Hesketh, ed, 1983)

The most important and useful parameter to monitor is **pressure** hence pressure instruments must be installed at strategic locations, namely on the **scrubber**, **mist eliminator** and **fan** as a minimum.

8.1 Regulatory Record Keeping Requirements

At the minimum the parameters stated in Table 7 must be monitored and data kept in log book and made available to the DOE officers for inspection. Typical forms to record performance data on gaseous scrubbers are depicted in Appendix III.

Table 7 : Records of performance data

Data	Comment
Temperature	The scrubber **inlet temperature** is monitored to prevent high inlet gas temperature. Inlet gas temperature higher than the design value could lead to excessive liquid evaporation resulting in damage to scrubber components. The scrubber **outlet temperature** is monitored to evaluate scrubber operation and to protect downstream equipment from excessive temperature. High outlet temperature may be indicative of poor liquid distribution or plugging of liquid inlet.
Pressure drop	To provide the most useful information, the pressure drop should be monitored across **specific scrubber components** i.e. scrubber chamber and mist eliminator instead of across the entire scrubber train.
Liquid flowrate	The **liquor feed rate** as well as the **water make up rate** should be monitored.
pH	The pH of the chemical and scrubbing liquid **feed streams** and the **recycle liquor** systems should be monitored.

9. PERFORMANCE MONITORING OF TRANSMISSOMETERS

Transmisometers are **opacity monitors** which are more commonly known as **smoke meters and recorders** in Malaysia. The instrument is generally installed across a **stack** or a **duct** that leads to the stack. Transmissometers are widely used to monitor the effectiveness of **dust arrestment device** and sometimes directly as a method of determining **compliance** with opacity emission standards.

A transmissometer is not per se an air pollution control equipment whose primary objective is to limit the discharge of containments into the atmosphere. Rather, it is an **instrumentation** system, hence a **quality assurance** program is imperative.

For continued smooth operation of this **continuous opacity monitoring** system (COMS), quality control activities should be performed to assure that quality data are generated from the system. A summary of preventive maintenance/quality control procedures for a transmissometer system is given in Table 8.

Table 8: Preventive and corrective maintenance for transmissometers

	Task	Frequency
Operation checks (daily check, observations, adjustment)	Check indicator (fault) lights status	Daily
	Record zero value Record span value Examine strip chart	
Routine maintenance	Clean outer surfaces, windows and filters	Monthly
And preventive maintenance	Check alignment, dessicants and blower motor	Monthly
	Check and replace lamps	1-2 years
Performance audit*	Assess the performance of the entire transmissometer system	3 years

* Performance audit is an involved exercise which should be independently conducted by the company's assurance group or a third party consultant.

9.1 Regulatory Record Keeping Requirements

To comply with regulatory record keeping requirements at the minimum the records summarized in Table 9 should be kept in a logbook and made available to the DOE officers. Typical forms for recording performance data of transmissometers are given in Appendix V.

Table 9 : Performance monitoring record for transmissometers

Daily record of **zero and calibration values**
Record of **window cleanings**
Record of **part replacements** (lamps, filters, electronic components)
Record of any **maintenance**
Summary and results of **audits**

10. ENFORCEMENT OF PERFORMANCE MONITORING REQUIREMENTS

Approval conditions for new installations of chimneys/air pollution control systems will include some conditions on performance monitoring requirements. During inspection duties the DOE enforcement officers will examine the **logs** kept at the factory premises for completeness of **entries** as specified in the preceding paragraphs entitled "Regulatory record keeping requirements" (paragraphs 5.1, 6.1, 7.1, 8.1, and 9.1) for each control equipment. This represents the minimum requirement. Other activities to be conducted by the officers during the inspection rounds are discussed in a separate document entitled "**Compliance Inspection of Air Pollution Control Systems**".

11. ADDRESSING UPSET CONDITIONS

Any upset situations such as malfunctioning of air pollution control system must be attended to immediately. The corrective actions taken should be recorded in the relevant form as illustrated in Appendix V.

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Appendix I

Typical Form to Record Performance Monitoring Data of Cyclones

(A) DAILY

Date	Pressure, mm Hg/H_2O		Opacity or Stack Condition	Discharge Hopper Condition
	In	Out		
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				

Entries made by:

Operator's name:

Signature:

Date:

Checked by:

Supervisor's name:

Signature:

Date:

(B) WEEKLY

Date	Procedure	Notes	Operator's signature	Supervisor's signature
	Check **fan bearings.** Check gaskets, valves, and other opening for **leakage.**			
	Check **fan bearings.** Check gaskets, valves, and other opening for leakage.			
	Check **fan bearings.** Check gaskets, valves, and other opening for **leakage.**			
	Check **fan bearings.** Check gaskets, valves, and other opening for **leakage.**			

(C) MONTHLY

Date	Procedure	Notes	Operator's signature	Supervisor's signature
	Check for sign of **corrosion** and other signs of **deterioration.** Inspect inlet and outlet for **dust-build up.**			

Appendix II

Typical Form to Record Daily Performance Monitoring Data of Bagfilters

(A) DAILY

Date	Pressure, mm Hg/H_2O		Opacity or Stack Condition	Discharge Hopper Condition
	In	Out		
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				

Entries made by:

Operator's name:

Signature:

Date:

Checked by:

Supervisor's name:

Signature:

Date:

(B) DAILY

Date	Procedure	Notes	Operator's signature	Supervisor's signature
	• Walk through system, listening for proper operation • Check for unusual occurrences in process • Observe control panel indicators • Check compressed-air pressure • Ensure that dust is being removed from system			
	• Walk through system, listening for proper operation • Check for unusual occurrences in process • Observe control panel indicators • Check compressed-air pressure • Ensure that dust is being removed from system			

(C) WEEKLY

Date	Procedure	Notes	Operator's signature	Supervisor's signature
	• Inspect screw-conveyor bearings for lubrication • Check packing glands • Operate damper valves • Check compressed-air lines, including line filters and dryers • Check that valves are opening and closing properly in bag-cleaning sequence • Verify accuracy of temperature-indicating equipment • Check pressure-drop-indicating equipment for plugged lines			
	• Inspect screw-conveyor bearings for lubrication • Check packing glands • Operate damper valves • Check compressed-air lines, including line filters and dryers • Check that valves are opening and closing properly in bag-cleaning sequence • Verify accuracy of temperature-indicating equipment • Check pressure-drop-indicating equipment for plugged lines			

(D) MONTHLY

Date	Procedure	Notes	Operator's signature	Supervisor's signature
	• Check all moving parts in shaker mechanism • Inspect fans for corrosion and material buildup • Check drive belts for wear and tension • Inspect and lubricate appropriate items • Spot-check bag tension • Spot check for bag leaks • Check hoses and clamps • Check accuracy of indicating equipment • Inspect housing for corrosion			

Appendix III

Typical Form to Record Performance Data of Gaseous Scrubbers

(A) DAILY

Date	Pressure of mist eliminator, mm WG		Pressure of scrubber body, mm WG		Temperature, of gas, °C		pH of liquor		Liquid flowrate, (or in terms of pressure)	
	In	Out	In	Out	In	Out	Feed	Recycle	Feed	Make-up
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

Entries made by:
Operator's name:
Signature:
Date:

Checked by:
Supervisor's name:
Signature:
Date:

(B) WEEKLY

Date	Procedure-Check point	What to look for	Notes	Operator's signature
	Pump	Leaking Increased noise		
	Valve	Position Leaks		
	Piping	Leaks		
	Body	Leaks		
	Pressure gage	Pressure change from previous day		
	Pressure gage ammeter combination	Changes in either or both pressure reading and ampere drawn from last clean system check readings		

Checked by:

Supervisor's name:

Signature:

Date:

(C) MONTHLY

Date	Procedure-Check point	What to look for	Notes	Operator's signature
	Spray bars	Plug nozzles Worn or missing nozzles		
	Pipes and manifolds	Plugging or leaks		
	Pressure gage	Check accuracy		
	Pumps and valves	Wear Valves operation		
	Main body of scrubber	Material feed building, Abrasion, Corrosion		

Checked by:

Supervisor's name:

Signature:

Date:

Appendix IV

Typical Form to Record Performance Monitoring Data of Transmissometers

(A) DAILY

Date	Procedure	Notes/Values	Operator's signature
	Check indicator (fault) lights status Record zero value Record span value Examine strip chart ***Check indicator (fault) lights status*** Record zero value Record span value Examine strip chart ***Check indicator (fault) lights status*** Record zero value Record span value Examine strip chart		

Checked by:

Supervisor's name:

Signature:

Date:

(B) WEEKLY

Date	Procedure	Notes/Values	Operator's signature
	Clean outer surfaces, windows and filters Check alignment, dessicants and blower motor Check and replace lamps (1-2 years) Clean outer surfaces, windows and filters Check alignment, dessicants and blower motor Check and replace lamps(1-2 years)		

Checked by:

Supervisor's name:

Signature:

Date:

Appendix V

General Form to Record Corrective Action for Upset Conditions
(applicable for all types of control equipment)

Month:

Date	Type of Upset Condition	Diagnosis of Cause of Upset condition	Any Non Compliance Of Discharge Standard Occurred? – Give Explanation	Corrective Action Taken	When Condition Returned to Normal	Name and Signature of Reporting Officer

Checked by:

Supervisor's name:

Signature:

ACKNOWLEDGEMENT

The Department is especially grateful to Ir. Dr. Shamsudin Ab. Latif, Deputy Director General (Development) for taking the initiatitive to write a series of **Technical Guidance Documents**, some for the use of DOE officers and some for the industries. It is our fervent hope that widespread use of these documents will value-add DOE's enforcement work, as well as industries' practices in pollution control. The final goal is to improve **regulatory compliance** and consequently, achieve a better **environmental quality** for all.

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