Book 1

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TECHNICAL GUIDANCE ON

PERFORMANCE MONITORING OF INDUSTRIAL EFFLUENT TREATMENT SYSTEMS

FOR THE USE OF THE INDUSTRIES AND CONSULTANTS

DOE Malaysia
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TECHNICAL GUIDANCE ON
PERFORMANCE MONITORING OF INDUSTRIAL EFFLUENT TREATMENT SYSTEMS

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FOREWORD

In successful organizations, typically the operators are tasked with specific responsibilities that include such daily chores as general daily **walk through inspection** of the Industrial Effluent Treatment Systems (IETS) to ensure no effluent pipe leakages, and equipment breakdowns, preventive maintenance, performance monitoring, sampling and record keeping. These activities need to be conducted in a coordinated manner to assure proper functioning of all the IETS components.

This **Technical Guidance Document** is intended to serve the following purposes:

(i) To promote the practice of **performance monitoring** as a routine function and an integral part of the operation of an industrial effluent treatment system

(ii) To standardize the elements of what constitutes a good **performance monitoring procedure/plan**

(iii) To provide guidance to the industries on the performance monitoring activities to comply with the **Written Permission** conditions

(iv) To provide guidance to the IETS operators on the relevant **tests** and **parameters** to be analyzed for performance monitoring purposes.

It is our fervent hope that widespread use of these documents will value-add DOE's enforcement work, as well as industies' practices in pollution control. The final goal is to 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 INDUSTRIAL EFFLUENT TREATMENT SYSTEMS

1.0 INTRODUCTION

Industrial effluents vary significantly in pollution characteristics hence different **unit processes** and **unit operations** are utilized to treat them. This document presents general guidelines and considerations on performance monitoring requirements so that effective monitoring program can be established for the varied unit processes and operations in an industrial effluent treatment system (IETS).

2.0 WHAT IS PERFORMANCE MONITORING?

Even though some industries are routinely conducting various tests to monitor the performance of the unit operations and unit processes which make up the effluent treatment system in their premises, by en large, the practice of **performance monitoring** of industrial effluent treatment systems in many industries is an exception rather than the norm. Performance monitoring can be understood to mean the following:

(i) **Preventive** or **routine maintenance** is "an orderly program of positive actions (equipment cleaning, adjustments and/ or testing, lubricating, reconditioning) for preventing failure of monitoring parts and systems during their use".

(ii) Failure of system or part of system calls for **corrective maintenance** (non routine maintenance).

Although the above has been defined in the context of performance monitoring of air quality monitoring and instrumentation and air pollution control equipment, the general idea can also be applied to performance monitoring in the field of effluent treatment or any kind of industrial process. Thus, performance monitoring is **proactive monitoring** of certain parameters to provide a diagnostic indication to ensure that unit operations and unit processes are operating optimally.

3.0 OBJECTIVES OF PERFORMANCE MONITORING PROGRAMS

3.1 Regulatory Requirements on Performance Monitoring

The **Environmental Quality Act,** 1974 provides the legal basis for environmental management in general and pollution control in particular. The most relevant subsidiary legislation on water pollution control is the **Sewage and Industrial Effluents Regulations**, 1979 (SIER). Written permissions issued under Regulation 4 of SIER may include **monitoring requirement** including **performance monitoring** of the industrial effluent treatment system (IETS) (Regulation 5 (2) of SIER). Performance monitoring is a component of preventive maintenance that forms an integral part **self regulation** approach. Performance monitoring of IETS is required by the Department of Environment under the approach of self monitoring and record keeping by the industry. This document provides guidelines on the type of parameters, location of sampling points, frequency and sample type that are recommended and the format of records to be kept by the industries. **Monitoring, recording, and reporting** of the IETS performance are required to demonstrate that the treatment system is **functioning correctly** and the effluent standards are being **complied** with.

4.0 PERFORMANCE MONITORING OF TREATMENT PROCESSES

4.1 General considerations

A successful effluent treatment is dependent upon all **components** of the industrial effluent treatment system (IETS) being operational in optimal condition. Problems with any one of the system components will affect the overall efficiency of the IETS resulting in poor **effluent quality**. To ensure successful treatment and regulatory compliance, each of the treatment processes (i.e. **unit processes** and **unit operations**) needs close monitoring on a regular basis.

4.1.1 Influent Monitoring

Usually, **Written Permission** will specify the location of **influent monitoring point**(s) within a factory. Influents are preferably sampled at points of highly **turbulent flow** in order to ensure good mixing. Influent monitoring includes measuring **flowrate** as well as sampling for **quality analysis**.

4.1.2 Effluent Monitoring

Written Permission will also dictate the location of the **final discharge point** which will also be the location where **flow measurements** are to be made and **final effluent samples** are collected for analysis.

4.1.3 Sampling

For performance monitoring purposes only **grab sampling** is required. A grab sample may be defined as an individual discrete sampling over a period of time not exceeding 15 minutes. It can be taken manually using a pump, scoop, pail, or other suitable device. **Composite samples** from ponds with long detention times may not be representative. Convenience, accessibility and practicability are important factors but they must not be compromised with the need for **representativeness** of sampling.

4.1.4 Analytical Requirements

Performance monitoring does not require very accurate analysis, hence in practice, the latter can be substituted by in-situ measurements using **portable equipment** widely available in the market. The industries are also encouraged to set up **on site laboratory** equipped with facilities to conduct routine/simple measurements and equipment calibration activities. Nevertheless, the analytical requirements for the final effluent samples need to follow the **Standard Methods** as the results are required to be reported to the Department of Environment to comply with the Written Permission conditions in order to demonstrate **compliance** with the **discharge standards**.

4.1.5 Flow Measurement

In many situations, flowrate measurements of influent and effluent are made by the use of **flow meters** which are available in various types. Alternatively, where applicable, other flow measuring devices such as orifice plate, weirs, V notches, or even the "pail and stop watch method" can be used.

4.2 Performance Monitoring of Biological Processes

To operate an industrial effluent treatment system (IETS) efficiently, several tests have to be conducted periodically to monitor the performance of the various processes. The "health" and performance of the treatment system can be monitored by monitoring the relevant parameters. Three different types of **monitoring parameters** can be distinguished.

(i) Parameters that are essential to ensure the biological process are **functioning** optimally such as pH, DO, and nutrients.

(ii) Parameters that provide **diagnostic check** on the "health" status of the various unit operations and unit processes e.g. mixed liquor volatile suspended solids (MLVSS), sludge volume index (SVI) for an activated sludge process,

(iii) Parameters that indicate the **efficiency** of the treatment system such as biological oxygen demand (BOD) and chemical oxygen demand (COD).

The importance of the various parameters/tests is discussed briefly below.

4.2.1 Dissolved Oxygen

Biological unit processes require a **sufficient** amount of dissolved oxygen (DO) for growth and metabolism of microorganisms. In practice the DO concentration of about **1.5 to 4 mg/L** needs to be maintained in all the areas of the aeration tank; 2 mg/L is a commonly used value. Higher DO concentration will not necessarily increase the biodegradation efficiency hence represents wasted energy. For every IETS an **optimum DO concentration** depending on the type of microorganism and effluent characteristics can be evaluated by optimizing the DO concentration and the **removal efficiency** (indicated by BOD or COD). Oxygen limited growth environments may promote the predominance of filamentous organisms affecting the **settleability** of sludge. DO can be measured by using a **portable** hand held DO meter or measured continuously by **on line** DO probe and transmitter equipped with recording device.

4.2.2 pH

Monitoring of pH is important from several standpoints. The optimum **biological activity** of the microorganisms for the treatment process is in the pH range from 6.0 to 9.0. Besides that a pH-value below 6.5 will be detrimental to concrete structures of the treatment system components.

4.2.3 Mixed Liquor Suspended Solids and Mixed Liquor Volatile Suspended Solids

The mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solids (MLVSS) are commonly used to represent the **microorganisms** in biological treatment processes especially the activated sludge process. MLVSS is the **volatile fraction** of the MLSS. Solids analysis is important in the control of biological and physical effluent treatment processes where the solids information is used in calculation of food to microorganism (F/M ratio), SVI, recirculation ratio, etc.

Typically, the MLSS concentration should be maintained within the range of 1500 to 3000 mg/L for a **conventional activated sludge** process and 3000 to 6000 mg /L for an **extended aeration activated sludge** process respectively,

4.2.4 Sludge Volume Index

The Sludge Volume Index (SVI) is used as an indication of the **settling characteristics** of the sludge. The SVI values which show a trend towards poor settling can be the forerunner of a treatment system experiencing upset conditions. SVI measurements also yield information used to establish the proper **recirculation ratio** for optimum process efficiency and maximum solids concentration in the waste sludge.

Poor settling sludge will result in low concentration of solids in the return-activated sludge and thus the concentration of microorganisms in the aeration tank drops. Subsequently, the aeration tank will be subject to conditions of higher F/M ratio which results in a reduced BOD/COD removal efficiency.

As a guide, typical SVI values indicating the settling characteristics of the sludge are given in Table 1 below:

Table 1: SVI values and sludge settling characteristics

SVI	Sludge settling characteristics
<50	excellent
50-100	Good
100-150	satisfactory
>150	poor-bulking of sludge

4.2.5 Nutrients

Many industrial effluents are deficient in nutrients, hence, to ensure adequate amounts of nutrients are supplied to the aeration tanks, **nutrient balance** should be periodically checked. In terms of the basic nutrients of Nitrogen (N) and Phosphorus (P), the rule of thumb for the weight ratio of BOD_5: N: P should be approximately 100: 5: 1. Typical signs of nutrient deficiency are **filamentous growth** and **bulking** of activated sludge.

4.2.6 Oxygen Uptake Rate

Respirometry measures the **oxygen uptake** of microorganisms. The utilization of oxygen by the microorganisms indicates the **biological activity** occurring in the aeration tank and is interpreted to mean that the effluent water is biodegraded. **Specific Oxygen Uptake Rate** (SOUR) is the amount of oxygen per unit mass of the mixed liquor suspended solids (mg O_2 $min^{-1}mg^{-1}$ of MLVSS). A sudden rise in SOUR indicates an upsurge of **organic load** while a sudden decrease indicates a **toxic or pH shock.**

4.2.7 Biological Oxygen Demand and Chemical Oxygen Demand

The overall performance of a biological treatment process in treating an organic effluent can be best monitored on the basis of either biological oxygen demand (BOD) and chemical oxygen demand (COD) or removal efficiencies or both.

Table 2 summarizes the parameters which are commonly monitored to indicate the performance of the various **biological unit processes** commonly used in the treatment of **organic effluents.**

Table 2: Performance Monitoring Testing Guide for Biological Unit Processes

Process	Test	Frequency	Remarks
Activated Sludge	Feed flowrate	Daily	
	PH	Daily	
	DO	Daily	
	SV_{30}	Daily	
	BOD	Weekly or Bimonthly	Influent & effluent (compute the removal efficiency)
	COD	Weekly	Influent & effluent (compute the removal efficiency)
	MLSS	Weekly or monthly	Monthly, when system is stable
	MLVSS	Weekly or monthly	Monthly, when system is stable
	SVI	Weekly or monthly	Monthly, when system is stable
	SS	Weekly	Sampling at effluent of clarifier
	F/M ratio	Weekly	By calculation to relate the efficiency of plant operation
	Nutrient	Monthly	
	Oxygen Uptake	When necessary	
	Microorganism Population	Optional	
Oxidation Ponds	Feed flowrate	Daily	
	PH	Daily	
	DO	Daily	
	SS	Weekly	Sampling at effluent of clarifier
	BOD	Weekly or bimonthly	Influent & effluent (compute the removal efficiency)
	COD	Weekly	Influent & effluent (compute the removal efficiency)
	Nutrient	Monthly	
	Microorganism Population	Optional	
Trickling Filters	Feed flowrate	Daily	
	Recirculation flowrate	Daily	
	PH	Daily	Influent & effluent
	DO	Daily	Test on effluent (before settling)
	BOD	Weekly or bimonthly	Influent & effluent (compute the removal efficiency)
	COD	Weekly	Influent & effluent (compute the removal efficiency)
	Nutrient	Monthly	

Process	Test	Frequency	Remarks
Rotating Biological Contactor (RBC)	Feed flowrate	Daily	
	PH	Daily	
	DO	Daily	
	BOD	Weekly or bimonthly	Influent & effluent (compute the removal efficiency)
	COD	Weekly	Influent & effluent (compute the removal efficiency)
	Nutrient	Monthly	
Anaerobic Upflow Sludge Blanket (AUSB)	Feed flowrate	Daily	
	PH	Daily	
	BOD	Weekly or bimonthly	Influent & effluent (compute the removal efficiency)
	COD	Weekly	Influent & effluent (compute the removal efficiency)
	MLSS	Weekly or monthly	
	VFA*	Weekly	
	Nutrient	Monthly	

Note:
* VFA: Volatile fatty acid
Processes listed in the Table are not exhaustive. This is a minimum sampling guide, and is subject to change with plant site, complexity of operation and problems encountered.
Either BOD or COD may be dropped depending on situation

4.3 Performance Monitoring of Physical and Chemical Processes

4.3.1 Heavy Metals Removal by Precipitation and Coagulation Reactions

Removal of heavy metals by coagulation reaction is heavily dependent on pH of the solution. The solubility of metals is controlled by the solution pH where the point of **minimum solubility** dictates the narrow pH range within which the precipitation process needs to be maintained.

4.3.2 Removal of Pollutants by Redox Reactions

Many of the chemical and the biochemical processes encountered in the treatment of industrial effluents can be described fundamentally **as oxidation-reduction** systems. Measuring and controlling **oxidation reduction potential** (ORP) levels is especially relevant in the treatment of industrial effluents involving an oxidation-reduction reaction such as **chrome waste treatment**.

The **Written Permission** may stipulate a requirement on ORP measurement for monitoring unit operations involving redox reaction.

ORP is a measurement of the **status** of an oxidation-reduction reaction. Although it can be used to monitor the degree of treatment in the reaction tank, ORP values cannot be equated to a specific concentration of the heavy metals such as chrome and therefore cannot be used as a final discharge effluent parameter. Additionally, by monitoring pH/ORP, **chemical usage** can be optimized resulting in cost savings.

In the field of industrial effluent treatment ORP measurement has been be utilized successfully to monitor cyanide oxidation and chromate reduction. The ORP measurement can be made electrometrically using the millivolt mode of a pH meter.

4.3.3 Removal of Metals by Ion Exchange

A metal-laden effluent that will undergo an ion exchange process is commonly collected in a buffer tank where **pH adjustment** may be carried out. The subsequent process of ion-exchange operations are usually monitored by monitoring **conductivity**. In practice more accurate control can be achieved by using **conductivity ratio** measurement. Comparison of **conductivity, pressure difference and metals concentration** at the column's inlet and outlet and within the column will enable one to detect the onset of **breakthrough**, hence the need for **column regeneration**.

4.3.4 Removal of Metals by Electrowinning

Electrowinning is an **electrochemical process** that can be employed to remove metallic ions from concentrated **rinse water, spent process solutions**, and **ion exchange regenerant**. An advantage of electrowinning is that the metal removed from the effluent is plated out as a **solid metal**. Sometimes to enable automated system operation and ensure consistent environmental performance, electrowinner is equipped with an **on-line metal sensor** to provide real-time monitoring of the concentration of the metal to be removed. To monitor the efficiency of the electrowinning process other parameters monitored are **current, voltage** and **temperature.**

4.3.5 Removal of Various Contaminants by Carbon Adsorption

The adsorption process in a carbon column will continue until the capacity of the carbon is reached (the **breakthrough time**). This time should be closely monitored to ensure that the carbon is **replaced** or **regenerated** before the stipulated time. The breakthrough time of carbon beds can be determined via several ways such as:

(i) By sampling of effluent from the column and monitoring the **concentration of pollutants** of interest (e.g. COD)

(ii) By consideration of the **hours of operation** of the column

(iii) By using total **volume of throughput**.

Table 3 presents a summary of the performance monitoring parameters which are typically monitored in the operation of common physico-chemical treatment processes.

Table 3: Performance Monitoring Testing Guide for Physico-Chemical Treatment Processes

Process	Test	Frequency	Remarks
Chemical Precipitation	Flowrate pH Chemical dosage Heavy metals (If process is for heavy metals removal)	Daily Daily Daily Daily	 To calculate the chemical dosage in mg/L Influent & effluent (to compute the removal efficiency)
Chemical Precipitation	SS (If process is for SS removal) COD (If process is for COD removal)	Daily Weekly	Influent & effluent (to compute the removal efficiency) Influent & effluent (to compute the removal efficiency)
Oxidation/ Reduction	Flowrate pH ORP Chemical dosage Heavy metals COD	Daily Daily Daily Daily Daily Daily	 To calculate the chemical dosage in mg/L Influent & effluent (to compute the removal efficiency) Influent & effluent (to compute the removal efficiency)
Dissolved Air Flotation (DAF)	Recirculation flowrate Pressure Air flowrate	Daily Daily Daily	

Process	Test	Frequency	Remarks
Ion Exchange	Flowrate Heavy Metals Pressure difference	Daily Daily or weekly Daily	 Influent & effluent (to compute the removal efficiency), more frequent as breakthrough is approached
Electrowinning	Flowrate Current Voltage pH Temperature Heavy metal (the relevant one)	Daily Daily Daily Daily Daily Per batch (if batch process)	 Influent & effluent (to compte the removal efficiency)
Carbon Adsorption [(a)]	Flowrate Contaminant to be removed (e.g. COD) Pressure difference	Daily Daily Daily	 Influent & effluent (to compute the removal efficiency), more frequent as breakthrough is approached

Note: [(a)] Additionally, the operator has to be mindful of the **breakthrough time** of the carbon column (based on throughput or hours of operation or contaminant concentration).

Processes listed in the Table are not exhaustive. This is a minimum sampling guide and is subject to change with plant site, complexity of operation, and problems encountered

5.0 EFFLUENT PARAMETERS FOR SPECIFIC INDUSTRIES

The Department of Environment is promoting the culture of **self monitoring** in the industrial sector and hence encourages the industries to self monitor the performance of their effluent treatment systems. This can be accomplished by conducting performance monitoring activities for the major unit processes and unit operations recommended in this Guideline including the monitoring of the **final effluent**. **Weekly** or **monthly** sampling of the final effluent is recommended except for **batch discharges** which have to be sampled for each batch. The relevant parameters of the final effluents recommended to be monitored for different industries are listed in Table 4. Nevertheless, the owners or operators of premises should consult the approval condition of the written permission for the actual parameters to be monitored.

6.0 RECORD KEEPING OF CORRECTIVE ACTIONS TO ADDRESS UPSET CONDITIONS

Industries are required to maintain the record of **performance monitoring data and corrective actions** taken to address upset condition encountered in the daily operation of the industrial effluent treatment systems. The recommended tables to be used are shown in the appendices. The record should be kept in a **log** or in a **dedicated file** and made available for the inspection of the officers of the Department of Environment during their enforcement duties. Appendix H is a recommended format for recording corrective actions taken by the industry to address upset situations.

Table 4: Priority effluent parameters for different industries (list not exhaustive)

Industry Type	Common Priority Parameters
Chlor-Alkali (Mercury Cell)	T, pH, SS, Chlorine, Mercury, Chlorides
Chlor-Alkali (Diaphragm Cell)	T, pH, SS, Chlorine, Chlorides
Metal Finishing and Electroplating	T, pH, SS, O&G, Arsenic, Cadmium, Chromium (trivalent), Chromium (hexavalent), Lead, Nickel, Mercury, Silver, Zinc, Fluorides, Cyanides-depending on the metals involved
Fertilizer (Nitrogenous)	T, pH, SS, Ammoniacal nitrogen, COD
Fertilizer (Phosphate)	T, pH, SS, Ammoniacal Nitrogen, COD, Fluoride
Pulp and Paper	T, pH, BOD_5' COD, SS, Sulfides
Petroleum Refining	T, pH, BOD_5, COD, SS, O&G, Phenolic compounds
Steel Industry	T, pH, COD, SS, Chromium (trivalent), Iron, O&G, Cadmium, Copper
Synthetic Fiber	T, pH, BOD_5, COD, SS, Oil & Grease, Sulfides
Tanning and Leather Finishing	T, pH, BOD_5, COD, SS, Sulfide, O&G, Chromium (trivalent), Chromium (hexavalent), Phenolic compounds
Textile Processing	T, pH, BOD_5, COD, SS, Chromium, Copper
Pigments and Dyes	T, pH, COD, Lead, Copper, Zinc
Thermal Power Plants	T, pH, SS, O&G
Rubber Products	BOD_5, COD, Zinc, Chromium, SS
Paints, Varnishes & Lacquers	pH, SS, COD, Lead, Chromium, Cadmium, Zinc, Barium

Industry Type	Common Priority Parameters
Pesticides	COD, Mercury
Printing	COD, Lead
Industrial Chemicals	pH, COD, Phenolic Compounds, Cyanide, Ammoniacal nitrogen, Cadmium, Lead, Chromium, Mercury, Nickel, Zinc, Arsenic, pH, COD, SS
Oil & Gas Production	T, pH, BOD_5, COD, SS, O&G, Chloride, Phenolic Compounds
Petrochemicals	T, pH, BOD_5, COD, SS, O&G, Phenolic Compounds
Dairy Industry	T, pH, BOD_5, COD, SS, O&G
Fruit and Vegetable Processing	T, pH, BOD_5, COD, SS
Food and Beverage	T, pH, BOD_5, COD, SS, O&G
Glass Manufacturing	T, pH, COD, SS, Barium, O&G
Sugar	T, pH, BOD_5, COD, SS, O&G
Detergent	pH, COD, O&G, An-ionic Detergent
Photographic	pH, COD, Silver, Cyanide, Fluoride
Glue Manufacture	pH, BOD_5, COD, Phenolic Compounds, Formaldehyde
Oil & Gas Exploration	T, pH, COD, SS, O&G, Chloride, BOD5, Phenolic compounds
Vegetable Oil Mills	T, pH, BOD_5, COD, SS, O&G
Plastic Materials and Products	SS
Wood Products	pH, SS, COD, Phenolic Compounds
Pharmaceutical	T, pH, BOD_5, COD, SS
Landfill Leachate	T, pH, BOD_5, COD, SS, Ammoniacal nitrogen

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Appendix 1

Tables to Record Performance Monitoring Data of Activated Sludge Process

A. DAILY RECORD

Date	Flow rate (m^3/h)	pH	DO (mg/L)	SV_{30} (mL)	Remarks*	Signature of operator or Reporting officer

B. WEEKLY OR MONTHLY RECORD

Date	BOD (mg/L)		COD (mg/L)		MLSS (mg/L)	MLVSS (mg/L)	SS of Clarifier (mg/L)	Nutrient (mg/L)	F/M Ratio (d^{-1})	SVI	Remarks*	Signature of operator or Reporting officer
	Inlet	Outlet	Inlet	Outlet								

* Include observation of upset or abnormal observation. Use Table H to record corrective actions taken if any.

C. COMPUTATION OF OXYGEN UPTAKE RATES

Date: ....

Time (min)	DO (mg/L)		Remarks*	Signature of operator or Reporting officer
		Oxygen Uptake rate = Slope of Dissolved Oxygen vs. Time graph		
		=		
		Mg/L.min		

The above tables can be used or modified for other biological unit processes (oxidation ponds, trickling filters, rotating biological contactors or anaerobic upflow sludge blankets)

Appendix II

Tables to Record Performance Monitoring Data of Physico-Chemical Processes

A. CHEMICAL PRECIPITATION OR OXIDATION REDUCTION

Daily Record

Date	Flowrate (m^3/h)	pH	ORP (mV)	Chemical Dosage (mg/L)	Heavy Metals (mg/L)	COD * (mg/L)	Signature of operator or Reporting officer

* If applicable

B. DISSOLVED AIR FLOATATION (DAF)

Daily Record

Date	Recirculation (m^3/h)	Flow rate (m^3/h)	Pressure (PSI or kPa)	Air Flow (m^3/h)	Signature of operator or Reporting officer

C. ION EXCHANGE

Daily Record

Date	Flow rate (m^3/h)	Heavy Metals* (mg/L)	Pressure Difference (kPa)	Conductivity (µS/cm)	Signature of operator or Reporting officer

* Daily or weekly or more frequent as breakthrough is approached.

D. ION EXCHANGE COLUMN REGENERATION RECORD

Date	Regeneration Site		If offsite name address company conducting regeneration	Signature of operator or Reporting officer
	Onsite	Offsite		

E. ELECTROWINNING

Daily Reporting

Date	Flow rate (m^3/h)	Current (amps)	Voltage (V)	pH	Temperature (^0C)	Heavy Metal Contaminant * (mg/L)	Signature of operator or Reporting officer

* per batch if batch process

F. CARBON ADSORPTION

Daily Reporting

Date	Flow rate (m^3/h)	Contaminant to be removed (e.g. COD) (mg/L)	Pressure Difference (kPa)	Signature of operator or Reporting officer

G. CARBON ADSORPTION COLUMN REGENERATION RECORD

Date	Regeneration Site		If offsite name address company conducting regeneration	Signature of operator or Reporting officer
	Onsite	Offsite		

H. GENERAL TABLE TO RECORD CORRECTIVE ACTIONS TAKEN TO ADDRESS UPSET CONDITIONS

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	Signature of operator or Reporting officer

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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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