

PETRONAS TECHNICAL STANDARDS

HEALTH, SAFETY AND ENVIRONMENT

GUIDELINE

Wastewater Management

PTS 60.3302

September 2011



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PREFACE

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Acknowledgement

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1.0 FOREWORD

The issue of water pollution has been given greater emphasis lately due to a greater demand for best environmental management practices from the public, especially in regions where water resources scarcity exists. Discharges from industrial sources have been known to be one of the contributors towards the pollution loading into water bodies and, in some cases, even contamination of the land. As far as pollution loading from discharges is concerned, the most important consideration shall be with regards to the assimilative capacity of the receiving water body. Therefore, it is important to recognise that every discharge from our facilities and project sites has the potential to cause deterioration of water quality and therefore causing negative environmental impacts including human and ecosystem health effects and the contamination of water supplies.

This guideline was developed as part of GHSED's effort to ensure a more effective management of liquid discharges from our operations and project sites. This guideline is also designed to assist the relevant staff to better understand the elements of good wastewater management practices and appreciate the importance of the need to do so.

This document provides the necessary support to meet the requirements set out in the 'Wastewater Management' element referred in the Environment Manual embedded in the HSE Mandatory Control Framework (MCF).

The guideline recognises that each site or project represents a unique situation with its own set of public expectations of relevant issues.

2.0 INTRODUCTION

2.1 OBJECTIVE

This document provides structured guidance on processes and criteria to ensure consistent practice in wastewater management across the Group.

Implementation of the elements described in this guideline will minimize the environmental risks associated with wastewater and storm water discharges.

2.2 SCOPE

This document provides description and guidance for the development and implementation of an effective management of wastewater and stormwater from all existing and new PETRONAS sites/facilities with any wastewater (including produced water) discharges to the environment.

PETRONAS sites refer to all OPU's and Joint Ventures, where PETRONAS has operational control.

Note: The scope of this PTS does not include shipping operations and other moving vehicles.

Definition

The word 'shall' indicates a requirement. The English language equivalent or interchangeable term of 'shall' is 'must'.

The word 'should' indicates a recommendation.

The word 'may' indicates a possible course of action.

3.0 MANAGEMENT OF WASTEWATER SOURCES

This section describes the various sources of wastewater and the appropriate means to manage them.

The details of the wastewater design and Performance Monitoring requirements are provided in Section 6 and 7 of this document, respectively.

The Management of Change process must be initiated for any modifications which can result in the alteration of the quality and quantity of the generated wastewater or have a different disposal, treatment or monitoring method.

Prior to implementing the various management requirements in this section, wastewater minimisation including reuse /recycling options shall be evaluated as described in Section 9.0.

The management of wastewater shall meet the requirements set out in this document. The design of a wastewater treatment system shall be in accordance to PETRONAS design specifications (Ref: **PTS 10.05.10.31 - Design of Wastewater Treatment System**). In meeting these requirements, it shall be ensured that the local regulatory requirements are fully complied with and if differences in any of the requirements arise, whichever is the more stringent shall apply.

There shall be a procedure in place to manage wastewater generated during normal and abnormal operations. Abnormal condition is resulted from operational changes in which the influent quality or quantity may have been altered, e.g. plant turnaround or planned shutdowns. Emergency situations are described under Section 8 of this PTS.

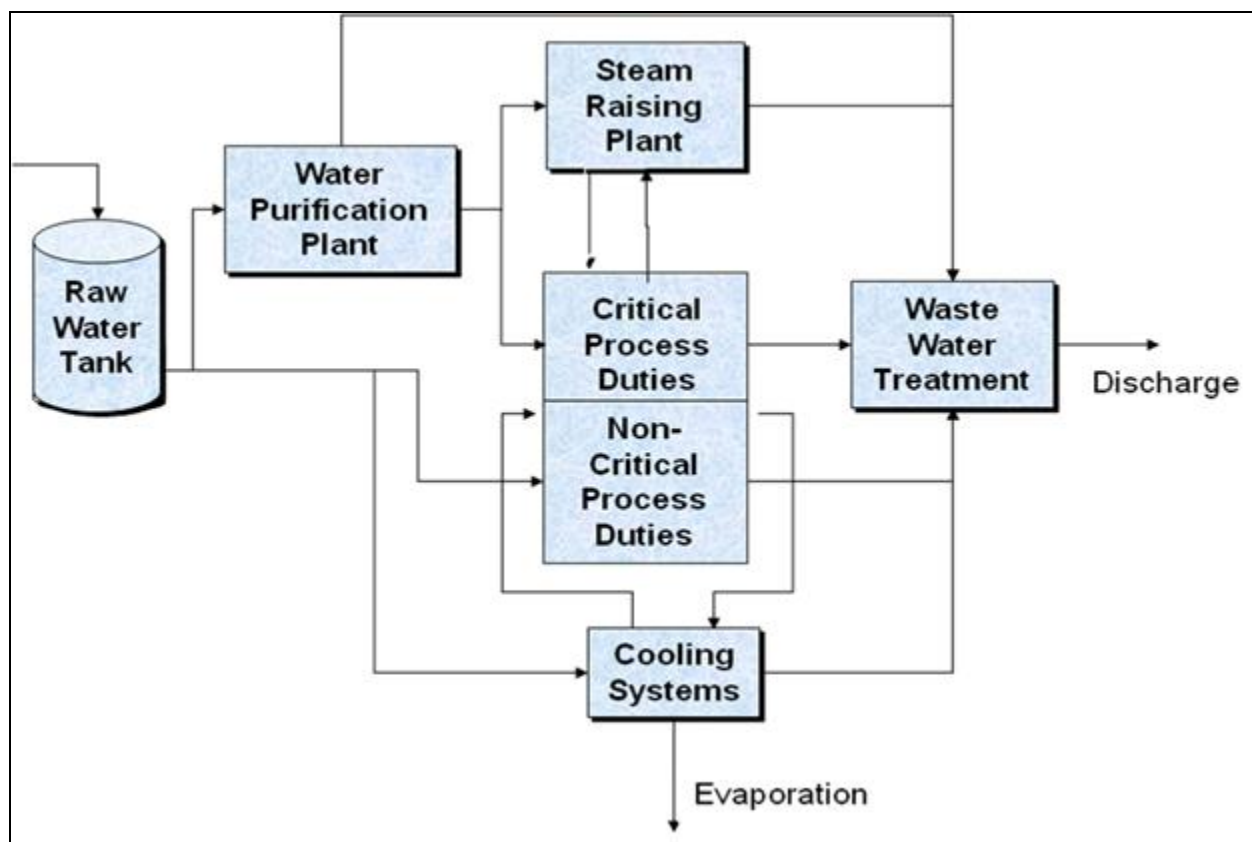
Public complaints related to wastewater management shall be addressed as per **PTS 60.0306 – Management of HSE Complaints**.

3.1 PROCESS WATER

3.1.1 Description of Process Water

Process water is wastewater generated from any operation (e.g. evaporation, gas synthesis, condenser, hydrolysis etc). It may also be generated from any routine operational activities (e.g. flushing, draining, backwashing, cleaning etc). Typical process water generation sources are shown in Figure 1.

Figure 1: Typical Process Water Generation Sources



If process water is not treated prior to discharge, it may harm the environment due to its harmful characteristics (e.g. high/low pH, high nutrients, high minerals, etc). A list of pollutants typically present from various wastewater streams of different processes is shown in Table 1.

Table 1: Typical Pollutants from Various Processes

REFINING			
	Water as % product	Hydrocarbons	Other Pollutants
Desalter	5 – 6 %	50 – 150 mg/l	NaCl, phenols, sulphides
Catalytic Crackers	6 – 10 %	100 – 150 mg/l	Sulphides, mercaptans, NH ₄ ⁺ , phenols
Condensates	2 – 2.5 %	50 mg/l	NH ₄ ⁺ , phenols
Vac Condensates	1 – 1.5 %	150 mg/l	NH ₄ ⁺ , phenols
Desulphurisation			NaOH, phenol, sulphides
STEAM CRACKING			
		Hydrocarbons	Other Pollutants
Ethylene, butadiene	propylene,	Phenols, organic acids, other hydrocarbons	Sulphides

REFORMING		
	Hydrocarbons	Other Pollutants
Methanol, Ammonia, Urea	Methanol, heavy alcohols	Ammonia, Urea
DERIVATIVES		
	Hydrocarbons	Other Pollutants
MTBE	Methanol, isobutene	
Ethylene Oxide	Ethylene Glycol, CO ₂ , acetaldehyde, hydrocarbons	
Acetic Acid	Formic acid, acetates, acetone	Acidic water, iodides, rhodium
Vinyl Chloride	Dichloroethane, hydrocarbons	HCl, NaCl
Polyethylene		Oil, TSS Catalysts
PVC	Methanol, acetates	Acidic water, TSS

Source: Degremont Water Handbook

3.1.2 Management of Process Water Under Normal Operations

Wastewater Collection

- 1) All wastewater sources (existing and future) must be identified and characterized.
- 2) There shall be consideration to segregate wastewater sources based on the pollutant type, concentrations and loading. Depending on the characteristics of the pollutant, the option of treating it at source shall be considered. E.g. Pre-treatment such as pH and temperature adjustment can be done prior to sending to main treatment facility
- 3) Sufficient equalization capacity must be provided as part of the collection system to ensure consistent load to the wastewater treatment facility to ensure that the loading would be sufficient and does not jeopardize the integrity of treatment system (overloading, underloading, toxic loading etc)

3.1.3 Management of Process Water Under Abnormal Operations

- 1) There shall be a procedure in place to manage abnormal operations. This shall include requirements for communicating abnormal conditions to the wastewater treatment owner.
- 2) During abnormal conditions, any wastewater that is exceeding the monitored limits must be sent to a diversion or off spec tank.
- 3) Any subsequent flow from the diversion or off-spec tank to the wastewater treatment facility (i.e. equalization tank) must be monitored to ensure that it is within the operating limits of the wastewater treatment facility.

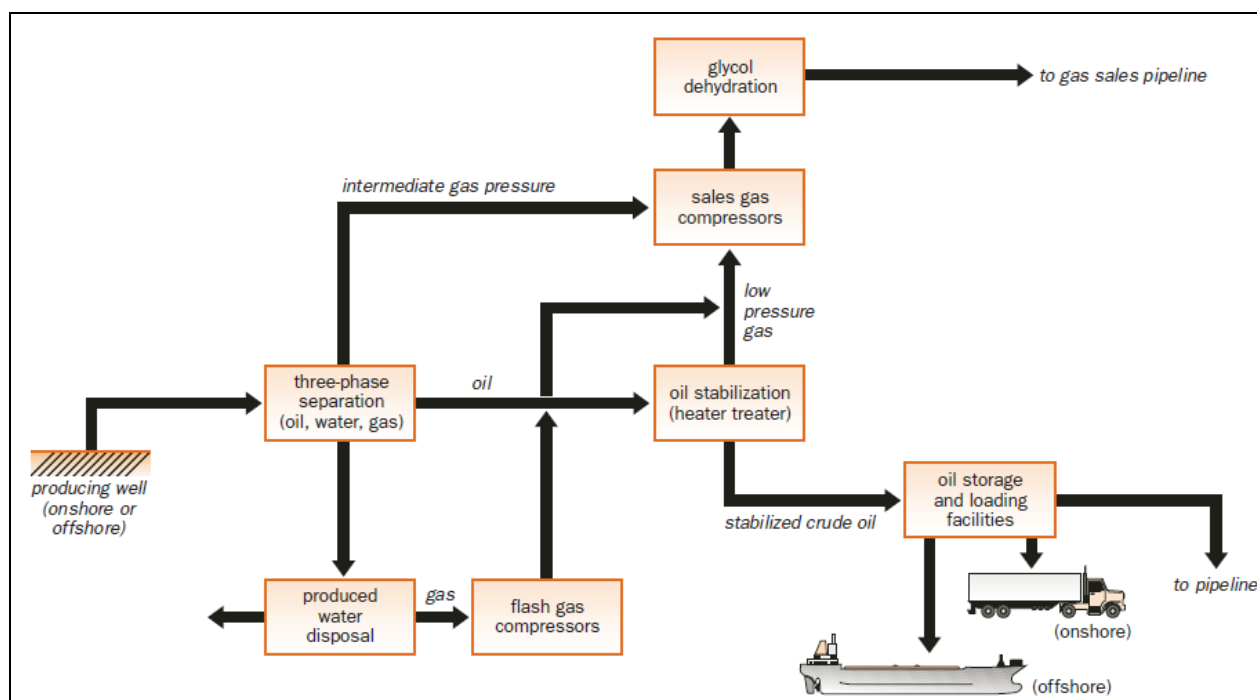
3.2 PRODUCED WATER

3.2.1 Description of Produced Water

Exploration and production (E&P) life cycle activities for conventional and unconventional hydrocarbons consist of exploration, appraisal, development, production and maintenance, and decommissioning. During production operation, hydrocarbon in the form of gas, condensate or crude oil is extracted from the sub-surface reservoir. Invariably, the formation water is extracted together with the hydrocarbon as a by-product.

This is then routed to a processing facility where it will undergo a process to separate oil, gas and water. The water by-product is known as 'produced water'. Oil and gas will be exported to the customer via pipelines or loading facilities while the produced water will go through a treatment system prior its disposal. A typical hydrocarbon processing facility is illustrated in Figure 2.

Figure 2: A typical hydrocarbon processing facility



Source: (UNEP, Environmental Management in Oil and Gas Exploration and Production)

Produced water generally resembles seawater as its major constituents are inorganic salts. Produced water contains residual quantities of dispersed and dissolved hydrocarbons (including aliphatic and cyclo-aliphatic compounds, aromatic substances and 'non-oil organic substances' e.g. fatty acids and phenols). Its minor constituents include trace elements (Fe, Hg, Cd, Pb, Zn, Cu, Cr, As, Ni, B) and very low concentrations of Naturally Occurring Radioactive Material (NORM). Several factors can further affect the constituents including the production location. In addition, technology such as Chemically Enhanced Oil Recovery (CEOR) can also affect the characteristics of the produced water via the alkaline and surfactant chemicals injection. Accordingly, the produced water generated from such processes/technology must take into account the associated potential environmental risks and therefore adopting an appropriate risk based discharge limits for the significant contaminants (also refer to Section 6 on this document).

Produced water volume and properties are determined by the characteristics of the reservoir and the maturity of the production. These are complex and vary throughout the lifetime of a reservoir and between reservoirs. Crude oil platforms generally produce higher volumes of produced water compared to gas platforms. These volumes increase with time.

3.2.2 Management of Produced Water from Offshore Wells

Management and disposal options for produced water shall be evaluated as part of the feasibility study of the E&P field development project. Options may include underground injection, segregation, treatment and disposal overboard into the marine environment or export to shore with produced hydrocarbons for treatment and disposal.

a) Underground injection

Typically there are two types of injection: into a suitable disposal well or into water injection wells as a secondary oil recovery technique. Disposal wells are typically depleted reservoirs that are converted for produced water disposal or a dedicated disposal well drilled to a suitable receiving subsurface geological formation. As part of a secondary oil recovery technique, produced water injected into injection wells is injected into oil-bearing layers of a reservoir to maintain reservoir energy. As this water is forced into the oil reservoir, it spreads out from the injection wells and pushes some of the remaining oil toward the producing wells. This technique is also known as water-flooding.

The injection option is dictated by the characteristics of the fluids to be injected, the constraints of the installations and the equipment, the evolution of the quality and quantity of produced water and the management history of the fields.

This option is frequently selected for onshore fields or sensitive near-shore environments. It is more operationally complex compared to others since a number of circumstances can occur that will interrupt injection. A good practice is to identify an alternative arrangement as a contingency plan. This alternative may include, but is not limited to:

- 1) use of stand-by injection wells
- 2) discharge to the sea (in compliance with relevant regulations)
- 3) diversion to treatment systems (if possible)
- 4) well shut-in

b) Overboard disposal into the marine environment

This option is the most common for offshore fields. If this is chosen then all means to reduce the water volume should be considered. These include:

- 1) adequate well management during well completion activities
- 2) re-completion of high water producing wells
- 3) use of down-hole fluid separation techniques, where possible
- 4) use of water shutoff techniques, when technically and economically feasible
- 5) shutting in high water producing wells

Prior to disposal, the produced water should be treated to a level that is ALARP, as determined by the risk assessment described in Section 5 of this PTS. However, the treated produced water should meet the standards set by relevant authority if this standard is more stringent than ALARP. A range of technologies exists for the offshore treatment of produced water. These are mainly

aimed at the removal of dispersed hydrocarbons (dispersed oil). The performance of these technologies is highly dependent on the process variables e.g. reservoir type, temperature, pressure, oil type and viscosity, water salinity, emulsion stability, oil droplet size, flow rate etc. at each location.

c) Export to shore with produced hydrocarbons for treatment and disposal

Extracted hydrocarbons (including produced water) from various offshore fields are sent to the onshore crude oil terminal or gas terminal via trunk-lines. The terminal dehydrate, store and export hydrocarbon products via single buoy mooring to export tankers (for crude oil) or via pipelines to the customer (for gas). The produced water by-product should undergo treatment to meet the standards set by relevant authorities prior to its discharge to surface water.

Many techniques are available for treatment of produced water at an onshore facility. Options are similar to other typical industrial effluent or process wastewater treatment systems. This may involve physical separation, chemical or biological treatment or a combination of technologies depending on the output requirement as well as economic feasibility. A key challenging factor to consider is that the performance of these technologies is highly dependent on the produced water characteristics which are in turn determined by its origin e.g. reservoir type, temperature, pressure, oil type and viscosity, water salinity, emulsion stability, oil droplet size, flow rate etc.

3.2.3 Management of Produced Water from Onshore Wells

The common alternatives that are currently being practiced worldwide are underground injection, re-use for land irrigation or industrial application and surface discharge. These alternatives shall be evaluated as part of the feasibility study of the project. The key determining factor includes site location, regulatory requirement, technical feasibility, cost and availability of infrastructure and equipment.

a) Underground injection

This option is similar to item 3.2.2 (a).

b) Re-use for suitable application

Re-using produced water is favourable provided its condition is compatible with the intended use.

Possible uses are:

- source of drinking water for livestock
- creation of an impoundment to retain and collect produced water and turning this into a habitat for fish and waterfowl. This can also provide additional recreational opportunities for hunting, fishing, boating, and bird watching
- irrigation of crops
- dust control by spraying the produced water on unpaved roads
- as a source of boiler feed water, cooling water or water for fire-fighting

In most cases, the water must be treated (via suitable treatment methods e.g. via bio-remediation technique using wetlands system for onshore sites) before it can be reused. The cost of treating the water to meet an end use is an important factor in determining the type of reuse options that will be considered.

c) Disposal into surface pit / evaporation pond

This may be an option for countries with typically hot weather throughout the year. This method allows produced water to be channeled into a constructed pit / pond where the water is allowed to evaporate under the hot sun. However, careful consideration to the worker and public health risks associated with this process must be evaluated and effective controls put in place before adoption of such an option (also *refer to Section 5 on risk assessment requirements*).

d) Surface discharge

Produced water discharges to surface waters or to land should be the last option considered and only if there is no other option available. Internationally acceptable discharge criteria like the World Bank's Standard (Appendix 1) is a good reference in determining the level of treatment required for discharging onshore.

In any case, prior to disposal, the produced water shall be treated to a level that is ALARP, as determined via a risk assessment described in Section 5 of this PTS to ensure no harm to environment and people. The treated produced water shall meet the standards set by relevant authorities if their standard is more stringent than ALARP

3.3 HYDROFRACTURING FLOWBACK WATER

3.3.1 Description of Hydrofracturing Flowback Water

Flow back water from hydraulic fracturing activities is considered a wastewater source as it contains pollutants that may contaminate an aquatic environment.

Hydraulic fracturing or hydrofracturing is a process that fractures a subsurface geologic formation such as coal bed and shale rock, by injecting fluids at a high pressure into the formation. Hydraulic fracturing is necessary to increase the efficiency of the oil or gas flow from the formation to the producing wellbore.

Upon completion of the fracturing process, the injected fluid is pumped back to the surface. The pumped volume is typically designed to be 110% of the total volume injected and the discharge is known as flow-back water. The injected fluid typically contains freshwater (may also contain produced water) and as much as 99.5% sand while the remaining 0.5% are additives such as acid, scale inhibitor, gelling agent, surfactant, friction reducer and biocide.

With the presence of the additives, even though at low concentration, the flow-back water poses a risk of polluting the environment if not disposed appropriately. Hence all flow-back water from on-shore wells, including those stored in temporary storage pits must be removed from the site.

3.3.2 Management of Hydrofracturing Flowback Water

Management and disposal options of hydrofracturing flowback water shall be evaluated as part of the feasibility study of the project.

The following are methods for disposal that can be considered:

- 1) **Appropriate treatment and discharge to an approved receiving water body.** This option may be a hindrance due to the impractical logistics as well as high capital and operating costs.
- 2) **Treatment at a third party facility.** The operating cost for transportation and disposal for this option can be high as the oil or gas field can be remote and the distance to the treatment facility can be far.
- 3) **Reuse/recycle for other drilling or fracturing activities.** This is the preferred option but may require some pre-treatment.
- 4) **Injection into a suitable aquifer.** Periodic monitoring of the receiving aquifer, as well as assessments of the impact to the aquifer need to be conducted. This option requires pre-treatment before injection to prevent contamination and failure of the injector and wellbore.

The level of treatment required shall be in accordance to the design considerations detailed in Section 6

3.4 BLOWDOWN

All blowdown potentially has some level of contaminants present. Accordingly, blowdowns shall be considered as a wastewater source and shall therefore be treated to meet the relevant discharge limits prior to discharge into the environment

3.4.1 Description of Blowdown

Blowdown sources can be divided into three categories.

- a. Cooling Towers.
- b. Boilers.
- c. Condensate systems.

For cooling towers, blowdown is usually done to maintain turbidity or cycles of concentration (CoC) accordingly to ensure good chemistry within the cooling water circulation system.

Chemical dosing within a cooling tower is usually done with Biocides (typically chlorine & bromine based chemicals), dispersants and inhibitors (usually phosphate-based chemicals but it may differ with type of treatment), or pH controls (typically caustic and acid).

For both boilers, and condensate systems, blowdown is typically done to maintain a low dissolved solids concentration. This is because at higher temperature, water containing dissolved solids impurities is boiled and the steam vapour is driven off. The solids will remain and eventually concentrate in the system. As this continues, this will eventually lead to scaling.

Typical chemical dosing for a steam system include pH adjustment chemicals (i.e. amines, caustic, etc), and oxygen scavenging chemicals. Chemicals used usually vary depending on the type of boiler and condensate system.

Boiler and condensate water if not treated may harm the environment due to its possible characteristics (e.g. high/low pH, high nutrients, high minerals, etc).

3.4.2 Management of Blowdown

- 1) All blowdown sources (existing and future) must be identified and characterized.
- 2) All blowdown generated must be segregated based on the pollutant concentrations and loadings. Depending on the characteristics of the pollutant, there should be consideration to treat it at source. E.g. Pre-treatment such as pH and temperature adjustment can be done prior to sending it to main treatment facility
- 3) Sufficient equalization capacity must be provided as part of the collection system to ensure consistent loads to the wastewater treatment facility to ensure that the loading would be sufficient and does not jeopardize the integrity of the treatment system (overloading, underloading, toxic loading etc)

All blowdown discharges must be analysed and meet the relevant discharge limits prior to discharging to the final discharge point.

3.4.3 Management of Blowdown under Abnormal Operations

- 1) Any wastewater that is exceeding the monitored limits must be sent to a diversion or off spec tank.
- 2) Any subsequent flow from the diversion or off-spec tank to the wastewater treatment facility (i.e. equalization tank) must be monitored to ensure that it is within the operating limits of the wastewater treatment facility.

3.5 WATER TREATMENT AND WATER PURIFICATION PLANTS

Liquid waste from water treatment and water purification plants is considered as wastewater and shall be collected and treated accordingly as described in Section 6, prior to discharge to the environment. Different wastewater streams can be present as described in Table 2 below.

A water treatment plant treats raw water extracted from water bodies (such as rivers, lakes and groundwater aquifers) for general use within the process plant. Many PETRONAS facilities do not require a water treatment plant as good quality water can be procured from the local municipality.

A water purification plant treats the water further to meet a specific water quality for a specific process reaction (such as for steam generation). Different process reactions may require different degrees of purity, hence different types and configurations of the treatment system that generates wastewater streams as described below, may be installed at site.