

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

GUIDELINE

MERCURY REMOVAL SYSTEM

PTS 10.04.10.40

FEBRUARY 2011



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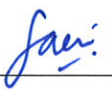
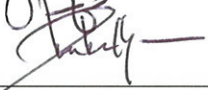
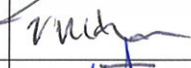
This new PTS 10.04.10.40 – Mercury Removal Systems (**February 2011, Revision 0**) has been developed to provide an overview of process configuration and minimum specifications of mercury removal system and recommendations for the design of mercury removal unit.

This PTS also includes PETRONAS Lessons Learnt and PETRONAS Best Practice for the subject matter Mercury Removal System.

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PREFACE

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1. INTRODUCTION

1.1 SCOPE

This PTS provides an overview of process configuration and minimum specifications of mercury removal system and recommendations for the design of mercury removal unit.

1.2 DISTRIBUTION, APPLICABILITY AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this document is confined to companies forming part of, or managed by PETRONAS, and to Contractors nominated by them.

This PTS is intended for use in associated and non-associated gas production and treatment facilities.

If national and/or local regulations exist in which some of the requirements are more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the authorities concerned with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General Definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor. Except where modified (e.g. 'chassis manufacturer', 'superstructure manufacturer', etc.) the term Manufacturer is intended to mean the party receiving the order from the Contractor and who retains responsibility for the performance of the completed fire fighting vehicle.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific Definitions

1.4 SYMBOLS AND ABBREVIATIONS

1.5 CROSS REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in (Part IV).

2. GENERAL

2.1 SOURCES OF MERCURY

Mercury is a naturally occurring contaminant distributed freely throughout production, processing, transportation and consumption systems. The toxic contaminants from these activities can enter into the environmental cycle and food chains easily, through emission during processing stages or unregulated disposal of wastes or accidents. Primary sources of mercury can be grouped into four categories:

- Natural sources from natural occurring mercury from the earth's crust such as volcanic activity and weathering of rocks
- Current anthropogenic releases from the mobilization of mercury activities from the raw materials such as fossil fuels, particularly coal and to a lesser extent of oil & gas
- Current anthropogenic releases resulting from mercury used intentionally in products and processes
- Remobilisation of historic anthropogenic mercury releases previously from deposited in soils, sediments and water bodies and landfills

Mercury occurring contaminant can be found in various form. Listed below are typical forms of mercury contaminants:

- Mercury vapour (i.e. elemental mercury)
- Mercury salts (i.e. mercuric nitrate, mercury chloride)
- Organo mercury compounds
- Mercury fulminate
- Mercury (II) oxide
- Dimethyl mercury (organic mercury)

2.2 PROBLEMS CAUSED BY PRESENCE OF MERCURY CONTAMINANTS

The presence of mercury in hydrocarbon can create the following problems

Safety, Health & Environment

- Exposure hazard to personnel during equipment maintenance and lab sampling
- Environmental pollutant to land, air & water during effluent discharge and vapour blow down

Process Unit and Equipment Integrity

- Due "self generated amalgam corrosion", mercury attacks may cause Liquid Metal Embrittlement (LME) to most aluminium based materials
- Deactivate metal-based hydrogenation catalysts
- Causes liquid embrittlement of some alloys
- Poisons precious metal catalysts such as platinum, palladium and nickel which acts as the active surface
- Equipment contamination

Product specification/quality

- Contaminate product specifications

3. MERCURY OVERVIEW

3.1 MERCURY MAPPING

Based on numerous mercury surveys concluded over the years, working on a diverse range of product streams around the world (i.e. Asia Pacific, North and South America, Europe, Africa and The Middle East), Figure 1 indicate best knowledge to the public of the amount of mercury content in production fields globally:



Figure 1: Mercury Occurrences in Production Around the World

Measuring mercury content out in the field accurately has always presented a complex challenge which tantamount to requiring a certain degree of analytical understanding, sample collection and sample analysis. The presence of other contaminants or mercury species can also impact the accuracy of the measurement.

The typical mercury concentration in natural gas/natural gas condensate is between 1 and 200 $\mu\text{g}/\text{m}^3$. Table 1 gives the estimates of world level of mercury in natural gas and condensate.

Location	Mercury Concentration	
	Gas ($\mu\text{g}/\text{m}^3$)	Liquids ($\mu\text{g}/\text{kg}$)
Europe	100-150	-
South Africa	50-120	50-100
Gulf of Thailand	100-400	400-1200
Africa	80-100	500-1000
Gulf of Mexico (USA)	0.02-0.4	-
Overthrust Belt (USA)	5-15	1-5
North Africa	50-80	20-50
Malaysia	1-200*	10-100
Indonesia	200-300	10-500

Table 1: Estimation of Regional Mercury Concentration

* Average figure. A concentration level as high as of 1000 ppb was found in Malaysia/Thailand border

As shown in Table 1 above, hydrocarbon from different geological location contain mercury in microgram level. The values shown are in estimation and may change from time to time, depending on geological factors and production practices.

3.2 SPECIES OF MERCURY

Mercury in natural gas condensate may be present in various chemical states: elemental, organic or inorganic forms, that all show unique species-dependent physical, physiological and chemical properties as illustrated in Figure 2 below.

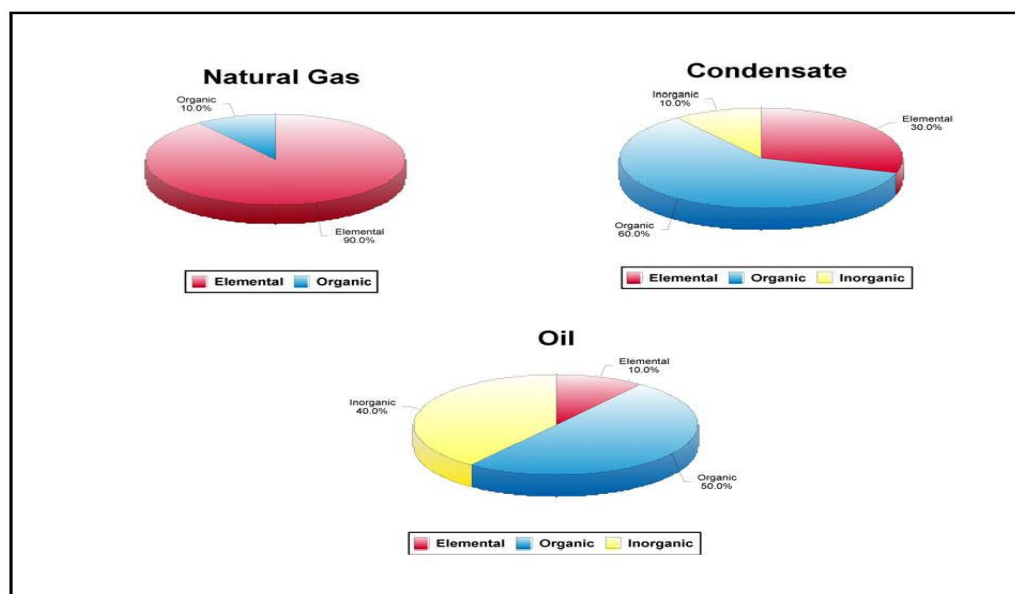


Figure 2: Mercury Species Distribution in Hydrocarbon

3.2.1 Elemental Mercury

Properties

Elemental mercury (Hg₀) (CAS No. 7439-97-6) is also known as metallic mercury, mercury metal, colloidal mercury, liquid silver, quicksilver, azogue and hydrargyrum. It has a relative molecular mass of 200.59, a melting point of - 38.87 °C, a boiling point of 356.72 deg C, and a density of 13.534 g/cm³ at 25 deg C.

Elemental mercury is the most volatile form of mercury. It has a vapour pressure of 0.3 Pa at 25 °C and transforms into the vapour phase at typical room temperatures. It is relatively insoluble in water (56 µg/litre at 25 deg C). Elemental mercury is soluble in lipids and nitric acid, soluble in pentane (2.7 mg/litre), insoluble in hydrochloric acid, and soluble in sulfuric acid upon boiling.

Health Effects

The vapor form of metallic mercury is readily absorbed through the lungs and is very toxic.

In children, reported symptoms following elemental mercury exposure include renal toxicity, skin rashes, hypertension and pulmonary toxicity. Neurological symptoms include behavioral changes (irritability, shyness, and nervousness), tremors, and reduced muscle coordination. Reports of death in children following acute elemental mercury exposure were related to respiratory failure. Acrodynia, or "pink disease" has been reported, and includes leg cramps, irritability, redness and peeling of the skin of hands, nose, and soles of the feet,