CHAPTER I

INTRODUCTION

1.1 Background and States of Problems

Mercury is a natural occurring element found in geologic hydrocarbons in the Gulf of Thailand where petroleum exploration and production activities have brought mercury to the surface. Mercury was initially reported by observation from the offshore oil and gas operations in the late 1980s (McDaniel, et al., 1998). The amounts and relative distribution of mercury compounds in liquid hydrocarbons depend on history and sources of the sample and include classes of compounds that have specific negative effects on people, equipment and catalysts. However, the dominant dissolved species in petroleum are elemental mercury and ionic halides (Wilhelm and Bloom, 2000). The mercury-laden hydrocarbons, upon contacting with steel for example those of petroleum pipeline and separation process, cause mercury deposition on their surfaces.

There has been no report on levels of mercury on steel surfaces used in natural gas production in the Gulf of Thailand. However, a study conducted at a North German gas wells located in the Rotliegend to assess mercury in steel equipment used for natural gas production reveals that mercury of less than 1 and more than 80 mg/kg was found in the tubings and pipelines. Moreover, it was reported that equipment in the low temperature separation facilities even showed mercury concentrations of more than 200 mg/kg. But according to the findings, mercury is only adsorbed to surfaces and does not penetrate the steel structure (Zettlizer and Kleinitz, 1997).

For offshore petroleum exploration and production activities in the Gulf of Thailand, subsea pipeline constitutes significant amounts of steel structure relatively compared with others, for example, platform and separation process equipments. The mercury contaminated pipelines upon decommissioning can potentially contribute to release of mercury into the surrounding environment, if not properly cleaned. It was reported that there are more than 1,500 kilometers of the subsea pipelines currently operational and potentially contaminated with mercury.

A study was conducted to identify mercury decontamination techniques on porous surfaces. It shows that chemical cleaning methods involving iodine as oxidizing and iodide as complexing agents (so called iodine/iodide lixiviant) can removed mercury up to 90% (Ebadian, 2001). However, the study was conducted with lower mercury levels by exposing steel coupon samples to mercury vapor, and no assessment was examined regarding mercury penetrating into the steel at depth. The study is thus a laboratory scale and has not been used in field application especially for mercury removal in petroleum subsea pipelines.

This study was therefore conducted to assess the scale and extent of mercury deposition on the pipeline internal surface and a methodology to remove it. The study simulates a worst-case scenario that enhance mercury adsorption specifically when elemental mercury pools are in direct contact with steel surface such as those in low temperature units mentioned above. It is noted that certain field and process conditions might contribute to differences in the forms and levels of mercury found between the field and prepared samples. However, in the study, more emphasis was given to residual elemental mercury that either remains on the surface or in the steel depth and if the employed decontamination methods can remove it. The study is still preliminary to identifying appropriate levels of cleaning chemicals to be applied for especially higher levels of mercury. Also, the study is fundamental to future application of in-situ mercury cleaning of subsea pipelines that has to be applied in conjunction with field technology for in-situ pipeline cleaning or flushing.

1.2 Research Objectives

The research objectives including the following:

1.2.1 To assess effects of Hg adsorption periods towards levels of mercury that adsorbs on the surface of the steel samples and which penetrates into the depth.

1.2.2 To assess forms of mercury found on the steel surface and that which penetrates into the metal at various adsorptions periods.

1.2.3 To assess the effect of I_2 used in decontamination towards surface corrosion and the Hg concentrations for both that found on the steel sample surface and in the depth profile.

1.2.4 To identify potential reactions of Hg oxidation and reduction found on the steel surface and in the depth profile, respectively.

1.2.5 To identify correlations between surface Hg concentrations those analyzed by a handheld XRF VS XPS techniques and potential future applications of the instruments.

1.3 Scopes of the Research

The research is conducted under the scopes as the following:

1.3.1 The steel coupon samples (hereafter called steel coupons) used in the research are limited to those of petroleum pipelines with the specification of API 5L-X52.

1.3.2 The study focuses on mercury in elemental form that can be found in the offshore petroleum subsea pipeline. Higher mobility attribute of elemental mercury poses more health and environmental exposure concerns. However, another form of mercury, e.g. HgO, found during the study is that converted from elemental mercury.

1.3.3 The assessment of mercury adsorption is undertaken at both on the steel surface and that penetrate the steel depth with respecting to different forms of mercury found both before and after decontamination.

1.3.4 The study on mercury adsorption also includes assessment of the depth of the steel impacted by mercury.

1.3.5 The study not only limited to identification of appropriate levels of iodine towards effective removal of mercury, but also changes and impacts towards steel surface morphology.

1.4 Anticipated Benefits

The anticipated benefits of the study include, but are not limited to the following:

1.4.1 The study will provide a fundamental understanding on levels and forms of mercury observed on the steel sample surface and in the steel sample depth that will lead to identification of appropriate decontamination techniques.

1.4.2 The study will identify suitable levels of iodine that has to be used for removal of mercury, both on the steel sample surface and in the depth profile in conjunction with changes of steel sample surface morphology and chemistry.

1.4.3 The results of study will provide a better understanding and basis for future application of in-situ mercury decontamination in offshore petroleum subsea pipeline.