132 – Offshore Norge
Recommended guidelines for identification, assessment, control and follow-up of mercury exposure

Translated version

PREFACE

These guidelines have been revised on the basis of experience from their use in the industry. Mercury has proved to be present to a greater extent than was assumed when the original edition was published in 2012. It has been updated with regard to changes in regulations and to include new findings from the International Petroleum Industry Environmental Conservation Association (IPIECA) and Britain's Integrating Knowledge to Inform Mercury Policy (IKIMP). Furthermore, best practice has been incorporated for mapping mercury in hydrocarbon/process streams flowing in and out of installations/plants.

These guidelines are recommended by the Offshore Norge specialist networks for occupational hygiene and for health and the working environment, the HSE Managers Forum and the Operations Committee. They have also been approved by the director general.

The responsible manager in Offshore Norge is the manager for HSE, who can be contacted via the Offshore Norge switchboard on +47 51 84 65 00.

These guidelines have been developed with broad participation by interested parties in the Norwegian petroleum industry, and are owned by Offshore Norge.

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CONTENTS

1 INTRODUCTION

1.1 Purpose

These guidelines have been developed to support enterprises in their efforts to reduce the risk of exposure to mercury in the petroleum industry. They recommend strategies and methods for identification, assessment, control and follow-up of mercury exposure in handling and processing crude oil, condensate and natural gas.

The guidelines address working environment and health challenges related to work on production facilities and at refineries in Norway. Occupational hygiene measurements are presented, and best practice is identified for sampling mercury in incoming/outgoing hydrocarbon/process streams. Beyond brief mentions, they do not deal with other issues related to plant integrity, discharges/emissions to the natural environment or further processing and treatment of waste and equipment from oil and gas production.

Where waste management is concerned, see Offshore Norge recommended guideline no 093 for waste management in the offshore industry.

All enterprises must identify where mercury exposure may occur. The risk must be assessed by competent personnel and measures (barriers) implemented to reduce and control the risk. The quality of these barriers must be checked regularly. Necessary information and training must be provided.

1.2 Regulations and limit values

Pursuant to the Norwegian Working Environment Act, the employer must ensure a fully acceptable working environment. The regulations concerning the performance of work require the employer to prevent their employees being exposed to hazardous substances through risk assessments (section 3.1), by making measurements (3.2) and by taking action (3.8). Where prevention of exposure is impractical, the employer must reduce its extent as far as practicably possible. When the exposure requirement has been achieved, the Alarp principle can be applied to reduce exposure even further.

Measures which eliminate exposure shall be preferred to technical and operational action which reduces exposure. The use of suitable personal protective equipment (PPE) shall be regarded as a temporary measure.

The following apply where mercury and mercury compounds (calculated as Hg) are concerned:

- limit value eight-hour working day: 0.02 mg/m^3 (20 µg/m^3)
- limit value 12-hour working day: 0.012 mg/m^3 (12 µg/m^3)

Owing to mercury's bio-accumulative properties, a short-term norm is not recommended.

The biological limit value in urine is 30 µg Hg/g creatinine.

1.3 Terminology and definitions

Alarp principle	The requirement that risk must be as low as reasonably practicable (Alarp) is enshrined in the Norwegian petroleum regulations. This principle is applied after requirements are met.
Metallic mercury	Metallic mercury is also termed elemental mercury. Chemical symbol Hg. The superscript 0 is often attached – Hg^0 – to emphasise that the elemental form is the one under discussion.
Mercury sulphide	Chemical symbol HgS. Normally found in solid form, when it has the suffix “s” – $HgS_{(s)}$. Can also be found dissolved in water in the presence of hydrogen sulphide, and then gets an “aq” – $HgS_{(aq)}$.

1.4 References

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- Regulations concerning action and limit values. (link)
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- Jahn, S D, Ignacio, J S and Bullock, W H (2015). *A Strategy for Assessing and Managing Occupational Exposures* (4th ed), AIHA.
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- Offshore Norge recommended guidelines for waste management in the offshore industry, no 093. (link)
- Offshore Norge recommended guidelines for health monitoring of employees exposed to chemicals, no 130. (link)
- Offshore Norge recommended guidelines for identification, assessment, control and follow-up of benzene exposure, no 131. (link)

- Offshore Norge recommended guidelines for fit testing of respiratory protective equipment, no 133. (link)

- Rieser, L A, Bishop, P, Suidan, M T, Piao, H, Fauche, R A and Zhang, J (2001). “Stabilization and testing of mercury containing wastes: Borden catalyst.” Department of civil and environmental engineering, University of Cincinnati, Cincinnati, Ohio 45221-0071. EPA/600/R-02/019 September 2001. (link)

1.5 Changes in this revision

The most significant changes in this revision are a new title, restriction of the guidelines to health and the working environment alone, inclusion of new findings from refineries (IPIECA) and the UK sector (IKIMP), and inclusion of information on vapour pressure. Furthermore, a change has been made from categorising installations by colour codes to a strategy based on the mass balance incoming and outgoing, best practice has been included on mercury sampling in hydrocarbon/ process flows, and exposure conditions for mercury related to temperature are included.

A more detailed overview of changes in this review are provided in appendix A.

2 MERCURY IN THE PETROLEUM INDUSTRY

Mercury can occur in the bedrock in most formations on the Norwegian continental shelf (NCS). Reservoirs with a low H_2S/CO_2 content and high temperature/pressure appear to have the highest mercury concentration. Oil and gas production involves complex multiphase flows, which vary fairly substantially as a result of temperature, pressure, phase, pH and redox potential as they move through the production system. While mercury chemistry in the system is not fully understood, it is known to be able to move between the various phases in the hydrocarbon system (oil/condensate/gas) when conditions change (IPIECA, 2014).

Metallic mercury may particularly occur in the light hydrocarbon fractions (C3-C5) and in sludge. It will normally concentrate at the low points in a process area because of its high density. Scrubbers and separators may contain metallic mercury. Deposition/scale can typically contain mercury, primarily as mercury sulphide but also in metallic form.

Metallic mercury easily forms amalgams with other metals (not iron), particularly aluminium, and has the potential to cause corrosion in welds, cryogenic components, heat exchangers, compressor seals/shafts/bearings and pump shafts.

2.1 Estimated extent of mercury

The extent of mercury in Offshore Norge production is thought to be significantly higher than was assumed only a few years ago. Norway’s environmental authorities put the figure at 10 kilograms per annum in 2010, based on produced water (Norwegian Climate and Pollution Agency, 2010), while a British report estimates that 270-750kg of mercury is generated annually in the UK from refining oil produced on the NCS (IKIMP, 2012). Since Britain imported roughly 40 per cent of total Norwegian output in 2012, it can be further estimated that the amount of mercury generated from the NCS in that year totalled in the order of 600-1 800kg.

IPIECA (2014) has estimated that 20 per cent of the mercury entering a refinery precipitates in the plant. Some accumulates in equipment, but the IPIECA estimates that the bulk (90-95 per cent) ends up in various waste fractions – including emissions to the air. The mercury content in international crude oil assays is presented in appendix B.

Based on these new findings from the IKIMP and the IPIECA, all production flows (crude oil, condensate, gas and produced water) in Norwegian petroleum operations should be assumed to contain some mercury, and that this will accumulate in process equipment and waste. Big differences may exist between wells, and differences in mercury content of the individual well can also be expected over time.

Sample calculations of potential annual mercury accumulation from the production of crude oil and gas are presented in appendix C.

2.2 Forms of mercury

The most important forms of this element found in the petroleum industry are metallic mercury and mercury sulphide. Their typical reactions are important for showing the potential of mercury to change form, and thereby its innate health hazard. For more information on other mercury forms, see IPIECA (2014).

2.2.1 Metallic mercury

Metallic mercury is the thick, shiny, silver-coloured liquid which most people associate with the name “mercury”. It is also termed elemental mercury. The liquid quickly forms droplets which can move freely and may spread over wide areas. These droplets easily become attached to clothing and textiles. Metallic mercury is easily visible against a dark background, and its droplets can be identified with the aid of a flashlight.

Metallic mercury has some unusual properties for a heavy metal – it is liquid at room temperature and has a measurable vapour pressure as shown in table 1.

Table 1: Vapour pressure of mercury at various temperatures.

Temperature °C	Vapour pressure	
	Pa	psi
0	0.027	0.00004
20	0.17	0.0002
40	0.86	0.001
60	3.5	0.005

Although the vapour pressure of mercury is high by comparison with other heavy metals, it is lower than for most liquids. Metallic mercury has a substantially lower vapour pressure than water at 20°C – just 0.17 Pa as against 2 487 Pa.

Laboratory studies have shown that mercury droplets vaporise very slowly in air at normal room temperature (15-20°C) and with normal ventilation. This is an important factor when responding to mercury spills. In general, droplets should be left undisturbed, possibly covered with a thin plastic foil, until they can be dealt with by appropriately trained personnel using appropriate procedures and equipment. That applies to room temperature. At 100°C (when steaming, for example), the vapour pressure of metallic mercury will be more than 400 times higher than at room temperature. See figure 1, which is based on data from the National Institute of Standards and Technology Interagency Report (NISTIR) (Huber et al, 2006).

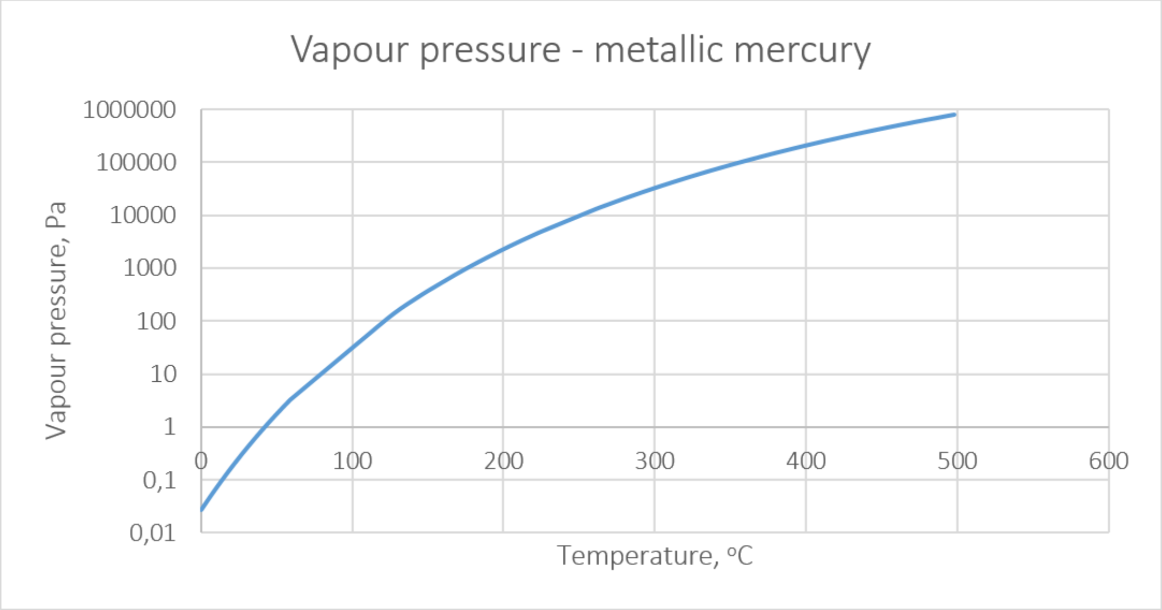


Figure 1: Vapour pressure for metallic mercury, 0-500°C.

Metallic mercury is unstable in the presence of sulphur and some sulphur compounds (H_2S) and will then form mercury sulphide, HgS. Metallic mercury easily forms amalgams with other metals, such as tin, copper, aluminium, chrome and nickel. Mercury vapour pressure from these amalgams at room temperature is very low but, like metallic mercury, rises with heating. Iron does not form amalgams with mercury. Mercury can accumulate in carbon steel. Metallic mercury also reacts with strong acids.

2.2.2 Mercury sulphide

Mercury sulphide is the dominant form of mercury in nature because of its strong affinity for sulphur. Although among the least mobile and most stable forms of the substance, mercury sulphide can decompose at high temperatures and release metallic mercury. In anaerobic (oxygen-free) conditions, mercury sulphide can be converted biologically to organic mercury compounds.

At room temperature, mercury sulphide is a solid with an extremely low vapour pressure. It is virtually insoluble in pure water or hydrocarbons. Its equilibrium molar concentration in pure water is estimated to be less than 10^{-26} (Rieser et al, 2001). Samples taken in the water phase with some sulphur content will therefore be a poor indicator of the presence of mercury. Another important factor is that the solubility of HgS in water can easily be affected in the presence of hydrogen sulphide (H_2S) through the formation of various soluble complexes of mercury-hydrogen-sulphide (Rieser et al, 2001). Both these properties are important for understanding how mercury behaves in process flows where sulphur or hydrogen sulphide are present.

When mercury sulphide is heated in connection with hot work (welding, grinding and so forth), it will start to decompose and convert to metallic mercury. The heat will cause the mercury to vaporise.

Mercury sulphide is less toxic than most other forms of mercury. Because of its low solubility in pure water and extremely low vapour pressure, exposure will normally be very small.

2.3 Physical properties

Physical data:

Melting point (Hg):	-39°C
Boiling point (Hg):	357°C
Vapour pressure (Hg):	0.0017mbar (0.17Pa) at 2°C
Solubility in water (Hg):	Negligible (in pure water)
Solubility in water (HgS):	Negligible (in pure water), partly soluble in water containing H_2S
Density (Hg):	13.53g/cm^3
Molar weight (Hg):	200.6/mol

2.4 Exposure route and health hazard

Mercury is classified as:

- toxic when inhaled
- able to accumulate in the body from repeated exposure
- highly toxic for aquatic organisms, may cause undesirable long-term effects in an aquatic environment (mercury is an environmental toxin since it accumulates in the food chain).

Metallic mercury is absorbed in the body through inhalation, skin contact and swallowing. Inhalation is the primary route (75-80 per cent). The rate of absorption through the skin is limited and very low via the digestive system (0.01 per cent). Absorption of mercury sulphide via digestion is lower than for metallic mercury because of its low solubility in water, and is therefore not regarded as toxic for humans and aquatic organisms. Easily soluble mercury salts (such as mercury chloride, $HgCl_2$) and methyl mercury can be readily absorbed through the digestive system and are highly toxic.

Acute exposure to mercury vapour can lead to poisoning similar to metal fume fever. This causes symptoms such as shivering, nausea, feeling generally unwell, chest pains, shortness of breath, coughing, stomatitis, inflammation of the gums, drooling and diarrhoea. Skin or eye contact, as well as ingestion, can cause irritation and allergic reactions.

Chronic exposure to mercury can cause permanent brain and kidney damage, and may be fatal. Damage to the nervous system can affect mobility and cognition. Mercury can accumulate in the body. Chronic exposure can result in weakness, fatigue, anorexia, weight loss and disturbances in the stomach and intestines. Trembling may also occur. This often begins with fingers, eyelids and lips before progressing to general tremors throughout the body, as well as severe chronic spasms in the extremities.

The development of tremors may be accompanied by behavioural and personality changes which could result in increased anxiety, memory loss, insomnia and depression. Abnormal blushing, exaggerated perspiration and rashes may occur.

Severe drooling and inflammation of the gums are also characteristic of chronic mercury exposure. Irritation of the airways and eczema are some of the milder symptoms.

Foetuses are very sensitive to the effects of metallic mercury. Nor can toxic effects on reproduction be excluded.

3 RISK ASSESSMENT

The starting point for conducting a risk assessment is information about the presence of mercury, in what form and to what extent, at the levels of installation and equipment. Where information is lacking about the installation/plant in question, experience transferred from other installations/plants can be used.

Once this information is to hand, conducting a risk assessment associated with work operations and groups at particular risk is recommended. Key issues here are measurement strategy, conduct of measurements, comparison with limit values and control of barriers.

Good measurement data combined with experience about where mercury exposure can occur will reduce uncertainty in the risk assessment. A safe level of mercury exposure should be based on the Alarp principle.

3.1 Presence of mercury on the installation

Where production and process installations offshore and on land are concerned, acquiring data on the presence of mercury in the hydrocarbon flow, its form and its extent is recommended. This can be done by sampling the hydrocarbon flow into and out of the installation. Available data on incoming mercury content (ppb, µg/m^3) and flow volume (m^3) provide a measure for the amount of mercury reaching the installation. Corresponding measurements of export products and produced water give a measure of the amount of mercury leaving the installations. The difference will provide an estimate for mercury accumulating in equipment as sediments in separators, scale and so forth. Figure 2 presents an outline of the mass balance.

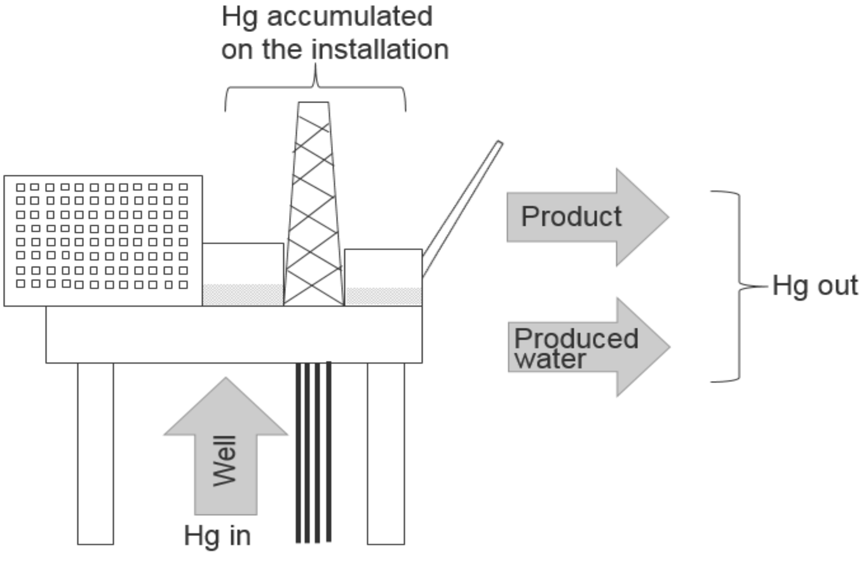


Figure 2: Outline of the mercury mass balance

This can provide answers to such questions as:

- how substantial is the mercury threat to the installation? (Hg_{in})
- will mercury accumulate on the installation? ($Hg_{installation} = Hg_{in} - Hg_{out}$)
- what is the mercury content in the products? ($Hg_{out, product}$)

3.2 Sampling flows in and out

Sampling mercury in hydrocarbon flows calls for special equipment. Although sampling is typically performed after reducing pressure in the system, samplers are required which can handle pressure (bombs). The propensity of mercury to adhere to surfaces poses a challenge for the materials in the sampling equipment, since they must be able to release the mercury for subsequent analysis. This requires special expertise and collaboration with laboratory staff/process technicians who possess the right competence. Specialist companies offer sampling in pressurised systems.

Incoming flows should be sampled as early as possible upstream. The earliest practical sampling point for a wellstream is typically the first-stage separator, where pressure has been somewhat reduced and connection points are provided. The test manifold could be another option. The sampling point should be flushed well before use, so that contaminants are not drawn in from the actual sampling loop. Recommended outgoing systems where measurements should be made are export gas, export oil and condensate. In order to be able to create a mass balance, all outgoing systems should be incorporated – including produced water and waste. Mercury-free produced water cannot be taken to mean that the substance is not present on/in an installation/plant.

Always including mercury as a parameter is recommended when analysing an assay for crude oil, condensate and gas. A review of the installation's sampling procedures is recommended here to check that materials in equipment and subsequent laboratory analysis are suitable for mercury (in other words, that mercury does not adhere to the surface of the sampling equipment and consequently fails to reach the analysis, and that detection in the analysis method is sufficient for measuring mercury at the ppb level).

Mapping mercury in sediments and other possible mercury-contaminated waste sent from the installation is also recommended. This can be done, for example, by taking samples from solid material, heating the sample and measuring outgassing with a direct-reading instrument. Supplementary equipment tailored for this purpose is available for direct-reading instruments (3.6.2).

How often samples should be taken from incoming and outgoing flows on the individual installations to detect mercury will depend on wellstream changes and installation age. Generally speaking, the older the installation, the more the mercury. Mercury measurements should be carried out when new wells are brought on stream or tied back. Measuring mercury in products should be part of the normal routine for specification of the assay/product. Information on accumulated mercury on the installation should be available when planning turnarounds/shutdowns, and such data should consequently be no more than three years old.

Where refineries are concerned, reference is also made to the guidelines in IPIECA (2014).

3.3 Categorisation of equipment

A decision should be taken on each installation about which equipment is most likely to:

a) accumulate metallic mercury
b) precipitate mercury sulphide.

Equipment should be assessed by technical, operational and maintenance personnel in collaboration with occupational hygiene competence. Equipment which experience shows is likely to be exposed to mercury is specified in 3.3.1 og 3.3.2.

Metallic mercury occurs particularly in the light (C3-C5) hydrocarbon fractions, but has also been found in the heavier ones (asphaltenes). All internal surfaces in process equipment where liquid mercury has been found are to be regarded as mercury-polluted. Absence of visible mercury does not mean the substance is not present in mercury-polluted facilities. Mercury can be deposited on equipment surfaces and partly diffuse into black steel. Metallic mercury and mercury sulphide are virtually insoluble in pure water. However, water may contain microdroplets of metallic mercury. Water containing sulphide can form soluble mercury complexes with mercury sulphide.

The accumulation of metallic mercury in equipment is typically associated with equipment where pressure and temperature fall. This could include separators, heat exchanges, dehydrators and so forth. Precipitation of mercury sulphide will probably follow from the same processes which cause other scale and sludge to precipitate.

3.3.1 Categorisation of equipment – upstream

The list of systems and equipment below can be used as a basis for installation-specific assessment offshore. This equipment is known to have a big potential for mercury accumulation:

- gas systems
  (tanks, gas dehydrators, amine plants, scrubbers, heat exchangers, demisters, condensate)
- pig launchers (receiving)
- separators
- mercury traps
- drain systems/sludge/waste
- produced water systems (including hydrocyclones).

Associated piping/pipes may also be contaminated with mercury, normally mercury salts. An overview of possible systems contaminated with mercury is provided in appendix D.

3.3.2 Categorisation of equipment – downstream

The list of systems and equipment below can be used as a basis for installation-specific assessment, particularly for refineries. This equipment is known to have a major potential for mercury accumulation:

- slug catchers
- desalters
- pipe still (incl boilers, air coolers and containers)
- propane/butane tanks
- power formers (PF)
- visbreakers (VB)
- slop tanks/sludge basins
- mercury traps.

Associated piping/pipes may also be contaminated with mercury, normally mercury salts. An overview of possible downstream systems contaminated with mercury is provided in appendix E.

3.4 Work activities posing a risk of mercury exposure

Typical work activities with a potential for mercury exposure are specified in table 2. Who performs these activities can vary from one installation/plant to another.

Particular attention should be devoted to activities which involve handling large quantities of metallic mercury, pulverisation of material containing mercury (both metallic mercury and mercury sulphide) and heating. The recommendation is therefore that the sub-points in table 3 are taken into account for each activity when conducting risk assessments of the work activities specified in table 2.

Specialist companies should be considered for dealing with large quantities of metallic mercury.

Table 2: Examples of activities with a potential for mercury exposure

Work activities
- Installation and removal of flanges, blind flanges, nozzles and baffles - Cutting, welding and other hot work - Mechanical work - Flowline inspections - Replacing glycol filters - Depressurisation - Steaming/cleaning - Opening manholes - Sampling - Draining - Waste handling - Cleaning tanks/entry - Removing gas filters - Inspections in tanks, derricks, etc

Table 3: Exposure conditions related to temperature

Exposure conditions	**Temperature ^{0}C**				
	< 20	20-50	50-150	150-250	> 250
Mercury sulphide/scale – good ventilation.	🟩	🟩	🟨	🟥	🟥
Metallic mercury (visible few and small droplets) – good ventilation	🟩	🟨	🟥	🟥	🟥
Splitting hydrocarbon piping, etc	🟨	🟨	🟥	🟥	🟥
Large quantities of metallic mercury. Aerosols containing metallic mercury.	🟥	🟥	⬛	⬛	⬛
Hot work	n.a.	n.a.	n.a.	🟪	🟪
Cleaning of separators and the like (through entry)	⬛	⬛	⬛	⬛	⬛

Table 3 uses the same colour code as guidelines 131 for benzene, appendix 4.

Simple rules of thumb or modelling can be used when assessing the potential for exposure. Examples are provided in appendix F.

3.5 Groups exposed to risk

A high risk of exposure is often related to opening equipment. The greatest risk of mercury exposure is expected for maintenance workers, process operators and inspectors. Hot work on equipment contaminated with mercury is expected to pose the highest risk of mercury exposure. Handling metallic mercury and aerosol formation from mercury-contaminated materials also carry a high level of risk.

Contractors often conduct the same type of maintenance activities on different installations. As a result, this group may be more frequently exposed to mercury. Pregnant women must not do work which could expose them to mercury. That also includes laboratory work. Foetuses are very sensitive to the effects of mercury exposure.

3.6 Occupational hygiene measurements

Occupational hygiene measurements of mercury should be performed to document the exposure level for different jobs and to verify assessments made on the basis of rules of thumb and models (see appendix F). This calls for special equipment.

Measurements should also be carried out to verify the effect of measures against and barriers to mercury exposure.

3.6.1 Measurement strategy

Qualified occupational hygienists should be responsible for establishing a measurement strategy. For guidance, see *A Strategy for Assessing and Managing Occupational Exposures* (Jahn et al, 2015).

The measurement strategy should be based on an assessment of the installation's "mercury status". See chapter 3.1. Measurements should be carried out

- during disassembly of flanges and connections
- before entry to and during work inside equipment
- during heating of metal assumed to be mercury-contaminated (welding, cutting and other hot work)
- during other heating of equipment – when the sun is shining directly on it, for example
- during steaming, cleaning and maintenance.

Introducing a programme for biological exposure monitoring of personnel carrying out work considered risky is also recommended. This is particularly relevant in connection with turnarounds or incidents which involve possible exposure to mercury. Biological exposure monitoring is also recommended for disassembly activities involving work on equipment which previously contained hydrocarbons.

Experience from all discoveries of mercury and the way these have been handled and followed up should be made available to the industry.

3.6.2 Measurement of the working atmosphere

Good direct-reading instrument have been developed today for measuring the concentration of mercury in the air. Such instruments should be easy to use and light in weight, have high availability, low cross-sensitivity and an adequate detection area, and preferably be EX approved. Instruments with atom absorption (such as Mercury Tracker (3000IP), Lumex (RA-915) and Nippon Instruments Corporation (NIC-EMP-1A)) are recommended in preference to ones with a gold film sensor (such as Jerome) because of cross-sensitivity (to welding fumes, CO and SO_2, for example). All results from direct-reading instruments should be recorded for documentation. As a minimum, such recording should include the date, equipment/tag number, background for measurement and result. See appendix G for examples of forms for documenting routine measurements during operation.

Personal air sampling (with dosimeter) can be performed using a specific absorbent for mercury which is submitted for analysis. The equipment can be attached to jacket/overalls near the inhalation zone.

3.6.3 Biological exposure measurements

Biological exposure measurement can be carried out by analysing mercury levels in urine.

4 RISK CONTROLS

The most important risk measure will be to design the facility in a way which minimises personnel exposure. Risk can otherwise be controlled with the aid of technical measures (such as mercury traps and closed cleaning system), administrative measures (safety instructions and work procedures) and personal protective equipment (PPE).

Where the downstream industry is concerned, a procedure/system for approval of crude oil and gas condensate is recommended to ensure risk management in the plant. A good system is necessary if an installation has to use crude oil or natural gas condensate with a high mercury content.

4.1 Design

When designing and engineering new installations or modifying existing facilities, consideration must be given to the mercury content in the production stream. This is particularly important when ordering long-lead items (separators, scrubbers and so forth).

The choice of materials and technical solutions such as mercury traps, a closed system for steaming/cleaning and so forth can reduce the risk of exposure for personnel.

Mercury traps should be utilised at an early stage in the process facility to protect against mercury exposure and to improve control of mercury at later stages. This also affects product quality and protects materials.

Equipment should be designed so that it can be cleaned without exposing personnel to mercury. Closed systems are recommended. So are solutions such as “cleaning in place”.

4.2 Procedures/safety instructions

The enterprise should have clear guidelines for measuring the mercury content in hydrocarbon flows in and out of the installation/plant and for equipment classification. Furthermore, guidelines should be in place for conducting occupational hygiene measurements, risk assessment, and the selection and use of PPE. The enterprise should have a procedure for waste management which deals with mercury.

Safety instructions should be prepared for particularly exposed work operations. See appendix H. These should be linked to the work permit system.

The following aspects should be included in the procedure/safety instructions:

- categorisation of equipment
- identified work operations involving a risk of mercury exposure
- technical and operational measures for reducing and controlling exposure
- results from occupational hygiene measurements of the relevant installation/plant and experience from corresponding work inside and outside the enterprise

- plan for occupational hygiene measurements of mercury exposure, including biological exposure monitoring
- training and information
- PPE.

4.3 Turnarounds and disassembly activities

Maintenance turnarounds and disassembly activities present many opportunities for mercury exposure. That makes it important to plan the work in a way which prevents such exposure. All work operations should be reviewed with an eye to exposure and protection. The plan should be completed in good time before the planned turnaround or disassembly work starts, so that measures and necessary training can be implemented. An occupational hygienist should be involved in the planning.

The existing procedure/maintenance instructions should be expanded to cover work during the planned turnaround or disassembly activity.

4.4 Information and training

Necessary information and training must be provided on the basis of identified risk and of the measures implemented to reduce risk. When PPE is utilised to prevent exposure, users must have received adequate training in its use. Before starting work which involves a risk of mercury exposure, information must be provided on this risk and on measures which have been implemented to control it.

Training must be provided at the same level for everyone involved, including contractor personnel. The training should be documented.

4.5 Personal protective equipment

PPE must be utilised when its use is indicated by the risk assessment and the risk is not adequately controlled in other ways. The choice of respiratory protection equipment and other PPE should be based on occupational hygiene measurements. Account must also be taken of other concurrent exposure when choosing PPE. For an overall assessment of PPE use, see appendix 4 to Offshore Norge guideline no 131 on benzene exposure concerning an example of a protective equipment regime for work on hydrocarbon equipment.

The purpose of respiratory protection is to avoid breathing in mercury vapour or dust/aerosols containing metallic mercury or other mercury compounds which can be absorbed through the respiratory system. See table 4 for suggestions.

Table 4 Respiratory protection

Concentration level	Respiratory protection
Mercury exposure is possible or proven below the limit value	A filtering half or full face mask with mercury filter is only recommended for short-term operations of less than an hour. For longer jobs, fan-assisted equipment is recommended for comfort.
Mercury concentration above the limit value and up to 10 times this limit.	Full face mask with compressed air (from compressor or gas bottle). Full face mask with mercury filter can be used for short-term operations (less than one hour). A filter mask must be tailored to the user and its tightness tested (see Offshore Norge guideline no 133).
Mercury concentration more than 10 times the limit value.	Full face mask with compressed air (from compressor or gas bottle).

Protective clothing is intended to avoid contamination of skin and clothes, and the spread of mercury to other, non-contaminated areas. See table 5 for suggestions.

Table 5 PPE

Type	Description
Clothing	Viton or PVC-PP-PE disposable clothing. Should a risk exist for other chemical spills, suits which protect against these must be worn.
Gloves	PVC or neoprene. Nitrile is used where hydrocarbons are also present. Use gloves which provide good forearm coverage.
Footwear	Neoprene boots.

4.6 Exposure surveillance

Where not enough is known about mercury exposure or where earlier measurements have identified this substance, a measuring programme should be developed to determine exposure extent. If the risk assessment indicates that the working environment should be monitored for mercury, a programme should be developed for periodic occupational hygiene measurements – including biological exposure measurements. Suppliers must have access to conduct the necessary mapping on site.

The measurement programme should be developed by qualified occupational hygiene competence.

4.7 Health surveillance

The employer must ensure that all personnel exposed to mercury undergo a suitable health examination. That also applies to the employer of contractor personnel. Biological exposure measurements can be used to determine who is exposed.

Health examinations shall be carried out by qualified medical personnel. See also Offshore Norge guideline no 130 on health monitoring.

Appendix A: Overview of changes in this revision

Minor language amendments and corrections of misspellings and word-division errors are not included as changes in this list.

Title: new title which better reflects the content of the guideline, coordinated with the titleof the guidelines on benzene exposure (131).

1.1 Purpose: new paragraph included to restrict the scope to health and the working environment.

1.2 Regulations and limit values: updated references to the regulations, definition of Alarp, regulation’s conversion factor of 0.6 for 12-hour limit value.

1.3 Terminology and definitions: defined Alarp as stated in the regulations. Specified that Alarp is applied after requirements are met.

1.4 References: updated links to existing references and included new ones. Removed references to Norsok S-002 and the Stami report since the text does not refer to them (nor did it in the previous version).

2. Mercury in the petroleum industry: earlier section on occurrence in the petroleum industry has been placed first. Incorporates new knowledge from the IPIECA.

2.1 Estimated extent of mercury: new section. Includes new knowledge on extent from the IPIECA and the IKIMP. Refers to the appendix on mercury in crude oil assays and to the appendix for estimation on the NCS.

2.2 Forms of mercury: new section. Emphasises that metallic mercury and mercury sulphide are the most important forms in the petroleum industry.

2.2.1 Metallic mercury: includes information earlier placed under physical properties. Includes information on vapour pressure. Table 1 and figure 1 are new. New references included.

2.2.2 Mercury sulphide: new section. Includes the information that mercury sulphide is the most stable form of mercury, low toxicity. Heating can change this.

2.3 Physical properties: updated with some additional data.

2.4 Exposure routes and health hazard: replaces “exposure” with “exposure route” in the heading, some minor additions about mercury sulphide, metallic mercury and mercury salts.

3. Risk assessment: new introduction.

3.1 Presence of mercury on the installation: changed from categorisation of installation with colour codes to strategy of mass balance for mercury in and out of the installation, and accumulation on the installation. Removed former table 2, included new figure 2.

3.2 Sampling flows in and out: new section. Included sampling in hydrocarbon/ process systems and proposals for measuring points. Refers to the IPIECA for refineries.

3.3 Categorisation of equipment: amended categorisation to relate to probability for accumulation. Removed table 2 and colour coding, using only text. Included “amine plants” in the list of equipment upstream.

3.4 Work activities posing a risk of mercury exposure: title changed from “operations” to “activities”. The former table 3 is slightly amended and renamed table 2. A new table 3 is included to present exposure conditions related to temperature.

3. 5 Groups exposed to risk: new information that handling of metallic mercury and aerosol formation of mercury-polluted material carry a high risk.

3. 6 Occupational hygiene measurements: included verification of rule of thumb and modelling. Former section on the natural environment has been removed since this falls outside the purpose of the guideline.

3.6.1 Measurement strategy: included a reference to the guidelines on measurement strategy, some minor adjustments.

3.6.2 Measurement of the working atmosphere: merged previous sections on “direct-reading instruments” and “personal air sampling”. Where direct-reading instruments are concerned, included information that measurements should be documented.

4. Risk controls: removed the recommendation of a system for approving crude oil and gas condensate before the introduction. Where downstream industry is concerned, this is handled in a separate section. No technical solution exists for accomplishing this upstream.

4. 1 Design: replaced “affect” with “can reduce”, included “cleaning in place”.

4. 2 Procedures/safety instructions: removed content on classification of installations. Included a new point on PPE.

4. 5 Personal protective equipment: included a reference to occupational hygiene measurements, reference to guideline 131 (benzene) for choosing PPE with other concurrent exposure. Included information on the purpose of respiratory protection and protective clothing. Table 4: used more precise names for types of respiratory protection, including new advice on distinguishing between below or above 10 times the limit value.

4. 6 Exposure monitoring: removed sentence that the enterprise should have a measurement programme for monitoring the wellstream, since this is not relevant to exposure monitoring. Information on sampling the wellstream is provided in section 3.2 on sampling incoming and outgoing flows.

4. 8 Disposal and waste management: this section has been removed. Waste management is not part of the purpose of the guidelines. Handling of scale and sludge as well as equipment for avoiding exposure are dealt with in other chapters.

Appendix A: New appendix (this one) providing an overview of changes.

Appendix B: New appendix providing the mercury content in international crude oil assays.

Appendix C: New appendix with sample calculations for mercury accumulation.

Appendix D: Former appendix 2.

Appendix E: Former appendix 3.

Appendix F: New appendix with sample calculations for mercury exposure.

Appendix G: New appendix. Incorporates the same form for registering measurements from direct-reading instruments used in guideline 131 on benzene.

Appendix H: An updated example of safety instructions. Replaces former appendix 1.

Appendix B: Mercury content in international crude oil assay

Where refineries are concerned, IPIECA (2014) provides guidelines which describe good practice and strategies for handling mercury. Information acquired by the IPIECA from its members on the mercury content in crude oils has resulted in a dataset of 446 crudes categorised by their mercury content, as shown in table B-1.

Table B-1: Mercury content in international crude oil assays (IPIECA, 2014)

Concentration (ppb)	Number	Per cent
≤ 2	284	64
2 - 5	68	15
5 - 15	42	10
15 - 50	33	7
50 - 100	6	1
> 100	13	3
	Σ 446	Σ 100

Appendix C: Sample calculation – annual accumulation of mercury

Great uncertainty attaches to the quantity of mercury produced as a consequence of oil and gas activities in Norway. Better analyses/quantification of mercury in both sales products and waste streams is therefore important.

The examples presented below are intended to assist in estimating the extent of mercury accumulated in the installation/plant under consideration. This supplements emissions reported annually on the basis of the mercury content in produced water.

IPIECA (2014) has assumed that about 20 per cent of the mercury entering refineries with the crude oil either accumulates in process equipment or ends up in various waste fractions. At the same time, it presents results from mass balance measurements made at four refineries in San Francisco which show a far higher proportion. The sample calculation presented below utilises 20 per cent accumulation.

Tables C-1 and C-2 calculate the potential annual accumulation of mercury in an installation/plant with the aid of the following formula.

Equation 1:

$$Accumulation = Production * Density * Hg\ content * Proportion$$

with the following specification.

Accumulation:	annual accumulation of mercury in an installation/plant (kg)
Production:	production per annum (mill Sm^3)
Density:	density crude oil (kg/Sm^3) or gas ($kg/1000\ Sm^3$)
Hg content:	content of mercury incoming from well/feedstock (µg/kg)
Proportion:	proportion of mercury in production flow expected to accumulate (per cent)

The following constants are used for the calculations in tables C-1 and C-2.

Density crude oil:	840kg/Sm^3
Density gas:	826kg/1 000 Sm^3 (70/30 relationship between methane and ethane)
Accumulation:	20 per cent

Table C-1: Mercury from crude oil production

Potential annual accumulation of mercury in kg per installation			
Mercury in crude oil	**1 µg/kg**	**10 µg/kg**	**200 µg/kg**
Low production (0.5 mill Sm^3)	0.084	0.84	16.8
Medium production (5 mill Sm^3)	0.84	8.4	168
Large production (10 mill Sm^3)	1.68	16.8	336

Table C-2: Mercury from gas production

Potential annual accumulation of mercury in kg per installation			
Mercury in raw gas	**0.1 µg/Sm^3**	**10 µg/Sm^3**	**100 µg/Sm^3**
Low production (1 bn Sm^3)	0.02	1.7	16.5
Medium production (20 bn Sm^3)	0.3	33	330
Large production (30 bn Sm^3)	0.5	50	496

If the IPIECA's estimate for accumulation in plants and removal in waste chains is transferrable, it can be assumed that roughly 90 per cent gets removed from the installations as waste. This will primarily occur during turnarounds, when solid matter deposited in separators and the like is removed.

What have others estimated?

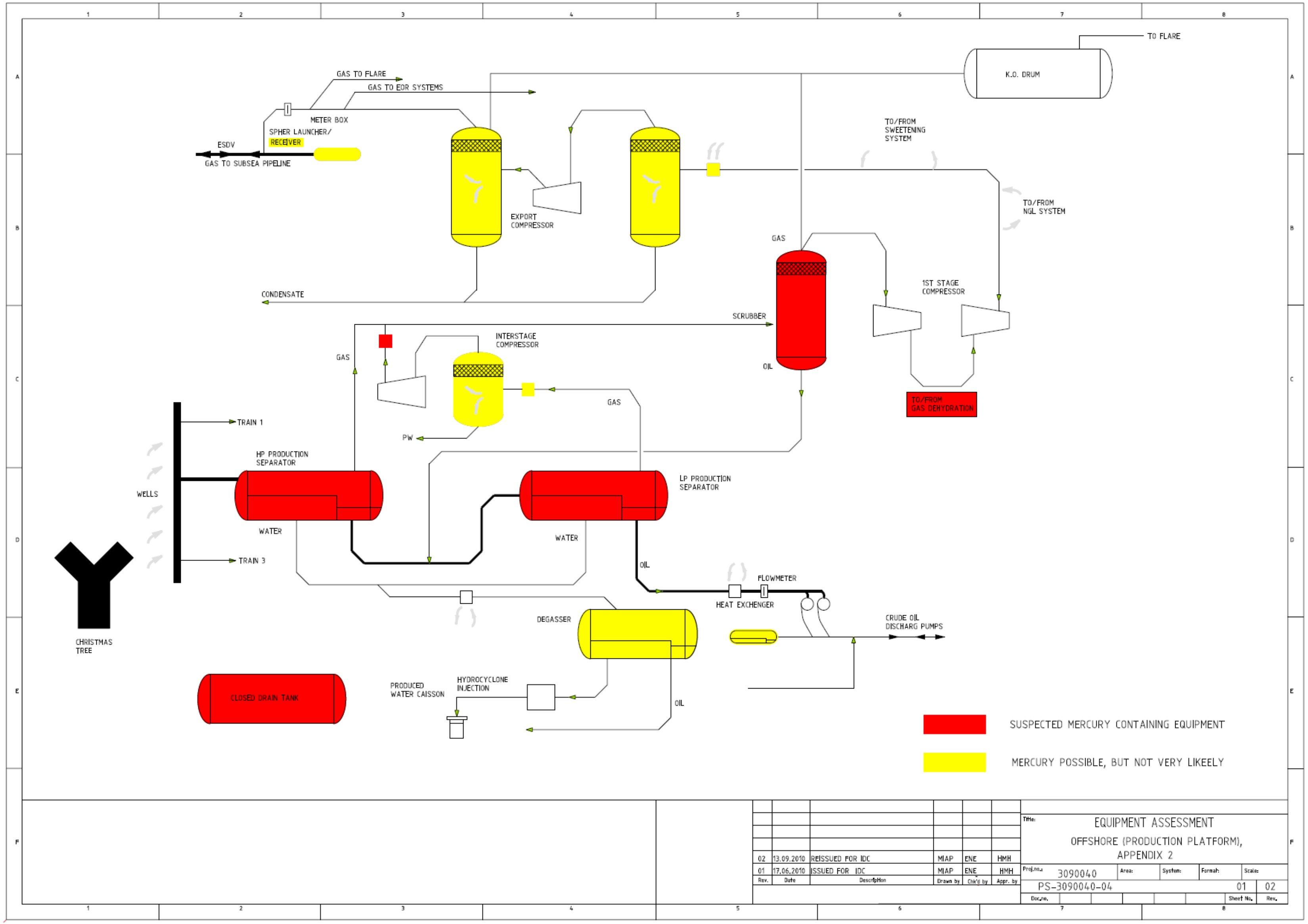
Exports of oil to the UK from the NCS amount to about 40 per cent of total production (Statistics Norway table for exports to the UK in 2012, Norwegian Petroleum Directorate (NPD) fact pages on total oil production in 2012). The IKIMP figure of 270-750 kg for Norway's annual contribution to Britain's mercury account accordingly amounts to only 40 per cent of the expected total quantity of mercury from the NCS. From this, it can be estimated that mercury accumulation from the NCS in 2012 was 600-1 800 kg.

References:

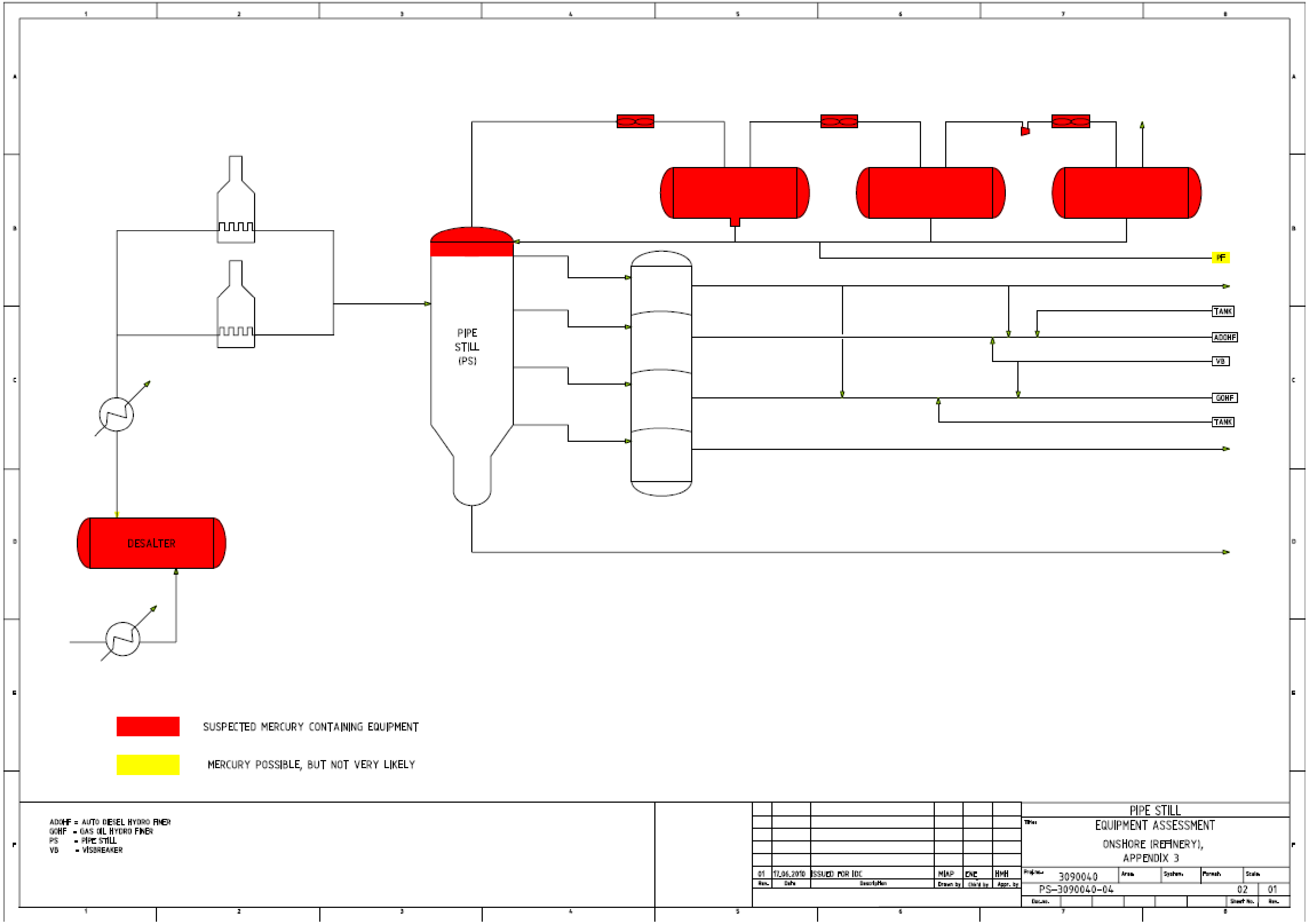
- NPD fact pages:
  http://factpages.npd.no/factpages/Default.aspx?culture=nb-no&nav1=field&nav2=TableView|Production|TotalNcsYear

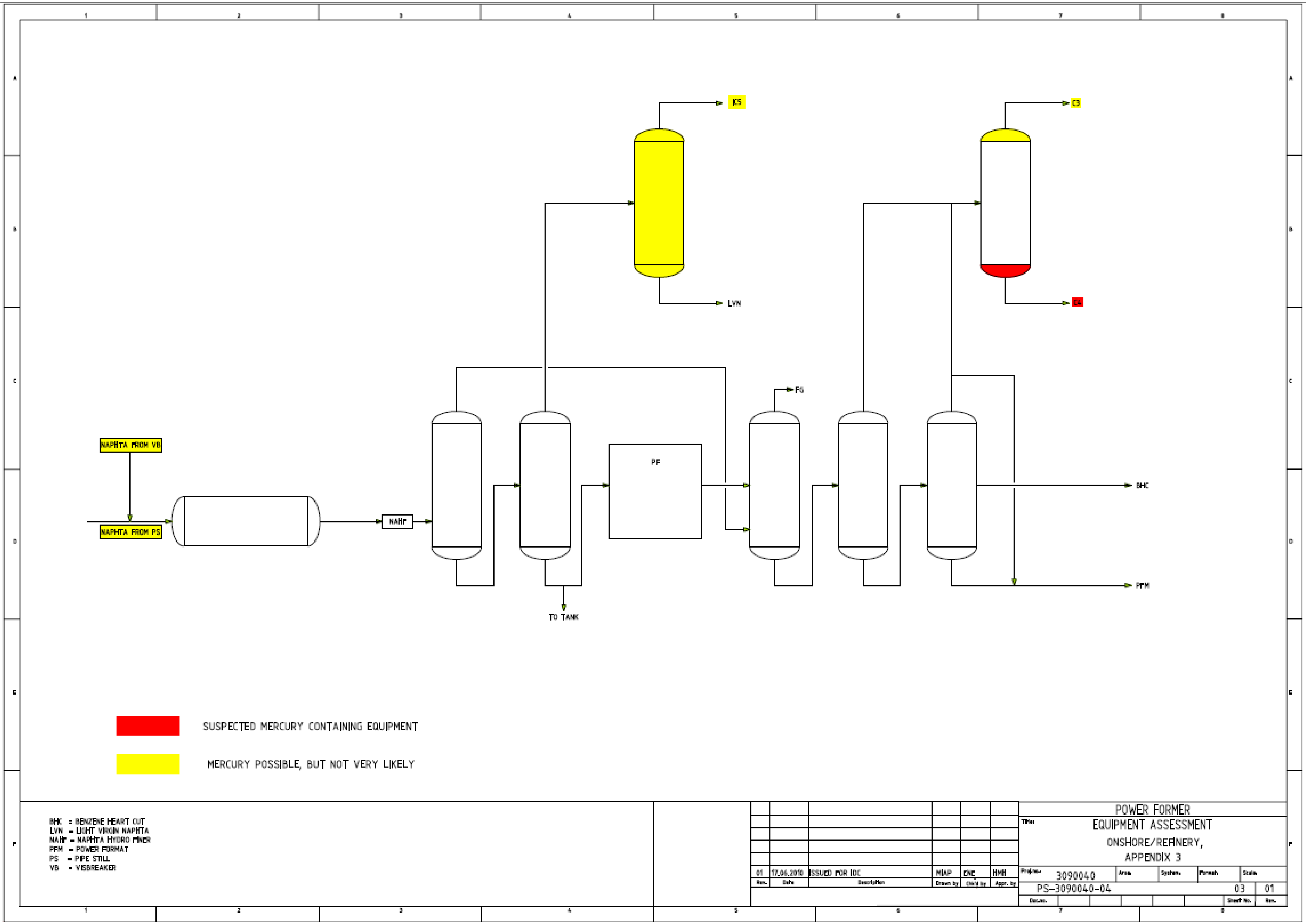
- Statistics Norway – exports of crude oil by country
  http://www.ssb.no/utenriksokonomi/statistikker/muh/aar-endelige/2015-05-15?fane=tabell&sort=nummer&tabell=226603

Appendix D: Example of mercury polluted system – upstream



Appendix E: Three examples of mercury polluted systems – upstream




C5
LVN
C3
C4
NAPHTA FROM VB
NAPHTA FROM PS
NAHF
PF
FG
BHC
PFM
TO TANK
🟥 SUSPECTED MERCURY CONTAINING EQUIPMENT
🟨 MERCURY POSSIBLE, BUT NOT VERY LIKELY
BHC = BENZENE HEART CUT
LVN = LIGHT VIRGIN NAPHTA
NAHF = NAPHTA HYDRO FINER
PFM = POWER FORMAT
PS = PIPE STILL
VB = VISBREAKER
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Scale
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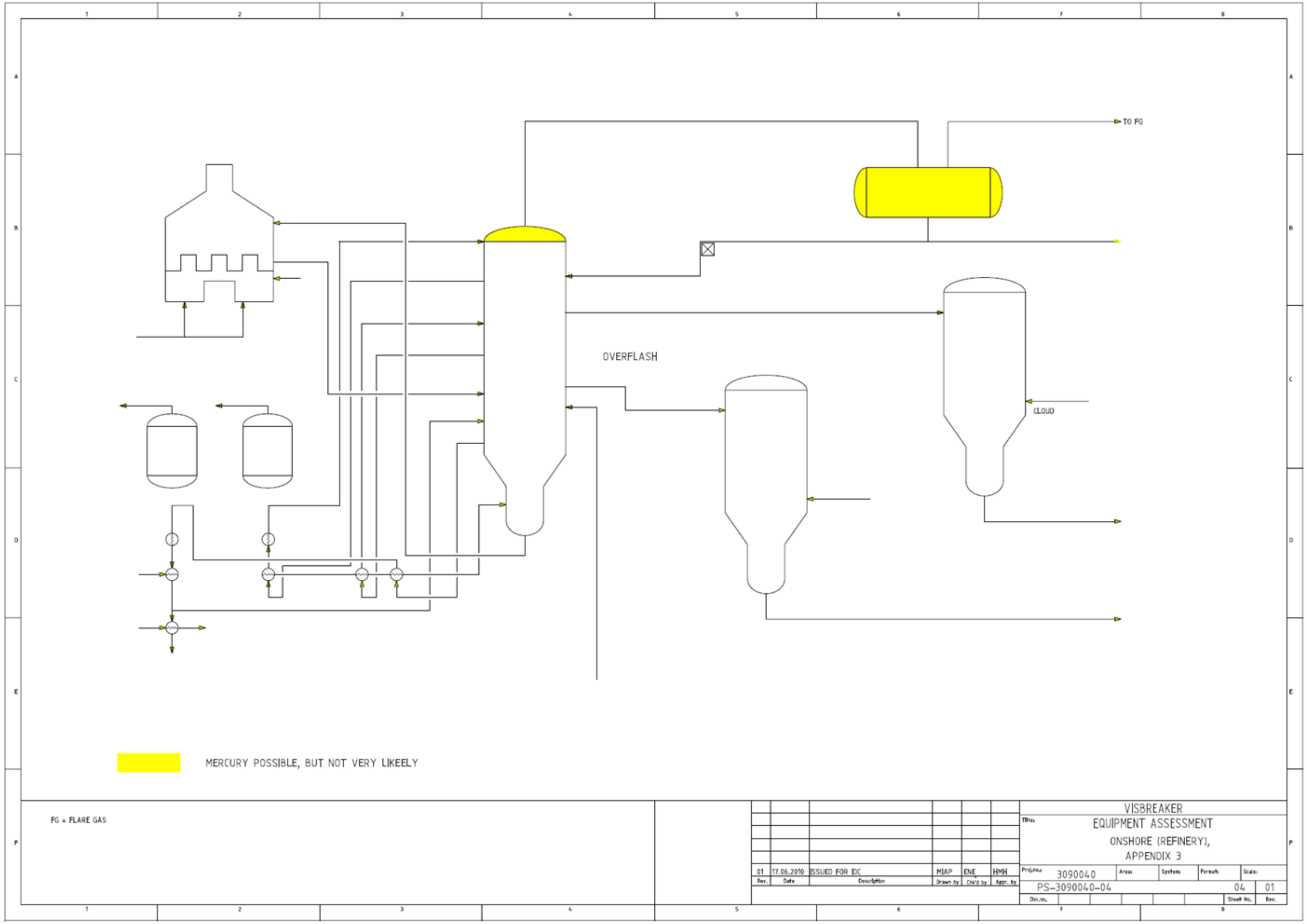
Rev.


TO FG
OVERFLASH
CLOUD
MERCURY POSSIBLE, BUT NOT VERY LIKEELY
FG = FLARE GAS
VISBREAKER
Title:
EQUIPMENT ASSESSMENT
ONSHORE (REFINERY),
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Appendix F: Sample calculations – mercury exposure

Two examples are provided here of ways to estimate possible exposure to mercury. The first is based on saturation concentration and the “rule of ten”, which is a set of rough assumptions about the maximum concentration under various ventilation conditions (Jahn et al, 2015). The second is based on using a simple single-zone model with complete stirring. However, the chosen zone is small in order to coincide with the near field (2 x 2 x 2) around a source (Keil et al, 2009).

Example 1: Saturation concentration and use of the rule of ten

When evaluating possible mercury exposure, measurements can be supplemented by some simple rules of thumb for assessing the exposure potential. These primarily involve mercury vapour pressure and the saturation concentration of mercury which results from this vapour pressure.

The relationship between saturation concentration and vapour pressure is provided by the following equation.

Equation 2:

$$Saturation\ concentation = \frac{vapour\ pressure}{total\ pressure} * 1\,000\,000$$

Where saturation concentration is at 25^0C (ppm), and vapour and total pressures are in Pa.

The calculation is then:

$$\text{saturation pressure (ppm)} = \frac{0.26 \text{ Pa}}{101\,325 \text{ Pa}} * 1\,000\,000$$
$$= 2.6 \text{ ppm } (21.27 \text{ mg/m}^3)$$

The saturation concentration is a theoretical upper concentration which cannot be exceeded, and is 1 000 times higher for mercury than the limit value of 0.02 mg/m^3 for exposure. Experience shows that the air concentration will always be substantially lower than this. Table F-1 presents rules of thumb for control verses the fraction of the saturation concentration.

Table F-1: Rule of thumb – rule of 10

Level of control	Fractions of saturation concentration
Confined space, no ventilation in practice	1/10 of saturation
Poor ventilation	1/100 of saturation
Good general ventilation – more than six changes of air per hour	1/1 000 of saturation
Good general ventilation plus local ventilation	1/10 000 of saturation
Contained system with ventilation	1/100 000 of saturation

This is supported by the fact that vaporisation of mercury at 25^0C is low – 0.056 mg/hr-cm^2 (assuming low air speed – in other words, no noticeable pressure).

Example 2: Single-zone model with complete stirring

No ventilation, room temperature

A single-zone model can be used to estimate possible exposure in an assumed near field around a spill which might contain mercury. In a zone of 2 x 2 x 2m (eight m^3) at 25^0C, with no ventilation and a spill of metallic mercury with a surface area of one cm^2, it will take about 20 minutes for the concentration to reach the exposure limit of 0.02 mg/m^3 and 300 hours for it to reach 1/10 of the saturation concentration. This assumes a vaporisation rate of 0.056 mg/hr-cm^2 at 25^0C.

Better ventilation

For the same space with a general ventilation of six air changes per hour, the concentration in the space – assuming good stirring – will reach an equilibrium of 0.0012 mg/m^3 between the amounts vaporised and removed. As a result, the limit value will not be exceeded even with a small spill of metallic mercury in the space. This is in line with the rules of thumb in table F-1.

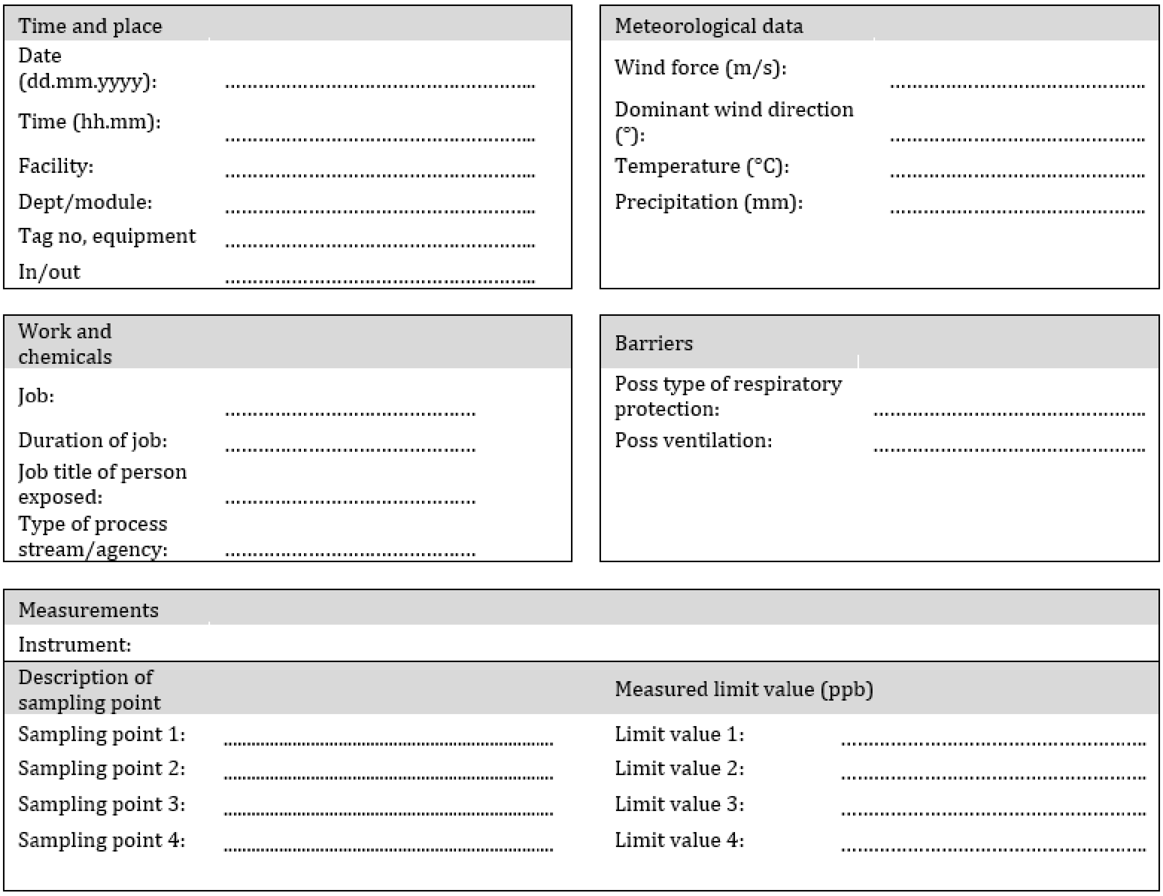
Rise in temperature

In the same space with six air changes per hour and a mercury temperature of 100°C, however, a mercury concentration on a par with the limit value will be achieved in less that 30 seconds, and the equilibrium concentration of mercury will be about 0.6 mg/m^3 (which could be reached in about 40 minutes).

This means that great caution should be displayed when assessing possible mercury exposure in relation to processes which involve heating/work temperatures above room temperature.

The IHMod tool developed by the American Industrial Hygiene Association (AIHA) has been used in the sample calculation above. This is an Excel spreadsheet which can be downloaded from the AIHA website at www.aiha.org. IHMod also contains a set of more advanced modelling methods which can be used for estimating occupational exposure. The models used are documented in *Mathematical Models for Estimating Occupational Exposure to Chemicals* (Keil et al, 2009).

Appendix G: Forms – registration of data from direct-reading instruments



Time and place

Date (dd.mm.yyyy): ……………………………………………

Time (hh.mm): ……………………………………………

Facility: ……………………………………………

Dept/module: ……………………………………………

Tag no, equipment ……………………………………………

In/out ……………………………………………

Meteorological data

Wind force (m/s): ……………………………………

Dominant wind direction (°): ……………………………………

Temperature (°C): ……………………………………

Precipitation (mm): ……………………………………

Work and chemicals

Job: ……………………………………

Duration of job: ……………………………………

Job title of person exposed: ……………………………………

Type of process stream/agency: ……………………………………

Barriers

Poss type of respiratory protection: ……………………………………

Poss ventilation: ……………………………………

Measurements

Instrument:

Description of sampling point		Measured limit value (ppb)	
Sampling point 1:	……………………………………………	Limit value 1:	……………………………………………
Sampling point 2:	……………………………………………	Limit value 2:	……………………………………………
Sampling point 3:	……………………………………………	Limit value 3:	……………………………………………
Sampling point 4:	……………………………………………	Limit value 4:	……………………………………………

(reverse of the form)

Possible sketch of the location and position, plus supplementary comments.

Appendix H: Example of safety instructions

This example is an actual set of safety instructions in an operator company and accordingly contains extensive specification of equipment and names by the operator itself. This guideline incorporates it as an example of how safety instructions could look.

H1. Purpose, target group and authority

The purpose of these safety instructions is to prevent personnel being exposed to mercury compounds from crude oil and natural gas, ensure correct handling of mercury-polluted solids and equipment, and contribute to understanding of the risk posed by working with mercury-contaminated equipment.
The target group is operators, maintenance personnel, contractors and HSE personnel who may be exposed to mercury during various operations.
Authority: Offshore Norge' recommended guidelines no 132 for identification, assessment, control and follow-up of mercury exposure.

H2. Safety instructions

H2.1 CHARACTERISATION OF INSTALLATION AND EQUIPMENT

Metallic mercury often occurs in the light hydrocarbon fractions (C3-C5) and in sludge. All internal surfaces in process equipment where liquid mercury has been found are to be regarded as mercury-polluted. Absence of visible mercury does not mean the substance is not present in mercury-polluted facilities. Mercury can be deposited on equipment surfaces and partly diffuse into black steel. Where hydrocarbons and water are in contact, mercury can also transfer to the water phase.

A risk of finding accumulated mercury exists with the following equipment.

- process equipment in service with C3-C5 streams
- equipment where streams are chilled (such as heat exchangers and coolers)
- gas systems (gas dehydrators, tanks/containers, scrubbers, heat exchangers, demisters, pig launchers (receivers), condensate)
- equipment with pressure drops
- separators
- sludge collector
- drainage system/sludge tanks
- equipment made of carbon steel or aluminium
- equipment coated with protective material or concrete (drums).

Mercury reacts with a number of metals and can accumulate in equipment over time. Associated piping systems may also be contaminated with mercury, normally mercury salts

H2.2 RISK CONTROL

H2.2.1 Work operations with a risk of mercury exposure

Typical work operations where personnel could be exposed to mercury:
- disassembly of flanges, blinds, nozzles and damper elements
- cutting, welding and other hot work
- flowline inspections
- replacing glycol filters

- depressurisation
- installing and removing blinds
- steaming/cleaning
- opening manholes
- sampling
- draining
- waste handling
- cleaning of tanks/entry
- removing gas filters
- internal inspections in tanks, derricks, etc.

H2.2.2 Barriers

- All personnel who may be exposed to mercury (and other hazardous chemicals such as benzene) when opening equipment shall use personal protective equipment (PPE) until the level of the mercury content has been clarified.
- Should a risk exist of spillage on the deck or on personnel when opening equipment, the surrounding area shall be cordoned off. A drip tray with water to rinse off boots shall be located at the entrance to the area.
- Use appropriate containers to collect (possible) mercury-contaminated spills, scale, water, polluted equipment and so forth. It must be possible to seal these containers with a suitable lid.
- Process equipment potentially contaminated with mercury must be prevented from contaminating its surroundings following disassembly. Equipment must be packaged and labelled as transport-classified waste, see section H2.3.
- The spread of contaminated fumes and water during cleaning must be prevented. Excess fumes shall be directed to a closed system, or to a safe area if a closed system cannot be provided. The surrounding area shall be secured to prevent personnel from being exposed to fumes. During cleaning, the wind direction shall be assessed to reduce the risk of possible mercury exposure.
- During cleaning/steaming, the water temperature shall be at least 60°C.
- Equipment shall be cooled as much as possible and ventilated prior to entry.
- Visible mercury shall, if possible, be covered with a suitable absorbent (such as zinc or aluminium powder, or aluminium foil (for small quantities)). Further handling should follow procedures for waste containing mercury.

H2.2.3 Measurements

Measurements must be made to establish whether mercury is present for work operations involving a risk of mercury exposure. When equipment is opened, measurements shall initially be made close to the actual opening and then in the breathing zone for personnel. These measurements are repeated in the same places after 10 minutes (following airing). Nobody shall work on the equipment without respiratory protection until the second set of measurements has been made.

- If the first set of measurement results exceed 0.1µg/m^3 (lower detection limit), the equipment shall be regarded as contaminated with mercury and dealt with on that basis. See section H2.3
- If the second set of measurements exceed 0.1µg/m^3 (lower detection limit) in the breathing zone, personnel shall be protected in accordance with section H2.2.4.

The LUMEX RA-915M mercury analyser is recommended for measuring the presence of gaseous mercury in the air.

Cleaned equipment which is allowed to stand for a while before opening can start to “sweat” mercury. Equipment heated by the sun can increase exposure.

A heat test can be carried out before hot work (steaming, welding, cutting or crushing, for example) on equipment which may be contaminated with mercury. The metal is heated for two minutes using a propane burner, for example (metal temperature above 200ºC), and the metal fumes are measured. If mercury is detected above the detection limit of 0.1µg/m^3, the metal is classified as contaminated with mercury. Countermeasures and the use of the correct PPE must be defined on this basis. When measuring large pipes/ equipment, several evenly spread measurements should be made in order to pick up where the pipe/equipment has been in contact with various product phases. If no heat test is carried out, the metal shall be treated as if it is mercury-contaminated. Personnel performing the measurements shall be trained for such work.

Measurement results must be documented – record them in a dedicated log book, even when measurements show that no mercury is present. Record:

- where the measurement was carried out
- which system was measured
- relevant activity (splitting, entry, steaming and so forth)
- date and time
- who performed the measurements.

The measuring instrument shall be stored indoors. Charging and maintenance must be carried out in accordance with the user manual.

H2.2.4 Personal protection

For protection against mercury vapour, the Sundstrøm SR599 (A1BE2K1HgP3R) filter shall be used. This also protects against benzene**.**

Table H-1 Respiratory protective equipment

Mercury concentration in the air	**Respiratory protective equipment**
<0.1 µg/m^3	No measurable mercury present. Respiratory protection unnecessary.
0.1–20 µg/m^3	Work/stay <2h: Full/half face mask with filter which protects against mercury. Work/stay >2h: Mask with battery powered fan unit and filter which protects against mercury.
20–1 000 µg/m^3	Full face mask or visor with battery powered fan unit and filter which protects against mercury.
1 000-10 000 µg/m^3 (1-10 mg/m^3)	Full face mask with supply of breathing air and separate breathing air reserve.
>10 mg/m^3	Work not permitted

Table H-2 Other PPE

Clothing	Microchem 4000 when entering and working where spills could be present.

Gloves	Thick nitrile.
Footwear	Neoprene boots.

In the event of questions, contact an occupational hygienist.

H2.2.5 Other precautions

- Pregnant women must not do work which could involve exposure to mercury.
- Mercury easily attaches to clothing and equipment.
- Disposable clothing must be taped to gloves and boots to prevent skin contact.
- Masks must be cleaned with a moist cloth before further disinfection.
- A LUMEX RA-915M mercury analyser can be used to check whether the PPE has been cleaned.
- Do not contaminate other areas, change clothing before entering clean areas.
- Avoid contaminating areas in the living quarters, possible cleaning must be done immediately.
- Shower at the end of the working day.
- Strict hygiene is necessary: wash hands with plenty of water and soap before taking breaks, eating, drinking, smoking or going to the toilet.

H2.2.6 Exposure control for groups exposed to risk

See protocols for assessing health hazard – mercury.

H2.3 HANDLING CONTAMINATED EQUIPMENT AND WASTE

Waste containing mercury can typically include:

- water from steaming operations, or which has been used to rinse boots and so forth
- black steel, aluminium or other metals contaminated with mercury
- used PPE
  - used disposable clothing and gloves
  - dirty clothing – shall be removed immediately and sealed
  - cloths used to clean masks
- porous materials such as insulation, fabric, cladding, fire protection, concrete and so forth which may contain mercury
- used mercury absorbent
- sludge/deposits in process equipment.

Solids and liquid waste collected after pigging jobs as well as from cleaning process equipment and pipelines could be contaminated with mercury. The concentration of environmentally hazardous components in waste material shall be determined. Send a sample to the agreed laboratory (contact the external environment coordinator) if analysis equipment is not available on site.

Equipment potentially contaminated with solids containing mercury should not be washed out on the installation. Should this nevertheless be done, the wash water must be stored, its mercury content determined and it must be treated as hazardous waste (shall not be discarded in the drainage system).

Surroundings must be secured against contamination from waste and equipment containing mercury by using full and sealed packaging:

- leakproof sealing

- UN-approved packaging, such as clamp ring barrel with lid.

All equipment and waste contaminated with mercury shall be collected in a container or the like which is assigned for the purpose.

Waste and equipment shall be transported to shore as TRANSPORT-CLASSIFIED WASTE, specifying that it contains mercury:

- liquid mercury compounds – use UN number 2024, pkg gr II or III, classification code 6.1, hazard label 6.1
- solid mercury compounds – use UN number 2025, pkg gr II or III, classification code 6.1, hazard label 6.1.

Clamp ring barrels are approved for both II and III.

The analysis result for mercury content must have been received before onward shipment to a receiving facility for hazardous waste. This is in order to declare the waste properly with regard to mercury.

Waste substance no 7081: waste containing mercury, shall be used when the Hg content exceeds 0.1 per cent (1 000 ppm). If values are lower than this, the waste can be declared under a different waste code, (such as 7022 for oil-contaminated solids/sludge), but with a cross against content of heavy metals and information about the measured mercury value in the comments section of the declaration form.

Reception on land and cleaning shall be carried out under the agreement with a company certified for this activity. The frame agreement includes the disposal of waste containing mercury. The existing contract does not cover cleaning of equipment containing mercury which is to be maintained and returned to the platform/ship. Where such activity is concerned, a separate agreement must be established on a job-by-job basis until contracts have been updated.

H3. Supplementary information

H3.1 HEALTH HAZARDS

Mercury can be found in crude oil and natural gas condensate. An extended producing life on the field can increase mercury levels in the wellstream. The commonest form is metallic mercury, which is a silver-coloured liquid. Mercury vaporises very quickly. Its vapour is colourless and odourless. Inhalation of mercury vapour is the commonest form of exposure. Heated mercury vaporises very quickly, significantly boosting the risk of exposure. The absence of visible liquid mercury does not mean that no mercury is present. Mercury reacts with a number of metals and is absorbed by metals such as carbon steel and aluminium. Metallic mercury also reacts with strong acids. In addition, mercury can be found as organic and inorganic compounds.

Mercury and all its compounds are toxic when inhaled and can accumulate in the body. The body can absorb 75-80 per cent of inhaled mercury vapour. Exposure to elevated levels can cause permanent brain and kidney damage, or may be fatal. Inorganic mercury compounds can cause serious health damage if they decompose into metallic mercury when heated. Exposure to very small quantities of this can result in neurological damage and death.

Foetuses are very sensitive to the effects of mercury, and pregnant women shall not do work which could expose them to it.

H3.2 PHYSICAL PROPERTIES OF METALLIC MERCURY

- Melting point: -39°C
- Boiling point: 357°C
- Vapour pressure: 0.0017 mbar at 20°C
- Solubility in water: negligible
- Density: 13.53g/cm^3

H3.3 LIMIT VALUES (NORWAY) FOR METALLIC MERCURY

eight-hour work day:	20µg/m^3	(0.02mg/m^3)
12-hour work day:	12µg/m^3	(0.012mg/m^3)