Onsite Mercury Management Procedure

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i  Revision History

The following is a brief summary of the most recent revisions to this document. Details of all revisions prior to these are held on file by the issuing department.

<table>
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<th>Date</th>
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ii  Related Business Processes

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<tr>
<td>EP.72</td>
<td>Maintain and Assure Facilities Integrity</td>
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iii  Related Corporate Management Frame Work (CMF) Documents

The related CMF Documents can be retrieved from the CMF Business Control Portal.
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1 Introduction

Mercury is a known neurotoxin that is extremely toxic even in small amounts. It directly affects the central nervous and renal systems, causing development delay, motor and brain problems like those associated with autism.

Mercury exists in three forms: inorganic metallic mercury, inorganic mercury compounds and organic mercury compounds.

For more details on mercury refer to SP-2087 Specification for Onsite Mercury Management.

1.1 Background

Oman gas reservoirs are producing mercury to the process facilities. All gas treatment facilities in PDO shall be considered as internally contaminated with mercury until proven otherwise through mapping and monitoring.

Additionally concentration of mercury have been found in the non-associated gas processed at some gas facilities, but to date these are very low level.

With natural gas some mercury is produced, the quantity dependent on the reservoir. In addition to metallic mercury the gas may also contain small quantity of mercury is/ can be liberated in or on:

- Vapour from steel walls of vessels, pipelines, pig launcher and receivers
- As a liquid in cold parts of the process
- In the gas and on glycol filters
- As a sludge
- On pieces of the installation itself
- In demisters
- In mercury removal beds
- As a mixture in condensate, water, glycol etc.

Important Note: unless demonstrated clean of mercury, all processing facilities which have been in contact with a mercury containing stream will be considered contaminated and all work conducted in accordance with this procedure.

1.2 Purpose

The purpose of this procedure is to ensure that all personnel, PDO or Contract, engaged in maintenance, repair, inspection, and modification activities at facilities where the hazards of exposure to mercury could be possible are informed of the precautions and actions to be taken to reduce or minimise that hazard. The hazards are normally encountered during intrusive activities i.e. maintenance, internal inspection, modification etc.

1.3 Distribution/ Target Audience

This procedure is intended for use by all Operations and Maintenance personnel, and Contractors working on behalf of PDO on facilities where mercury contamination is or maybe present during normal operations.
1.4 Changes to the Document

Responsibility for the upkeep of the Document shall be with the Functional Production Manager UOP, the Owner. Changes to this document shall only be authorised and approved by the Owner.

Users of the Document who identify inaccuracy or ambiguity can notify the Custodian or his/her delegate and request changes be initiated.

The Document Owner and the Document Custodian should ensure review and re-verification of this procedure every 5 years.

1.5 Step-out and Approval

This procedure is mandatory and shall be complied with at all times. Should compliance with the procedure be considered inappropriate or the intended activity cannot be effectively completed or safely performed, then step out authorisation and approval shall be obtained in accordance with PR-1001e – Operations Procedure Temporary Variance, prior to any changes or activities associated with the procedure being carried out.

1.6 ALARP

ALARP is the acronym for ‘As Low As Reasonably Practicable’ which simplified means, ‘reducing the risk to a level at which the cost and effort (time and trouble) of further risk reduction are grossly disproportionate to the risk reduction achieved’. Full Compliance to PDO Standards and Procedures is a key element in achieving ALARP.
## Roles and Responsibilities

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| Operations Support Engineer (Mercury Focal Point) | - To advise on all matters relating to Mercury Management during shutdowns and maintenance operations  
- To carry out audits on mercury mapping and database  
- To check that procedures used or developed by Contractors for the work are in compliance with PDO Mercury Specification and Procedure  
- To advise on developments and improvements to Mercury Management within the Industry and implement where agreed |
| Delivery Team Leader                      | - To promote mercury awareness within their area  
- To ensure compliance to Mercury Management Procedure within their area.  
- To ensure all cases of non-compliance are reported and investigated  
- To provide assistance to the Mercury Focal Point when conducting audits |
| Production Coordinator                    | - To ensure compliance to Mercury Management Procedure within their area.  
- To ensure that mercury risks are highlighted during Team briefings for work where mercury is suspected or known to be present  
- To ensure Mercury Map and Database are maintained current |
| Production Supervisor                     | - To undertake site inspections and check that decontamination and exclusion zones are identified  
- To ensure compliance to Mercury Management Procedure  
- To ensure all personnel are aware of decontamination and exclusion zones that are in force during work |
| Area Authority                            | - To ensure that mercury procedures are attached to PTW for all work that will be undertaken in risk areas  
- To maintain awareness of mercury risk to all personnel entering the facility  
- To ensure that mercury testing is undertaken prior to or during the course of work where mercury is or suspected of being present  
- To ensure compliance to Mercury Management Procedure |
| HazMat Team                               | - To test and decontaminate in case of mercury present when containment is broken.  
- To provide assistance when spills occur and ensure that the incidents are reported.  
- To conduct onsite monitoring of the work site to ensure mercury levels are recorded and to provide warning to personnel when levels rise or exceed the safe limits. |
3 Mercury Management Plan

Prior to any major activities being carried out on a facility where there is or could be mercury contamination a Mercury Management Plan shall be put in place. The plan will provide detailed procedures and precautionary steps to be taken for normal operations, planned shutdowns and unplanned events or incidences.

The Mercury Management Plan should provide applicable details of:

- Risk Management in the event of a mercury incident
- High risk daily activities
- Mercury reporting and maintenance of a Mercury Register
- Location of personal protective equipment for use with Mercury
- Location and availability of Mercury Spill and Cleanup equipment
- Location and status of Mercury Monitoring equipment
- Equipment decontamination
- Handling of contaminated waste such as:
  - Contaminated waste containers
  - Contaminated PPE
  - Contaminated Sludge / Residue (including rust scale)
  - Waste transportation
- Personnel Decontamination

The Mercury Management Plan should also contain detailed procedures to cover:

- Use of decontamination chemicals
- Decontamination methods for:
  - Monitoring and opening of flanges and breaking containment
  - Vessel internals
  - Confined space visual inspection and entry
- Hot working on contaminated surfaces
- Pigging
- Sludge removal

**NOTE:** Provisions in the Method Statement must ensure Hg waste as a result from cleaning is as little as possible to prevent costly disposal costs. Vessel cleaning will be assessed taking into consideration type of repair and/or inspection required.

3.1 Identification of the Mercury Risk

On facilities known to have or suspected of having mercury contamination in the process streams a map of the facility with known / predicted exposure levels should be prepared and maintained by the Asset Holder (e.g. marked up PFS). This can be achieved in the following manner:

a. Historical Data: mapping the mercury contamination during a previous shutdown or when intrusive maintenance has been undertaken.

b. Predictive Data: obtaining mercury contamination data from a facility that is operating under similer conditions and using this as a “benchmark” OR using facility operating
parameters and data from the industry to predict possible contamination levels and “hot spots”.

The following simplified flow diagram (courtesy No-Heat Resourses) illustrates a possible extent of mercury contamination throughout the process path in a gas treatment and export facility.

As can be seen the contamination is reduced throughout the process the concentration of mercury being left behind dependant on the process element i.e. temperature, pressure and type of phase. It can also be seen that contamination is transferred to interfacing mediums such as amine and glycol. Regardless of the number of processes there will be contamination at the outlet of the process.

**NOTE:** The level of contamination will be dependent on the level of mercury in the well fluids entering the process.

Using the above illustration as a guide all points of the process can be tagged and measured to provide a map of risk areas.

### 3.2 Mercury Risk Database

A mercury risk database based on the findings of the Mercury Risk Map detailed in 3.1 must be maintained by the Asset Holder who will keep up-to-date records of mercury contamination and its location. A database shall be devised for each facility and shall be updated whenever work is undertaken that requires ‘breaking’ the pressure envelope and presenting a risk of mercury exposure. Monitoring points for the database can be established using the Mercury Risk Map.

With reference to Appendix 1 – Personal Protection Equipment, to ensure consistency, the same Identification Criteria shall be used when identifying mercury risk levels in the facility / plant.
Green shall be considered as safe and no mercury above the lower limit of <0.025 mg/Nm³ expected.

Red shall be considered as a mercury risk with mercury >0.025 mg/Nm³ expected or likely to be found. Additionally Red shall be further divided into Levels 1, 2 and 3 and shall align with Appendix 1.

The database shall be structured to reflect this philosophy.

3.3 High Risk Daily Activities

On facilities or equipment where mercury contamination is possible or suspected, all normal activities undertaken by Operations and Maintenance that shall be considered ‘high risk’ with regards to exposure, shall be identified i.e. sampling liquids to open tundish, venting or working around open vents etc. These activities shall only be allowed if the correct PPE (refer to Appendix 1) is worn and the area / equipment is inspected and tested safe.

These activities shall be entered in the mercury risk database. The database shall be updated whenever the activity is undertaken and the data maintained current.

3.4 PPE and Equipment for Mercury Management

At facilities that are identified as having a mercury risk, PPE specific for mercury exposure and equipment and tools required for mercury decontamination shall be available.

The PPE and equipment shall be under the control of the HazMat Team Leader and comprise, but not be limited to:

- Respirators
- Face protection
- Coveralls
- Gloves and boots

**IMPORTANT** - Mercury can adhere to clothing and footwear, which may lead to continuous exposure. Therefore clothing and footwear needs to be manufactured from material which is non-adhesive for mercury.

Refer to Appendix 1 for details of PPE required for type of work undertaken and possible limits of exposure.

3.5 Mercury Containment Lay-down Area

A designated shaded facility to store Mercury waste is located in QA. This area shall have controlled access and be subjected to periodic monitoring.

3.6 Handling Contaminated Waste

Procedures and guidelines require being in-place which shall address the handling of contaminated waste.

Refer to **PR-1975 Waste Management**
3.6.1 Liquid Waste

Liquid waste i.e. flushing from vessels or draining from decontamination, shall be removed and stored in suitable containers until it has been treated or removed from site. Large quantities of liquid may be pumped or suctioned in to a vacuum tanker.

Smaller quantities may be decanted or pumped to drums i.e. 45 gallons metal or plastic types. The drums shall have a liquid tight seal when filled and be marked clearly to indicate their content. Any spillages outside of the containment shall be sprayed with a decontaminant chemical and monitored for mercury vapour.

Vacuum tanker shall be cleaned internally using a chemical wash and externally using a spray once all waste liquids have been discharged to the treatment area. No vacuum tanker shall be allowed to leave the containment area until it has been thoroughly checked for mercury contamination.

Smaller drums once emptied shall be treated in a similar manner and cleaned internally and externally before being re-used.

Large quantities of liquid waste shall be treated chemically (as advised by specialist company) to concentrate the mercury waste from the liquid. Refer to SP-2087 Specification for Onsite Mercury Management section 7.

3.6.2 Solid & Disposable Wastes

Such as sludge and rust scale shall be removed and stored in containers or drums as illustrated below:
Polythene sheeting should be used to cover the sludge and an air tight lid and sealing arrangement fitted. The contents and nature of the risk shall be clearly stated on the outside of the drum.

If required, due to spillage of the content during loading, the outside of the drums shall be sprayed with a decontaminant chemical. The drums shall be stored in a containment area until removal for disposal.

3.6.3 Recyclable Waste

Some items exposed to mercury may be re-used i.e. PPE like boots, nitrile rubber gloves and face masks. This will be stored in containers and then sent for processing and cleaning.

3.7 Material / Equipment sent for Scrap or Repair

Strict controls shall be exercised over all material and equipment that is moved off site for scrap or repair. The following shall be followed:

- All equipment or material that leaves the designated containment areas shall be tested for mercury and decontaminated accordingly.
- All items that are to be sent for repair or scrap shall be decontaminated externally if mercury contamination is identified.
- Items such as valves, pipe, cooler bundles etc, shall have open ends and identified leak paths covered in polythene or similar to mitigate spillage.
- Labeling indicating the mercury risk level i.e. Green, Red 1, 2 or 3, for those items where contamination has been identified shall be attached to all items shipped off site.

The transporters of the equipment or scrap shall be advised of the mercury hazard and any precautions / actions that require observing / carrying out in the event of an incident during transit.
The repairer if a 3rd Party shall be provided with any information regarding the item being shipped and precautions / procedures to be followed for decontamination during disassembly.

**NOTE:** PDO shall ensure that 3rd Party contractors have procedures in place for dealing with mercury contamination as part of the vetting process.

### 3.8 Personal Decontamination

Decontamination shall be used for personnel exposed to mercury. Decontamination may be as simple as a foot washes tray and changing area to a full chemical wash down.

**NOTE:** All tools and special equipment that has been used on site in the mercury contamination environment must be decontaminated as well.

The procedure for a full decontamination shall comprise of the following steps:

1. When leaving work area, wash boots and glove at foot bath station
2. Walk through dedicated pathway to personnel decontamination station
3. Enter Wet Decontamination Station and get stand-by Technician to spray Decontamination chemical on contaminated PPE followed by a water wash.
4. Leave the Wet and go to Dry Decontamination Unit; Technician will assist in the removal of all worn PPE.
5. When all PPE has been removed, leave the Dry Decontamination Station.
6. The Dry Decontamination Unit Technician will dispose of the contaminated suit into waste drum provided.
4 Mercury Management Procedures

4.1 General

4.1.1 Elimination and Control of Risk

Exposure to mercury vapour shall be limited to ALARP.

**IMPORTANT NOTE:** All risk assessments shall be carried out in line with PR-2271 Developing Operational Risk Assessment

The following needs to be considered in order of priority during work planning:

1. Chemical treatment. – Consideration shall be given to the use of chemicals to clean and pre-treat the equipment prior to work being undertaken.

2. Install forced ventilation. - With forced ventilation safe levels of mercury vapour in air may be achieved without the need for PPE. This could apply for work inside vessels and confined spaces providing all other risks i.e. hydrocarbons are assessed and mitigated

3. Separate the mercury containing installation (open vessels and equipment) from the workforce by erecting barriers around them with warning signs.

If option 1 and 2 are not possible, use applicable PPE (when mercury levels are above 0.025 mg/Nm3). Refer Appendix 1.

4.1.2 Mercury Vapour Measurments

Before and during work on installations suspected of containing mercury, mercury vapour measurements shall be executed to check if mercury vapour is present.

Requirements for mercury vapour measurments are:

1. The measurements need to be executed by a trained person (PDO or HazMat) and familiar with the test equipment.

2. The equipment needs to be calibrated on a frequency specified by OEM.

3. The measurements shall be executed in the breathing zone. The results of these measurements determine whether PPE is necessary.

4. For procurement of Mercury Direct reading Instrument - PDO SAP # 1001178573 should be used.

The Occupational Health Exposure Limit (OEL) is currently 0.025 mg/Nm3. If concentrations above this value are measured, full PPE needs to be used. Refer Appendix 1. Below this concentration the work can continue as normal.

Measurements shall be taken at regular intervals and take account of charging climatic conditions i.e. wind, temperature and humidity.

Mercury vapour measurements shall be required when:

1. Vessels, equipment and pipework etc., are opened up.

2. Prior to draining / cleaning / maintenance any of storage tanks / large vessel containing process fluids (oil, gas).

3. Confined space entry is required where Mercury contaminations expected to be present.
The following strategy for measuring mercury vapours is recommended:

1. Start with a baseline measurement prior to the start of the work.
2. Carry out a second measurement when there is a potential for exposure.
3. If the result is below 0.025 mg/Nm³, start the work and repeat measurement as necessary.
4. If the result is above 0.025 mg/Nm³, take control measures, repeat measurements regularly.
5. Log the results on a sheet attached to the PTW in line with gas test requirement.

**NOTE:** Samples to be taken based on Service Level Agreement (SLA) requirements.

### 4.2 Use of Decontamination Chemicals

For shutdowns and multiple breaks in to the containment envelope to remove, replace or repair equipment and pipework, the use of specialist chemicals is recommended to assist in decontamination and control mercury vapours released.

Chemicals may be supplied and administered by a 3rd party specialist contractor or supplied for application by PDO staff. Whichever route of supply and use is selected all work shall be controlled under the PTW system and with reference to the SHOC card for that chemical and/or the MSDS (Material Safety Data Sheet).

Prior to any chemicals being used by PDO sufficient training shall be given by the chemicals supplier to ensure that staff is able to safely undertake:

- Storage
- Correct selection of PPE
- Correct mixing for all applications
- Application according to requirement
- Collection and disposal
- Emergency spill clean up

### 4.3 Decontamination Methods

Vessels known to be or suspected of being contaminated with mercury shall be decontaminated before entry.

**NOTE:** It is essential to minimise (liquid) waste production because of difficult disposal procedures and very high associated costs.

Different methods of decontamination can be used and the correct method depends on:

- Reason for manned entry i.e. is it practicable for inspectors to work in full mercury PPE
- Amount of mercury / sludge expected in the system
- System dynamics and available facilities (Steam, hot nitrogen, route to flare, size of the vessel etc)

Decontamination (for mercury) is performed after the systems / equipment has been isolated, drained, gas freed and purged in accordance with established procedures already in force.

**PR-1077  Preparation of Static Equipment for Internal Maintenance and Inspection**
PR-1079  Gas Freeing and Purging of Tanks

PR-1082  Pipeline Piping Procedure

**NOTE:** Special attention must be given to condensate that can remain behind on trays after draining. This could be removed by flushing with water from bottom to top. The strength of the column and its foundation shall be checked to ensure that excessive loads are not applied.

### 4.3.1 Breaking Containment (flanges) and Opening to Atmosphere

Prior to breaking flanges, removing valves, swinging spectacle blinds or breaking containment etc., monitoring and decontamination shall be carried out. The spray is applied directly on to the area to combine with mercury vapour or elemental mercury to form a solution which will be collected in a receptacle positioned under the break.

This task will be the responsibility of a HazMat Team.

1. The position of the break (flange, valve etc.) shall be identified and the area prepared. A suitable container will be placed under where the break is to be made and provision made to contain any spills (polythene covers etc.)
2. The HazMat Team shall monitor and record the base reading before any breaks are made.
3. The bolts / nuts shall be slackened off starting at the top and working to the bottom. Appropriate PPE as indicated on the Risk Map shall be worn by all operatives for this task.
4. The area around the break shall be monitored again with the bolts / nuts slacked off. If the reading on the monitor is above the OEL (0.025 mg/m³) a decontaminant spray shall be applied to the area as shown below.

5. The decontaminant will be given time to work (approximately 10 – 15 mins) and the area monitored again and recorded. The bolts / nuts can be removed and placed in a container for cleaning / decontamination and the flanges broken or the valve removed etc. **NOTE:** For large pipe or fittings suitable lifting equipment may require to be used this must be monitored and decontaminated if required after use.

6. All pipe and / or fittings removed shall be bagged or wrapped if contaminated and sent to the prescribed area for cleaning. The ends of the fixed pipe shall be either wrapped or blanked to prevent cross-contamination.

7. Attach a colour coded Tag to identify levels of Hg detected:

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<th>Hg Level (mg/Nm³)</th>
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4.3.2 Manual Spray

Where the vessel is small, decontamination can be undertaken using a manually operated spray as follows:

1. Open manway access observing all precautions required for confined space entry and gas testing.
2. Take and record the base reading of the mercury vapour in the vicinity of the manway (HazMat Team).
3. If decontamination is required, mask off the manway with clear polythene sheeting.
4. Make a penetration in the polythene sheeting and direct the spray around the vessel internals through the penetration.
5. Allow time for decontaminant to act (10 – 15 minutes) and take and record another mercury vapour reading.
6. Repeat steps 4 & 5 (if required) until conditions within the vessel are below 0.025 mg/Nm3.
7. Drain liquids from the bottom of the vessel to a closed drain system or toxic waste storage drums / vacuum tanker.

Work can now be undertaken wearing the appropriate PPE. Mercury vapour reading shall be taken at regular intervals (specialist supervisor to advise). **Work shall be stopped and decontamination repeated if levels of mercury vapour increase above safe levels (0.025 mg/Nm3).**
4.3.3 Mechanical / Steam Injection

On larger more complex vessels such as columns i.e. glycol contactors, stabilisers etc., decontamination may require a mechanically pumped or steam injection system to be used.

The pumping system should utilise a high point for injection of the spray where as the steam injection should be at a low point to allow for the steam vapour (with the decontaminant) to rise up through the vessel and internal fittings, venting any vapour remaining to the flare or vent system.

1. Observe all requirements for confined space entry and gas testing.
2. Connect temporary fittings to existing pipework or install temporary spools if required. Observe all precautions regarding mercury contamination when undertaking this work.
3. Take and record the base reading of the mercury vapour in the vessel at suitable access points on the vessel (HazMat Team).
4. Start the decontamination process. Allow sufficient time for the decontamination chemical to contact the vessel internals and make its way down to the bottom of the vessel for removal.
5. Stop the spray / steam injection process and take / record vapour readings at same points as base readings.
6. Repeat steps 3 & 4 (if required) until conditions within the vessel are below 0.025 mg/Nm3.
7. Drain liquids from the bottom of the vessel to the closed drain system or toxic waste storage drums / vacuum tanker.
Work can now be undertaken wearing the appropriate PPE. Mercury vapour reading shall be taken at regular intervals (specialist supervisor to advise). **Work shall be stopped and decontamination repeated if levels of mercury vapour increase above safe levels (0.025 mg/Nm³).**

### 4.3.4 Continuous Circulation

Circulation and soaking of the chemical mix may be considered where heavy mercury contamination or internal corrosion is identified or suspected; or where there is a possibility that the mercury has combined with corrosion scale.

During circulation the chemical will be pumped around the system and vessel and allowed to soak on the surfaces or into the scale that may be dislodged. Circulation may be up to 12 hours or more and require the installation of a portable pumping loop. The solution is then vacuumed from the system by a vacuum tanker. The chemical binding of any mercury contaminants will reduce or prevent vapours being given off when the system or vessel is opened.

**NOTE:** This method of decontamination may require some engineering work to remove / install the pipework and equipment for pumped circulation if no suitable means is available in the design of the system / equipment.

The procedure for Continuous Circulation depends on the configuration to be used; however the following shall be applicable:

- Breaking containment (flanges) and removing pipework and valves shall be undertaken.
- Monitoring and recording base line mercury vapour readings should be carried out at suitable man ways ensuring all other relevant procedures have been adhered to. The manways should be covered with polythene and sampled through penetrations in the cover.
- Regular checks will be carried out on the course strainer. Personnel shall wear appropriate PPE during cleaning all waste. Waste should be treated as toxic and monitored / stored correctly.
Work can be undertaken on the vessel when all draining has been completed and the mercury vapour levels are <0.025 mg/Nm3.

Mercury vapour reading shall be taken at regular intervals (specialist supervisor to advise). Work shall be stopped and local decontamination undertaken if levels of mercury vapour increase above safe levels (0.025 mg/Nm3).

### 4.3.5 Confined Space Visual Inspection and Entry

Confined space visual inspection and full entry shall be treated differently when testing for the presence of mercury vapour.

- The “heads and shoulders only” inspection where a full entry is not required also requires that confined space has been certified for entry under the PTW system.

Then a visual inspection, only requires the immediate vicinity of the access point to be monitored for mercury vapour and a decontamination chemical spray applied in that vicinity to remove it, if found. The “heads and shoulders only” inspection can then be carried out after a second round of vapour monitoring has been undertaken to confirm conditions are safe.

Where a full entry to the confined space is required for repair or inspection then the following steps shall be taken:

1. Confirm that the Confined Space Entry Certificate is valid.
2. Monitor the access point and record the base reading (HazMat Team).
3. Apply decontaminant spray if required. Use PPE as per Appendix 1 for Confined Space Entry and enter the confined space (HazMat Team). **NOTE:** All safety precautions detailed in PR-1148 Entry in to a Confined Space
4. Monitor the internal space of the confined space and record any ‘hot spots’.
5. Apply decontaminant spray as required to treat the areas. Pay particular attention to internal fittings and solids / liquids in the bottom of the space.
6. When the confined space has been monitored and all hot spots recorded / treated, work can be allowed to be undertaken. Ventilation with forced extract shall be installed for areas where mercury vapour is suspected or anticipated to accumulate.
7. Mercury vapour reading shall be taken at regular intervals (specialist supervisor to advise). **Work shall be stopped and local decontamination undertaken if levels of mercury vapour increase above safe levels (0.025 mg/Nm3).**

When full access is required for a confined space then PPE should be provided that prevents skin contact with the internals of the space where mercury contamination may be or still is present. Additionally a face mask must be worn to prevent ingress in to the eyes.

### 4.3.6 Hot Working on Mercury Contaminated Surfaces

The following shall be noted when considering ‘Hot Work’ on surfaces that are known to be or likely to have been contaminated due to mercury exposure.

- All equipment that comes in contact with mercury contaminated gases or produced fluids should be considered to be Mercury Contaminated. (The amount of mercury absorbed into the metal surface will vary.)
- Mercury can enter the matrix of a metal surface and form amalgams with other substances which will not vaporise and will therefore not be detectable with a mercury vapour analyser. When these surfaces are disturbed and / or heated the mercury will vapourise.
c. Decontamination of a surface does not make the equipment ‘Mercury Free’. Heat will release mercury that is previously not detectable and the vaporisation rate is likely to be extremely high. **NOTE:** When mercury is heated in the presence of air to above 350 deg C it is converted to Mercuric Oxide. At 500 deg C it decomposes separating the Hg and the Oxygen.

**WARNING:** Mercury analysers do not detect Mercuric Oxide (HgO).

d. When welding or grinding mercury contaminated metal, remove the equipment to a well ventilated area and keep people that are not required for the work well away. Refer section 4.1.3 Exclusion Zones.

e. Most mercury chemical suits are flammable and therefore a fireproof overall must be worn over the chemical suit. **NOTE:** This fireproof overall is likely to become mercury contaminated and must be disposed or soaked in decontamination chemicals and tested prior to being placed in the normal laundry.

f. Personnel working in the vicinity of the hot work must wear correct PPE etc.

g. All hot work undertaken on equipment with mercury present shall be ‘upwind’ in an Exclusion Zones. Welding work where there are elevated levels of mercury vapour present should be assessed by HSE and the Specialist Supervisor and where necessary ‘positive flow face masks’ shall be used by all persons in the direct vicinity of the welding.

### 4.4 Pigging Operations

On facilities where there is a risk of mercury contamination, consideration should be given to pigging (launching and receiving) operations. The highest risk will be in the receiving operations due to the higher risk of exposure to sludge; launching will still have a risk but this will be limited, as sludge will not tend to be present. Refer to **PR-1082 Pipeline Pigging Procedure**

#### 4.4.1 General

The following are areas of general awareness that should be addressed:

- Launcher and receiver liquid drains should be provided with a means of capturing liquids for storage and disposal as hazardous waste. **NOTE:** Most PDO facilities do not have this provision (yet).

- Launcher and receiver vents should be routed to a safe area away from where personnel are working.

- Drip trays should be provided under the launcher and receiver doors to capture any spillage.

- A laydown area for toxic waste shall be provided that is clearly marked with warning signs.

- Pigging crews shall be provided with suitable barrier materials with which to place pigs and tools for transportation until they can be decontaminated and cleaned.

**WARNING:** Pigs and tools shall not be transported loose after they have been exposed to possible mercury contamination.
4.4.2 Pigging

The following procedure shall be followed for Pipeline Pigging Operations. The steps below should be included where relevant:

1. Correct PPE for the mercury risk must be worn. If the risk is unknown, respirators face mask and gloves shall be worn until limit of risk is ascertained.
2. Monitor and record base line reading around the vicinity of the launcher / receiver before pigging operations start (HazMat Team).
3. Set up a decontamination point for all personnel working on the pigging operation. The decontamination point should be equipped with storage for hazardous mercury waste.
4. Ensure that all liquid draining from the launcher / receiver barrel is monitored and recorded. All liquids shall be captured in a container. Any spills shall be monitored, treated and recorded.
5. Ensure that provision is made to contain any spills when the pig launcher / receiver door is opened.
6. HazMat team shall be present and monitor when the pig launcher / receiver door is opened. Decontaminant chemical shall be used as required to address mercury vapour release.
7. Before loading the pig, monitor and record the conditions in the launcher.
8. The used pig and sludge from the pig receiver shall be treated as hazardous. The pig shall be bagged and tagged and all sludge, including absorbent waste shall be placed in containers and sealed. The containers shall be tagged and marked according to the level of contamination.
9. Monitor and decontaminate working party as required and store all contaminated PPE in a sealed container. Contaminated tools shall be bagged and sent for cleaning.
10. Move all hazardous waste containers to the designated area. Monitor and decontaminate external surfaces if required. Load waste securely on transport and ship to designated mercury waste storage and treatment area. **NOTE:** The contaminated pig shall be sent for cleaning before it can be returned for use.

4.4.3 Sludge Removal

When dealing with sludge the following HSE Specifications shall be referenced and adhered to:

- [SP-1170 HSE Specification - Naturally Occurring Radioactive Materials (NORM)]
- [SP-2194 Specification for Environmental Management]

A proportion of the mercury contamination, 15% to 20%, shall be found mixed with the hydrocarbon sludge that accumulates in the pipelines, in the bottoms of vessels and at low points on the equipment. [PR-1077 Preparation of Static Equipment for Internal Maintenance and Inspection] covers the preparation of static equipment, which includes vessels and pipework and has a specific Section about cleaning in particular.

Sludge can occur in a vessel that is very difficult to dislodge and may require to be treated to make it possible to remove.

**IMPORTANT:** Sludge can also contain other contaminants that require to be handled in a particular manner i.e. NORM, and this shall be taken into consideration.
When dealing with sludge the following shall be considered and adhered to where applicable:

- Continuous monitoring for mercury vapour shall be carried out while the work is being undertaken and forced extraction ventilation system used where applicable to reduce mercury vapour.
- Personnel removing the sludge manually shall be provided with positive flow air masks and full face shields if the risk level warrants this level of protection.
- All bare skin that may come into contact with the sludge or contaminated metal surfaces shall be covered and protected.
- Footwear shall be safety rubber boots as a minimum.
- Before loading into waste drums or a vacuum tanker the sludge shall be sprayed with a decontaminant chemical to reduce the mercury vapour released.
- Full decontamination including disposal / cleaning of all PPE shall be required for all personnel involved with the sludge removal within a confined space.
- Refer to Section 3.8 for sludge waste handling and removal.
- Before transporting drums containing mercury waste the haulage contractor shall be advised on the dangers and provided with details of actions to be taken in the event of a spillage.
- Waste drums shall be loaded in a vertical orientation and secured to restrict any movement.
- The journey plan for the movement of mercury waste should be notified to the ROP as a hazardous waste shipment.
Appendix1 – Personal Protection Equipment
(As per World Health Organization and SHELL)

PPE External Exposure

<table>
<thead>
<tr>
<th>Hg Level (mg/m³)</th>
<th>Respiratory</th>
<th>Hand</th>
<th>Foot</th>
<th>Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hg &lt;0.025</td>
<td>Not required</td>
<td>Cotton gloves</td>
<td>Safety boots</td>
<td>Nomex coverall</td>
</tr>
<tr>
<td>Hg 0.025 to &lt;0.250</td>
<td>Half face mask with mercury cartridge</td>
<td>Nitrile rubber gloves</td>
<td>Wet conditions rubber safety boot</td>
<td>Mercury disposable coverall Example Tyvex Type C</td>
</tr>
<tr>
<td>RED 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hg0.250 to &lt;1.250</td>
<td>Half face mask with mercury cartridge</td>
<td>Nitrile rubber gloves</td>
<td>Wet conditions rubber safety boot Dry conditions Safety boots</td>
<td>Mercury disposable coverall Example Tyvex Type C</td>
</tr>
<tr>
<td>RED 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hg &gt;1.250</td>
<td>Full face mask with mercury cartridge</td>
<td>Nitrile rubber gloves</td>
<td>Wet conditions rubber safety boot Dry conditions Safety boots</td>
<td>Mercury disposable coverall Example Tyvex Type C</td>
</tr>
<tr>
<td>RED 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IMPORTANT NOTE:** ‘Moon Suit’ will be provided when working inside vessels and tanks with high level of Hg.
Guideline – PPE Confined Space Entry  
(As per World Health Organization and SHELL)

<table>
<thead>
<tr>
<th>Hg Level (mg/m³)</th>
<th>Respiratory</th>
<th>Hand</th>
<th>Foot</th>
<th>Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hg &lt;0.025</td>
<td>Half face mask with mercury cartridge</td>
<td>Dry conditions</td>
<td>Wet conditions</td>
<td>Normal disposable coverall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cotton gloves</td>
<td>rubber safety boot</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nitrile rubber</td>
<td>Dry conditions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>gloves</td>
<td>Safety boots</td>
<td></td>
</tr>
<tr>
<td>Hg 0.025 to &lt;0.250</td>
<td>Half face mask with mercury cartridge</td>
<td>Nitrile rubber</td>
<td>Safety rubber boots</td>
<td>Mercury disposable coverall</td>
</tr>
<tr>
<td>RED 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hg 0.250 to &lt;1.250</td>
<td>Full face mask with mercury cartridge</td>
<td>Nitrile rubber</td>
<td>Safety rubber boots</td>
<td>Mercury disposable coverall</td>
</tr>
<tr>
<td>RED 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hg &gt;1.250</td>
<td>Air supplied respirator with mask</td>
<td>Nitrile rubber</td>
<td>Safety rubber boots</td>
<td>Chemical suit (Viton material)</td>
</tr>
<tr>
<td>RED 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Changing Disposable Coverall and other PPE

- **RED**
  - Damage due to Wear & Tear
  - Contaminated with dirt /sludge.

- **RED 2**
  - Once per day
  - Damage due to Wear & Tear

- **RED 3 / Confined Space**
  - Once per every break
  - Damage due to Wear & Tear

*NOTE: Nitrile Rubber Gloves & Safety Rubber Boots can be reused after decontamination and washing.*
Appendix 2 – Exposer and First Aid

Exposure Levels

- WHO & Shell OEL
  The Occupational Health Exposure Limit (OEL) is currently **0.025 mg/m³** (World Health Organization and SHELL). If concentrations above this value are measured, full PPE needs to be used. Refer Appendix 1. Below this concentration the work can continue as normal.
- ACGIH TLV
  The American Conference of Governmental Industrial Hygienists has assigned mercury vapour a threshold limit value (TLV) 0.025 mg/m³ as a TWA for a normal 8-hours workday and a 40-hours workweek and considers mercury vapour an A4 substance (not classifiable as a human carcinogen).

Rationale for Limits
The limits are based on the risk of central nervous system damage, eye, skin, and respiratory tract irritation.

Mercury Contact with the Skin

- Not known to irritate to skin.
- Allergic reaction may develop.
- Elemental liquid and vapour can be absorbed through the skin and will contribute to overall absorption and toxicity.
- Organic mercury can easily pass through the skin and into the body.

Mercury in the Eyes

- Not known as a direct eye irritant.
- High concentrations of elemental mercury vapour can cause redness, burning and inflammation of the eyes.
- Organic mercury can be absorbed by eyelids and move into blood stream.

Prevention of Exposure

- **Train** employees in proper equipment and chemical handling and procedures. All employees should be made aware of the high risk areas in the facility and the procedures to combat this risk.
- **Label** mercury-containing instruments. Make sure facility has a mercury spill cleanup kit. Make sure staff are trained in proper cleanup procedures.
- **Clean spills immediately** and treat soiled towels as a hazardous waste. Do not place mercury-containing materials in biohazards waste receptacles.
- **Follow procedures** when cleaning or refilling mercury-containing instruments.
# Appendix 3 - WORKFLOOR INSTRUCTION CARD - Mercury

<table>
<thead>
<tr>
<th>Element Identifier</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Found As</td>
<td>Vapour; Liquid; Solid</td>
</tr>
<tr>
<td>Found Where</td>
<td>Process Equipment and Pipe work of Gas Process Facilities</td>
</tr>
<tr>
<td>Exposure Category</td>
<td>Highly Toxic</td>
</tr>
<tr>
<td>Occupational Health Exposure Limit (OEL)</td>
<td>1.25 mg/m³</td>
</tr>
</tbody>
</table>

## Primary Risk
May accumulate in the body (harmful in the long term). May cause harm to the unborn child. Toxic by inhalation (may cause pneumonia and/or metal vapour fever). Product is absorbed through the skin. May cause irritation to skin, eyes and respiratory system. Reacts violently with sodium, potassium and lithium (alkali metals) and may cause fire/explosion. Mercury forms an explosive combination with ammonia, amines, oxalic acid and acetylene. Several metals (gold, silver, copper, zinc, and aluminum) dissolve in mercury. Very toxic to aquatic organisms and harmful in the long term.

## Toxic Dangerous for the Environment

<table>
<thead>
<tr>
<th>Prevention Measures</th>
<th>Fire Extinguishing / First Aid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevent contact with alkali metals (for example sodium potassium and lithium)</td>
<td>FIRE / EXPLOSION Powder, foam, spray water or carbon dioxide (CO2) Not inflammable and/or explosive</td>
</tr>
<tr>
<td>Respiratory protection; filter type ABEKhg/P3</td>
<td>INHALATION Fresh air and rest, apply artificial respiration if necessary. Obtain medical attention immediately and if possible show packaging and/or label and this card.</td>
</tr>
<tr>
<td>Liquid tight clothing and gloves (butyl rubber, neoprene or PVC)</td>
<td>SKIN CONTACT Remove contaminated clothing and wash skin with plenty of water and soap. Obtain medical attention immediately and if possible show packaging and/or label and this card</td>
</tr>
<tr>
<td>Combined eye and respiratory protection</td>
<td>EYE CONTACT Rinse using plenty of water (remove any contact lenses if possible). Get medical attention if there are symptoms and if possible show packaging and/or label and this card</td>
</tr>
<tr>
<td>When using do not eat, drink or smoke</td>
<td>INGESTION If victim is conscious, allow victim to rinse mouth and after that let him drink 2 glasses of water. DO NOT induce vomiting. Obtain medical attention immediately and if possible show packaging and/or label and this card</td>
</tr>
</tbody>
</table>

## Storage
Storage inside a well ventilated storage at floor level. Separated from all other products. Keep container tightly closed

## Specific Risks:
EVACUATE WARNING ZONE AND NOTIFY EXPERT by large spills!!!

## Personal Protection:
As minimum respirators; full face visor, boots, gloves and coveralls. Types of PPE dependant on extent or severity of spill

## Cleaning Up
Remove large spills in consultation with an expert. Take up small spills by an absorbing agent and collect in drums/containers. Wash away the remains with water (prevent discharge of scouring water into sewer/surface water). Transport drums/containers according to local rules
Appendix 4 – Site and Equipment Warning Signage

The following are examples of Warning Signage to be found at PDO locations where the risk of Mercury is present.
Appendix 6 – Mercury Spillage

1. **Spill Notification**
   - Monitor the mercury vapour releasing from the spillage source and area to reduce (all directions)

2. **Barricade the Contact Area**

3. **Erect ‘Mercury Contaminated Area’ Signage**

4. **Spray McDonald to Suppress Mercury Vapour where the Concentration above OEL**

5. **Carry Out Investigation for Further Risk Appraisal**

6. **Propagate Sulphur Powder onto Elemental Mercury to Reduce and Control Evaporation Rate**

7. **Collect Elemental Mercury and other Contact Elements (Safety Sand, etc.) using Syringe / Vacuum Cleaner / Scoop**

8. **Monitor Mercury Vapour Level**

   - **If Above 0.025:** Spray McDonald
     - Check for any remaining mercury traces
     - Monitor mercury vapour level
     - If below 0.025: Decontamination completed
     - Drum all waste and label as mercury contaminated waste
     - If above 0.025: Monitor mercury vapour level

   - **If Below 0.025:**

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Appendix 7 – Decontamination of Offline Equipment

- Ensure working on offline system or out from the plant process.
- Prepare masks in backpack sprayer.
- Check initial mercury vapour readings.

1. If above 0.025, spray masks to suppress mercury vapour.
   - If elemental mercury found, collect and store in bottle sample, use spill KIT or mercury vacuum, where appropriate.
2. If below 0.025:
   - Monitor mercury vapour level.
     - If above 0.025, spray masks to suppress mercury vapour.
       - If required, spray heavy duty cleanser to remove oil/wax/gel/dge stain.
     - Monitor mercury vapour level.
       - If above 0.025, flush and rinse with fresh water, as final stage.
       - Drain all waste and label as mercury contaminated waste.
     - If below 0.025, decontamination complete.

- Carryout continuous monitoring.
Appendix 8 – Personnel Decontamination

1. Check readiness of equipment:
   1. Body suit in backpack spray
   2. Rinse water in backpack spray
   3. Decon station
   4. Wash drum mercury analyzer

2. Read personnel mercury vapour reader

3. Personnel decontamination at decon station

4. Step into decon station

5. Ready/standby for decon process

6. Decon with bore suit

7. Flush with rinse water following the same steps during decontamination with bore rinse

8. Monitor mercury vapour levels

   - If above 0.025 mg/L, go back to decon station
   - If below 0.025 mg/L

9. Exit decon unit

10. Decontamination completed

11. Drain all waste into bags as mercury contaminated waste

12. Techique on either side:
   1. Spray safety/summer boot
   2. Spray hand glove
   3. Spray body suits—top to bottom
   4. Turn around and repeat procedure on other side
## Appendix 9 – Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARP</td>
<td>As Low As Reasonably Practicable</td>
</tr>
<tr>
<td>JSP</td>
<td>Job Safety Plan</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquid Petroleum Gas</td>
</tr>
<tr>
<td>OEL</td>
<td>Occupational Health Exposure Limit</td>
</tr>
<tr>
<td>OEM</td>
<td>Original equipment manufacturer</td>
</tr>
<tr>
<td>PE</td>
<td>Polyethylene</td>
</tr>
<tr>
<td>PP</td>
<td>Polypropylene</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal Protection Equipment</td>
</tr>
<tr>
<td>PTW</td>
<td>Permit to Work</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl chloride</td>
</tr>
<tr>
<td>SHOC</td>
<td>Safe Handling of Chemical</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
</tbody>
</table>
Appendix 10 – Reference Material

PDO Documents

Code of Practice

- CP-114 Maintenance and Integrity Management CoP
- CP-115 Operate Surface product Flow Assets

Specification

- SP-1170 HSE Specification - Naturally Occurring Radioactive Materials (NORM)
- SP-1230 HSE Specification - Medical Examination, Treatment and Facilities
- SP-1231 HSE Specification - Occupational Health
- SP-2087 Specification for Onsite Mercury Management
- SP-2194 Specification for Environmental Management

Procedures

- PR-1073 Gas Freeing, Purging & Leak Testing of Process Equipment
- PR-1076 Isolation of Process Equipment
- PR-1077 Preparation of Static Equipment for Internal Maintenance and Inspection
- PR-1079 Gas Freeing and Purging of Tanks
- PR-1082 Pipeline Piping Procedure
- PR-1148 Entry in to a Confined Space
- PR-1975 Waste Management

Mercury Mapping Study

- Mercury Mapping