Decontamination of NORM Contaminated Equipment

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1.0 Introduction

NORM contaminated equipment currently stored in the Bahja NORM yard includes tubulars, sucker rods, valves, pumps, Xmas trees, flanges, spools, separators, cable ties, and cables.

It is not possible to accurately measure the activity of the NORM in the field as this requires sensitive instrumentation and at least 24 hours of analysis. Portable direct reading instruments are utilised by competent staff to detect low levels of NORM contamination in the field.

PDO classifies equipment as NORM contaminated when it records 5 counts per second (cps) above background (abg) when measured with a Mini 900 series meter with either the 44A or EP15 probes. Typically background in Oman is approximately 2 - 4 cps with using a portable calibrated Mini 900 series meter with a 44A probe (scintillation or NORM meter).

When a NORM meter is used by a competent user and records less than 5 cps above background, PDO can be confident that the activity is very low and below the PDO unconditional release limit of 1 Bq/g for Ra-226. NORM contaminated equipment may continue to be used in situ, but it must be identified, labelled and the NORM Register updated by the Asset.

PDO has stipulated the following for NORM contaminated equipment:

1. NORM contaminated equipment taken out of service and requiring servicing MUST first be decontaminated prior to going to any workshop.

2. Equipment for scrapping MUST be decontaminated prior to handing over to scrap merchants as this may lead to third party exposures.

Decontamination of NORM contaminated equipment shall only be conducted by approved contractors in accordance with the most current version of SP1170 and the NORM Guidelines. Decontamination of all items generally will be carried out, but not limited to, using high pressure water jetting or ultra high pressure water jetting. All items decontaminated shall have no visual trace of scale on them. All items will be decontaminated to background level or at least no more than 5 cps above background when monitored with calibrated PDO approved meters.

1.1 Objective

To define the radiological precautions for dismantling and decontaminating NORM contaminated equipment in the Bahja NORM Yard and to provide guidance to HSE Advisors, Contract Holders and Representatives responsible for ensuring decontamination is conducted in accordance with best practice.

1.2 Scope

This guideline applies to all contractor personnel involved in dismantling and decontaminating NORM contaminated equipment and storing NORM waste within the Bahja NORM Yard.
2. Responsibilities

2.1 Contract Holder

The Contract Holder is responsible for ensuring that the Contractor and any Sub-Contractors meet all the requirements of the NORM decontamination contract. This may be achieved through regular inspections, audits and employing a Company Site Representative with NORM experience. The Contract Holder must verify that a written risk assessment is conducted for the proposed scope of work and is reviewed in line with the Company guidelines. This will be in addition to any risk assessments required for work as part of the HSE Management System. The risk assessments are also required to identify the need for any Supervised or Controlled Working Areas. After identifying any risks associated with Radiation Activities, there is a requirement to apply precautions to mitigate the risk.

2.2 Company Site Representative (CSR)

The CSR is responsible for ensuring the Contractor meets the health safety and environment, quality assurance and decontamination criteria. This will be verified through inspections, monitoring of decontaminated equipment, independent analysis and audits/reviews. The CSR must possess sufficient experience with regard to NORM and a working knowledge of SP1170 and the NORM Guideline for decontamination.

2.3 Radiation Protection Supervisor (RPS)

The RPS employed by the Contractor is responsible for ensuring that equipment scheduled for decontamination is in fact NORM contaminated by monitoring with PDO approved meters. The RPS shall ensure that cleaned equipment meets the agreed acceptable criteria before issuing a certificate of decontamination.

The RPS shall receive appropriate training, for example from an RPA, and it should reflect the work scope to be undertaken. If the RPS feels that instructions being given to work may contravene the health and safety of a worker or other, he may consult the RPA before either proceeding to comply with the instruction. Under no circumstances shall the RPS permit any practices within the Controlled or Supervised Areas set up by him that might compromise the integrity of the safe system of work he devised to minimise potential risks to any personnel arising from Ionising Radiations.

The RPS must understand the performance of work and should not be appointed unless he:

- Knows and understands the requirements of the Regulations and Radiation Management System, PDO NORM Specification and Guidelines.
- Commands sufficient understanding of the system of work and controls to be implemented to minimise workers and others exposures to ionising radiation
- Can manage emergency situations

2.4 Radiation Protection Advisor (RPA)

The Contractor must have appointed a suitably qualified RPA (on staff or under contract) for their operations in Oman. All RPA’s must be formally trained in all aspects of their work and possess a
valid certificate of competence from a National Accreditation Board, or equivalent. The RPA shall be available at all times through a call-out system, but the permanent presence of the RPA at the worksite is not required.

The contractor carries the responsibility of compliance with the Oman Radiation Regulations and performance of the Contract. He cannot delegate that responsibility to the RPA any more than he can to the Radiation Protection Supervisor.

2.5 Contractor

The Contractor is responsible for decontaminating NORM contaminated equipment to the agreed criteria and ideally to background to enable equipment to be safely scrapped or refurbished and put back into service.

The Contractor shall develop their own decontamination procedures which shall include a

- HSE management system
- Quality Assurance to ISO 9001
- Radiological Management System in line with MWMEWR 249/97 Control and Management of Radioactive Materials, the most current version of SP1170 and the PDO NORM Guidelines.

The Contractor shall ensure that the RPS is issued with the Radiological Management System often referred to as Local Rules. The Contractor shall appoint each RPS and the RPA in writing by a Company authorised signature. A copy of the appointment letter will be retained on file and be available to the Contract Holder or Company Site Representative.

2.6 Radiological Classified / Non Classified Workers

Must ensure that they are aware of the provisions of SP1170 and the NORM Guidelines and its requirements to effectively control the inherent risks associated with the working in or in proximity to the NORM decontamination facility

Have a responsibility to themselves and others to comply with the NORM Specification and Guidelines and to ensure that the requirements of the HSE Management system and risk assessment are fully met.

Shall report to the RPS or other Supervisor any damaged equipment or inadequate PPE and/or work practice in line with the HSE Management System, the PDO Golden and House Rules.

3. Performance

3.1 Risk Assessments

Prior to work commencing the Contractor shall have documented procedures for cleaning equipment which includes written risk assessments for specific equipment. The risk assessments shall address all risks from ionising radiations and any other hazardous operations associated with the work. Where possible these risks must be removed through the hierarchy of controls i.e. by engineering controls, personal protective equipment (PPE) or other procedures. Contingency plans must be in place to deal with any risks which can not be eliminated.
Decontamination of NORM Contaminated Equipment

Prior to commencing work, the Contractor shall ensure the availability of all PPE and auxiliaries to undertake the work in accordance with their own standard operating procedures.

Copies of risk assessments shall be kept for a minimum of 5 years and updated in accordance with changes in Company procedures or as a minimum every 5 years. Copies of all NORM records shall be kept for a minimum of 5 years by the RPS. The records shall then be archived.

3.2 Radiological Safety measures and work instruction

3.2.1 General

All personnel shall attend a NORM awareness courses and be familiar with the hazards and safeguards involved with NORM decontamination. This may also involve specific tool box talks prior to work commencing. In the event of Sub-Contractor coming into the facility, the Contractor shall discuss with the workforce in his charge the work content and working methods to be adopted and will satisfy himself that everyone fully understands the HSE risk, especially from Ionising Radiation prior to the work commencing.

3.2.2 Dismantling Operations

Dismantling of NORM contaminated equipment must be carried out in suitably designed facility using qualified technicians for items of equipment such as electrical submersible pumps, cables, well heads and valves. The work must be done under the supervision of an appropriately qualified engineer with an appreciation of the radiation risks.

3.2.3 Monitoring equipment

NORM contamination from oil/water production facilities and equipment must be monitored with the recommended contamination meters which are capable of monitoring for Ra-226 and Ra-228. The PDO approved meters for crude oil facilities is the calibrated Mini 900 Series Meter with the 44A probe (Gamma and high energy beta probe). Note: this meter is not intrinsically safe and will require a hot work permit if used in flammable atmospheres.

NORM contamination from gas production facilities and equipment use monitors to measure for Pb-210. The PDO approved meters for crude oil facilities is the calibrated Mini 900 Series Meter with the EP15 probe (alpha & beta probe). Note: this meter is not intrinsically safe and will require a hot work permit if used in flammable atmospheres.

If the counts exceed 100 cps with either meter and probe, dose measurements should be undertaken to determine if the area and equipment become a supervised or controlled area in which case a dose meter such as the Graetx X5 DEx, Gammtrol PRI 90s or Tracerco T201 Dose rate meters or equivalent may be used.

All detection monitors shall only be used by trained and competent personnel who hold a letter of appointment from the Contractor as a competent meter user.

All final contamination monitoring must be carried out when the equipment is dry not wet. The final monitoring must be verified by the Company’s Site Representative/RPS and recorded in the Contractors Decontamination Record Sheet. The Contractor must present a copy of all decontamination record sheets to the Company Site Representative to verify that equipment has been decontaminated to the required standards as stated in the Contract and this Guideline.
Decontamination of NORM Contaminated Equipment

For PDO operations, where the main concern is NORM compromising of radionuclides radium-226 and radium-228, the Mini 900 with 44A probe can be used to detect the presence of NORM on the inside and outside of the equipment. If the equipment is dry we can use the more sensitive Mini 900/EP15 to detect the presence of beta particles on the surface of equipment and the interior, however this meter cannot be used for closed equipment as the metal will shield any alpha or beta particles.

For equipment which has come from dry gas fields, the main isotopes of concern from NORM are Po-210 and Pb-210. These isotopes do not possess sufficient energy to be detected through metal walls. The mini 900 with 44A is therefore not suitable for exterior measurements and the Mini 900/EP15 must be used for direct measurements of contaminated surfaces (interior or exterior).

Conclusion

**Oil/Gas/Water production equipment**

Mini 900 with 44A probe: To be used on the outside and inside of equipment to detect the presence of NORM (Ra-226 & Ra-228). May not always detect these radiation from exterior measurements owing to the wall thickness, therefore internal measurements must always be made and recorded.

**Dry Gas production equipment**

Mini 900/EP15: To be used on internal and external surfaces of equipment that have conveyed gas to detect the presence of NORM (Pb-210/ Po-210). Will not detect NORM on the exterior of equipment that has only conveyed fluids internally.

### 3.3 Designated Areas

**Controlled and Supervised Areas**

The worksite shall be declared a Controlled Area or Supervised Area if any of the following criteria apply or are exceeded

#### 3.3.1 Controlled Area

Where the Instantaneous Area dose rate exceeds 7.5 uSv/hr or where the annual dose is likely to exceed 6 millisieverts when working in that area.

**OR**

Whenever NORM Contamination exists and exposure is possible through inhalation or ingestion a “Controlled Area” should be established. Entry into the Controlled Area is restricted to classified persons. The area should be properly designated with Trefoil radioactive warning and a written warning in the language appropriate to the workers (English, Arabic or Hindi).
3.3.2 Supervised Area

Where the instantaneous area dose rate exceeds 2.5 μSv/hr, but does not exceed 7.5 μSv/hr shall be designated as Supervised Areas. Only authorised persons under the permission of the RPS shall enter into such areas.

3.3.3 Access to Controlled and Supervised Areas

Access to Supervised or Controlled Areas where there is a contamination hazard will be restricted to those named and authorised to enter the designated areas. Classified persons (Radiation workers) will be authorised to enter a Controlled or Supervised Area and must be recorded on the Contractor Log sheet. Such persons will undergo medical surveillance and wear a Personal Monitoring Badge (TLD).

Persons entering Controlled or Supervised Areas will wear PPE as stipulated in the written risk assessments. The PPE must be appropriate for the types of exposures and risks associated with the activity. Hand held water blasting to remove NORM shall require the use of Full Face positive pressure breathing apparatus, water proof protective clothing, rubber gloves, rubber boots and ear plugs.

Eating, drinking, smoking, personal handkerchiefs and any operation likely to increase the risk of ingestion of NORM scale/debris is not permitted in these areas. Surface contamination meters, water, soap, paper towels and NORM heavy duty plastic waste bags must be available at the access/exit of the designated area. Before leaving, each persons body and clothing will be monitored for surface contamination and be decontaminated to background levels. Results will be recorded using the on-site record sheet. Removed PPE shall be stored in the designated area. Persons leaving will be advised to wash their hands and face.

The Contractor shall establish maps of Supervised and Controlled Areas for their designated area within the facility.

3.3.4 Non-classified workers

To ensure that all persons working with NORM and other persons in the facility receive doses that are as low as reasonably practicable, the RPS will be responsible for undertaking a documented risk assessment for any work in the facility and classifying Job Types. All Non-classified workers shall be inducted into the facility by the RPS and where required wear the appropriate PPE and follow the Contractor Radiation Management System. Non classified workers shall not enter a Controlled Area.
3.4 Occupational Exposure limits

Ionising radiation doses for individuals shall not exceed the levels stipulated in Table 1.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Dose Limit (mSv/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum annual effective dose permitted from occupational exposures as a radiological worker</td>
<td>10</td>
</tr>
<tr>
<td>Annual effective dose received from occupational exposures to classify radiological worker</td>
<td>6</td>
</tr>
<tr>
<td>For pregnant radiological workers. Maximum equivalent dose received by the foetus during the entire term of pregnancy</td>
<td>1</td>
</tr>
</tbody>
</table>

In order to confirm that external radiation doses are kept to an absolute minimum, a personal cumulative dosimetry badge system sensitive to the type of ionising radiation must be put in place. For example, TLD Badges are used to assess the radiation doses received by persons who are involved in work with Ionising Radiations and are not just for use by classified workers. If the risk assessment indicates that a worker may receive an external dose > 2 mSv/year above background the worker shall wear a TLD Badge (unless it is from ingestion). Such badges shall be controlled by a recognised and competent dosimetry service, who shall supply the employer with reports on the dose received during the period of use and the cumulative annual and lifetime dose of the wearer.

- The dosimeter shall always be used in the holder provided with the users’ name or identification number clearly visible.
- The dosimeter shall only be used by the person to whom it was issued
- A lost dosimeter shall be reported immediately to the RPS and the worker shall refrain from working with radioactive materials until a replacement badges is issued.
- Dosimeters shall be attached to the outside of normal work overalls and not placed inside pockets where they could be shielded.
- If workers suspect a TLD badge has been mishandled or damaged they should report and return it to the RPS for replacement.
- Dosimeters shall be worn when there is any risk of exposure to ionising radiation whilst at work.

For any work where the exposure is likely to exceed 75 uSv in one day, radiation workers conducting the work shall carry, in addition to the cumulative dosimeter badge, a personal meter, which shall be controlled and reset after each work period. The readings for each day shall be recorded and kept on file by the RPS.
3.5 Sampling and Analysis

Representative samples, as laid down by PDO and the MRMEWR, must be taken and sent to an agreed analytical laboratory for radiological analysis. The results of this analysis must be clearly identified against the item being cleaned and must be made available to PDO. Material having a specific activity greater than 1 Bq/g for Ra-226 or Ra-228 confirmed by radiochemical analysis, must be recorded and stored in the designated area with the NORM facility. Material below 1 Bq/g for Ra-226 or Ra-228 shall be taken stored separately for disposal.

Plastic sample containers must be labelled and must indicate from which container or drum the material was sampled from. At least 3 samples will be collected and mixed together to give one representative sample for Gamma Spectrum Analysis. All samples taken during the work scope shall be given to the Company Site Representative and copied to the Company’s Corporate Radiation Focal Point.

The Contractor is responsible for correctly packing, labelling and recording all records with regard to samples. The RPS shall ensure that a system exists to ensure that the exterior of all sample containers are not NORM contaminated. Contamination levels in cps and uSv/hr shall be recorded with the sample records.

3.6 Control of Exposure

All NORM contaminated materials must be handled in a manner that reduces external doses and ensures no ingestion, inhalation or absorption of contaminated scale, sludge, sand or debris.

The Contractor shall establish a set of procedures or local rules to:

- Ensure persons decontaminating or working with NORM and other persons in the decontamination area receive doses as low as reasonably practicable and in any case do not exceed the statutory dose limits.
- Contain the NORM within the designated cleaning areas and prevent environmental contamination to the surrounding NORM yard.
- Enable correct storage of all NORM debris removed during and following the decontamination of equipment.

3.6.1 Dedicated Decontamination Chamber

NORM contaminated items such as spools, Xmas trees, ESP’s & disposal pumps, valves, tubulars, sucker rods, cables and cable ties etc will be high pressure water blasted in a dedicated decontamination chamber(s). All water used to remove the scale from the equipment must be collected in the sump(s) of the chamber and filtered prior to any reuse. The Contractor shall specify in the risk assessment the acceptable water quality for water blasting by an operator and by mechanical means.

The material accumulating in the sump will be collected and transferred into suitable drums with removable and sealable lids. Once the drum is full, representative samples shall be collected for radiochemical analysis in accordance with Section 3.2.6. Contamination and dose rate measurements shall be taken of the drums and they shall be appropriately labelled as NORM Contaminated and stored until the laboratory results are provided.
3.7 Written Procedures

The Contractor shall develop written procedures and undertake written risk assessments in order to decontaminate equipment safely including:

- Work on or inside NORM contaminated vessels and separators
- Handling NORM contaminated spools, cables/wire, tubulars, Xmas trees, pumps (including centrifugal electrical submersible pumps, screw type) for scrap or reuse
- Handling and storing drummed NORM solid and liquid waste

4.0 Storage of NORM

All NORM must be stored in drums of an agreed standard. Each drum must be durably numbered and clearly labelled with the quantity of NORM in it and the total activity of Ra-226, Ra-228 and Pb-210 and a separate record kept for audit and review.

5.0 Training

All staff working in the area must be suitably trained in the removal and decontamination of radioactive material (NORM). Records of this training must be available for audits. This training must reflect the standards laid down by PDO in latest revision of SP1170 and the company’s own training matrix. The following courses are a minimum

- HSE Induction
- NORM awareness course on the hazards associated with radioactive materials.
- RPS will attend and successfully complete a RPS course. Refresher training to be undertaken at least every four years.
- Course on the use and daily maintenance of positive pressure breathing apparatus, other respiratory protection such as half-face disposable masks, ear plugs and other specific PPE as stipulated in the risk assessments.
- High Pressure and Ultrahigh Pressure water jetting courses.
- Confined space entry certificates for vessel cleaners
- Defensive Driving (graded surfaces)

6.0 Record Keeping and Certificates of decontamination

The Contractor shall maintain the following records

- Staff details and training records
- NORM sample and analysis results (5 years and then after sent to PDO for archiving)
- Certificates of decontamination of all items of plant including RPS measurements (5 years)
- Personal Protective equipment
- Medical records for classified workers (30 years)
- Potential overexposure to NORM (30 years)
7.0 Emergency Planning

The Contractor shall develop written emergency plans to respond to an emergency which might arise from the decontamination, storage and transportation of ionising radiation. Such plans shall include, but not be limited to, the following emergencies:

- Accidental overexposure to ionising radiation
- Loss or theft of NORM contaminated equipment
- Potential overexposure to Radioactive Materials (NORM)
- Spillage or Radioactive Materials (NORM)
- Loss and unauthorised Dispersal of Radioactive Material (NORM)
- Emergency Entry into a “Controlled” or “Supervised Area”
- Contamination of the environment with NORM

8.0 References

### Glossary of Abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Alpha particle</td>
<td>High energy positively charged particle ejected from the nucleus of an unstable (radioactive) atom when it decays, consisting of 2 protons and 2 neutrons</td>
</tr>
<tr>
<td>Background Radiation</td>
<td>The radiation to which an individual is exposed arising from the natural radiation sources such as terrestrial radiation and cosmic radiation. Typical background in Oman is 3-4 cps with the Mini 900/44A instrument.</td>
</tr>
<tr>
<td>Beta particle</td>
<td>An electron emitted from the nucleus of an unstable atom</td>
</tr>
<tr>
<td>Classified Radiation Worker</td>
<td>Employees who have the potential to receive exposures to radiation sources as a result of their work above 6 mSv/year.</td>
</tr>
<tr>
<td>Controlled Area</td>
<td>An area where the external dose rate exceeds 7.5 uSv/hr or the potential for the dose is greater than 6 mSv/year</td>
</tr>
<tr>
<td>NORM Guidelines</td>
<td>A prescriptive set of procedures specially designed for activities that PDO or its contractors shall utilise when NORM may be encountered</td>
</tr>
<tr>
<td>NORM Contamination</td>
<td>Items of plant that exceed background levels by 5 cps when measured with a Mini 900/44A instrument for oilfield deposits or Mini 900/EP15 for gas fields.</td>
</tr>
<tr>
<td>Supervised Area</td>
<td>An area is classified as a NORM Supervised Area when the external dose rate as measured by a dose-rate meter equals or exceeds 2.5 uSv/hr</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal Protective Equipment</td>
</tr>
<tr>
<td>RPT</td>
<td>Radiation Protection Technician</td>
</tr>
<tr>
<td>RPS</td>
<td>Radiation Protection Supervisor</td>
</tr>
<tr>
<td>RPA</td>
<td>Radiation Protection Advisor</td>
</tr>
<tr>
<td>NORM</td>
<td>Naturally Occurring Radioactive Material</td>
</tr>
<tr>
<td>Unconditional Release Limit</td>
<td>Scales and sludge which has been radiochemically analysed and demonstrated to contain less than 1 Bq/g for Ra-226.</td>
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</table>