



**GUIDELINES ON RADIOLOGICAL MONITORING FOR  
OIL AND GAS FACILITIES OPERATORS  
ASSOCIATED WITH TECHNOLOGICALLY  
ENHANCED NATURALLY OCCURRING RADIOACTIVE  
MATERIALS (TENORM)**



Lembaga Perlesenan Tenaga Atom  
Tingkat 2 & 13, Plaza Pekeliling,  
No. 2, Jalan Tun Razak,  
50400 Kuala Lumpur.

Tel : 03-40423657/658/633  
Faks : 03-40415855  
homepage: [www.aelb.gov.my](http://www.aelb.gov.my)

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## 1.0 SCOPE OF THE GUIDE

- 1.1. This guide addresses the scope of radiological monitoring, which can be applied to the oil and gas exploration and production facilities.
- 1.2. This guide contains recommended parameters to be monitored, locations for monitoring and other general requirements.
- 1.3. The general guidelines are also for;
  - a. Dealing with radioactive contamination with TENORM in the oil and gas exploration and production facilities;
  - b. Entry, inspection and repair for large vessels;
  - c. Inspection and maintenance of equipment suspected of being contaminated with TENORM;
  - d. Cleaning of items of equipment contaminated with TENORM;
  - e. Pulling well tubular contaminated with TENORM; and
  - f. Transport of equipment contaminated with TENORM.
- 1.4. This guide shall be subjected to changes by the AELB from time to time when or where necessary.

## 2.0 GLOSSARY

**"AELB"** means Atomic Energy Licensing Board.

**"Annual dose"** means the dose received over a period of one calendar year.

**"Annual dose limit"** means the value of the annual dose that must not be exceeded.

**"Approved registered medical practitioner"** means a registered medical practitioner who is approved by AELB to be responsible for the medical surveillance of workers.

**"Classified person"** means a person who has been so designated in accordance with the following conditions:

1. Subject to paragraph (3), the employer shall designate as classified persons those of his employees who are likely to receive a dose of ionising radiation, which exceeds three-tenths of the annual dose limit and shall forthwith inform those employees that they have been so designated.
2. The employer shall not cease to treat an employee as a classified person except at the end of a calendar year, unless he is required to do so by an approved registered medical practitioner, and in any case where he ceases to treat an employee as a classified person the employer shall forthwith inform the employee that he is no longer a classified person.
3. An employer shall not designate an employee as a classified person unless:
  - a. That employee is aged 18 years or over; and
  - b. Subject to an approved registered medical practitioner has certified in the health record that, in his professional opinion, that employee is fit to be designated as a classified person.

**"Clean area,"** means an area where the annual dose received by a worker is not likely to exceed one-tenth of the annual dose limit.

**"Contamination"** means the presence of any radioactive material, nuclear material or prescribed substance on a surface in quantities in excess of 0.4 Becquerel per square centimetres (Bq cm<sup>-2</sup>) for beta and gamma and low toxicity alpha emitters, or 0.04 Bq cm<sup>-2</sup> for all other alpha emitters.

**"Controlled area"** means an area where the annual dose received by a worker is likely to exceed three-tenths of the annual dose limit.

**"Conveyance"** means includes a ship, train, vehicle, an aircraft, and any other means of transport by which persons or goods may be carried.

**"Dose rate"** means the dose per unit time.

**"Designated areas,"** means:

- a. Where there is external radiation only:  
A controlled area is one where the dose rate exceeds  $7.5 \mu\text{Sv h}^{-1}$   
A supervised area is one where the dose rate exceeds  $2.5 \mu\text{Sv h}^{-1}$  but is less than  $7.5 \mu\text{Sv h}^{-1}$
- b. Where there is surface contamination only (assuming radium-226, natural thorium and progeny):  
A controlled area is one where the contamination on a surface exceeds  $7 \text{ Bq cm}^{-2}$   
A supervised area is one where the contamination level exceeds  $2 \text{ Bq cm}^{-2}$  but is less than  $7 \text{ Bq cm}^{-2}$
- c. Where there is airborne contamination only (assuming natural thorium as the most restrictive radionuclide):  
A controlled area is one where the airborne contamination level exceeds  $1 \times 10^{-2} \text{ Bq cm}^{-3}$ .  
A supervised area is one where airborne contamination is between  $3 \times 10^{-3} \text{ Bq m}^{-3}$  and  $1 \times 10^{-2} \text{ Bq m}^{-3}$
- d. Where there is a combination of two more of external radiation, surface contamination or airborne contamination:  
A controlled area is one where the dose rate or contamination level is greater than that appropriate to a supervised area for each separate component. For example, a controlled area would be designated if:  
External dose rate exceeds  $2.5 \mu\text{Sv h}^{-1}$   
and surface contamination exceeds  $2 \text{ Bq cm}^{-2}$   
or  
External dose rate exceeds  $2.5 \mu\text{Sv h}^{-1}$   
and airborne contamination exceeds  $3 \times 10^{-3} \text{ Bq m}^{-3}$

**"Environment"** means shall have the meaning assigned to that expression Section 2 of the Environmental Quality Act 1974 and, in addition thereto, shall include the marine environment.

**"Exploration and production"** means oil and gas exploration and production refer to all activities and/or facilities that are involved in the exploration of petroleum (oil and/or gas) which begin after sufficient exploration/appraisal programme has been initiated and end when the petroleum is made available at the point of export, ready to be export or further processed.

**"Radioactive contamination"** means the contamination of any material, surface or environment or of any person, including both external skin contamination and internal contamination, irrespective of method of intake, by any radioactive material, nuclear material or prescribed substance.

**"Radioactive material"** means any nuclear fuel, radioactive product or radioactive waste.

**"Radiation Protection Officer (RPO)"** means a technically competent person appointed by the licensee and approved by AELB in writing, to supervise the implementation of the appropriate radiation protection regulations, measures and procedures.

**"Radiation Protection Supervisor (RPS), (may also be known as an assistant RPO)"** means a technically competent person appointed by the licensee and approved by AELB in writing to assist the RPO in supervising the implementation of the appropriate radiation protection regulations, measures and procedures.

**"Radioactive waste"** means any waste, which consists wholly or partly of-

- a. A substance or article which if it were not waste would be radioactive material; or
- b. A substance or article which has been contaminated in the course of the production, storage or use of any radioactive material, nuclear material or prescribed substance or by contact with or proximity to any other waste within the meaning of paragraph (a) of this definition.

**"Supervised area"** means an area where the annual dose received by a worker could exceed one-tenth but is not likely to exceed three-tenth of the annual dose limit.

**"TENORM"** means technologically enhanced naturally occurring radioactive material.

**"Transport"** means all operation and conditions associated with and involved in the movement of radioactive material, nuclear material or prescribed substance, including the preparation, consigning, handling, carriage, storage in transit and receipt at the final destination of a package.

**"Worker"** means any person working under the instruction of the licensee, whether or not employed by the licensee, in the handling or use of, or in any activity that will bring him into contact with, any radioactive material, nuclear material, prescribed substance or irradiating apparatus.

### 3.0 BACKGROUND

- 3.1. The presence of technologically enhanced naturally occurring radioactive materials (TENORM) were detected in association with oil and gas production as early as 1904 in Canada and have since been observed in many hydrocarbon provinces. Discovery of TENORM in scales and sludges on production equipment during the late 1980's in Malaysia oil and gas production industry spotlighted potential health hazards from radiation.
- 3.2. Scale begins to form in oil production tubing and process equipment as a consequence of associated water production. In offshore areas, seawater injection for reservoir pressure maintenance can aggravate the situation if there are chemical incompatibilities between the seawater and formation water. The less saline seawater may dissolve additional salts from minerals present in reservoir strata. Temperature and pressure changes as the well fluids pass through production equipment cause scale deposits under certain conditions. The most common scales are calcium carbonate, calcium sulphate, and barium sulphate and strontium sulphate.
- 3.3. TENORM found in oilfield operations originates in subsurface oil and gas formations and is typically transported to the surface in produced water. As the produced water approaches the surface and its temperature drops, precipitates form in tubing strings and surface equipment. The resulting scales and sludges may contain radium as well as other uranium and thorium daughter products. In addition, radon is sometimes contained in produced natural gas and can result in the formation of thin radioactive lead films on the inner surface of gas processing equipment.
- 3.4. Measurements on the outer surface of equipment containing TENORM usually indicate levels of radiation that are below levels considered to be concern. When equipment is opened for inspection or repair, personnel can be exposed to radioactivity by inhaling or ingesting TENORM. Therefore, in this situation, workers should take precautions to prevent the generation of dust and wear protective equipment. It is also important that TENORM waste or equipment containing TENORM be managed and disposed by methods that protect the public from unnecessary exposures.

#### 4.0 THE ATOMIC ENERGY LICENSING ACT 1984 (ACT 304)

- 4.1. The Atomic Energy Licensing Act 1984 prescribed by provision of Section 12(1) b, quotes.

"Without prejudice to the requirements of any other law, no person shall deal in, possess or dispose of any ***radioactive material***, nuclear material, prescribed substance or irradiating apparatus, unless he is the holder of a valid license issued under section 16(5) by the Board".

- 4.2. With regard to accumulation, disposal or transport of radioactive waste Section 26(1), 27(1) and 30(1) of the Act quotes respectively,

"No person shall disposed of or cause to be disposed, any radioactive waste without the prior authorization in writing of the appropriate authority".

"No person shall accumulate or cause to be accumulated any radioactive waste or any premises without the prior authorization in writing of the appropriate authority".

"No person shall transport any radioactive waste without the prior authorization in writing of the appropriate authority".

#### 5.0 MONITORING PARAMETERS

- 5.1. All operators shall employ a Radiation Protection Officer (RPO) [regulation 23(1) Radiation Protection (Basic Safety Standards) Regulations 1988] or appoint a consultant approved by the Board [regulation 23(2) Radiation Protection (Basic Safety Standards) Regulations 1988] for the purpose of monitoring and consultation on radiological hazards. The monitoring shall include but not limited to the following parameters.

##### 5.1.1. External Radiation

External radiation from deposited scales is normally low due to shielding effect of the vessel walls. In situ monitoring could be conducted using calibrated survey meters and for long term accumulation using thermoluminescent dosimeters (TLD). The external radiation shall not exceed **0.5  $\mu\text{Sv h}^{-1}$** , which is equivalent to **1.0 mSv a year**.

##### 5.1.2. Surface Contamination

Surface alpha and beta contamination shall be monitored using portable contamination monitors on any accessible surfaces. The surface will be considered to be contaminated if for alpha emitters it exceeds **0.04 Bq cm<sup>-2</sup>** and others **0.4 Bq cm<sup>-2</sup>**

### 5.1.3. Airborne Contamination Monitoring

In dusty working environment, airborne dust shall be sampled and analyzed for gross alpha and beta activity for determination of uranium 238 and thorium 232 activity. The activity concentration shall not exceed **0.01 Bq m<sup>-3</sup>** for uranium and **0.001 Bq m<sup>-3</sup>** for thorium dust.

### 5.1.4. Management of Scales and Sludge

Scales and sludge collected from any works shall be sampled and analyzed for its radioactivity content. The scales and sludge collected shall not be accumulated or disposed without prior approval by the AELB. For disposal purpose the operators shall be required to carry out a **Radiological Impact Assessment (RIA)** of all proposed disposals to demonstrate that no member of public will be exposed to more than 1 **msv/year** from all activities. Scope of RIA is shown in Appendix A.

- 5.2. The routine monitoring is recommended to be conducted at a suitable frequency for at least once a year for normal operation and shall include parameters 5.1.1 and 5.1.2.
- 5.3. Similar monitoring shall also be conducted prior to and after shutdown, workover, and descaling and related equipment maintenance, which shall include parameters 5.1.1, 5.1.2 and 5.1.3

## 6.0 MONITORING REQUIREMENT

- 6.1. Once the existence of scales is established, it is essential that regular monitoring of the overall production system is performed in order to establish the extent of deposition. The monitoring shall include but not limited to the following locations.

### 6.1.1. Top Side Production System

The deposition could extent throughout the oil production train, the produced water system and the gas separation system, Consequently, many equipment's are liable to scaling, and these may undergo maintenance, replacement or simple cleaning. Personnel must have prior knowledge of how to deal safety and effectively with this problem prior to commencing such works.

### 6.1.2. Offloading Points

The monitoring shall also be conducted on associated flow lines in order to establish whether the scales have been transferred through the risers to be deposited within these offloading points.

### 6.1.3. Terminals

Processing terminals from installations shall also routinely monitored. The deposition may similarly extend throughout the whole oil processing and water treatment system.

## 7.0 GENERAL GUIDELINES

- 7.1. When and where the derived limits in section 5.0 are exceeded, the operators shall inform the AELB for negotiation of the necessary regulatory requirements.
- 7.2. Scope of RIA (Appendix A).
- 7.3. Guidelines for radioactive contamination with TENORM in oil and gas exploration and production facilities (Appendix B).
- 7.4. Guidelines for the entry, inspection and repair of large vessels (Appendix C).
- 7.5. Guidelines for the inspection and maintenance of equipment suspected of being contaminated with TENORM (Appendix D).
- 7.6. Guidelines for the cleaning of item of equipment contaminated with TENORM (Appendix E).
- 7.8. Guidelines for pulling well tubular contaminated with TENORM (Appendix F).
- 7.9. Guidelines for the transport of equipment contaminated with TENORM (Appendix G).
- 7.10. The operators shall organize a suitable training programme for all personnel working in supervised or controlled areas on a regular basis. The training shall include basic introduction to radiation protection to detail technical work procedures involving radioactive scales, surface contamination and contaminated air.
- 7.11. The transportation of any scales, sludges, contaminated tubing or any equipment shall be in accordance with the requirements of Radiation Protection (Transport) Regulation 1989.
- 7.12. All descaling process shall be conducted, monitored or supervised by RPO or Radiation Protection Supervisor (RPS) or consultant recognised by the AELB.

## 8.0 USEFUL REFERENCES

The following are useful references to be read together with this guide:-

1. Atomic Energy Licensing Act 1984 (Act 304): AELB, Kuala Lumpur.
2. Atomic Energy Licensing Act 1984. Radiation Protection (Licensing) 1986: AELB, Kuala Lumpur.
3. Atomic Energy Licensing Act 1984. Radiation Protection (Basic Safety Standards) 1988: AELB, Kuala Lumpur.
4. Atomic Energy Licensing Act 1984. Radiation Protection (Transportation) 1989: AELB, Kuala Lumpur.
5. International Atomic Energy Agency (1983). Radiation Protection of Workers in Mining and Milling Radioactive Ores: IAEA Safety Series No. 26, IAEA, Vienna.
6. International Atomic Energy Agency (1995). IAEA Expert Reports Project 544 MAL/9/011-4 Technical Assistance to AELB, IAEA, Vienna.

**APPENDICES**

## APPENDIX A

### RADIOLOGICAL IMPACT ASSESSMENT (RIA) FOR OIL AND GAS SLUDGES

#### RIA METHODOLOGY

The methodology for the RIA study that will be employed for the project is outlined as follows: -

Assessment of the radiological impact or consequences of releases of contaminated sludge into the environment involves a quantities estimate.

The assessment involves the following steps:

- i. Collection/compilation of site specific data characterising the geohydrological setting, background radiation levels and radioactivity concentration in various environmental media including soil, subsoil, surface water, ground water, airborne dusts, fauna and flora.
- ii. Identification and quantification of the source terms (input of naturally occurring radioactive materials into the proposed landfill), the chemical and physical form of the radionuclides, the points of release, and the time distribution of release.
- iii. Identification of the potential environmental pathways.
- iv. Identification of the critical population.
- v. Assessment of the individual and collective dose and its associated excess cancer risks using a computer modelling.

#### REPORTING

The report will be formatted as follows:

EXECUTIVE SUMMARY (English and BM versions)

PROJECT BACKGROUND

- Project title
- Project initiator
- Statement of need

PROJECT DESCRIPTION

- Technical data
- Maps and diagrams
- Emissions to the environment

THE EXISTING ENVIRONMENT

POTENTIAL SIGNIFICANT IMPACT

RADIOLOGICAL IMPACT ASSESSMENT

- Scope
- Source of impact
- Nature of Impact (magnitude and duration)
- Significance of impact

MITIGATION AND ABATEMENT MEASURES

RESIDUAL IMPACTS

CONCLUSIONS

DATA SOURCES

DETAILS OF ASESMENT MODELS

LIST OF REFERENCES

## APPENDIX B

### GUIDELINES FOR RADIOACTIVE CONTAMINATION WITH TENORM IN THE OIL AND GAS EXPLORATION AND PRODUCTION FACILITIES

1. This guidelines applies to non-classified persons who must be aged 18 years or over and are employed in CONTROLLED AREAS in the inspection, operation, manipulation, maintenance and cleaning of equipment which is contaminated by TENORM.
2. **A CONTROLLED AREA** means any area in which either the dose equivalent rate is greater than  $7.5 \mu\text{Sv h}^{-1}$  or the surface contamination is greater than  $7 \text{ Bq cm}^{-2}$  or where the dose equivalent rate exceeds  $2.5 \mu\text{Sv h}^{-1}$  and the surface contamination level exceeds  $2 \text{ Bq cm}^{-2}$  and where the dose equivalent rate does not exceed  $30 \mu\text{Sv h}^{-1}$ .  
  
[The dose equivalent rate limit of  $30 \mu\text{Sv h}^{-1}$  is such that a person who works in that area for the maximum permissible time of 500 hours is likely to exceed three-tenths of the annual dose limit for a radiation workers of  $50 \text{ mSv/year}$  (i.e.  $15 \text{ mSv}$ )].
3. The equipment referred to in paragraph no. 1 (Appendix A) means any pipework, enclosed vessel or component of plant which is contaminated or is liable to be contaminated by scale, sludge or active and to a level in exceeds of  $7 \text{ Bq cm}^{-2}$  or which gives rise to a dose equivalent rate to penetrating radiation in exceeds of  $7.5 \mu\text{Sv h}^{-1}$  but nor exceeding  $30 \mu\text{Sv h}^{-1}$ .
4. No person shall be employed in **CONTROLLED AREAS** in the processes specified in paragraph no. 1 (Appendix A) for more than 500 hours in any calendar year.
5. No person shall stay longer than necessary in a **CONTROLLED AREA**.
6. A record of the time spent in the controlled area and the dose rate and surface contamination level shall be kept for each person employed in accordance with these guidelines.
7. No person shall be employed in a **CONTROLLED AREA** or engaged on the maintenance, cleaning or manipulation of equipment unless Work Permit in accordance with paragraph no. 8 (Appendix A) has been issued.

8. Every Work Permit issued for the purposes of paragraph no. 7 (Appendix A) shall state:
- a. The name of the person to whom it is issued;
  - b. The equipment and work to which it refers;
  - c. The guidelines under which the work is to be carried out; and
  - d. The period of time for which it is valid

and shall be signed by the RPO or RPS.

9. Any person working in accordance with the conditions of a Work Permit specified in paragraph no. 7 (Appendix A) and no. 8 (Appendix A) shall wear suitable protective clothing as specified in the appropriate guidelines.
10. Dedicated washing, changing and monitoring facilities shall be provided as close as is reasonably practical to the exit from a **CONTROLLED AREA**. After decontamination, any person leaving a **CONTROLLED AREA** must be monitored for contamination and should be advised to wash his face and hands as soon as possible.
11. Eating, drinking, chewing of gum, or doing anything, which might encourage the ingestion of contamination, will be prohibited when working with TENORM.
- Minor cuts, etc, must be covered with suitable waterproof adhesive dressings before entry to the area.
12. All reasonably practical measures, as specified in the relevant guidelines, shall be taken to reduce the production of airborne radioactive material and to prevent the spread of surface contamination within the plant.
13. On completion of work and before removing the restriction, designated areas must be monitored and the contamination levels and doses equivalent rates shown to be less than 2 Bq cm<sup>-2</sup> and less than 2.5 μSv h<sup>-1</sup> respectively.
- Where it is not possible to decontaminate to these levels, the area must remain **SUPERVISED** or **CONTROLLED** and appropriate precautions taken and records amended.
14. The dose equivalent rate shall be measured frequently whilst work is being carried out in a **CONTROLLED AREA** or on relevant equipment. In the event that a dose rate exceeds 30 μSv h<sup>-1</sup> work shall cease in that area or on that equipment and the RPO or RPS shall be immediately notified. Work will only be allowed to commence under new terms which will be specified after consultation between the Company Safety Officer or Platform Supervisor and the RPO or RPS.

15. The RPO or RPS must ensure that workers employed under these guidelines are familiar with the procedures laid out in these guidelines and in any relevant guidelines, which are in force.
16.
  - a. The RPO or RPS shall keep radiological Exposure Records for the calendar year to which they apply. The records shall be kept for a minimum of five years from the date of the last entry.
  - b. Permit to work shall be kept for a minimum of five years from the date of the last entry.
  - c. Records relating to long term SUPERVISED or CONTROLLED AREAS (see no. 13, Appendix A) shall be kept the RPO or RPS at site until restrictions can be lifted.

## APPENDIX C

### GUIDELINES FOR THE ENTRY, INSPECTION AND REPAIR OF LARGE VESSELS

1. These GUIDELINES apply to work on or inside vessels affected or potentially affected by TENORM. Since these vessels may be or may give rise to CONTROLLED or SUPERVISED AREAS, work should only proceed when suitable calibrated radiation dose rate and surface contamination measuring instruments are available, under the guidance of the RPO or RPS, and in accordance with the measure described below.
2. Before any work is carried out on the vessel, dose equivalent rates should be measured external to the vessel in order to give a preliminary indication of the extent of the TENORM within the vessel. Attempts should then be made to remove as much sand and sludge from the vessel as possible by remote means such as sand washing. The sand and sludge from the vessel may itself be contaminated and if so should be disposed of in accordance with no. 12 (appendix B) of the guidelines.
3. Prior to work commencing, a marked area of minimum practical size should be set up at point of access to the vessel and at any point where pipework is to disconnect from the vessel.  
Eating, drinking, etc must be prohibited within this area.
4. The marked areas should have suitable sheeting, laid on the floor or scaffolding platform and should be cordoned off and clearly marked. Waterproof protection clothing, comprising of one-piece coveralls, gloves, boots and respirators should be available at the entrance to the areas. Water and paper towels should also be provided for decontamination.
5. It should be assumed that the marked areas would become contaminated to at least SUPERVISED AREA levels. Entry to them shall be strictly limited to workers working in accordance with these guidelines. Periodic contamination measurements shall be made to determine if there are needs to be upgraded to a CONTROLLED AREA at which time entry would be restricted to Classified Workers or persons working in accordance with the guidelines.
6. All workers entering a SUPERVISED or CONTROLLED AREA must wear protective clothing and the respirators provided.
7. When pipework is disconnected from the vessel the RPO or RPS should take measurements to ascertain whether contamination is present inside the pipework. If so, the ends of the pipework should be sealed (e.g. wrapped with plastic sheeting) and any smaller items such as gasket rings should be sealed in plastic bags.

8. After the access points to the vessel have been opened, the interior of the vessel should be hosed down to remove loose contamination, sand and sludge. So far as is possible this should be done from the points of access, and before anyone actually enters the vessel. The hoses used should be earthen to the vessel.
9. The RPO or RPS should make an initial assessment of the radiation hazard by measuring radiation dose rates and contamination levels through the access point.  
  
The first person to enter the vessel will be the RPO or RPS and he will wear full breathing apparatus and protective clothing.  
  
The RPO or RPS will make radiation dose rate and surface contamination measurements within all accessible areas of the vessel and will declare areas of the vessel either free of contamination, a SUPERVISED AREA or a CONTROLLED AREA. A normal Work Permit will be issued for a vessel free of contamination. If contamination is present a Work Permit will specify that work may continue in accordance with these GUIDELINES. If the vessel is declared a CONTROLLED AREA entry will be strictly limited to Classified Workers or persons working in accordance with the guidelines. Work will not proceed if the measured dose rate exceeds  $30 \mu\text{svh}^{-1}$  and the Platform Supervisor or Company Safety Officer must be immediately notified.
10. Workers authorised in accordance with the vessel's area designation may now enter the vessel. If high pressure water jetting or grit blasting is to be carried out the workers should wear approved breathing apparatus or filter respirators in addition to their protective clothing. For other operations inside the vessel workers should wear a filter respirator and appropriate protective clothing.
11. When work starts on equipment which has been declared a CONTROLLED AREA, the RPO or RPS should ensure that a record is kept for each non-classified person as detailed in the guidelines (no.6, Appendix A).
12. Any discharge from the vessel may comprise radioactive waste and therefore must be disposed of in accordance with the conditions of the issued to the site or installation.
13. When any components inside the vessel are loosened for removal, any scale which might be released should be washed away. The component parts themselves should be cleaned as far as possible before they are removed from the vessel.
14. All items of equipment removed from the vessel should be monitoring for contamination. If contamination greater than  $2 \text{ Bq cm}^{-2}$  is present and cannot be removed within the designated are, the items should be wrapped in plastic prior to their removal to another designated storage or cleaning area. Items to be cleaned should be cleaned in accordance with **the GUIDELINES FOR CLEANING CONTAMINATED EQUIPMENT** (Appendix E).

15. Prior to any worker leaving the vessel his protective clothing should be washed down to remove any loose contamination.
16. Before any worker is allowed to leave a SUPERVISED or CONTROLLED AREA his protective clothing, must be monitored for contamination. If any contamination is present it should be wiped down using wet paper towels until the contamination is less than 2 Bq cm<sup>-2</sup>. All protective clothing used inside a SUPERVISED or CONTROLLED AREA should be removed before leaving the area. The worker should be advised to wash his face and hands as soon as possible.
17. All tools and ancillary equipment used inside the vessel should be monitored for contamination when they are removed from the vessel. If contamination is present it should be wiped off using wet paper towels.
18. Any item of equipment which are contaminated, and which are to be disposed of, should be disposed of in accordance with the **GUIDELINES FOR THE TRANSPORT OF EQUIPMENT CONTAMINATED WITH TENORM** (Appendix F).
19. On completion of the job the floor coverings used in SUPERVISED or CONTROLLED AREAS should be removed and the floor should be monitored for contamination. If contamination is present the floor should be cleaned until the contamination is below 2 Bq cm<sup>-2</sup>.
20. Any drains used within the SUPERVISED or CONTROLLED AREA should be flushed with copious amounts of water on completion of the job.

## APPENDIX D

### GUIDELINES FOR THE INSPECTION AND MAINTENANCE OF EQUIPMENT SUSPECTED OF BEING CONTAMINATED WITH TENORM

1. These guidelines apply to work on pipework of equipment in areas affected for potentially affected by TENORM. They apply in addition to normal Work Permit requirements. This equipment may be or may give rise to CONTROLLED AREAS or SUPERVISED AREAS. Work should proceed only when suitable calibrated radiation and surface contamination measuring instruments are available; under the guidance of the RPO; and in accordance with the measures described below.
2. A marked area of minimum practical size should be set up around the piece of equipment to be worked on. Eating, drinking, etc. must be prohibited within the marked area.
3. The marked area should have sheeting laid on the floor, or scaffolding platform. The areas should be cordoned off and clearly marked. Waterproof protective clothing, comprising one piece coveralls, gloves, boots and respirators should be available at the entrance to the areas. Water and paper towels should also be provided for decontamination.
4. The area should be cordoned off, and entry to the area should be strictly limited to workers working in accordance with these guidelines.
5. All workers entering the area must change into the protective clothing provided.
6. When the equipment has been opened up, the RPO or RPS will make radiation dose rate and surface contamination measurements and will declare the equipment either free from contamination, a SUPERVISED AREA or a CONTROLLED AREA. A normal Work Permit will be issued for equipment free from contamination. If contamination is present a Work Permit will specify that work continue in accordance with these GUIDELINES. If the equipment is declared a CONTROLLED AREA, entry to the marked area will be strictly limited to persons working in accordance with the guidelines or Classified Workers. Work will not proceed if the measured dose rate exceeds  $30 \mu\text{Sv h}^{-1}$ .
7. When it is practicable, component parts should be hosed down in situ before they are removed from the piece of equipment being worked. All components, tools, etc. removed from the equipment should be monitored for contamination. If contamination greater than  $2 \text{ Bq cm}^{-2}$  is present and cannot be removed within the designated area the items should be wrapped in plastic prior to their removal to another designated storage or cleaning area. Items to be cleaned should be cleaned in accordance with the GUIDELINES FOR CLEANING CONTAMINATED EQUIPMENT.

8. Items of equipment which are to be scrapped or sent for renovation should be disposed of in accordance with the GUIDELINES FOR THE TRANSPORT OF CONTAMINATED EQUIPMENT.
9. The RPO or RPS should ensure that representative samples of the radiological contamination encountered on the equipment are taken and sent for content and specific activity ( $\text{Bq g}^{-1}$ ) analysis.
10. Before any worker is allowed to leave a SUPERVISED or CONTROLLED AREA his protective clothing, must be monitored for contamination. If any contamination is present it should be wiped down using wet paper towels until the contamination is less than  $2 \text{ Bq cm}^{-2}$ . All protective clothing used inside a SUPERVISED or CONTROLLED AREA should be removed before leaving the area. Workers should be advised to wash their faces and hands as soon as possible.
11. When work starts on equipment which has been declared a CONTROLLED AREA the RPO or RPS should ensure that a record is kept for each non-classified person as detailed in the guidelines (no. 6, Appendix A).
12. On completion of the job any tools and equipment used during the job should be monitored for contamination. If any contamination is present this should be removed by wiping with wet paper towels.
13. On completion of the job the floor covering, used in a SUPERVISED or CONTROLLED AREA should be removed and the floor should be monitored for contamination is present, the floor should be cleaned until contamination of the job.
14. Any drains used within the SUPERVISED or CONTROLLED AREAS should be flushed with copious amounts of water on completion of the job.

## APPENDIX E

### GUIDELINES FOR THE CLEANING OF ITEMS OF EQUIPMENT CONTAMINATED WITH TENORM

1. These guidelines should be applied when it is necessary to clean items of equipment contaminated with TENORM.
2. A SUPERVISED or CONTROLLED AREA should be set up as appropriate in which the cleaning operations are to be carried out. Eating, drinking, etc must be prohibited in the area.
3. It is responsibility of the RPO or RPS to choose the location for the SUPERVISED or CONTROLLED AREA and to approve its design and construction.  
  
The CONTROLLED or SUPERVISED AREA should be set up in such a way as to prevent the spread of radioactive contamination from it. Waterproof protective clothing, comprising one piece coveralls, gloves, boots and respirators should be available at the entrance to the area. Water and paper towels should also be provided for decontamination.
4. The preferred method for cleaning is by water washing or high pressure water jetting. If mechanical means are used, the item of equipment being cleaned should be kept wet at all times to minimise the production of airborne contamination.
5. Workers carrying out the cleaning must wear protective clothing, comprising one piece coveralls, glove and boots. If high pressure jetting is being used, airline breathing apparatus or approved respirators should be worn. If mechanical means are being used, filter respirators should be used. If the area is CONTROLLED, work must be carried out by Classified Workers or in accordance with the SCHEME CONTROLLED, works must be carried out by Classified Workers or in accordance with the guidelines.
6. When items have been cleaned to a satisfactory mechanical condition they should be monitored to check for residual radioactive contamination. If contamination in excess of 2 Bq cm<sup>-2</sup> is present the items should be wrapped in plastic bags before they are removed from the SUPERVISED or CONTROLLED AREA and until they are re-installed IN THE PLANT OR DISPOSED OF AS APPROPRIATE. If no contamination is present the items can be handled in a normal manner.
7. Before any worker is allowed to leave a SUPERVISED or CONTROLLED AREA, his protective clothing must be monitored for contamination. If any contamination is present it should be wiped down using wet paper towels until the contamination is less than 2 Bq cm<sup>-2</sup>. All protective clothing used inside a SUPERVISED or CONTROLLED AREA should be removed before leaving the area. Workers should be advised to wash their face and hands as soon as possible.

8. When work starts on equipment which has been declared a CONTROLLED AREA the RPO or RPS should ensure that a record is kept for each non-classified person as detailed in the guidelines (see no. 6, Appendix A).
9. Any solid lumps of TENORM released during the job should be collected and placed in a container. The lumps should then be broken up and disposed of in accordance with the conditions of the disposal licence [Radiation Protection (Licensing) Regulations 1986 Part 11 Classification of License Section 3(G) and also Part IV Application for Amendment and Renewal of License, Section 13 (I)] .
10. The RPO or RPS should ensure that representative samples of the radiological contamination encountered in the vessel are taken and sent for content and specific activity ( $\text{Bq g}^{-1}$ ) analysis.
11. On completion of the job any tools and equipment used should be monitored for contamination before they are removed from the area. If any contamination is present it should be wiped off with wet paper towels.
12. On completion of work and before removing the restrictions, designated areas must be monitored and the contamination levels and doses equivalent rates shown to be less than  $2 \text{ Bq cm}^{-2}$  and less than  $2.5 \mu\text{svh}^{-1}$  respectively.  
Where to decontaminate to these levels, then the area must remain SUPERVISED or CONTROLLED and appropriate precautions taken and records amended.
13. The drains within the SUPERVISED or CONTROLLED AREA should be flushed with copious volumes of water on completion of the job.

## APPENDIX F

### GUIDELINES FOR PULLING WELL TUBULARS CONTAMINATED WITH TENORM

- 1 The guidelines must be applied when it is known or suspected that the well tubular to be pulled have internal or external surface contamination is excess of  $2 \text{ Bq cm}^{-2}$

Note: The **GUIDELINES FOR INSPECTION AND MAINTENANCE OF EQUIPMENT** apply to the removal of flow lines, Xmas trees, etc.

2. A permit to work, countersigned by the RPO or RPS, must be issued to allow the opening of any equipment which is suspected or know to contact TENORM.
3. Prior to pulling tubular the working area of the drill floor, excluding the doghouse, should be designated and marked as a SUPERVISED AREA. Entry to this area should be strictly limited to those working in accordance with these GUIDELINES. Eating, drinking, etc must be prohibited within the marked area.
4. As far as is practicable, the flooring of the designated area should be covered with sheeting.  
Protective clothing comprising one piece coveralls, gloves, boots, respirators should be available at the entrance to the drill floor. Workers handling uncapped tubular must wear this clothing.
5. Water and paper towels should be provided inside SUPERVISED and CONTROLLED AREAS for decontamination of protective clothing.
6. The first five joints of tubing recovered should be monitored by the RPO or RPS -for contamination and dose rate. If contamination and dose rate greater than  $2 \text{ Bq cm}^{-2}$  and  $2.5 \mu\text{Sv h}^{-1}$  are found, the area will remain SUPERVISED or if greater than  $7 \text{ Bq cm}^{-2}$  and  $7.5 \mu\text{Sv h}^{-1}$  be upgraded to CONTROLLED AREA when the guidelines will apply.

If contamination is less than  $2 \text{ Bq cm}^{-2}$ , restrictions may be relaxed, but the contamination level should me measured every ten joints or when the interior condition of the tubing appears to change if this is sooner.

Subsequent restrictions will depend upon the contamination levels found.

7. If contamination is found and the drill floor working is continues to be designated a SUPERVISED or CONTROLLED AREA. All personnel working in the drill floor must wear full protective clothing.  
  
The protective clothing must be monitored of contamination. If any contamination is present it should be wiped down using wet paper towels until the contamination is less than 2 Bq cm<sup>-2</sup>. All protective clothing used inside a SUPERVISED or CONTROLLED AREA should be removed leaving the designated area personnel should be advised to wash their faces and hands.
8. Before each tubing connection is broken, it should be checked to ensure that it is drained of fluid. The bottom of each joint of contaminated tubing should be capped with a solid cap immediately the connection is broken or immediately after carrying out the contamination survey. The joint must be capped while it is still hanging vertically. As the joint is swung out through the 'V' door the top of the joint should be capped with a solid cap.
9. Each joint of contaminated tubing should be clearly marked with an identification number and labelled 'TENORM Contamination'. The identification number should be such that the well of origin and the position of the joint in the well can be traced.
10. Radiation dose rate measurements should be made around bundles of tubing on the pipe rack. If the dose rate is greater than 7.5  $\mu\text{Sv h}^{-1}$  entry to this area should be restricted and a record to how long anyone spends inside the area will have to be kept as detail in the GUIDELINES.  
  
If the dose rate measurement is between 2.5  $\mu\text{ h}^{-1}$  to 7.5  $\mu\text{Sv h}^{-1}$  the area will become a SUPERVISED AREA.  
  
If the absence of surface contamination (i.e. the radioactive material is sealed inside the capped tubular the requirement to wear respirators will not apply.
11. The RPO or RPS should ensure that a record is kept for all non-classified workers involved in CONTROLLED AREAS in handling uncapped tubular, decontaminating the CONTROLLED AREA or entering a CONTROLLED AREA which may exist due to accumulation of tubing on the piperack.
12. Regular check should be made to monitor whether any contamination is present on surfaces of the drill floor, well compartment and pipe deck storage area. If any contamination is present this should be wiped away using wet paper towels.  
  
Hosing away of contamination should only be done when the contamination can be directed straight into drains leading to the sea sump or mud outfall. On completion of the job a full check should be made of all CONTROLLED or SUPERVISED AREAS and areas below them which may have become contaminated for residual contamination.

13. Samples of any scale or sludge found inside the tubing string should be taken and sent for radiochemical analysis to determine its specific activity.
14. If contamination has been found, the mud system should be flushed, drained and checked to ensure that no contamination remains on completion of the workover. All tools used during the workover must be monitored for contamination, which should be removed by wiping with wet paper towels.
15. The procedure for transport and disposal of contaminated tubular is detailed in **GUIDELINES FOR THE TRANSPORT OF EQUIPMENT CONTAMINATED WITH TENORM (APPENDIX G)**.

## APPENDIX G

### GUIDELINES FOR THE TRANSPORT OF EQUIPMENT CONTAMINATED WITH TENORM

#### GENERAL

Disposal of any equipment contaminated with radioactive scale must be in **STRICT ACCORDANCE** with the terms of the licence issued by the **Atomic Energy Licensing Board** for the particular installation or terminal.

1. Equipment contaminated with TENORM must be sent for decontamination prior to its 'disposal'. These guidelines govern the transportation of equipment for decontamination. They apply to all equipment contaminated with radioactive scale or sludge which has a surface contamination greater than  $0.04 \text{ Bq cm}^{-2}$ . In this context 'disposal' means equipment, which may later be resold, reused or scrapped.

2. The equipment must be sent for decontamination to a company, which is licensed to carry out such work by the Atomic Energy Licensing Board.

Prior to shipment, the RPO or RPS must make an estimate of the total weight of scale contained within the equipment. Samples of the scale should also be taken and sent for content and specific activity analysis.

3. The loss of TENORM from each item must be prevented. This may be achieved in the case of small items by wrapping in plastic sheeting or in the case of pipework, tubular or large items by capping or sealing each opening.

4. Items suitable for containerisation must be individually labelled and securely stowed within a cargo carrying unit allocated and labelled specifically for that particular consignment of equipment contaminated with TENORM.

Tubular / deck cargo must be segregated and labelled in accordance with the Radiation Protection (Transport) Regulations 1989 and prepared for shipment in the normal manner.

5. Prior to shipment the RPO or RPS should ensure that each individual item including each tubular is clearly marked with an identification number (ID).

In addition tubular will have an ID number, which should relate to the well of origin and the position of the joint in the well.