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CODE OF PRACTICE ON RADIATION PROTECTION RELATING TO TECHNICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIAL (TENORM) IN OIL AND GAS FACILITIES

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Contents **Pages**

PART I Introduction

1.0 General 3

2.0 Purpose of Code of Practice 5

3.0 Scope 5

4.0 Specific Meanings of 'shall' and 'should' 5

5.0 Definitions, Abbreviations and Units 5

PART II Regulatory Aspects

6.0 General 10

7.0 Control limits

7.1 External Radiation Dose Rate 10

7.2 TENORM Waste 11

7.3 Transportation of TENORM Waste 11

7.4 Disposal of TENORM Waste 11

PART III Licensing Decision

8.0 General 11

8.1 Operation and Maintenance 11

8.2 Waste Management 12

PART IV Radiation Protection Programme (RPP)

9.0 General 13

10.0 Summary of the RPP 13

PART V Operational Radiation Safety Assessment

11.0 General 14

12.0 Radiation Safety Assessment (RSA) 15

13.0 Routine Radiological Monitoring (RRM) 16

14.0 Specific Radiological Monitoring (SRM) 17

15.0 Post-Disposal Radiological Monitoring (PDRM) 17

PART VI TENORM Waste Management

16.0 General 18
17.0 Accumulation and Storage 19
18.0 Transport 19
19.0 Recycling, Treatment or Recovery 20
20.0 Disposal 20
21.0 Radiological Impact Assessment (RIA) 21

PART VII Decommissioning 21

APPENDIXS

Appendix 1 Control limits
Appendix 2 Method of calculating Total Activity Concentration (TAC)
Appendix 3 Licensing decision process for oil and gas facility
Appendix 4 Waste management decision process
Appendix 5 Registrant and licensee checklist of requirements for oil and gas facility
Appendix 6 Registrant and licensee checklist of requirements for TENORM waste management
Appendix 7 Monitoring checklist
Appendix 8 Conversion factor for S.I. unit

Contributors on Drafting and Review
Bibliography

PART I
INTRODUCTION

1.0 General

1.1 Naturally Occurring Radioactive Materials (NORM) (uranium, thorium and their decay products such as radium-226, radium-228 and radon gas) are present in all geological materials. The activity concentrations of NORM vary widely and typically is low in clay and limestone and higher in sandstone, shale and granite. .

1.2 Oil and gas are formed in reservoirs within many types of geological formations and are often present together with water, termed as formation water. During the millions of years that this water has been in contact with the rocks in its formation, some of the rocks would have been dissolved by the water. Some of the dissolved materials are radioactive comprising of radium-226 (uranium series) and radium-228 (thorium series).

1.3 During the oil and gas production, water is brought to the surface. In many cases the water is separated from the oil and gas and discharged from the processing facility with the dissolved material remaining in solution. This is termed as produced water.

1.4 Under certain circumstances, conditions within the reservoir or the processing facility or the use of water injection to enhance reservoir pressure or maintain production, leads to a situation where some dissolved materials precipitated from the solution and forms scale containing radium, other sulfates and carbonates in well tubular, piping systems, vessels, valves and water separation facilities.

1.5 In other circumstances, solid material from the reservoir, such as sand that had been eroded from the rocks may come to the surface with the oil and be deposited as sludge in tanks during the separation process. This again may result in radioactive contamination of the processing facility.

1.6 Some sludge containing radioactive materials may be carried over downstream to refinery installations and collected during tank

cleaning. A small quantity of sludge containing traces of radioactive materials may also be produced in the gas processing plant.

1.7 This operation of oil and gas facilities involving NORM can result in the formation of **T**echnologically **E**nhanced **N**aturally **O**ccurring **R**adioactive **M**aterial, known by the acronym **TENORM**.

1.8 The presence of TENORM at the oil and gas facilities could lead to radiation exposure to workers through external radiation from radium daughters and internal exposure through inhalation (airborne dust and gas) and possible ingestion of radioactive materials at work sites.

1.9 Thus, monitoring of radiation and radioactivity levels at oil and gas facilities during normal operation and maintenance work is very essential. This will ensure the safety of the workers involved.

1.10 TENORM waste from oil and gas facilities can be categorized into two groups:

a. Group I which can be measured by Total Activity Concentration (TAC), which may include sludge, scales, contaminated sands etc; and

b. Group II which cannot be easily measured by TAC. However, it is normally measured by way of external dose rate (contaminated materials such as tubular, pump etc)

This waste must be properly managed to reduce the risk to workers as well as to members of the public and the environment.

1.11 Thus, the presence of TENORM in the operation of oil and gas facilities and the management of TENORM waste shall be carefully addressed and properly monitored.

1.12 In addition, other non-radioactive contaminants such as hydrogen sulfate gas, mercury, benzene, etc. may also be present and should require separate safety measures.

2.0 Purpose of Code of Practice

The purpose of this Code of Practice is to provide guidance to operators of oil and gas facilities to assist them to recognize the presence of TENORM and establish procedures to minimize its consequences.

3.0 Scope

3.1 This Code of Practice deals with TENORM in the oil and gas facilities covering oil and gas production until refinery excluding treatment, recycling and recovery; and

3.2 It provides guidance on the radiation protection and licensing requirements, if appropriate, for the oil and gas facility operation and waste disposal practice.

4.0 Specific Meanings of 'shall' and 'should'

The words 'shall' and 'should', where used in this Code, have specific meanings: 'shall' indicates that the particular requirement is considered as necessary or essential, 'should' indicates that the particular requirement is to be applied, wherever practicable.

5.0 Definitions, Abbreviation and Units

5.1 In this Code of Practice, unless otherwise changed by AELB through a special order, the following terms used have the meaning as described below:

'Act 304' means Atomic Energy Licensing Act 1984;

'activity concentration' means the *activity* per unit mass or volume of the material in which the radionuclides are essentially uniformly distributed;

'airborne contamination' means the activity concentration for radionuclides in the atmosphere exceeding the regulatory control limit;

'approved laboratory' means a laboratory that is approved by the appropriate authority to perform the radiological and environmental monitoring;

‘Board’ means Atomic Energy Licensing Board (AELB) established under section 3 of the Act 304;

‘consultant’ means personnel or agency recognized and approved by the appropriate authority, and employed by the licensee to carry out the duties of a radiation protection officer or the radiological monitoring;
‘contamination’ means the presence of radioactive material in or on a material or the human body or other places where they are undesirable or could be harmful;
‘Control limit’ means an established limit which may or may not derived base on regulatory limit;

‘critical group’ means a group of members of the public which is reasonably homogeneous with respect to its exposure for a given radiation source and is typical of individuals receiving the highest dose through the given pathway from the given source;

“disposal’ means the emplacement of radioactive waste or the direct discharge of effluents;

‘dose constraint’ means a prospective restriction on dose, primarily intended to be used to discard undesirable options in an optimization calculation;

‘dose limit’ means the value of the effective dose or the equivalent dose to individual from practice that shall not be exceeded;

‘disposal site operator’ means the operator or any other third party responsible for the disposal site;

‘environment monitoring programme’ means the measurement of external dose rates due to sources in the environment or of radionuclide concentrations in environment media;

‘exposure’ either the act or condition of being subject to irradiation, or the amount of ionization produced in air by ionizing radiation;

‘monitoring’ means the measurement of dose or contamination for reasons related to the assessment or control of exposure to radiation or radioactive materials, and the interpretation of the results;

‘NORM’ means a radioactive material in its natural state containing no significant amounts of radionuclides other than naturally occurring radionuclides;

‘oil and gas facilities’ means a plant or installation used for the production, processing refining or storage of oil, gas or associated produced water;

‘operator’ means the operator of the oil and gas facility who has the legal responsibility in respect of the employment of workers on the site and the provision of safe working conditions;

‘Post-Disposal Radiological Monitoring (PDRM)’ means monitoring carried out at the disposal site to monitor changes of environment radiation level and radiation exposures to the members of the public as a result of the disposal;

‘produced water’ means water which comes to the surface of an oil well as a result of oil and gas production activities;

‘production’ means oil and gas exploration and production and refers 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 exported or further processed;

‘radiation protection officer’ means a technically competent person appointed by the licensee and approved by the appropriate authority to supervise the application of appropriate radiation protection regulations, measures and procedures;

‘radiation protection programme (RPP)’ is a programme established by the licensee to ensure that the requirements of the Atomic Energy Licensing Act, 1984 and the Regulations are complied with;

‘radiation protection supervisor’ means a person responsible to oversee radiation protection in the absence of the radiation protection officer;

‘Radiation Safety Assessment (RSA)’ means an assessment carried out during normal operation to determine the radiation levels at the processing facility;

‘registrant’ means the registered operator with the appropriate authority who deals with TENORM at the level below the control limit;

‘Routine Radiological Monitoring (RRM)’ means monitoring carried out during normal operation to ensure the safety of the workers from radiation exposure;

‘Specific Radiological Monitoring (SRM)’ means monitoring carried out during maintenance to determine that the control limit has not been exceeded;

‘surface contamination’ means the presence of any radioactive material, nuclear material or prescribed substance on a surface;

‘S.I Unit’ means International System of Units used in this Code of Practice as in **Appendix 8**;

‘TENORM’ means a material in which the activity concentrations of the naturally occurring radionuclides have been technologically enhanced from its natural state;

‘TENORM waste’ means materials having no foreseeable use that contains or is contaminated with radionuclides at concentrations or activities greater than control limit as established by the appropriate authority;
‘transport’ means all operations and conditions associated with and involved in the movement of radioactive material, nuclear material or prescribed substance, including the preparations, consigning, loading, carriage including in transit storage, unloading and receipt at the final destination of a package;

‘waste treatment’ means the operations intended to benefit safety and economy by changing the characteristics of the waste through volume reduction, removal of radionuclides from the waste and change of composition;

‘waste’ means any materials from oil and gas facilities having no foreseeable use which may or may not contain TENORM or hazardous material;

‘waste management’ means all activities, administrative and operational, that are involved in the handling, pretreatment, treatment, conditioning, transportation, storage and disposal of waste from a oil and gas Facility;

‘worker’ includes any person working under the instruction of the licensee, whether or not employed by the licensee, in the handling or use of, or who will come into contact with any radioactive material or irradiation apparatus.

5.2 The following abbreviations, which are used throughout this Code of Practice, have their meanings as stated below, unless otherwise they are described to have a different meaning in a particular section:

Act 304 – Atomic Energy Licensing Act, 1984
AELB – Atomic Energy Licensing Board
LSA – Low Specific Activity
LSA-1 – Low Specific Activity 1
NORM – Naturally Occurring Radioactive Material
PDRM – Post-Disposal Radiological Monitoring
RIA – Radiological Impact Assessment
RPP – Radiation Protection Programme
RPO – Radiation Protection Officer
RRM – Routine Radiological Monitoring
RSA – Radiation Safety Assessment
SRM – Specific Radiological Monitoring
TAC – Total Activity Concentration
TENORM – Technologically Enhanced Naturally Occurring Radioactive Material

5.3 The units and symbol used in this Code of Practice should be read as below:

Symbol/unit	Definition
α	alpha
Bq/cm²	Becquerel per centimeter square
Bq/cm³	Becquerel per centimeter cubic
Bq/g	Becquerel per gram
Bq/l	Becquerel per liter
dis/s	disintegration per second
µSv/h	mickrosieverts per hour
mSv/h	millisieverts per hour
mSv/y	millisieverts per year

PART II
REGULATORY ASPECTS

6.0 General

6.1 The law of Malaysia with respect to the use and control of all sources of ionizing radiation, whether artificial or man-made is prescribed in the Atomic Energy Licensing Act, 1984 and its subsidiary legislations.

6.2 The main purpose of the above regulations is to minimize the radiological risk to workers, the public and the environment. This is done by setting dose limits, normally on an annual basis, for workers and members of the public, requiring that all exposure to ionizing radiation should be justified. Work must be planned and monitored so that exposure is kept as low as reasonably practicable.

6.3 This Code of Practice should be read in conjunction with the following guidelines:

a. 'Guidelines on Radiological Monitoring for Oil and Gas Facilities Operators Associated with Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)' LEM/TEK/30; and

b. 'Guidelines for Documentation of Radiation Protection Program for TENORM Activities' LEM/TEK/45(E).

7.0 Control Limits

Control limits have been set to provide guidance with regard to the level of activity or radiation which a practice needs to be controlled by the Board. The summary of these limits is given in **Appendix 1**. In most cases, the background levels are to be subtracted from the measured values prior to comparing with the control limits. In practice only working areas with potential radiation exposures area monitored. With regard to wastes which are exempted from control by the Board based on the control limits, they may still be subjected to other regulatory requirements such as the Environment Quality Act. It is the responsibility of the operators to manage non-controlled wastes in a manner that is in line with the requirement of other legislations.

7.1 External Radiation Dose Rate

Control limit for external radiation dose rate is 0.5 µSv/h. This limit is applicable for Radiation Safety Assessment, Routine Radiological Monitoring, Specific Radiological Monitoring and for the classification of radioactively contaminated materials.

7.2 TENORM Waste

Control limit for TENORM waste is 3.0 Bq/g (inclusive background) of TAC. The method of calculating TAC is shown in **Appendix 2**. This limit is applicable for the handling of solid or semi-solid wastes generated at offshore and onshore oil and gas facilities. Handling includes accumulation, storage, treatment, recycling and disposal. The waste could be in the form of sludge, scales, contaminated sand and etc. Waste with TAC less than this control limit is not controlled by the appropriate authority.

7.3 Transportation of TENORM Waste

The Radiation Protection (Transport) Regulation 1989 shall be referred to and complied with for the transportation of TENORM waste. TENORM waste of more than 3 Bq/g TAC is classified as Low Specific Activity (LSA) material under category LSA-I. The required package shall satisfy the requirement of Industrial Package Type 1 (IP-1). The radiation level shall not exceed 0.1 mSv/h at 1 m and 2 mSv/h at the surface.

7.4 Disposal of TENORM Waste

Control limit for TENORM waste disposal is 0.3 mSv/y based on dose constraint. A Radiological Impact Assessment (RIA) shall be conducted to assess the dose received by a critical group of the public as a result of the disposal of TENORM waste higher than 3 Bq/g TAC. The calculated dose shall not exceed the stipulated control limit.

PART III
LICENSING DECISION

8.0 General

The flowcharts of licensing decision making process for operation and waste management in the oil and gas facilities are shown in **Appendix 3** and **Appendix 4** respectively. All operators can only operate the facility and commence the disposal of waste with written approval from the appropriate authority.

8.1 Operation and Maintenance

8.1.1 In order to determine whether the facility needs to be licensed or registered, the operator of an oil and gas facility shall conduct Radiation Safety Assessment (RSA) and submit the report to the appropriate authority.

8.1.2 If RSA shows that one or more control limit (**Appendix 1**) is exceeded, operators are required to apply for a license (according to licensing regulation) upon being advised by the appropriate authority. The operator will become the licensee to the appropriate authority and shall comply with all the license conditions issued by the appropriate authority.

8.1.3 If the control limit is not exceeded, the operators are required to register with the appropriate authority and shall follow all instruction given by the appropriate authority. As the accumulation of TENORM in processing equipment may take some years to be detected, the appropriate authority may carry out enforcement inspection at the facility. If the radiological monitoring result shows that the radiation level exceeded the control limits, the registrant shall apply for a license (**Appendix 5**).

8.1.4 For normal operation, the licensee is required to carry out Routine Radiological Monitoring (para 13). The monitoring report shall be submitted to the appropriate authority.

8.1.5 Prior to every maintenance work, radiation survey (using survey meter) shall be conducted to identify whether the area or component is contaminated with TENORM. If the level is higher than the general background of clean area at the worksite, the licensee shall conduct Specific Radiological Monitoring (para 14). The monitoring report shall be submitted to the appropriate authority.

8.1.6 The various requirements for the registrant or licensee are summarized in **Appendix 6.**

8.2 Waste Management

8.2.1 TENORM wastes are assessed against the type of process to be undertaken as prescribed in **Appendix 4**.

8.2.2 If TENORM wastes are to be accumulated and stored at the oil and gas facilities or other approved facility, the operators shall obtained a written authorization from the appropriate authority and follow all standard radiation protection procedures set by the appropriate authority.

8.2.3 If TENORM wastes are to be recovered or treated, the operator shall refer to the appropriate authority.

8.2.4 If TENORM wastes are to be disposed of by landfill, the disposal site operator shall carry out RIA and submit the assessment report to the appropriate authority for approval.

8.2.5 If the RIA report shows that the dose to members of the public is less than the control limit (0.3 mSv/y), the *disposal* (as mentioned in Radiation Protection (Radioactive Waste Management) Regulations) is exempted by the appropriate authority.

8.2.6 If the RIA report shows that the dose to members of the public is more than the control limit (0.3 mSv/y), the disposal site operator shall apply for and obtain a license prior to disposal.

8.2.7 The disposal site operator shall carry out Post-Disposal Radiological Monitoring Program as per licensing condition issued by the appropriate authority. The disposal site operator shall submit the monitoring report to the appropriate authority.

8.2.8 As for Group II materials, the operator (through approved consultants) needs to check whether the wastes exceed the control limit. If it is less than the limit, the waste is not controlled by the appropriate authority. If the limit is exceeded, the operator shall refer to 8.2.1.

PART IV
RADIATION PROTECTION PROGRAMME (RPP)

9.0 General

When the facility is subjected to the conditions of a license, the RPP shall be established by the licensee in line with the format issued by the appropriate authority. The details of the RPP is given is LEM/TEK/45 (Section E) [6] and summarized in section 6.2.

10.0 Summary of the RPP

The RPP shall consist of the following elements:

a. A specification of the organizational structure pertaining to radiation protection;
b. Responsibility of licensee, Person Responsible towards License, Radiation Protection Officer, Radiation Protection Supervisor and Operator (TENORM);

c. The arrangement for the medical surveillance of radiation workers;
d. The arrangement for the personal monitoring of radiation workers;
e. The arrangement for carrying out area monitoring programme for both external radiation and surface and airborne contamination during operations and maintenance;
f. The setting up of operational limits for workers;
g. The classification of working area;
h. Special working procedures to ensure the safety of workers during normal operation, maintenance and occasional entry into confined areas in the facility.
i. Emergency response procedures;
j. The procedures for the transportation of TENORM and contaminated items;
k. Requirements for training of radiation workers and supervisors; and
l. The procedures for record keeping, maintenance and surveillance of the documents.

PART V
OPERATIONAL RADIATION SAFETY ASSESSMENT

11.0 General

Operational Radiation Safety Assessment (ORSA) includes Radiation Safety Assessment (RSA) after notification (**Appendix 3**) and monitoring. The monitoring shall include normal operation (Routine Radiological Monitoring–RRM), maintenance works (Specific Radiological Monitoring–SRM) and after the disposal of TENORM wastes from oil and gas facilities (Post-Disposal Radiological Monitoring–PDRM).

11.1 ORSA parameters include the measurements of external dose rate, surface contamination level, airborne dust activity level and radionuclide concentration. Surface contamination level (Bq/cm^2) and airborne dust activity concentration (Bq/cm^3 gross α) should be monitored wherever airborne dust is generated, and the results reported to the appropriate authority.

11.2 Measurements shall be carried out at appropriate locations which include but not limited to:

a. the most likely parts of the facility where scales may built up;
b. the most likely parts of the facility where sand, sludge or other solids may accumulate; and
c. that parts of the facility which may be contaminated by TENORM and is likely to be opened for the purpose of maintenance;

Measurements shall also be made for any components that may be removed for maintenance or cleaning.

11.3 It is the duty of the operator to identify, document and notify the appropriate authority of the appropriate measurement locations.

11.4 It is the duty of the operator to submit the Monitoring Program to the appropriate authority.

11.5 The monitoring checklist is shown in **Appendix 7**.

11.6 All equipment used for the above purpose shall be suitable and in compliance with the current relevant Guideline.

12.0 Radiation Safety Assessment (RSA)

12.1 The purpose of this assessment is to determine radiation levels at the processing facilities and to compare it with the control limits in order to decide whether licence is required for the new and existing operation.

12.2 RSA is required to be carried out during normal operation by the operator upon receiving instruction from the appropriate authority.

12.3 In RSA, operators are required to measure external dose rate (using survey meter) and surface contamination level (using contamination survey meter) in potential areas of

TENORM accumulation and contamination, once in every 6 month for a period of one year for baseline data establishment.

12.4 The new and existing operator should report the results of RSA to the appropriate authority. The appropriate authority will verify the result if it is deemed necessary.

12.5 If the results area above the control limits, the operator shall apply for a licence upon advice by the appropriate authority. The licensee shall then carry out the necessary RRM.

12.6 If the results are below the control limits as specified in Appendix 1, the operator shall follow the instructions given by the appropriate authority (i.e. carry out normal radiation protection measures, similar to RRM but at a lesser frequency).

13.0 Routine Radiological Monitoring (RRM)

13.1 The purpose of RRM is to ensure the safety of workers from radiation exposure during normal operation by monitoring the TENORM accumulation, trends and to identify and classify the contaminated equipment or areas.

13.2 The monitoring shall be carried out by the operators once a year or as advised by the appropriate authority.

13.3 RRM is required to be carried out by the operators once a year or as advised by the appropriate authority.

13.4 In RRM, external radiation and surface contamination area also measured in potential areas of TENORM accumulation and contamination.

13.5 The RRM program is summarized in **Appendix 7**.

14.0 Specific Radiological Monitoring (SRM)

14.1 The purpose of SRM is to determine whether the control limits as specified in **Appendix 1** have been exceeded. SRM will also confirm the effectiveness of safety measures implemented by the operator during maintenance work. The result is always compared with the control limits.

14.2 SRM shall be conducted by the operator whenever maintenance work is being carried out in the areas expected to be contaminated with TENORM.

14.3 In SRM, external radiation is normally measured. However, if the operation is dusty, airborne and surface contamination shall be measured. For the airborne contamination evaluation, air sampling is carried out onsite and the radionuclide analysis is conducted in approved laboratory.

14.4 The SRM program is summarized in **Appendix 7**.

15.0 Post–Disposal Radiological Monitoring (PDRM)

15.1 The purpose of PDRM is to monitor changes of environmental radiation level and radiation exposures to members of the public as a result of the disposal.

15.2 PDRM shall be carried out by the disposal site operator.

15.3 In this monitoring, external radiation is measured once a year at the disposal site using survey meters.

15.4 Radionuclide concentrations in soil and ground water shall also be measured. These areas carried out by good sampling practice, followed by analysis in the approved laboratory.

15.5 The analysis of the other samples, apart from the above, is subject to the requirements of the Board.

15.6 The PDRM program is summarized in **Appendix 7**.

PART VI
TENORM WASTE MANAGEMENT

16.0 General

16.1 In oil and gas facilities, wastes such as produced water, sludge and scales are generated.

16.2 Produced water is generated from the production system. It may contain radium. The volume produced varies according to location and age of the well. It is common in other countries that produced water is discharged into the sea. By so doing, dilution and dispersion will take place.

16.3 Sludge comprising of sand, clay, hydrocarbon, heavy metals and radionuclide are collected in separators, skimmer tanks and etc. The sludge is accumulated and collected from the cleaning process. Some sludge may also come from refineries but very little from gas production facilities.

16.4 Scales are hard deposits that comprise of sulphates and carbonates of calcium, strontium and barium formed in the wet part of the facility such as well head, valves, production tubular, pumps and separators. Scales are produced and accumulated after rescaling process. The use of scale inhibitor improve production has reduced the volume of scales very significantly.

16.5 Small volumes of waste are expected from gas production facilities. However, in some cases, wastes in the form of pyrophoric iron sulphide are also formed at the gas production facility.

16.6 After many years of operation, contaminated materials such as tubular, topsides equipment and piping are generated due to the accumulation of sludge and scales.

16.7 Wastes are generated during the decontamination process of pipes, vessels, tanks and other components. Care should also be given to the release of hydrogen sulphide gas,

mercury and benzene vapour that can cause potential hazard during the decontamination process.

16.8 Sludge and scales or sands (precipitates from waste water) are collected and kept in drums.

16.9 All of the above wastes may contain radionuclide that exceed the control limits.

16.10 Waste management covers the following but not limited to the:

a. accumulation or storage;
b. transport;
c. recycling, treatment or recovery; and
d. disposal.

17.0 Accumulation and Storage

17.1 TENORM waste arising as a result of maintenance, decontamination and refurbishment activities in oil and gas facilities must be stored in a manner which it is adequately contained such as in drums and cannot contaminate other items. An area used for TENORM waste storage shall be designated. The operator shall follow standard Radiation Protection Program as outlined by the appropriate authority in order to protect the workers at the facility from TENORM exposure. The storage of waste is a temporary measure while awaiting further processing or disposal.

17.2 All the waste generated shall be segregated in accordance to the source of origin and with proper labeling.

17.3 Waste sampling and analysis shall be done in accordance with the technique approved by the appropriate authority.

18.0 Transport

The transportation of the TENORM waste shall be done in accordance to the current Radiation Protection (Transport) Regulations.

19.0 Recycling, Treatment or Recovery

The possible treatment methods in waste recycling, treatment or recovery destined at reducing, the volume or organic content includes:

a. Low temperature recovery;
b. Incineration or thermal treatment; and
c. Biological treatment or land farming.

It is noted that such treatment may lead to the generation of secondary waste with possible enhancement of radioactivity.

20.0 Disposal

20.1 Waste arising from oil and gas facilities may also be contaminated by other toxic or hazardous materials. A method of disposal which may be appropriate for the TENORM wastes may not be suitable for other toxic hazardous waste. Therefore, a preferred method for the disposal of TENORM wastes shall address all issues of radioactive and non-radioactive contaminants that comply with all related regulations, e.g. environmental quality.

20.2 Routes for disposal which may be available in certain circumstances are subject to approval by authorities, such as:

a. reinjection of aqueous or slurry wastes into the oil field or abandoned well;
b. dilution of produced water and aqueous wastes by discharge into a large volume of water for example into the sea from an offshore installation;
c. encapsulation and burial of solids, sludge and scales;
d. engineered facility for burial of encapsulated or unencapsulated wastes;
e. landfill of treated sludge or slag or ash and scales; and
f. other appropriate technologies.

21.0 Radiological Impact Assessment (RIA)

Radiological Impact Assessment (RIA) is required to be carried out by the disposal site operator to dispose of TENORM wastes of more than 3 Bq/g TAC by landfill or other methods. Guidance to the content of RIA is spelt out in the relevant guidelines, such as LEM/TEK/30, LEM/TEK/49 and so forth. In RIA, it is essential to identify the volume of the wastes, the activity level, the proposed site for disposal, the scenario of the future use of the disposal site, etc.

PART VII
DECOMMISSIONING

The decommissioning of licensed are subjected to the approval of the appropriate authority. Any decommissioning proposal shall be submitted by the licensee to the appropriate authority according to the requirements of the current Radiation Protection (Licensing) Regulations. Any queries on this matter shall be submitted to the appropriate authority.

Appendix 1

CONTROL LIMITS

Item	Parameter	Limit
1.	External dose rate	0.5 μSv/h
2.	Contaminated materials: - External dose rate at 5 cm from surface	0.5 μSv/h
3.	Waste categorization based on TAC: - Total Activity Concentration (TAC)	3.0 Bq/g (inclusive background)
4.	Waste disposal: - Dose to critical group	0.3 mSv/y

Appendix 2

METHOD OF CALCULATING TOTAL ACTIVITY CONCENTRATION (TAC)

Formula:

TAC = (6 x Ra-226) + (8 x Ra-228) Bq/g

Where:
TAC is Total Activity Concentration
Ra-226 is Activity concentration for Radium-226
Ra-228 is Activity concentration for Radium-228

Example:

A sludge sample having:

i. Activity concentration of Ra-226 = 0.25 Bq/g
ii. Activity concentration of Ra-228 = 0.25 Bq/g

Using the above formula, the average TAC = (6 x 0.25 Bq/g)+(8 x 0.25 Bq/g)
= **3.5 Bq/g**

Interpretation:

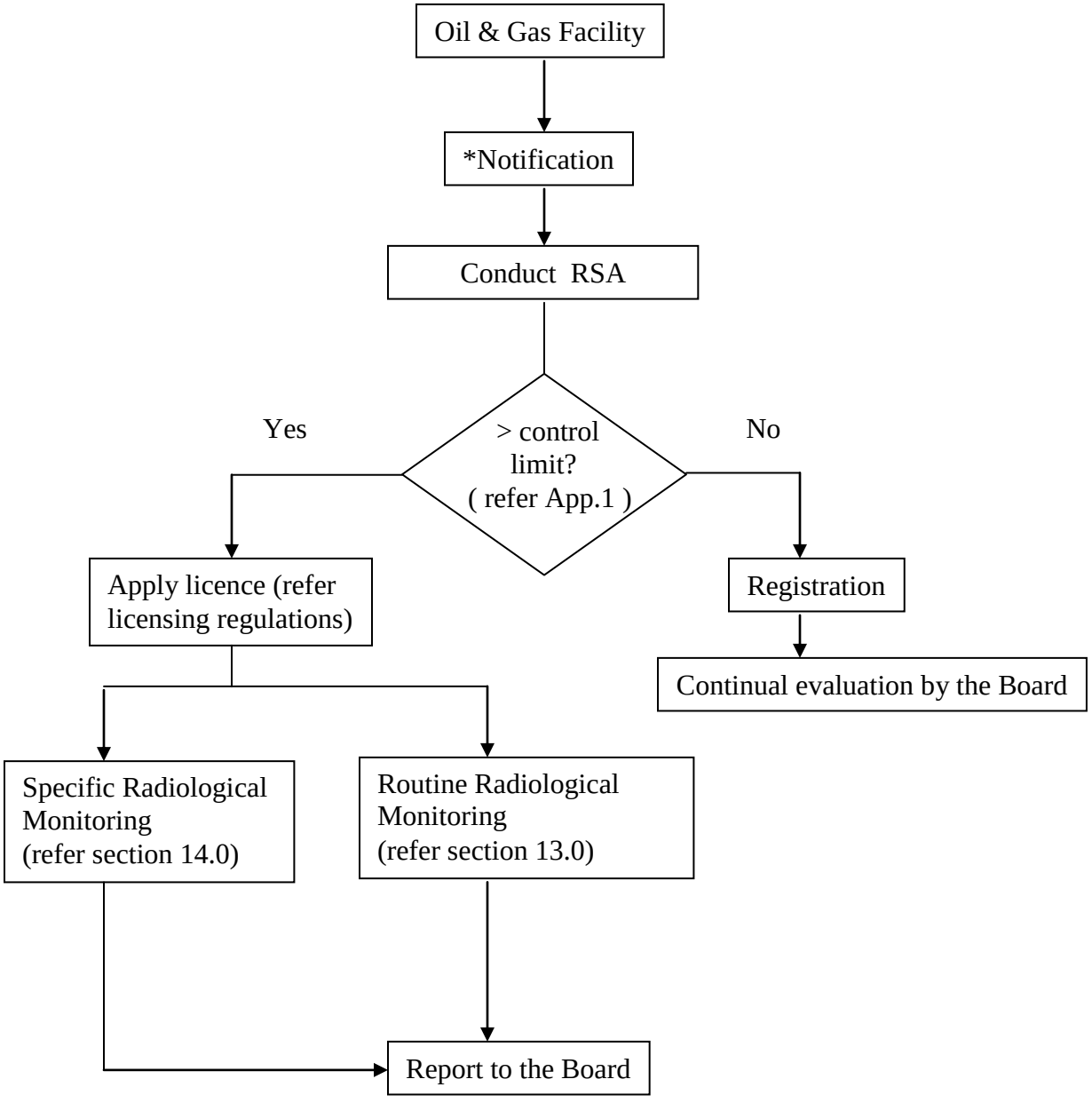
The control limit for TENORM wastes is 3.0 Bq/g (inclusive background) TAC, since the calculated value exceed the control limit therefore the management of the sludge requires a **valid licence** from the Board.

Note:

The average background activity concentration of soil in Malaysia is 1.1 Bq/g.

Appendix 3

LICENSING DECISION PROCESS FOR OIL AND GAS FACILITY

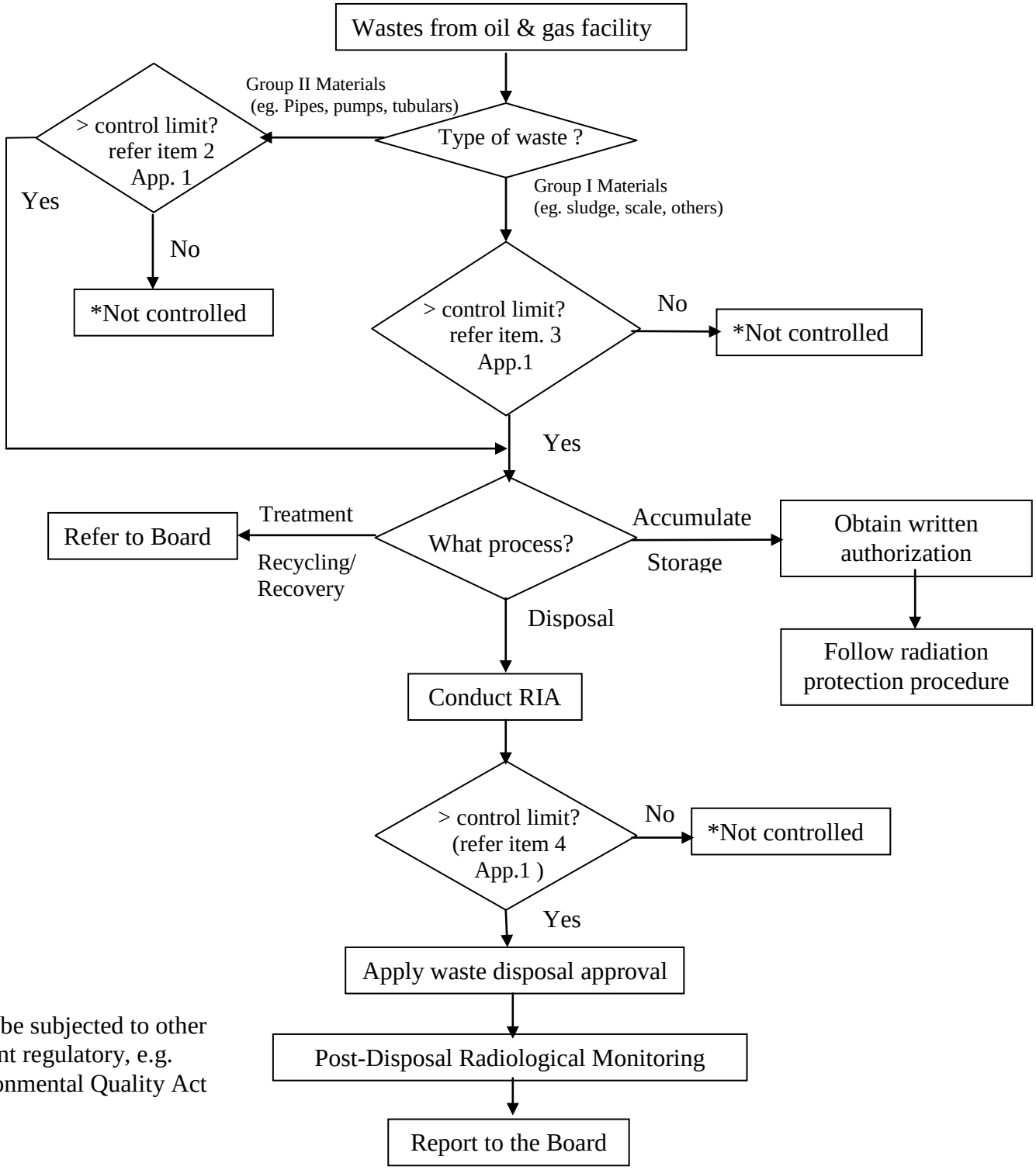


Note

*Notification applicable to new installation/platform/industry. The existing facilities need to update the notification process.

Appendix 4

WASTE MANAGEMENT DECISION PROCESS



*May be subjected to other relevant regulatory, e.g. Environmental Quality Act

Appendix 5

REGISTRANT AND LICENSEE CHECKLIST OF REQUIREMENTS FOR OIL AND GAS FACILITY

Requirement	Registrant	Licensee
1. Appoinment of RPO or Consultant	√ (*)	√
2. Radiation Safety Assessment	√	√
3. Licence Application	*x*	√
4. Radiation Protection Program (RPP)	*x*	√
5. Routine Radiological Monitoring	√ (**)	√ (***)
6. Specific Radiological Monitoring (During Maintenance)	√ (**)	√

Note:
(*) case by case basis and subject to the Board requirements.

(**) as determined by the Board

(***) once a year or as advised by the Board

Appendix 6

REGISTRANT AND LICENSEE CHECKLIST OF REQUIREMENTS FOR TENORM WASTE MANAGEMENT

Requirement	Disposal	Storage	Recycle/Recovery Treatment
1. Appointment of RPO or Consultant	√	√	Not covered by this Code of Practice
2. Radiation Safety Assessment (RSA)/ Radiological Impact Assessment (RIA)	√ (RIA)	√ (RSA)	
3. Licence Application	√	√	
4. Routine Radiological Monitoring	√ (*)	√ (**)	
5. Specific Radiological Monitoring (During Maintenance)	√	*x*	
6. Radiation Protection Programme (RPP)	√	√	
7. Post-disposal Monitoring	√	*x*	

Note:
(*) as determined by the Board.

(**) once a year or as advised by the Board.

Appendix 7

MONITORING CHECKLIST

Type of Monitoring	What	How	Where	When/ Frequency	Oil & Gas Operation	Waste Management
Routine Radiological Monitoring	External dose rate, μSv/h	Use survey meter	Potential areas of TENORM accumulation	Once a year	√	√
	Surface contamination level, Bq/cm^2	Contamination survey meter and wipe test	Potential area of contamination	Wherever airborne dust is generated	√	√
	Airborne dust activity, Bq/m^3 gross α	Air sampling, lab analysis	Potential dusty areas	Wherever airborne dust is generated		√
Specific Radiological Monitoring	External dose rate, μSv/h	Use survey meter	Maintenance sites	During Maintenance	√	√
	Airborne dust activity, Bq/m^3 gross α	Air sampling, lab analysis	Potential dusty areas	Wherever airborne dust is generated	√	√
	Surface contamination level, Bq/cm^2	Contamination survey meter and wipe test	Potential dusty areas	Wherever airborne dust is generated	√	√
Post-Disposal	External dose rate, μSv/h	Use survey meter	Disposal site	Once a year		√

Radiological Monitoring	Radionuclide concentration, i. Ground water, Bq/l ii. Soil, Bq/g	On-site and off-site sampling, lab analysis	Disposal site	Once a year		√

Appendix 8

CONVERSION FACTORS FOR S. I. UNITS

Radiological Old Unit Quantity	Old unit	S. I. Unit	Relationship between units
Activity of a radioactive material	**Curie (Ci)** 1 Ci = 3.7×10^{10} dis/s	**Becquerel (Bq)** 1 Bq = 1 dis/s	1 Bq = 2.7×10^{-11}Ci 1 Ci = 37×10^{9} Bq
Exposure	**Roentgen (R)** 1 R = the production of ions (of one sign) carrying a charge of 2.58×10^{4} C/kg of air.	**Coulomb per kilogram (C/kg)**	1 R = 2.58×10^{4} C/kg
Absorbed dose	**rad** 1 rad = 0.01 J/kg	**Gray (Gy)** 1 Gy = l J/kg	1 Gy = 100 rad 1 rad = 0.01 Gy
Dose equivalent	**rem** 1 rem = 1 rad x Q (Q is quality factor)	**Sievert (Sv)** 1 Sv = 1 Gy x Q x N N is the product of all other modifying factors (currently taken as 1 by ICRP)	1 Sv = 100 rem 1 rem = 0.01 Sv

Note: 1 rem is equivalent to 1 rad (for gamma and X-ray)

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