

Occupational Radiation Protection in the Oil and Gas Exploration Involving Exposure to Naturally Occurring Radioactive Material (NORM) Waste Product



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1. Background and Goal of the present work

The oil and gas exploration industry was well known to indirectly generate Naturally Occurring Radioactive Material (NORM) waste products known as oil sludge and scale (Fig.1). Oil sludge and scale formed during the borehole logging process in the process to obtain crude oil from the reservoir rock. In this process, various impurities were sucked out which eventually precipitation and deposition were formed in the oil and gas production tubular, valves, pumps and transport piping systems. The waste products are commonly associated with natural radioactivity of ^{226}Ra , ^{228}Ra , ^{210}Po from ^{238}U and ^{232}Th series and also ^{40}K . In addition, this process might involve the presence of radon (^{222}Rn) which formed the thin radioactive lead films on the inner surface of gas processing systems.



Fig.1: Oil sludge and scale waste

2. Legal Requirements

The Atomic Energy Licensing Act 1984 (Act 304) is the main Act in Malaysia that provides the regulation and control of atomic energy, for the establishment of standards on liability for nuclear damage and for matters connected therewith or related thereto. Atomic Energy Licensing Board (AELB) is the regulatory body enforced several Regulations and Order under the Act 304 especially for the oil and gas exploration industries such as:

- Radiation Protection (Licensing) Regulations 1986;
- Radiation Protection (Transport) Regulations 1989;
- Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010;
- Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011; and
- Radiation Protection (Low activity radioactive sources) (Exemption) Order 2020.

Any radioactive waste managements were referred to the Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011. In the Second Schedule of the regulation, the activity concentration of the radionuclides below the clearance level are release from AELB. This regulation is made in accordance to the IAEA standards documents, Basic Safety Standards 115 (1996) and Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, GSR Part 3 (2014).

Table 1 shows the control limit for the licensing of activities involving with NORM. For the disposal of oil sludge and scale waste containing NORM above the stated limit, is subjected to the regulatory control, licensed and approved by the AELB.

Table 1: Control limit (licensing) for the activity concentration of raw material and waste containing NORM

Radionuclide	Activity Concentration (Bq/g)
^{40}K	10
Each radionuclide in the chain of Uranium and Thorium decay	1

3. Measurement Methodology

External radiation monitoring is important when radioactive material are present inside or outside any oil and gas system and have potential to cause exposures to the workers. The external radiation level is a good indicator to decide the requirement of surface contamination measurement. The waste products oil sludge and scale normally sampled and analysed prior to the disposal. The sample analysis after the waste generated helps the operator to manage the waste accordance to the regulations which then lead to the classification, identification and management of the waste.

Most common measurement methodology used in the oil and gas exploration are as followed:

- Background radiation level;
- External radiation;
- Surface contamination;
- Activity concentration of airborne dust; and
- Activity concentration of sand.

6. Conclusions

- Oil sludge and scale waste classified as Very Low Level Waste (VLLW) accordance to the guidelines of International Atomic Energy Agency (IAEA) GSG-1 and TECDOC 1712. Therefore, it is recommended that the oil sludge and scale waste handled with appropriate waste management and then disposed of in the secured landfill.

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3.1. Routine Radiological Monitoring (RRM) & Specific Routine Monitoring (SRM)

Most of the monitoring activities are conducted at the processing plant of onshore and offshore oil platform facilities at the Peninsular of Malaysia, Sarawak, and Sabah. From the monitoring activities, the result indicates that parameter monitored during Routine Radiological Monitoring (RRM) in normal operations are below the limits regulated under the Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011. During Specific Routine Monitoring (SRM) where the maintenance works are conducted, the result for several parameters indicates fluctuated trend and some are exceeding the Clearance Level.

4. Oil and Sludge Waste Management

As mentioned earlier, decontamination activity will be conducted at the suspected location that exceeds the control limit by cleaning up the contaminated equipment. The oil sludge and scale collected will be placed in a drum and then disposed of in processing and disposal facilities as required under the conditions of the license and regulated under the Radiation Protection (Licensing) Regulations 1986 and Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011.

In Malaysia, there were only 2 facilities that dispose the oil and sludge waste categorized as NORM which located at Peninsular of Malaysia and Sarawak respectively. Fig.2 shows the diagram where the oil sludge and scale placed in the drum will undergo incineration process at 1000 °C in combustion chamber and produce slag followed by incineration in the second combustion chamber to ensure a perfect combustion of flue gas and waste resulting from the main combustion. The flue gas from the second combustion chamber will then go through the recovery boiler and then be cooled, treated with activated carbon and lime which will produce fly ash.

The slag produced in the combustion plant will be extracted in a slag extractor while the fly ash will be collected from the silo and sent to the solidification plant. The fly ash will be mixed with lime, sand, cement and undergo physical chemical treatment (PCT) with process water. Slag and fly ash resulting from the oil sludge and scale waste treatment process will be disposed at the disposal facility in a secured landfill area approved by the AELB (Fig.3).

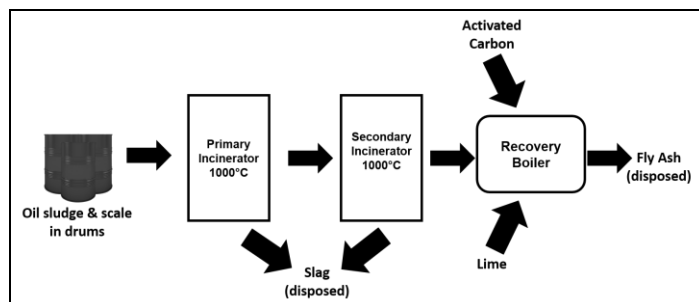


Fig. 2: Oil sludge and scale dispose via incineration process



Fig. 3: Oil sludge and scale processing and disposal facilities

5. Mitigation Measures

Best practice to implement the mitigation measures to minimize radiological impact resulting from the operations, personnel and environment related to the oil and gas exploration activities can be include:

- Decontamination of the contaminated items;
- Conducted RRM during normal activity;
- Conducted SRM during specific activity;
- Implementation of a comprehensive procedure in waste management;
- Personnel equipped with proper Personal Protective Equipment (PPE); and
- Required personnel well trained in safety and radiation protection.