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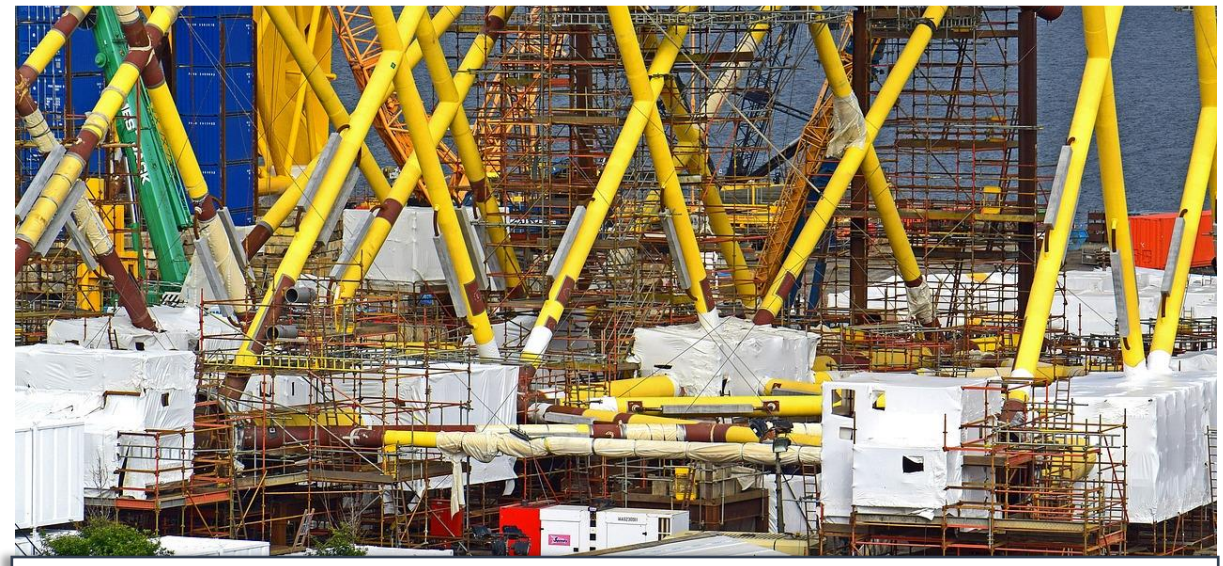
SAFE AND SUSTAINABLE DECOMMISSIONING OF OFFSHORE STRUCTURES TAKING INTO CONSIDERATION THE PECULIARITIES OF THE ASEAN & SOUTH ASIA REGIONS



TECHNICAL GUIDELINES

FOR SAFE AND SUSTAINABLE RECYCLING FACILITIES AND WASTE MANAGEMENT FACILITIES FOR DECOMMISSIONED OFFSHORE STRUCTURES IN SOUTHEAST ASIA

2024

AUTHORS

Huyen Thi Le[1], Wonsiri Punurai[2], Hooi-Siang Kang[3], Jing-Shuo Leow[4], Sari Amelia[5], Rakesh Bhargava[6], Omar Bin Yaakob[7], Noor Amila Wan Zawawi[8], Thor Sterker[9], Klitsadee Yubonmhat[10], Evin Yuliati[11], Teng Iyu Lin[12], Pornpong Asavadorndeja[13] Nhung Thi Phuong Nguyen[14], Thanh Thanh Le[15], Kiet Van Nguyen[16], Nurul Anis Kamarudin[17], Sy Van Le[18], Jin Wang[19], Arun Kr. Dev[20], Dega Damara Aditramulyadi[21], Bisri Hasyim[22], Chintan Kalthia[23], Mohd Arif Ismail[24]

[1]PetroVietnam University, 762 Cach Mang Thang Tam Street, Long Toan Ward, Ba Ria City, Ba Ria-Vung Tau Province 790000, Vietnam (corresponding author). ORCID: https://orcid.org/0000-0002-9720-8152. Email: huyenlt@pvu.edu.vn.

[2]Mahidol University Thailand, 999 Phuttamonthon 4 Road, Salaya, Nakhon Pathom 73170, Thailand. ORCID: https://orcid.org/0000-0003-1260-084X. Email: wonsiri.pun@mahidol.ac.th.

[3]Marine Technology Centre, Institute for Vehicle System & Engineering / Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia. ORCID: https://orcid.org/0000-0002-0292-4376. Email: kanghs@utm.my.

[4]Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia. ORCID: https://orcid.org/0009-0001-1606-9569. Email: jsleow2@graduate.utm.my.

[5]Institut Teknologi Bandung, Jl. Ganesa No.10, Lb. Siliwangi, Kecamatan Coblong, Kota Bandung, Jawa Barat 40132, Indonesia. Email: sariameliaaa@gmail.com.

[6]Sea Sentinels Pte Ltd., One Raffles Place #34-04, 1 Raffles Place 048616, Singapore. Email: rakesh.bhargava@sea-sentinels.com.

[7]Marine Technology Centre, Institute for Vehicle System & Engineering / Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia. ORCID: https://orcid.org/0000-0002-3381-513X. Email: omaryaakob@utm.my.

[8]Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia. ORCID: https://orcid.org/0000-0002-5699-5348. Email: amilawa@utp.edu.my.

[9]PB Consultants, Heerhugowaard, The Netherlands. Email: sterker@planet.nl.

[10]Radioactive Waste Management Center, Thailand Institute of Nuclear Technology, Bangkok 10900, Thailand. ORCID: https://orcid.org/0000-0003-2815-1209. Email: klitsadee@tint.or.th.

[11]Nuclear Energy Regulatory Agency, Jl. Gajah Mada No. 8, Jakarta Pusat 10120, Indonesia. Email: y.evin@bapeten.go.id.

[12]Department of Atomic Energy Malaysia, Ministry of Science, Technology and Innovation, Batu 24, Jalan Dengkil, 43800 Dengkil, Selangor Darul Ehsan, Malaysia. Email: yulin@aelb.gov.my.

[13]Synterra Co. Ltd, 129/9 Soi Hatsadisewi, Sutthisan Winitchai Road, Huai Khwang Subdistrict, Huai Khwang District, Bangkok, 10310, Thailand. Email: p.asavadorndeja@synterra.co.th.

[14]PetroVietnam University, 762 Cach Mang Thang Tam Street, Long Toan Ward, Ba Ria City, Ba Ria-Vung Tau Province 790000, Vietnam. Email: nhungntp@pvu.edu.vn.

[15]PetroVietnam University, 762 Cach Mang Thang Tam Street, Long Toan Ward, Ba Ria City, Ba Ria-Vung Tau Province 790000, Vietnam. Email: thanhlt@pvu.edu.vn.

[16]PetroVietnam University, 762 Cach Mang Thang Tam Street, Long Toan Ward, Ba Ria City, Ba Ria-Vung Tau Province 790000, Vietnam. Email: kietnv@pvu.edu.vn.

[17]Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia. Email: anis.kamarudin@utp.edu.my.

[18]PetroVietnam Maintenance and Repair Corporation, 7th floor, Petrovietnam Tower, 1-5 Le Duan Street, Ben Nghe Ward, District 1, Ho Chi Minh City, Vietnam. Email: sylv@pvmr.vn.

[19]Liverpool John Moores University, 70 Mount Pleasant, Merseyside L3 5UX, United Kingdom. ORCID: https://orcid.org/0000-0003-4646-9106. Email: j.wang@ljmu.ac.uk.

[20]Naval Architecture Marine Technology Programmes, Newcastle University, Singapore. Email: a.k.dev@newcastle.ac.uk.

[21]Institut Teknologi Bandung, Jl. Ganesa No.10, Lb. Siliwangi, Kecamatan Coblong, Kota Bandung, Jawa Barat 40132, Indonesia. Email: degadamara@itb.ac.id.

[22]PT. Meindo Elang Indah, Lt.27 Menara Batavia, Jl. K.H. Mas Mansyur No.126, Karet Tengsin, Kecamatan Tanah Abang, Kota Jakarta Pusat, Daerah Khusus Ibukota Jakarta 10220, Indonesia.

[23]R. L. Kalthia Ship Breaking Pvt. Ltd., 201, Sarthik Complex, Atabhai Chowk, Bhavnagar-364001, Gujarat, India. Email: ck7664@gmail.com.

[24]Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia. ORCID: https://orcid.org/0009-0002-4479-2671. Email: marif7@graduate.utm.my.

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PREFACE

With more than 500 structures to be decommissioned in the coming years, Southeast Asia is in need of research on decommissioning to make the process safe and sustainable. The pecularities of the region include shallow water (<100 m depth), tropical climate which makes the structures more prone to heavy marine growth, and mercury hot spot which makes the mercury concentrations in oil and gas reservoirs at the highest levels in the world. The research project "Safe and Sustainable Decommissioning of Offshore Structures Taking into Consideration the Peculiarities of the ASEAN & South Asia Regions" (SEELOS1920\1\111) aims to address these challenges, with three Work Packages and specific objectives as follows:

Work Package	Objective
1	To develop methods and guidelines which will enhance the safety of decommissioning process within the specific environment of the region
2	To identify and help improvement of recycling facilities for decommissioning offshore structures in the region
3	To develop a long-term network for sharing information, best practices, facilities and capacity building in the region

In order to achieve the above-mentioned objective, Work Package (WP) 2 has the following activities:

Sub-Work Package	Activities
WP2A	Identify existing facilities in the region and select one as a case study for gap analysis against the Hong Kong Convention 2009 standards for safe and sustainable recycling of decommissioned offshore structures
WP2B	Assess the compliance of downstream waste management facilities to deal with hazardous materials (especially mercury & NORM) with respect to the related national and international regulations
WP2C	Provide guidance for the candidate facilities to improve and achieve standards of the safe, green and sustainable recycling facilities

This document is the research result of WP2. It was undertaken by WP2 members, including:

1. PetroVietnam University (PVU) – WP2 and WP2B Leader
2. Universiti Teknologi Malaysia (UTM) – WP2A Leader
3. Mahidol University (MU) – WP2C Leader
4. Institut Teknologi Bandung (ITB)
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1. Introduction

Despite having 1,700 fixed offshore structures, with more than 500 structures to be decommissioned in the coming years, Southeast Asia has very few onshore dismantling yards that are capable of handling decommissioned offshore structures. Such yards are mainly located in Thailand (STP&I, UWM and ITD yards, to name a few); some in Indonesia (Meindo Elang Indah (Handil) and Elnusa (Cilegon)), and one in Malaysia (Muhibbah Engineering). Due to the legal constraints on transboundary movement of hazardous waste in Southeast Asia, each country in the region needs to handle decommissioned offshore structures by itself. In this context, some scholars suggested upgrading the current shipbuilding and offshore fabrication yards to include decommissioning activity, given the availability of primary facilities in those yards, such as the quay facility for structure load-in/ offloading operations, a large fabrication area which could be upgraded into a dismantling area, as well as workshops and equipment to support onshore dismantling operations. However, onshore dismantling of offshore structures is not just a simple reverse engineering of shipbuilding. While decommissioned offshore structures contain hazardous waste residues accumulated from oil and gas production, shipbuilding yards often lack adequate waste handling capability to handle such residues.

The Technical Guidelines for Safe and Sustainable Recycling Facilities and Waste Management Facilities for Decommissioned Offshore Structures in Southeast Asia (hereinafter known as the “Guidelines” were prepared to provide guidance for shipbuilding yards as well as the existing dismantling facilities in Southeast Asia to achieve safe and sustainable dismantling of decommissioned offshore structures. Guidance is also provided for waste management facilities, which are actually Zone F of a dismantling facility, to safely and sustainably handle hazardous waste generated from offshore structures in the region.

2. Purpose

The purpose of this document is to provide guidance for dismantling of decommissioned offshore structures in Southeast Asia and for management of hazardous waste decontaminated from such structures in a safe and sustainable manner.

3. Scope and Applicability

The Guidelines are applicable to the decommissioning of offshore oil and gas structures in Southeast Asia. They are limited to onshore dismantling operations and waste management activities thereafter.

4. Regulatory Frameworks

4.1 Regulatory Frameworks for Managing Oil and Gas Decommissioning and Ship Recycling Facilities

The regulation of offshore oil and gas decommissioning is mainly based on the laws and policies of the country where the offshore structure is located. Some related international regulations and guidelines include the *United Nations Convention on the Law of the Sea* (1982), the *Convention on the Continental Shelf* (1958); and the *Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone* (1989). In contrast, the international legal framework for ship recycling is relatively mature and widely accepted. Some of the regulations for ship recycling, such as the Basel Convention's *Technical Guidelines on the Environmentally Sound Management of the Full and Partial Dismantling of Ships* (2003) and the *Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships* (2009) can be used as good references for onshore dismantling of offshore structures. The former "provides information and recommendations on procedures, processes and practices that shall be undertaken to achieve Environmentally Sound Management" at ship dismantling facilities (UNEP 2003). The latter sets requirements to "prevent, reduce, minimize and, to the extent practicable, eliminate accidents, injuries and other adverse effects on human health and the environment caused by Ship Recycling, and enhance ship safety, protection of human health and the environment throughout a ship's operating life", where Ship Recycling refers to the complete or partial dismantling of a ship at a ship recycling facility so as to recover components and materials for reprocessing and re-use, together with taking care of hazardous and other materials, as well as the related operations such as in situ storage and treatment of components and materials, but not their further processing or disposal in separate facilities (IMO 2009). In addition, the *Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal* (UNEP 1989) applies to both ship recycling and onshore

dismantling of offshore structures. It aims to reduce the generation of hazardous waste and promote environmentally sound management of hazardous waste, wherever it is disposed; restricts the transboundary movement of hazardous waste, except where the principles of environmentally sound management are fulfilled; and provides a regulatory system for cases where transboundary movements are allowed (Basel Convention n.d.).

For regional regulations and guidelines on decommissioning of offshore structures, Southeast Asia has only one regional guidance, which is *ASCOPE Decommissioning Guideline (ADG) for Oil and Gas Facilities.* However, the document only focuses on the technical offshore decommissioning and disposal options, and does not include guidance on onshore dismantling (ASCOPE 2012). Meanwhile, offshore decommissioning in the North Sea, one of most experienced and active regions in terms of onshore dismantling, is regulated under the *OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations* and benefited from some guidance, such as *Guidelines: Managing Offshore Decommissioning Waste* (DECOM North Sea 2018) and the UK *Guidance Notes on Decommissioning of Offshore Oil and Gas Installations and Pipelines* (BEIS 2018). While the guidance on onshore dismantling and disposal is mentioned generally in the former, it is further detailed in the latter. Some technical reports of decommissioned offshore structures and yard facilities in the North Sea (CRF Consultants 2016; Shell U.K. Limited. 2017, 2019) can also be seen as comprehensive guidance for onshore dismantling in this region as well as other parts of the world. **Table 1** summarises the international and regional regulations and guidelines on ship recycling and onshore dismantling/ decommissioning of offshore structures in Southeast Asia and the North Sea.

Table 1 International and regional regulations and guidelines on ship recycling and onshore dismantling/ decommissioning of offshore structures in Southeast Asia and the North Sea

<table>
<tr><th colspan="2">Ship Recycling</th><th colspan="2">Oil and gas Decommissioning</th></tr>
<tr><td colspan="2">International regulations and guidelines</td><td colspan="2">International regulations and guidelines</td></tr>
<tr><td colspan="2">- Basel Convention's Technical Guidelines on the Environmentally Sound Management of the Full and Partial Dismantling of Ships (2003)
- Hong Kong International Convention For The Safe And Environmentally Sound Recycling Of Ships (2009)
- Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal (1989)</td><td colspan="2">- United Nations Convention on the Law of the Sea (1982)
- Convention on the Continental Shelf (1958)
- 1989 Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone (IMO Resolution A.672 (16))
- London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) (1972) and the Protocol to the London Convention (1996)</td></tr>
<tr><td colspan="2">Regional regulations and guidelines</td><td colspan="2">Regional regulations and guidelines</td></tr>
<tr><td>Southeast Asia</td><td>North Sea</td><td>Southeast Asia</td><td>North Sea</td></tr>
<tr><td>Not available</td><td>- Regulation (EU) No. 1257/2013 on ship recycling and amending Regulation (EC) No 1013/2006 and Directive 2009/16/EC</td><td>- ASCOPE Decommissioning Guideline (ADG) for Oil and Gas Facilities</td><td>- OSPAR Decision 98/3 on the Disposal of Disused Offshore
Installations
- Guidelines: Managing Offshore Decommissioning Waste
- UK Guidance Notes on Decommissioning of Offshore Oil and Gas Installations and Pipelines</td></tr>
</table>

4.2 Regulatory Frameworks for Hazardous Waste Management Facilities

The most important regulatory frameworks for hazardous waste management facilities which particularly serve for decommissioning of offshore structures include the regulations and guidelines for hazardous waste in general, and for mercury waste and Naturally Occurring Radioactive Material (NORM) waste in particular.

4.2.1 Hazardous Waste Management

Table 2 summarises the regulatory frameworks for hazardous waste management in ASEAN. The review of such regulatory frameworks shows that, among the ASEAN member states, Brunei, Indonesia, Lao PDR, Malaysia, the Philippines, Singapore and Vietnam have dedicated laws and/or legal and guiding documents on hazardous waste management, whereas Cambodia, Myanmar and Thailand only have the relevant ones. Compared to other countries, the Philippines has the most comprehensive regulatory framework for hazardous waste management.

Table 2 Regulatory frameworks for hazardous waste management in ASEAN (updated from Le et al. (2022), under the copyright of ASRANet)

Country	Regulatory framework
Brunei	Hazardous waste management is based on the Poisons Act. The hazardous waste export, import and transit are controlled under the Hazardous Waste Order of 2013 (Constitution of Brunei Darussalam 2013).
Cambodia	Hazardous waste is managed under the Environmental Protection and Natural Resources Management Law 1996 and its Sub-Decree on Solid Waste Management 1999 (MOE (Cambodia) 1999; Royal Government of Cambodia 1996).
Indonesia	Hazardous waste is regulated under: (1) Law No. 32 of 2009 on Environmental Protection and Management; (2) Government Regulation No. 22 of 2021 on Environmental Protection and Management; and (3) Regulation of the Ministry of the Environment and Forestry No. 6 of 2021 on the Procedures and Requirements for the Management of Hazardous Wastes.

Country	Regulatory framework
Lao PDR	Hazardous waste is regulated under: (1) the Environmental Protection Law (2013, revised) and (2) the Ministerial Instructions on Hazardous Waste Management, No. 0744/MONRE (2015).
Malaysia	Hazardous waste is mainly regulated under: (1) the Environmental Quality Act (EQA) of 1974 and (2) the Environmental Quality (Scheduled Wastes) Regulations 2005.
Myanmar	No specific law on hazardous waste waste management. Hazardous waste is managed under: (1) Environmental Conservation Law (No. 9/2012); (2) Environmental Conservation Rules (No. 50/2014); (3) National Waste Management Strategy and Master Plan for Myanmar (2018-2030); and (4) National Environmental Policy of Myanmar 2019.
Philippines	Hazardous waste is regulated under: (1) Republic Act 6969 (1990); (2) DENR Administrative Order (DAO) 1992-29; (3) DAO 2004-36; and (4) DAO 2013-22.
Singapore	Hazardous waste is regulated under: (1) Environmental Public Health Act 1987 (revised 2002); (2) Environmental Public Health (Toxic Industrial Waste) Regulations 1988 (revised 2000); and (3) Hazardous Waste (Control of Export, Import and Transit) Act 1997 (revised 2020).
Thailand	Hazardous waste is regulated under the Notification of the Ministry of Industry B.E.2548 (2005) (MOI (Thailand) 2005a).
Vietnam	Hazardous waste is mainly regulated under: (1) Law on Environmental Protection No. 21/VBHN-VPQH; (2) Decree No. 38/2015/ND-CP on Regulation of Waste and Discarded Materials; and (3) Circular 02/2022/TT-BTNMT Detailing on Implementation of the Law on Environmental Protection.

4.2.2 Mercury Waste Management

Mercury waste from decommissioned offshore structures should be of particular concern. Mercury originates from volcanic rocks covering hydrocarbon reservoirs and is naturally part of hydrocarbon production (Kelland 2014). Mercury release could pose health and safety risks to workers and damage the environment (Crafts and

Williams 2020). Notably, Southeast Asia has the highest levels of mercury concentrations in oil and gas reservoirs compared to other parts of the world ((25-275 times for crude oil, 11.7-70 times for natural gas and 11-25 times for LPG) (Mok 2016; Le et al. 2023).

The summary of the ASEAN regulatory frameworks for mercury waste management is presented in **Table 3**, more details can be found in Le et al. (2023). Mercury waste is regulated as part of hazardous waste management in most ASEAN member states, except the Philippines which has specific legal documents on mercury waste management. The Philippines also has the most comprehensive regulatory framework for mercury waste management. All the countries have set mercury emission standards for different activities; however, only Myanmar and the Philippines have specific standards for oil and gas activities.

Table 3 Regulatory frameworks for mercury waste management in ASEAN (reproduced from Le et al. (2023), with permission from ASCE)

Country	Regulatory framework
Brunei	Mercury waste is covered under the Poisons Act and Hazardous Waste Order of 2013 (Constitution of Brunei Darussalam 2013; MOH (Brunei) 2004). It is also managed in accordance with the Pollution Control Guidelines for Industrial Development 2003 and the Guideline on Healthcare Waste Management 2019 (MOD (Brunei) 2003; MOH (Brunei) 2019). The Pollution Control Guidelines for Industrial Development 2003 set out the mercury emission standards for discharge to the water and air environment for any trade, industry or process (MOD (Brunei) 2003).
Cambodia	Mercury waste is regulated as hazardous waste under the Sub-Decree on Solid Waste Management 1999 (MOE (Cambodia) 1999). It is also managed under the Sub-Decree on Water Pollution Control 1999 (with revisions in 2021) where standards for effluent discharge which contain mercury are specified (Council of Ministers (Cambodia) 1999; Umeyama 2021).

Country	Regulatory framework
Indonesia	Mercury waste is regulated as hazardous waste under: (1) Law No. 32 of 2009 on Environmental Protection and Management; (2) Government Regulation No. 22 of 2021 on Environmental Protection & Management; and (3) Regulation of the Ministry of the Environment and Forestry (MOEF) No. 6 of 2021 on the Procedures & Requirements for the Management of Hazardous Wastes. It is also regulated specifically under the Ministry of Health Regulation No. 41 of 2019 on the Elimination and Withdrawal of Mercury-Containing Medical Devices in Healthcare Facilities (AIT 2021). The MOEF Regulation No. 6 of 2021 sets out mercury standards for hazardous waste (B3 waste) treatment-related activities (MOEF (Indonesia) 2021).
Lao PDR	Mercury waste is regulated under: (1) Environmental Protection Law (2012, revised); and (2) Ministerial Instructions on Hazardous Waste Management No. 0744/MONRE (2015). The Decision on National Environmental Standards (2017) specifies the mercury emission levels released into the air, water and soil environment from different industries; nevertheless, it does not refer to the oil and gas industry (MONRE (Lao PDR) 2017).
Malaysia	Mercury waste is mainly regulated under: (1) Environmental Quality Act (EQA) of 1974; and (2) Environmental Quality (Scheduled Wastes) Regulations 2005. The permissible exposure limit for the level of mercury exposure at the workplace is indicated in the Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000 (MOHR (Malaysia) 2000).
Myanmar	There is no specific law on mercury waste management. Mercury waste is managed under: (1) Environmental Conservation Law (No. 9/2012); (2) Environmental Conservation Rules (No. 50/2014); (3) National Waste Management Strategy & Master Plan for Myanmar (2018-2030); and (4) National Environmental Policy of Myanmar 2019. A National Hazardous Waste Management Master Plan (2020-2030) and Hazardous Waste Management Rules have also been drafted for the nation (Government of Myanmar 2020; Win 2021). The mercury emission levels for oil and gas activities are specified in the National Environmental Quality (Emission) Guidelines (MONREC (Myanmar) 2015).

Country	Regulatory framework
Philippines	Mercury waste is regulated as hazardous waste under: (1) Republic Act 6969 (1990); (2) DENR Administrative Order (DAO) 1992-29; (3) DAO 2004-36; and (4) DAO 2013-22. It is also regulated specifically as a commodity and as waste under the DAO 1997-38 and the DAO 2019-20 (DENR (the Philippines) 1997, 2019). The Republic Act 8749 sets out the mercury emission standard (maximum permissible limit of 5 mg Hg/NCM) for any trade, industry, process, fuel-burning equipment or industrial plant emitting air pollutants (Congress of the Philippines 1999), whereas the DAO 2016-08 specifies the mercury standards for effluents from different sectors, including the oil and gas industry into different water bodies (DENR (the Philippines) 2016).
Singapore	Mercury is regulated as hazardous waste under: (1) Environmental Public Health Act 1987 (revised 2002); (2) Environmental Public Health (Toxic Industrial Waste) Regulations 1988 (revised 2000); and (3) the Hazardous Waste (Control of Export, Import and Transit) Act 1997 (revised 2020). Mercury and its compounds are regulated as commodities under (4) the Environmental Protection and Management Act (EPMA) 1999 (revised 2020) and (5) the Environmental Protection and Management (Hazardous Substances) Regulations 2008. Compared to the Philippines, Singapore sets out a stricter mercury emission standard (maximum permissible limit of 0.05 mg Hg/Nm^3) for any trade, industry, process, fuel-burning equipment or industrial plant emitting air pollutants in the Environmental Protection and Management (Air Impurities) Regulations 2001 (revised 2008) (NEA (Singapore) 2008a). The mercury limits for trade effluents into controlled watercourses and other watercourses are specified in the Environmental Protection and Management (Trade Effluent) Regulations 1999 (revised 2008) (NEA (Singapore) 2008b).
Thailand	Mercury is regulated as hazardous waste under the Notification of the Ministry of Industry B.E.2548 (2005) and as a commodity under the Notification of the Ministry of Industry B.E. 2556 (2013) (MOI (Thailand) 2005a, 2013). The Notifications of the Ministry of Industry B.E. 2548 (2005), B.E. 2545 (2002) and B.E. 2549 (2006) set out the mercury emission limits for furnace oil in industry, industrial hazardous waste incinerators and general manufacturing (MOI (Thailand) 2002, 2005b, 2006).

Country	Regulatory framework
Vietnam	Mercury waste is regulated as hazardous waste under: (1) Law on Environmental Protection No. 21/VBHN-VPQH; (2) Decree No. 38/2015/ND-CP on Regulation of Waste and Discarded Materials; and (3) Circular 02/2022/TT-BTNMT Detailing on Implementation of the Law on Environmental Protection. The maximum mercury limit for air emissions from industrial waste incinerators is specified in the National Technical Regulation on Industrial Waste Incinerator (QCVN 30:2012/BTNMT), while the value of mercury parameter, which is used to calculate the maximum mercury limit in industrial wastewater, is indicated in the National Technical Regulation on Industrial Wastewater (QCVN 40:2011/BTNMT) (MONRE (Vietnam) 2011, 2012).

4.2.3 NORM Waste Management

Similar to mercury, Naturally Occurring Radionuclides (NORs) exist in the Earth's crust and hence are present in natural concentrations in global petroleum formations. Due to extraction processes, the concentrations of NORs in well fluids may rise, creating NOR enriched deposits within production facilities and thus forming Naturally Occurring Radioactive Material (NORM) such as produced water, scales, sludge and pigging debris (IOGP 2016). NORM waste released from oil and gas production and decommissioning activities can have toxicological effects on marine organisms, while exposure to radioactive elements in produced water particularly can lead to cancer and other consequences to human beings, animals, plants and insects (Ali et al. 2020; Jensen et al. 2016; MacIntosh et al. 2022).

A summary of the regulatory frameworks for NORM waste management in Indonesia, Malaysia, Thailand and Vietnam is presented in **Table 4**, more details can be found in Le et al. (2024).

Table 4 Regulatory frameworks for NORM waste management in four ASEAN countries (reproduced from Le et al. (2024), with permission from ASCE)

Country	Regulatory framework
Indonesia	NORM is managed under (i) Government Regulation (GR) No. 33 Year 2007 on Safety of Ionizing Radiation and Security of Radioactive Sources; (ii) GR No. 58 Year 2015 on Radiation Safety and Security on the Transport of Radioactive Materials; (iii) BAPETEN Chairman Regulation (BCR) No. 9 Year 2009 on Intervention on Exposure from TENORM; and (iv) BAPETEN Chairman Regulation (BCR) No. 16 Year 2013 on Radiation Safety of the TENORM Storage. In addition, the Act No.10 Year 1997 on Nuclear Energy is being amended to include NORM.
Malaysia	The overarching legal document related to NORM is the Atomic Energy Licensing Act 1984 (Act 304). NORM is also managed under the following documents: **Regulations:** (i) Radiation Protection (Licensing) Regulations 1986; (ii) Radiation Protection (Transport) Regulations 1989; (iii) Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010; and (iv) Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011. **Orders and Conditions of License:** (i) Atomic Energy Licensing (Exemption) (Small Amang Factory) 1994; and (ii) Atomic Energy Licensing (Exemption) (Low Level Radioactive Material) Order 2020. **Guidelines, Codes and Standards:** (i) Guidelines for the Preparation of a Radiation Protection Program (LEM/TEK/45, 2021); (ii) Guidelines on Radiological Monitoring for Oil and Gas Facilities Operations Associated with Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) (LEM/TEK/30, 2016); (iii) Code of Practice on Radiation Protection Relating to Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) in Oil and Gas Facilities (LEM/TEK/58, 2016); and (iv) Criteria for Siting of Disposal Facility for Waste Containing Naturally Occurring Radioactive Material (NORM) (LEM/TEK/76, 2020).
Thailand	The principal law related to radioactive waste management is the Nuclear Energy for Peace Act, B.E. 2559 (2016) which was amended by the Nuclear Energy Act for Peace No. 2, B.E. 2562 (2019). NORM is also managed under the following documents:

Country	Regulatory framework
	Ministerial Regulations (MR): (i) MR on Radioactive Waste Management, B.E. 2561 (2018); (ii) MR on Radiation Safety, B.E. 2561 (2018); (iii) MR on Permission to Import Radioactive Waste into and Export out of the Kingdom, B.E. 2561 (2018); (iv) Draft MR on Rules, Procedures, and Conditions Regarding Nuclear and Radiation Safety and Security in Transportation of Radioactive Material, Nuclear Material, Radioactive Waste, Nuclear Fuel, and Spent Nuclear Fuel (2017); and (v) Draft MR on Prescribing Rules, Procedures, and Conditions for Radioactive Waste Management by Radioactive Waste Producers and Radioactive Waste Transferred to the Government Agency for Management (2017). **Nuclear Energy for Peace Commission (NEPC) Requirement:** NEPC Requirement on Safety Criteria, B.E. 2562 (2019). **Office of Atoms for Peace (OAP) Guideline:** Draft OAP Guideline on Designation of the Customs Checkpoints that License Imports, Exports, or Transits Radioactive Material, Nuclear Material, or Radioactive Waste (2016).
Vietnam	Radioactive waste, including NORM waste, is managed under the Law on Atomic Energy (2008). Although a National Technical Regulation on Naturally Occurring Radioactive Material Waste (QCVN 23:2023/BKHCN) has been adopted, it does not apply to the oil and gas industry. Related regulatory documents include: • Ordinance No. 50-L/CTN on Radiation Safety and Control (ORSC) 1996; • Decree No. 50/1998/ND-CP on Implementation of the ORSC 1996; • National Standard on Radiation Protection, Radioactive Waste Management & Classification of Radioactive Waste TCVN 6868-2001; • Circular No. 23/2012/TT-BKHCN on Safe Transportation of Radioactive Materials; • Circular No. 04/2016/TT-BKHCN on Appraisal of Radiation Safety Evaluation Reports on Exploration and Exploitation of Radioactive Ores; and • Decree No. 142/2020/ND-CP on Implementation of Radiation Activities and Support Services for Using Atomic Energy.

5. Parameters for Developing the Guidelines

5.1 Technical Preparedness Checklist of Shipbuilding / Onshore Dismantling Facilities Based on The Literature Review

There are similarities in the processes, facilities, and hazardous material management between decommissioning of offshore structures and ship-breaking activities. **Figure 1** shows a conceptual layout of a model ship-breaking yard with the flow of ship recycling process at each zone, as indicated in the Basel Convention's *Technical Guidelines on the Environmentally Sound Management of the Full and Partial Dismantling of Ships* (UNEP 2003). This layout is also commonly used for decommissioning yards. The process begins with the placement of the structure at the yard on the Containment Zone. Then, the structure will be moved to block breaking areas (Zone A and Zone B) for several stages of dismantling and demolition. The demolished materials must be sorted, decontaminated, and overhauled, according to their material properties, in Zone C. Lastly, the materials will be sent to Zone D for storage, or Zone F for hazardous waste disposal.

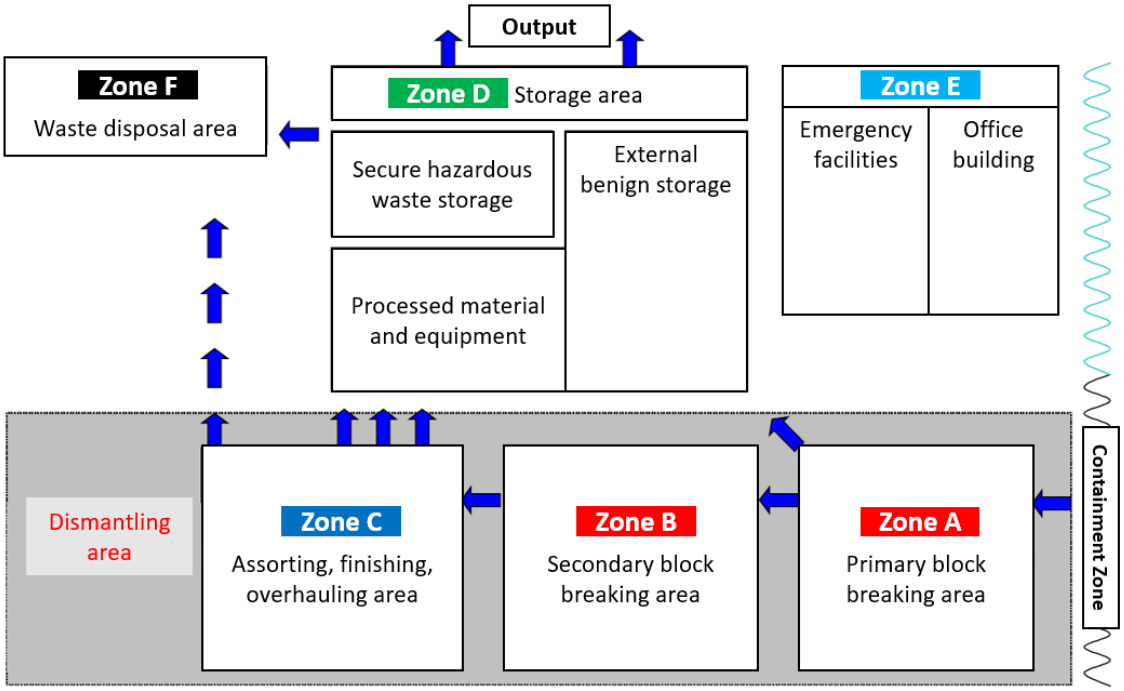

Figure 1 Conceptual layout of a model ship-breaking yard (modified from UNEP 2003)

Table 5 summarizes the crucial parameters for evaluating the technical preparedness of shipbuilding/ onshore dismantling facilities to receive decommissioned offshore structures, with particular attention to each zone as identified in UNEP's (2003) conceptual layout of a model ship-breaking yard mentioned above. This checklist integrates the information from the regulations and guidelines for ship recycling indicated in Section 4.1 and some technical reports of decommissioning yards in the North Sea. This checklist was published in Leow et al. (2023).

Table 5 Checklist of shipbuilding/ onshore dismantling facilities (CRF Consultants 2016; European Commission 2013; IMO 2009; Norwegian Climate and Pollution Agency 2011; Shell U.K. Limited. 2019; UNEP 2003; reproduced from Leow et al. (2023), with permission from OSE)

Zone	Characteristic		Description
	Site Description	Site General Info	Facility Location
			Facility Area (m^2)
			Distance to Open Sea
			Restriction in the Approach Channel (Air Draft/ Width)
			Approach Channel Depth (m)
			Past Offshore Construction Project
			Demolition License Permit
		Site Restriction	Limit for Release to Air
			Limit for Release to Water
			Noise Limit
			Permitted Working Hour
			Requirement Related to Specific Area
			Requirement For an Impermeable Surface
		Facility Future Potential	Industrial Footprint Area (m^2)
			Potential Area for Future Development (m^2)
		On land Transportation	On land Transportation Facilities
A, B	Facilities Information	Heavy Lifting Machine Info	Crane Number
			Crane Type
			Crane Capacity (t)
C			Workshop Number

Zone	Characteristic		Description
		Workshop's Info	Workshop Type
			Workshop Area (m^2)
D		Storage Area Info	Storage Area Size (m^2)
			Storage Site Characteristic
E		Emergency Facilities	Quarantine Areas (m^2)
			Emergency Areas (m^2)
A, B	Working Area Information	Load-In Capabilities	Bollard Pull Capacity (t)
			Load-In Points Capacity (t/m^2)
		Quay Info	Quay Numbers
			Quay Foundation Bearing Capacity (t/m^2)
			Berthing Capacity
			Water depth Near Quay (m)
		Working Area Properties	Facilities to Contain Liquid Waste Within Working Area
			Working Area Size (m^2)
			Impermeable Surface
D	Scrap Storage Area Information	Laydown and Pad Info	Laydown Area Size (m^2)
			Pad Capacity (Length and Maximum Pressure)
			Pad Characteristic (Material)
			Presence/ Availability of Impermeable Surface
C, D	Waste Management Information		Waste Handling Capacity (ton per year)
			Distance to a Waste Management Center

5.2 Self-Developed Technical Preparedness Checklist of Shipbuilding/ Onshore Dismantling Facilities

As part of our research, the following checklist of shipbuilding/ onshore dismantling facilities was developed based on the checklist mentioned in **Table 5** above, with the added information (marked in blue) from the checklist utilised by Sea Sentinels, a ship recycling compliance auditor, for Green Ship Recycling yard audit, and in consultation with the Basel Convention's *Technical Guidelines on the Environmentally Sound Management of the Full and Partial Dismantling of Ships* (Basel Convention's Technical Guidelines for the Dismantling of Ships) (2003), the *Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships* (Hong Kong Convention) (2009), and the *European Council Directive 89/656/EEC on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace* (European Council Directive 89/656/EEC). This checklist is highly recommended for assessing the technical preparedness of shipbuilding/ onshore dismantling facilities to receive decommissioned offshore structures.

Table 6 Self-developed technical preparedness checklist of shipbuilding/ onshore dismantling facilities (adapted from Leow et al. (2023), with permission from OSE)

Zone	Characteristic		Description	Requirement
	Site Description	Site General Info	Facility Location	Where is the dismantling yard located?
			Facility Area (m^2)	- Do you have an approved yard layout plan/ map? - Do you have a secondary recycling site apart from the main one (Backyard)? If yes, is the secondary recycling site certified by the state authority? - Does the yard have sufficient area for large-scale demolition of modules/ topsides and jackets?
			Distance to Open Sea	How far is it from the oil and gas platform to the dismantling yard by sailing?
			Restriction in the Approach Channel (Air Draft/ Width)	What are the draft and air draft restrictions in the approach channel for heavy lift vessels and barges?
			Approach Channel Depth (m)	What is the depth of the approach channel?
			Past Offshore Construction Project	How many decommissioning projects has the yard undertaken so far?

Zone	Characteristic		Description	Requirement
			Demolition License Permit	Do you hold a dismantling permit issued by the state authority of your country? If yes, please give reference to respective documents.
			Certification	- What are the valid certificates that the yard has? For example, ISO 9001, 14001 and 45001, International Association of Classification Societies (IACS) certificates, etc. and issued by whom? Any other valid certificates and issued by whom? - Are you a member of any registered ship recycling association?
			Structure Dismantling Facility Plan and Structure Dismantling Plan	- Do you have a Structure Dismantling Facility Plan? If yes, please give reference to the respective document. - Do you have procedures in place for preparation of a Structure Dismantling Plan? If yes, please give reference to the respective documents.
			Inventory of Hazardous Materials (IHM)	- Do you have procedures in place to identify hazardous materials from decommissioned offshore structures? If yes, please give reference to the respective documents.

Zone	Characteristic		Description	Requirement
				- Do you have procedures in place to receive and use IHM from decommissioned offshore structures? If yes, please give reference to the respective documents. - Do you have an IHM for decommissioned offshore structures? Who develop the IHM?
			Safe and environmentally sound management of hazardous materials	- Do you provide any kind of barrier to prevent hazardous materials accessing the marine environment, shore, land and air? If yes, which ones? - Do you have procedures in place describing how to handle hazardous materials during dismantling activities? If yes, please provide reference to the documents. - Do you have overflow water/ rainwater collection, treatment and disposal systems on site? - Do you distinguish between normal operational emissions and polluting incidents/ accidents? If yes, please specify the monitoring method.

Zone	Characteristic		Description	Requirement
				- Is the waste generated from the dismantling activity and its quantity well documented?
			Prevention of accidents	- Do you have procedures/ permits in place to ensure 'safe-for-entry" and "safe-for-hot work" in enclosed/ open spaces or protection of working at heights? If yes, please give reference to the relevant documents. - Does the facility establish management and monitoring systems, procedures and techniques which have the purpose of preventing, reducing, minimising and to the extent practicable, eliminating health risks to the workers concerned and to the population in the vicinity of the dismantling facility, and adverse effects on the environment caused by structure dismantling? - Do you maintain an accident/ incident/ injury record and who is the responsible person to do this?

Zone	Characteristic		Description	Requirement
			Emergency preparedness and response	- Have you established a list of possible emergency situations? If yes, please give reference to the respective document. - Does the dismantling facility establish and maintain an emergency preparedness and response plan; ensure rapid access for emergency response equipment, such as fire-fighting equipment and vehicles, ambulances and cranes, to all areas of the dismantling facility? - Do you provide first-aid and medical assistance in your dismantling facility in case of emergency? Do you have a dedicated first-aid room? - Do you have a procedure to carry out emergency preparedness mock drills? - Do emergency vehicles have access to your dismantling facility in case of emergency? If yes, please describe how and locations.
			Worker safety and training	- Do you provide personal protective equipment (PPE)? If yes, please describe the standards and types of PPE, and for which purposes.

Zone	Characteristic		Description	Requirement
				- Do you check if your staff is capable of performing the job they are assigned to? If yes, how? - Do you provide training for the staff to perform safe and environmentally sound structure dismantling? If yes, please give reference to the respective documents. - Do you provide worker safety and training, including ensuring the use of PPE for operations requiring such use? Do you have qualified safety inspectors on site who can ensure compliance? - Do you impart periodic training to the yard and sub-contractor's workers? Do you have an induction and familiarization training for all new and existing workers? - Do you maintain a training record book and who is the responsible person to maintain this?
			Reporting	- Do you report on incidents, accidents, and/or chronic effects regarding environmental and/ or safety issues? How is

Zone	Characteristic		Description	Requirement
				the record maintained? If yes, how and to whom? - What procedures are followed to prove that the relevant authorities are being notified on the respective dismantling activities?
			Workers' health and welfare	- Do you provide accommodation for your workers? If yes, what facilities do you provide them? - Do you provide periodic health checkups for your workers? If so, please provide the details. - Do you provide a clean canteen and a mess room? - Do you provide any recreational area for workers? - Do you have an equipped emergency medical room on site? - Do you have a process whereby yard workers can voice and resolve concerns and grievances regarding all workplace issues without fear of retribution?

Zone	Characteristic		Description	Requirement
				- Does the company require facilities to enable yard workers to associate and bargain collectively?
		Site Restriction	Limit for Release to Air	Which air emission limit does the yard follow? Which regulation/ standard does it come from?
			Limit for Release to Water	Which water pollution limit does the yard follow? Which regulation/ standard does it come from?
			Noise Limit	Which noise exposure limit does the yard follow? Which regulation/ standard does it come from?
			Permitted Working Hour	What are the permitted working hours in the yard? Which regulation/ standard specifies these?
			Requirement For an Impermeable Surface	Do you provide impermeable floor(s) for the dismantling area(s)?
		Facility Future Potential	Industrial Footprint Area (m^2)	How large is the industrial footprint area in the yard? Have you planned to upgrade it?
			Potential Area for Future Development (m^2)	Can the yard be extended (especially the dismantling area) to enhance its activities

Zone	Characteristic		Description	Requirement
				(eg: receiving large topsides and jackets)? How large is the extended area?
		On land Transportation	On land Transportation Facilities	Name the types, quantities and capacities of on land transportation facilities that the yard possesses.
A, B	Facilities Information	Heavy Lifting Machine Info	Crane Number	Do you have lifting devices (e.g., heavy lift cranes) for lifting the structure/ structure´s sections directly to the yard? If yes, how many?
			Crane Type	Please provide the crane type(s).
			Crane Capacity (t)	- Please provide the crane capacity(ies). - Can your heavy lifting machines lift off all the structure/ structure´s sections to the yard without dropping them in the beach area/ water? Are the heavy lifting machines rated for this? Please provide the ratings and inspection/ certification documents for the heavy lifting machines.
C		Workshop Info	Workshop Number	How many workshops are there in the yard?
			Workshop Type	What types or workshops are they? Were they designed to accommodate a particular hazardous material, e.g.: mercury or NORM?

Zone	Characteristic		Description	Requirement
	Working Area Information		Workshop Area (m^2)	How large are the workshops?
D		Storage Area Info	Storage Area Size (m^2)	How large is the storage area?
			Storage Site Characteristics	- What are the characteristics of the storage site(s)? - How is the storage of potentially oil leaking equipment managed?
E		Emergency Facilities	Quarantine Area (m^2)	Does the yard have a quarantine area to prevent the spread of disease? How large is it?
			Emergency Area (m^2)	Does the yard have an emergency refuge area to hold occupants during a fire or other emergency situations when evacuation may not be safe or possible? How large is it?
A, B		Load-In Capabilities	Bollard Pull Capacity (t)	What are the pull capacities of the bollards in the yard?
			Load-In Points Capacity (t/m^2)	Can the yard offload barges, sheer legs, mono hull vessels and heavy lift/ single lift vessels? What are the capacities of the load-in points?
		Quay Info	Quay Numbers	How many quays does the yard possess?

Zone	Characteristic		Description	Requirement
			Quay Foundation Bearing Capacity (t/m^2)	What are the quay foundation bearing capacities?
			Berthing Capacity	Can the yard berth barges, sheer legs, mono hull vessels and heavy lift/ single lift vessels? What is the berth capacity?
			Water depth Near Quay (m)	What are the water depths near the quays?
		Working Area Properties	Facilities to Contain Liquid Waste Within Working Area	- Do you have containment areas to limit oil spill at key locations so that the yard contamination can be avoided? - Do you have an adequate liquid waste collection system on site?
			Working Area Size (m^2)	What is the size of the working area?
			Impermeable Surface	Do you provide impermeable floor(s) for the dismantling area(s)?
D	Scrap Storage Area Information	Laydown and Pad Info	Laydown Area Size (m^2)	What is the size of the laydown area?
			Pad Capacity (Length and Maximum Pressure)	What is the pad capacity, i.e., its length and maximum pressure?
			Pad Characteristic (Material)	What is the pad made of?

Zone	Characteristic		Description	Requirement
			Presence/ Availability of Impermeable Surface	Do you provide impermeable floor(s) for the storage area(s)?
C, D, F	Waste Management Information		Waste storage	Do you have storage areas for non-hazardous materials, scrap metals, reusable materials and hazardous materials prior to disposal, sale or further treatment? Are these areas in accordance with the regulations and properly maintained?
			Waste Handling Capacity (ton per year)	What is the waste handling capacity (ton per year) of the yard?
			Distance to a Waste Management Center	How far is it from the yard to the closest waste management center?
			Downstream Waste Management	- Do you have procedures in place to control downstream waste handling? If yes, please give reference to the respective documents. - Do you choose specific downstream waste management facilities? If yes, please provide a list of companies and the waste they are handling.

6. Guidelines

6.1 Guidelines for Safe and Sustainable Recycling Facilities

The following guidelines were developed for upgrading shipbuilding/ onshore dismantling facilities to become safe, green and sustainable recycling facilities for decommissioned offshore structures, based on the self-developed technical preparedness checklist mentioned above.

6.1.1 Critical Aspects and Environmental Challenges

The Basel Convention's Technical Guidelines for the Dismantling of Ships specify important aspects to be considered during the dismantling process of ships and the potential environmental challenges (UNEP 2003). Given the similarities and differences between ship dismantling and oil and gas structure decommissioning, such aspects and challenges have been revised as in **Table 7** to accommodate oil and gas structure decommissioning practices.

Table 7 Critical aspects and environmental challenges of oil and gas structure decommissioning (adapted from UNEP (2003))

Critical aspects	Challenges
Access	It is important to ensure easy controllable overall access, which can be facilitated by requiring the dismantling candidate to meet certain norms. ✓ IHM: prepared IHM – physical marking of hazardous materials. ✓ Facility specifics which can influence access significantly, for example: restriction in the approach channel (air draft/ width) and approach channel depth.
Containment	The process of structural dismantling, sorting/ material preparations, storage, disposal and transport can inevitably cause potential releases to the environment (air/ sea/ ground): debris, liquid residues, fumes following cutting/ burning. Containment needs to be maintained to ensure such releases are within the national limits.
Recycling, removal, disposal	There are components and materials generated from the dismantling process which are feasible for reuse or recycling and will be transported out of the facility. Some of these components and materials may be contaminated (coated steel plating), hazardous, or undesirable for return to market. Some materials such as polychlorinated biphenyls (PCBs), other persistent organic pollutants (POPs), and asbestos must under no circumstances be recycled. Sufficient, safe, monitored storage and disposal facilities must be available for hazardous waste.
Training	Awareness and skills are essential from environmental, occupational health and safety aspects. Proper focus should be given to workers' training in operational/ technical/ environmental procedures and use of PPE. Only adequately trained personnel are allowed to access various areas in the dismantling facility.

- **Environmental concerns - potential releases to air, water and ground**

It is extremely important to correctly handle substances released from dismantling so as to avoid contamination of air, drinking water and the food chain. Contamination can make both acute and long-term impacts on both the yard's personnel and the adjacent community (UNEP 2003).

Major environmental concerns relate to:

- ✓ Location: The nature of the dismantling facility may not conform to the location's vulnerability or the local community's requirements.
- ✓ Operation: The facility specifics may be inadequate in respect of containment and prevention of toxins from entering water, sediments/ ground and/ or air.

Such concerns should be fully addressed by the Environmental Impact Assessment (EIA). The EIA must consider the national legal framework and include preventative measures for mitigating negative environmental impacts. It should be implemented at the planning stage and initiated as early as possible (UNEP 2003).

Onshore decommissioning operations should pay attention to 25 types of hazardous materials commonly found from offshore structures (SEPA 2018; UNEP 2003). Such hazardous materials are categorized as primary and non-primary hazardous materials based on the level of toxicity, which differ by countries. For example, in the North Sea, four of them are categorized as primary hazardous materials, particularly natural occurring radioactive material (NORM) or low specific activity (LSA) material, mercury, asbestos, and PCBs (ABS 2018; DECOM North Sea 2018; European Commission 2013). **Table 8** presents some of such hazardous materials and their potential environmental effects.

Table 8 Side effects of some hazardous materials from offshore structures (ABS 2018; Du et al. 2018; Norwegian Climate and Pollution Agency 2011; SEPA 2018; reproduced from Leow et al. (2023), with permission from OSE)

Hazardous materials	Side effects
LSA	Emits hazardous radiation that could harm the human body.
Asbestos	Potentially accumulates in the human body for a long time and causes lung cancer. Symptoms may not show up until many years after exposure.
Mercury	Toxic, bio accumulative, and affects the nervous system.
PCBs	Potentially induce cancer and damage to liver, neurological and immune systems.
Lead	Causes damage to neurological system, hearing, vision, reproductive system, blood vessels, kidneys, and heart, especially to children's physical and neurological development.
Cadmium	Leads to cancer and organ system toxicity to skeletal, urinary, reproductive, cardiovascular, central, peripheral nervous, and respiratory systems.
Hexavalent chromium	Leads to lung cancer, irritation or damage to nose, skin and eyes.
Oil and fuel	Poisonous through inhalation or consumption of contaminated water or fish. May result in fire and explosion.
Polyvinyl chloride (PVC)	Potentially causes cancer, asthma, and impairment to human reproduction systems. Burning may generate carbon monoxide, highly toxic dioxins, and furans etc. Burial may release chemicals to groundwater.
Halon Gas	Environmental pollution.
Organotin compounds	Contaminates sea products, potentially making hazardous effects on human health.
Chloroparaffins	Suspected of causing cancer in humans and considered as endocrine disruptors.
Phthalates	Interferes with the production of male sex hormones.

6.1.2 Site Procedures

6.1.2.1 Structure Dismantling Facility Plan and Structure Dismantling Plan

- Structure Dismantling Facility Plan

Based on Hong Kong Convention's requirements for a Ship Recycling Facility Plan, a Structure Dismantling Facility Plan needs to be prepared by the dismantling facility and include:

- a policy that ensures workers' safety and the protection of human health and the environment, including the establishment of objectives that lead to the minimization and elimination to the extent practicable of the negative impacts on human health and the environment caused by structure dismantling;
- a system for ensuring the attainment of the goals set out in the policy of the dismantling yard, and the continuous improvement of the procedures and standards used in the structure dismantling operations;
- identification of roles and responsibilities for employers and workers when implementing structure dismantling operations;
- a programme for providing suitable information and training of workers for the safe and environmentally sound operation of the structure dismantling yard;
- an emergency preparedness and response plan;
- a system for monitoring the structure dismantling operation;
- a record-keeping system that shows how structure dismantling is undertaken;
- a system for reporting discharges, emissions, incidents and accidents that cause damage, or with the potential of causing damage, to workers' safety, human health and the environment; and
- a system for reporting occupational diseases, accidents, injuries and other negative impacts on workers' safety and human health (adapted from IMO (2009)).

- Structure Dismantling Plan

Based on Hong Kong Convention's requirements for a Ship Recycling Plan, a Structure Dismantling Plan needs to be developed by the dismantling facility prior to dismantling a structure and fulfil the following criteria:

- being developed with consideration of the information provided by the structure's owner; and
- including information concerning *inter alia*, the establishment, maintenance, and monitoring of Safe-for-entry and Safe-for-hot work conditions and how the type and amount of materials including those identified in the Inventory of Hazardous Materials will be managed (adapted from IMO (2009)).

6.1.2.2 Inventory of Hazardous Materials (IHM)

Based on Hong Kong Convention's requirements about IHM for ships, an offshore oil and gas platform must have an IHM which is verified by the government which has the authority over it, taking into account the national legal framework, including any threshold values and exemptions set out in such legal framework, and updated before dismantling (adapted from IMO (2009)).

6.1.2.3 Prevention of Accidents

- Safe-for-entry

According to Hong Kong Convention, "safe-for-entry" means the space that fulfils the following criteria: (i) the oxygen content of the atmosphere and the concentration of flammable vapours are within safe limits; (ii) any toxic materials in the atmosphere are within permissible concentrations; and (iii) any residues or materials associated with the work authorized by the governmental authority will not produce uncontrolled release of toxic materials or an unsafe concentration of flammable vapours under existing atmospheric conditions while maintained as directed (adapted from IMO (2009)).

- Safe-for-hot work

According to Hong Kong Convention, "safe-for-hot work" means a space that fulfils the following criteria:

- a safe, non-explosive condition, including gas-free status, exists for using electric arc or gas welding equipment, cutting or burning equipment or other forms of naked flame, as well as heating, grinding, or spark generating operations;
- safe-for-entry requirements are met;
- existing atmospheric conditions will not change due to the hot work; and
- all adjacent spaces have been cleaned, or inerted, or treated adequately to prevent the start or spread of fire.

- Working at heights

According to the European Council Directive 89/656/EEC, the following PPE can be used for protection against falls from a height, such as retractable type fall arresters, full body harnesses, sit harnesses, belts for work positioning and restraint and work positioning lanyards, energy absorbers, guided-type fall arresters including an anchor line, rope adjustment devices, anchor devices that are not designed to be permanently fixed and that do not require fastening works before use, connectors, lanyards, rescue harness (European Council 1989).

6.1.2.4 Emergency Preparedness and Response

Based on IMO's (2009) requirement for a ship dismantling facility, an oil and gas decommissioning facility must establish and maintain an emergency preparedness and response plan. Such a plan must be prepared with consideration of the location and environment of the decommissioning facility, as well as the size and nature of activities associated with each platform decommissioning operation. The plan must also:

- ensure that the necessary equipment and procedures shall be followed when emergency occurs, and that drills are conducted regularly;

- ensure that the necessary information, internal communication and coordination are provided to protect all people and the environment in the case of an emergency;
- provide for communication with, and information to, the relevant governmental authority(ies), the neighbourhood and emergency response services;
- provide for first-aid and medical assistance, fire-fighting and evacuation of all people at the dismantling facility, pollution prevention; and
- provide for relevant information and training to all staff of the dismantling facility, at all levels and according to their competence, including regular exercises in emergency prevention, preparedness and response procedures (adapted from IMO (2009)).

In addition, according to the Basel Convention's Technical Guidelines for the Dismantling of Ships, emergency should ensure: (i) the exposure of staff is limited as much as possible during the dismantling operation; (ii) contaminated areas are cleaned and if necessary disinfected; and (iii) effects on the environment are as limited as possible. In particular, a procedure for responding to injuries or exposure to hazardous substances should be set up (UNEP 2003). Minimum of training should be provided to all staff with the following procedures:

- providing immediate first aid, such as eye splashing, cleansing of wounds and skin, and bandaging;
- immediately reporting to a responsible designated person;
- if possible, retaining the item and details of its source for identifying possible hazards;
- providing rapid additional medical care from medical personnel;
- conducting medical surveillance;
- recording the incident; and
- investigating, determining and implementing remedial action (UNEP 2003).

UNEP (2003) also emphasises response to spills, with establishment of a spill cleaning procedure including safe handling operations and suitable protective clothing. UNEP's (2003) guidance on a general procedure for spill cleaning is presented in **Table 9**.

Table 9 General procedure for spill cleaning (UNEP 2003)

Action No.	Description of action
1	Evacuating the contaminated area
2	Providing immediate eye and skin cleaning of exposed personnel
3	Informing designated personnel
4	Determining the nature of the spill
5	Providing first aid and medical care to injured personnel
6	Securing the area to prevent additional exposure of persons
7	Providing sufficient protective equipment to personnel involved in clean up
8	Limiting the spreading of the spill
9	Neutralising or disinfecting the spill or contaminated area if necessary
10	Collecting and rinsing the spill and the contaminated area into suitable bags and containers
11	Neutralising, disinfecting and rinsing the used equipment and personal protective equipment
12	Determining personnel injury status. If required, seeking immediate medical assistance.

6.1.2.5 Worker Safety and Training

Based on Hong Kong Convention's requirements, dismantling facilities must provide for worker safety by measures including:

- ensuring the availability, maintenance and use of personal protective equipment and clothing needed for all dismantling operations;
- ensuring that training programmes are provided to enable workers to safely undertake all dismantling operations they are tasked to do; and
- ensuring that all workers at the dismantling facility have been provided with appropriate training and familiarization prior to performing any platform decommissioning operation (IMO 2009).

6.1.3 Site Restriction

- Limit for Release to Air, Limit for Release to Water, Noise Limit

The yard must adhere to national regulations and standards for air emission limit, water pollution limit and noise exposure limit, and if possible, international standards for these. Since there are risks associated with exposure limits, a general assessment of exposure risks in the dismantling facility should be conducted for different waste streams (UNEP 2003). UNEP (2003) provides guidance on exposure assessment as illustrated in **Figure 2**.

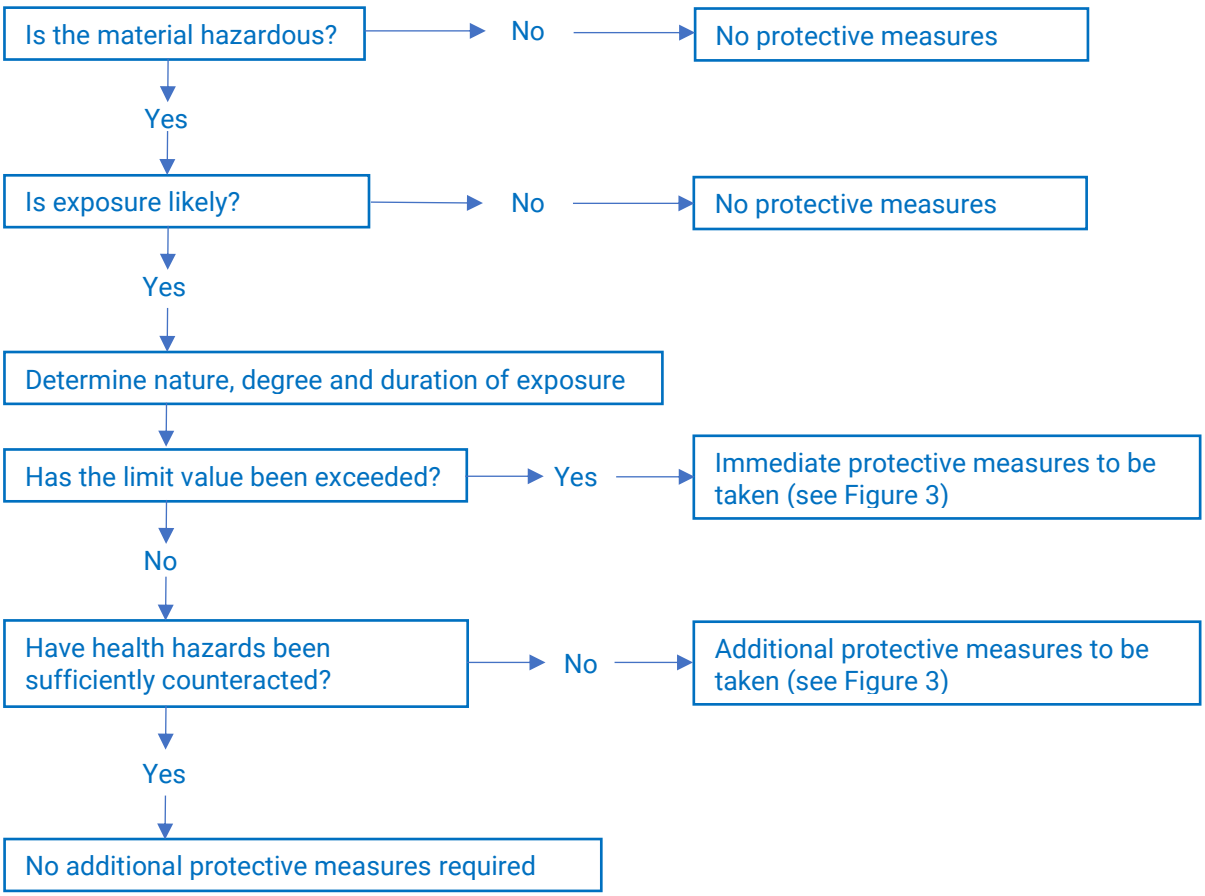

Figure 2 Exposure assessment (modified from UNEP (2003))

When exposure levels exceed legal limits, measures must be undertaken by the yard to decrease such exposure levels. In addition, when there are still health risks associated with the exposure levels that are below the legal limits, additional measures need to be applied to minimise risks to the highest possible level (UNEP 2003).

The best practice is to take measures as close to the source as possible. The levels of control measures should be as follows:

- 1st level: Measures at the source
- 2nd level: Compartmentalisation and isolation
- 3rd level: Application of PPE

The procedure for defining exposure control measures is presented in **Figure 3**.

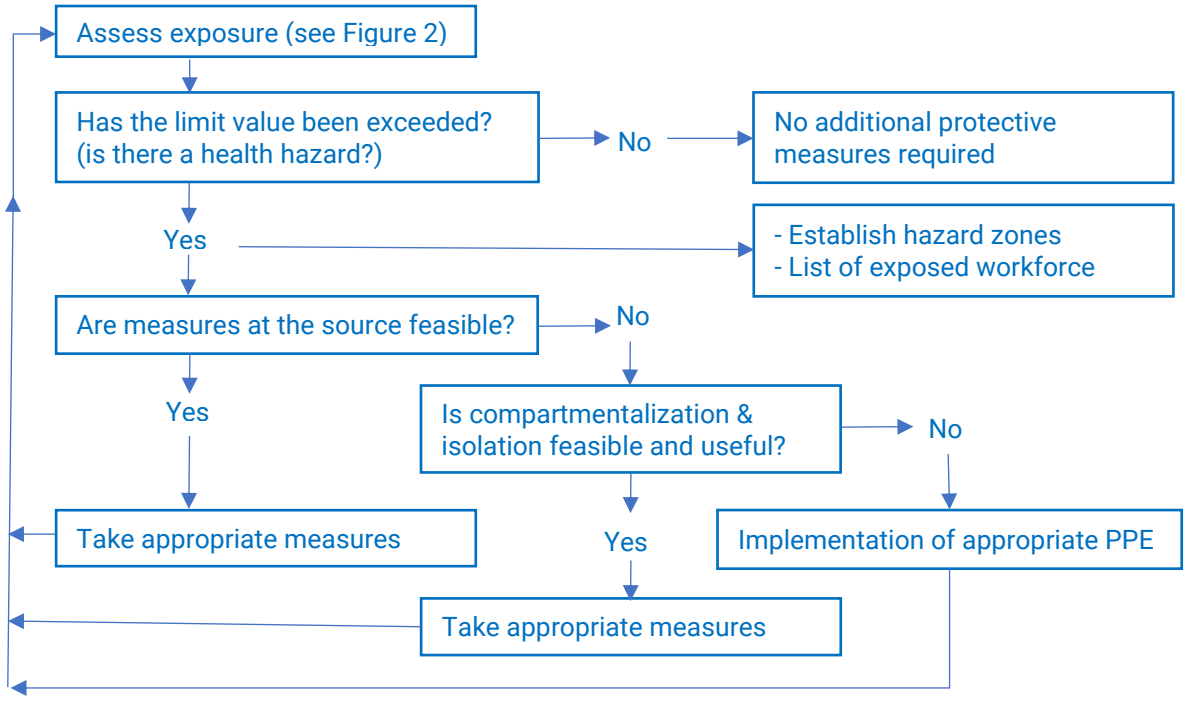

Figure 3 Exposure control measures in dealing with hazardous waste (modified from UNEP (2003))

6.1.4 Stepwise Improvement Approach for Upgrading Existing Dismantling Facilities

The upgradation of existing dismantling facilities can be achieved by applying a stepwise improvement approach, with the actions reflecting their impacts on human health and the environment (UNEP 2003). Based on the Basel Convention's Technical Guidelines for the Dismantling of Ships, realistic actions can be undertaken immediately or within a short timeframe (one year), including mostly operational measures and low-cost physical measures, such as training and awareness building, as well as PPE provision (UNEP 2003). Adapted from UNEP's (2003) guidance, long-term actions for structure dismantling should mainly focus on realising the physical needs for environmentally sound dismantling of offshore structures, including: impermeable floors for dismantling area(s), removal of mercury/ NORM by high standards; a landfill with sufficient environmental protection; and a wastewater treatment facility. The stepwise improvement approach adapted from UNEP (2003) for dismantling of offshore structures in ASEAN is presented in **Table 10**.

Table 10 Stepwise upgradation of existing dismantling facilities in ASEAN for offshore structures (adapted from UNEP (2003))

<table>
<tr><th>At the latest within 1 year</th><th>At the latest within 5 years</th><th>At the latest within 10 years</th></tr>
<tr><td>Inventory of hazardous materials</td><td rowspan="10"></td><td rowspan="15"></td></tr>
<tr><td>Hot work certification</td></tr>
<tr><td>Cleaning and testing before dismantling</td></tr>
<tr><td>Hazardous waste storage</td></tr>
<tr><td>Firefighting equipment</td></tr>
<tr><td>Basic PPE</td></tr>
<tr><td>Suitable protective equipment against respiratory hazards</td></tr>
<tr><td>Waste segregation and collection</td></tr>
<tr><td>Hazardous waste (especially mercury and NORM) handling procedures</td></tr>
<tr><td colspan="2">Sufficient transfer operations facilities</td></tr>
<tr><td colspan="2">Spill containment equipment</td></tr>
<tr><td colspan="2">Sufficient stormwater discharge facilities</td></tr>
<tr><td colspan="2">Special respiratory protective equipment for paint removal operations</td></tr>
<tr><td colspan="2">Improved hazardous waste (especially mercury and NORM) removal facilities</td></tr>
<tr><td colspan="3">Sufficient draining and pumping equipment</td></tr>
<tr><td colspan="3">Provide sufficient treatment/ disposal facilities for different hazardous materials</td></tr>
<tr><td colspan="3">Spill cleanup equipment</td></tr>
<tr><td colspan="3">Separate area for paint removal operations, with impermeable floor. Cover, isolate area, and ventilate. Install proper air filtering system.</td></tr>
<tr><td colspan="3">Create a dedicated area for segregation of hazardous materials</td></tr>
<tr><td colspan="3">Complete containment for all structure dismantling activities</td></tr>
<tr><td colspan="3">Removal of mercury by high standards</td></tr>
</table>

6.2 Guidelines for Waste Management Facilities

Waste management facilities are actually Zone F of a dismantling facility. Some dismantling facilities can have waste management facilities (such as landfilling, incineration or wastewater treatment) on site (for example, Able UK, Greenhead Base, or Harland & Wolff yards in the UK (CRF Consultants 2016)) or further away. The following guidelines were developed based on the review of the regulatory frameworks for hazardous waste management facilities in Southeast Asia, some international guidelines, as well as the case studies/ review of hazardous waste, mercury waste and NORM waste management facilities in the region.

6.2.1 Operational Procedures

Waste management facilities should develop operational procedures based on the national regulations and guidelines, and if possible international standards. The operations of such facilities should be certified with ISO 9001, ISO 14001 and ISO 45001 (previously OHSAS 18001) which are international standards for quality management systems, environmental management systems and OHS (occupational health and safety) management systems, respectively (OSHAS Project Group 2007). Based on Le et al.'s (2022) case studies on PT Prasadha Pamunah Limbah Industri (PPLi) in Indonesia and Kualiti Alam Waste Management Centre (Kualiti Alam) in Malaysia, some international standards should be achieved for hazardous waste handling equipment/ facilities are EU regulatory standards for the-Waste-to Energy plant; US EPA, APHA, ASTM standards for laboratory management services; World Bank, US EPA, and EU standards for the eco-landfill; EU emission requirements for the incinerator; and US EPA standards for the waste management procedures, and dehalogenation for PCBs waste. Le et al.'s (2023) case study on BMT Thailand (Thailand) shows that mercury waste management should comply with the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* and *the Minamata Convention on Mercury* as well as the technical guidelines of these conventions.

6.2.2 Important Facilities and Techniques

- **Incinerator**

Table 11 presents information of the incinerators in Kualiti Alam and PPLi, which can be used as references for installing incinerators. The design and image of such incinerators are shown in **Figure 4** and **Figure 5**.

Table 11 Incinerators in Kualiti Alam and PPLi

Kualiti Alam	PPLi
The Incineration Plant has the capacity of 33,000 metric tonnes of scheduled waste yearly, treating organic waste such as mineral oil waste, waste solvents, pesticide waste and waste containing halogens and sulphur; and inorganic waste such as metal hydroxide sludge with more than 10% Total Organic Carbon (TOC) (Cenviro 2023). The incineration is monitored by the Continuous Emissions Monitoring System (CEMS), ensuring the emissions meet the national environmental standards (Cenviro 2022). Fully computerised and equipped with CEMS, the Incineration Plant represents the latest standard in rotary kiln incineration technolgy (Kualiti Alam 2019). The incineration facilities have increasingly used reconstituted oil instead of diesel as fuel sources, underlining Kualiti Alam's commitment to reducing their dependence on fossil fuels (Cenviro 2022).	The Incinerator can treat both hazardous and non hazardous waste, in solid and liquid forms (PPLi 2019). Particular waste that can be treated includes combustible organic waste, oilly sludge, paint sludge, used rags, plastic waste, expired and off-spec materials and products, used drilling mud from oil and gas exploration, expired chemicals and residual samples from laboratories, medical waste from healthcare facilities, POPs such as PCBs, and pesticides (PPLi 2022). The amount of CO_2 emissions released from the Incinerator, which is of a vertical stoker type, is reduced dramatically compared to conventional incinerators (PPLi 2019). The Incinerator is also equipped with the emission control equipment to be able to meet both the Indonesian and EU emission requirements (PPLi 2021b, 2022).

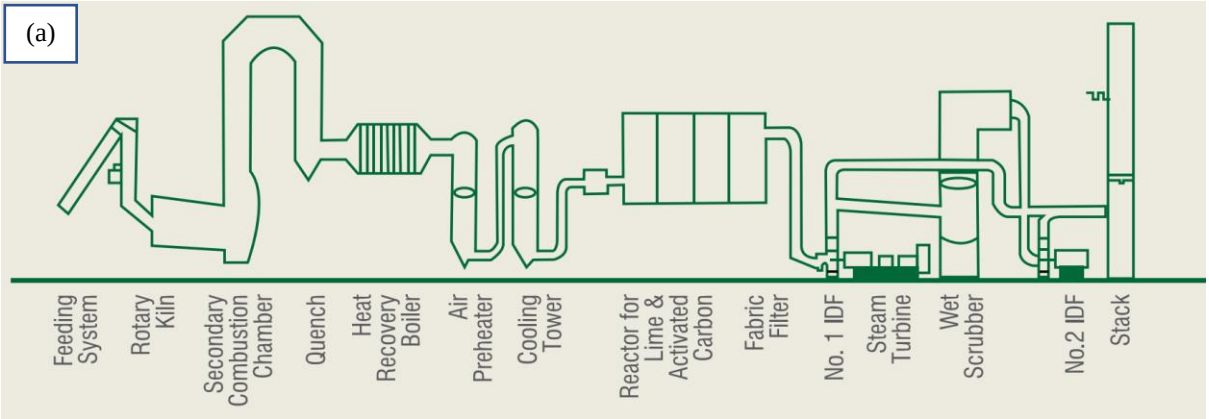

Figure 4 The design (a) and image (b) of Kualiti Alam's Incineration Plant (reproduced from Cenviro (2023) and Kualiti Alam (2019), with permission)

Figure 5 PPLi's Incinerator (reproduced from PPLi (2022), with permission)

- **Landfill**

Table 12 presents information of the landfills in Kualiti Alam and PPLi, which can be used as references for constructing landfills. The sketch and image of such landfills are given in **Figure 6** and **Figure 7**.

Table 12 Landfills in Kualiti Alam and PPLi

Kualiti Alam	PPLi
The Vertical Secured Landfill was constructed in 2015 to replace the existing secured landfill in Kualiti Alam (Cenviro n.d.). Geogrid walls were built along the existing secured landfill, potentially extending the landfill life by over 30 years and saving 45 acres of land (Cenviro 2022). As of 2022, the waste disposed at Phase 1 site was 124,576 tonnes, leaving the remaining capacity to be 5%. Ready to be utilised once Phase 1 site reaches its full capacity, Phase 2 site has the estimated lifespan of 12 years (Cenviro 2022). Waste deposited in the Landfill includes slag from the Incineration Plant, solidified waste from the Solidification Plant, inert waste from the Clinical Waste Treatment Centre, and waste that fulfils the direct Landfill Waste Acceptance Criteria (Cenviro 2023).	PPLi's Eco-Landfill is authorized as the only hazardous waste landfill in Indonesia and meets Indonesian, World Bank, US EPA and EU standards (DOWA Ecosystem 2019; PPLi 2020). The Class 1 Eco-Landfill has operated since 1994 while the Class 2 Eco-Landfill has been in service since 2007 (PPLi 2020). The Landfill provides various waste treatment services, including waste transportation, mixing/conversion to energy, classification/recycling, liquid waste treatment and landfill (DOWA Ecosystem 2019). It is equipped with high-level environmental monitoring and audit systems to ensure long-term security. PPLi is developing a system in the Landfill to convert the methane gas produced by the waste into electricity for empowering all the company's facilities (PPLi 2020).

Figure 6 The sketch (a) and image (b) of Kualiti Alam's Vertical Secured Landfill (reproduced from Cenviro (2023), with permission)

Figure 7 PPLi's Eco-Landfill (reproduced from PPLi (2021a), with permission)

- **Waste-to-Energy system**

Table 13 describes the Waste-to-Energy systems in Kualiti Alam and PPLi, which can be used as references for constructing these systems. The images of such systems are presented in **Figure 8** and **Figure 9**.

Table 13 Waste-to-Energy systems in Kualiti Alam and PPLi

Kualiti Alam	PPLi
The Scheduled Waste to Energy Plant commenced operations in 2018 as the first of its kind in Malaysia (Cenviro 2022). Meeting both Malaysian and EU standards, the Plant can incinerate 33,000 metric tonnes of scheduled waste annually. The thermal energy produced from the incineration is used to power a boiler and steam turbine to generate electricity, which will be exported to the national grid (Cenviro 2022, 2023). In 2022, the Plant generated 8,731 MW of electricity, significantly contributing to the national grid and supporting Malaysia's renewable energy targets (Cenviro 2022).	The energy recovery facilities have operated since 1994 and are currently the only fully-permitted facilities in Indonesia. The facilities convert liquid waste into synthetic fuels through a process called fuels blending, and solid waste into AFR (Alternative Fuel and Raw Materials). Liquid waste materials with a calorific value are carefully blended under stringent control to ensure no adverse chemical reactions and then manufactured into an alternative fuel. Solid organic waste is fully destroyed in a cement kiln, given the high temperature of 1,200-1,400^{0}C and long retention times, and converted into alternative fuel and/or alternative raw materials. The alternative fuel from both processes is used to replace fossil fuels in cement making (PPLi 2020).

Figure 8 The Scheduled Waste to Energy Plant in Kualiti Alam (reproduced from Cenviro (2023), with permission)

Figure 9 Waste-to-Energy facilities in PPLi (reproduced from PPLi (2020), with permission)

- **NORM waste disposal landfills**

Disposal is the final step in the radioactive waste life cycle. A complete solution should be provided, ensuring the disposal option is practicable, sustainable, acceptable and designed to achieve long-term safety (IAEA 2013). Given the lack of proper NORM waste disposal landfills in Southeast Asia (Le et al. 2024), such landfills should be developed and their design could be based on the guidance from the Malaysian Atomic Energy Licensing Board (AELB) as follows.

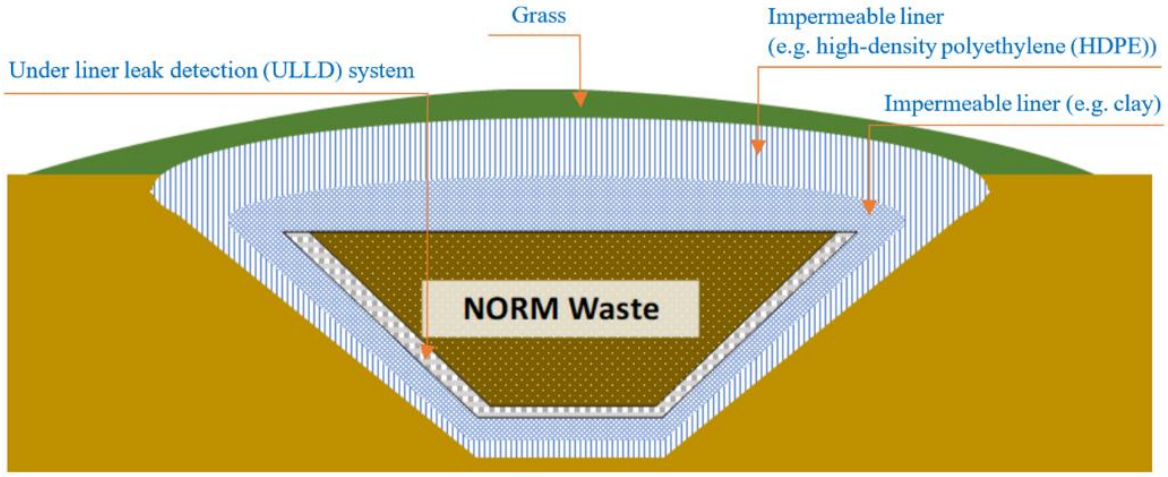

Figure 10 Sketch of a landfill disposal facility with engineered surface features (reproduced from AELB (2020), with permission)

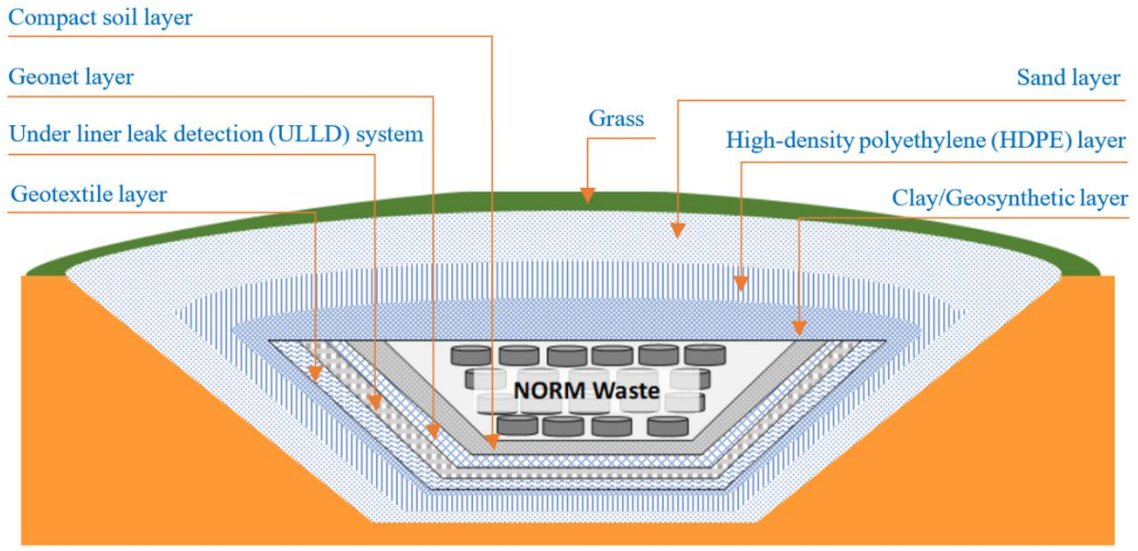

Figure 11 Sketch of a landfill disposal facility with engineered near surface features (reproduced from AELB (2020), with permission)

As illustrated in **Figure 10**, the landfill disposal facility with engineered surface features would be suitable for very low-level waste, which has an activity concentration lower than 100 Bq/g. Whereas, the landfill disposal facility with engineered near surface features (**Figure 11**) would be appropriate for low-level waste – NORM waste with the activity concentration higher than 100 Bq/g and up to 400 Bq/g, since it can provide robust containment and isolation for several centuries (AELB 2020).

- **Thermal desorption technique for mercury waste treatment**

Thermal desorption is recommended by the Basel Convention's *Technical Guidelines for the Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Mercury or Mercury Compounds* for the treatment of mercury waste. It is a technique using indirect or direct heat exchange to heat primarily organic contaminants to a high enough temperature to volatilize and separate them from a contaminated solid matrix and then either collect or destroy them (SBC 2015). Thermal desorption which uses indirect heat exchange is recommended for mercury and its compounds. Mercury waste can be treated via some evaporation processes, including rotary kiln distillation and vacuum thermal processing / vacuum distillation (SBC 2015). Thermal desorption (vacuum distillation) technique is applied by BMT Thailand for treating mercury waste (BMT Thailand 2021). Following the treatment process, the extracted mercury will be stabilised to mercury sulfide, which is less toxic than most other forms of mercury, and permanently stored; whereas the mercury free residue can be disposed of or recycled as normal industrial waste (BMT, internal document, n.d.; IPIECA 2014).

Figure 12 Thermal desorption (vacuum distillation) system (reproduced from BMT (n.d.), with permission)

7. Conclusion

At present, Southeast Asia possesses very few onshore dismantling yards that are capable of handling decommissioned offshore structures although many offshore structures in the region are expected to be decommissioned soon. Current capable yards are mainly located in Thailand and some in Indonesia and Malaysia; however, given the legal restrictions on transboundary movement of hazardous waste in Southeast Asia, each nation in the region needs to dismantle decommissioned offshore structures by itself. Based on the international and regional regulations and guidelines for ship recycling and some technical reports of dismantling yards in the North Sea, this guidance has summarised important parameters for evaluating the technical preparedness of an onshore dismantling yard to receive decommissioned offshore structures. A checklist has also been developed, in consultation with the checklist used by Sea Sentinels, a ship recycling compliance auditor, for Green Ship Recycling yard audit, and some international and regional regulations. Given the availability of many shipbuilding yards in Southeast Asia and their potential to be upgraded for onshore dismantling activities, such checklist should be used as a reference for the upgradation. Specific guidance has also been provided for some important aspects in such checklist, based on the Basel Convention's Technical Guidelines for the Dismantling of Ships, the Hong Kong Convention, and the European Council Directive 89/656/EEC. Guidelines have also been developed for waste management facilities, which are actually Zone F of a dismantling facility. Such guidelines mainly focus on the operational procedures of waste management facilities and important facilities and techniques used for the treatment of hazardous waste, mercury waste and NORM waste. The guidelines were developed based on the review of the regulatory frameworks for hazardous waste management facilities in Southeast Asia, some international guidelines, as well as the case studies/ review of hazardous waste, mercury waste and NORM waste management facilities in the region.

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