



Waste Lubricant Oil Management: A Review of Technical Aspects and Regulatory Compliance (Study Case Coal Mining PT X)

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ABSTRACT:

PT X, one of the largest coal mining companies in Indonesia, is located in Berau District, East Kalimantan. The company's mining activities produce waste lubricant oil, a dominant hazardous waste containing toxic materials that can significantly pollute the environment if not properly managed. Given the critical importance of managing waste lubricant oil, Indonesia has established several regulations for hazardous waste management. This study aims to evaluate both the technical aspects and regulatory compliance of PT X's waste lubricant oil management by comparing existing practices with technical criteria and applicable regulations. The methodology involves assessing the capacity of hazardous waste storage facilities based on the generation of waste lubricant oil, regulatory requirements, and transportation frequency, alongside compliance assessments of packaging, storage, and in situ utilization practices. Results indicate that PT X's storage capacity for waste lubricant oil is adequate and that its internal management practices fully comply with regulations. However, nonconformities were found in the hazardous waste management practices of third-party entities, particularly in packaging and storage. This research highlights the need for improved monitoring and regulation of third-party waste management practices to ensure comprehensive compliance and environmental protection.

Keywords: Coal Mining, Technical and Regulatory Compliance, Waste Lubricant Oil Management.

INTRODUCTION

Waste lubricant oil is the most dominant liquid hazardous waste generated from mining operations (Ali et al., 2021; Sun et al., 2022). Waste lubricant oil from repair and maintenance activities of heavy equipment units was originally pure oil derived from crude oil refining (mineral base oil) or obtained through chemical synthetics (synthetic base oil) consisting of C18-C40 hydrocarbons (Pinheiro et al., 2021). Generally, oil consists of base oil and additives with an

average component content of 80-90% and 10-20%, respectively. During use, the physical and chemical properties of oil degrade and form Waste lubricant oil that absorbs impurities such as water, metal particles, and organic acid salts (Yu et al., 2023). The main hazardous contaminants present in waste lubricant oil are heavy metals, polychlorinated hydrocarbons (PCBs) and poly aromatic compounds (PAHs) which are highly toxic to human health and can cause environmental damage if not properly managed and treated (Campitelli et al., 2019; Pinheiro et al., 2017).

Lubricant oil serves a variety of purposes, such as lubrication, heat and power transfer, component cleaning, part protection, and so forth. They can be manufactured or produced from petroleum sources (Ratiu et al., 2022). Waste lubricant oils are created when these oils become polluted or deteriorate based on the use and operating environment. As a result, they must be disposed of. These waste lubricant oils are categorized as hazardous waste and belong to subgroups Y8 and Y9 of the Basel Convention (Secretariat of the Basel Convention. & United Nations Environment Programme., 2002). Because waste lubricant oil has a high concentration of hazardous pollutants, it is seen as a threat to both human health and the environment. The most well-known of these are: polycyclic aromatic hydrocarbons (benzanthracene, benzopyrene, naphthalene, etc.); these are organic compounds that were once used as lubricant additives; they arise from incomplete fuel combustion and pose a significant risk of cancer]. Their high toxicity and potential for cancer make them especially harmful, the wear process of the engine's metal components produces heavy metals (Fe, Cr, Ni, Pb, Cu, Zn (ATSDR, 2018). In terms of sustainable development, the appropriate handling of spent lubricating oils is consistent with concepts that are addressed globally and has major positive effects on the social, economic, and environmental domains. To improve reverse logistics performance, waste management procedures and activities must be reorganized (da Cruz Gonzaga et al., 2021).

Management of Hazardous Waste in Indonesia is generally regulated by Government Regulation No. 22 of 2021 on the Implementation of Environmental Protection and Management (Pemerintah Republik Indonesia, 2021). The procedures and requirements for managing hazardous waste are outlined in Minister of Environment and Forestry Regulation No. 6 of 2021. Hazardous waste storage is the activity of storing hazardous waste carried out by hazardous waste producer to temporarily store the hazardous waste (Menteri Lingkungan Hidup dan Kehutanan, 2021). Appropriate hazardous waste storage facilities include buildings, tanks, and/or containers, silos, hazardous waste piles, and hazardous waste impoundments. Hazardous waste building storage facilities must comply with the following requirements such as the design is under the type, characteristics, and amount of hazardous waste, the storage space area matches the amount of hazardous waste, the design and construction protect the hazardous waste from rain and are enclosed, the roof is made of non-flammable material, ventilation system for air circulation, the lighting system is adjusted according to the design of the hazardous waste storage facility, the floor is waterproof and wave-free floor, interior floor slopes downward towards the

spill containment sump with a maximum slope of 1%. the exterior floor is designed to prevent rainwater from entering the hazardous waste storage building, drainage channels for hazardous waste spills, leaks, and/or cleaning water from spills or leaks, and equipped with hazardous waste symbols according to regulations.

Waste lubricant oil is categorized as hazardous waste with toxic characteristics, therefore the building must comply following requirements such as roof, wall, and floor construction must be resistant to corrosion and fire and provide with explosion-proof lighting. Hazardous waste storage facilities in tanks and/or containers must comply to requirements such as building is built in the ground surface with a waterproof floor, tanks and/or containers and their support systems must be made of materials compatible with the characteristics of the stored hazardous waste, not easily broken or leaking, equipped with drainage channels around the tanks and/or containers leading to spill containment sumps, protected from direct sunlight and rain, equipped with hazardous waste symbols according to regulations, spill containment must be able to shelter at least 110% of the total capacity of the tank or container. Emergency response equipment for hazardous waste storage facilities is equipped with Fire detection and suppression systems; and/or other appropriate emergency response equipment.

Packaging requirements for hazardous waste storage must comply packaging requirements such as packaging made of metal or plastic materials that can package hazardous waste in accordance with the characteristics of hazardous waste, able to confine hazardous waste to remain in the packaging, tight cover to prevent spillage during storage, handling, and/or transport, and in a condition that is not leaking, not rusted, and not damaged. Requirement of hazardous waste packaging must consist of the category or characteristics are the same as the previous hazardous waste or the category or characteristics are compatible with the previously packaged hazardous waste or has been cleaned for hazardous waste packaging with different types and/or characteristics.

Waste lubricant oil is hazardous waste that is mostly produced at PT X. Hazardous waste is produced during repair and maintenance heavy equipment machinery, appliances, and automobiles. Activities related to storage, transportation, processing, and utilization are all activities of waste lubricant oil management in PT X. Waste lubricant oil mostly contain of hydrocarbons, hazardous heavy metals, mono- and poly aromatic chemicals, and additives with a high potential for harming the environment. A part of the waste lubricant oil produced by PT X is subsequently processed and used by the company directly inside its operational area, while a part is handled by outside partners that act as collectors and carriers to customers of Waste lubricant oil outside of Kalimantan.

For the sustainability of resources and improve environmental, economic, and social advantages, a strategic approach to waste lubricant oil management through utilization activities is crucial (Botas et al., 2017) (Du đak et al., 2021). The Ministry of Environment and Forestry must grant permits for any use of hazardous waste (Pemerintah Republik Indonesia, 2021). In addition

to conducting field-scale experiments, the company conducted technical and operational investigations pertaining to the use plan. In line with waste lubricant oil utilization permit number S.539/PSLB3/VPLHB3/ PLB.3/10/2021.

Utilization is one of the most effective activities in managing waste lubricant oil. Some utilization activities include reuse, processing, and recycling. Some previous studies that discuss the utilization of waste lubricant oil include the use of waste lubricant oil as an explosive in blasting (ANFO) (Ali et al., 2021) (Bellico et al., 2020) (Moorthy et al., 2012) (Widiyanto, 2016), recycling technologies of waste lubricant oil (Boughton & Horvath, 2004) (Moses et al., 2023), processing and recovery of waste lubricant oil by pyrolysis method xx (Lam et al., 2016; Mishra et al., 2021; Santhoshkumar & Ramanathan, 2020), solvent extraction (Altaee et al., 2022) but further studies are needed regarding technical evaluation and compliance with regulations in waste lubricant oil management.

This research aims to evaluate the existing conditions of waste lubricant oil management in the PT X case study compared to applicable regulations in Indonesia. The activities evaluated include packaging, storage, utilization, collection, and transportation. The results of the evaluation are shown by the percentage of compliance with regulations, then recommendations for improvement are given as a follow-up to fulfill the non-conformity gap.

RESEARCH METHODS

Literature Study

Literature study is the process of collecting regulations and literature relevant to the research topic. The literature study provides a conceptual foundation and regulatory basis for the research conducted. Some of the literature used in this study comes from regulations regarding waste lubricant oil management that apply in Indonesia and waste lubricant oil utilization permits owned by PT X, scientific journals, and proceedings. Some of the regulations used as the basis for evaluation consist of Government Regulation No. 22 of 2021 and Minister of Environment and Forestry Regulation No. 6 of 2021, and waste lubricant oil utilization permit of PT X.

Evaluation of existing conditions of waste lubricant oil management with related regulations

Technical Aspects

1. The storage of waste lubricant includes the location, type, capacity, building conditions of storage facilities for hazardous waste, symbol and labeling.
2. Calculation of the adequacy of waste lubricant oil storage capacity in accordance with regulations and actual transportation frequency
3. Waste lubricant oil packaging includes the process of waste lubricant oil containerization when it will be transported to the processing site.

4. Transportation of waste lubricant oil from storage facility to waste lubricant oil processing plant (WOPP) which includes the type and condition of the transportation vehicle
5. Utilization of waste lubricant oil includes the utilization process, utilization term and condition, properties of hazardous waste utilized, composition, products, compliance with environmental quality standards or standards in accordance with permits, trials of utilization methods, monitoring of air pollution.

Legality and Institutional Aspects

Evaluation of the legality and institutional aspects is carried out by conducting interviews and collecting data on the storage and utilization permits of PT X and third parties as hazardous waste transporters and collector. Data of hazardous waste third parties includes business licenses, recommendations for transporting hazardous waste, registration of GPS Tracking connected to Silacak (website application of Environmental and Forestry Ministry for tracking hazardous waste transportation) compared with applicable regulations.

RESULTS AND DISCUSSION

Waste Lubricant Oil Properties, Characteristic, and Generation

The waste lubricant oil generated by PT X comes from engine oil, hydraulic oil, and transmission oil from vehicle maintenance and repair in 2023. The percentage of waste lubricant oil generation is more than 70% of the total hazardous waste generated by PT X. Based on the results of laboratory analysis, the waste lubricant oil produced by PT X has a density of 0.85 kg/liter, has toxic characteristics, the flash point ranges from 210-225°C, not classified as flammable liquid hazardous waste.

Waste Lubricant Oil Management

Based on waste lubricant oil generation, waste lubricant oil is the dominant type of hazardous waste, classified as waste from non-specific sources category 2 (code B105d) based on Government Regulation No. 22 of 2021 and has toxic characteristics which is need proper management to prevent environmental pollution. This research focuses on waste lubricant oil management which consists of packaging, storage, utilization, collection, and transportation. Waste lubricant oil management at coal mining PT X is conducted internally and externally as shown in Figure 1.

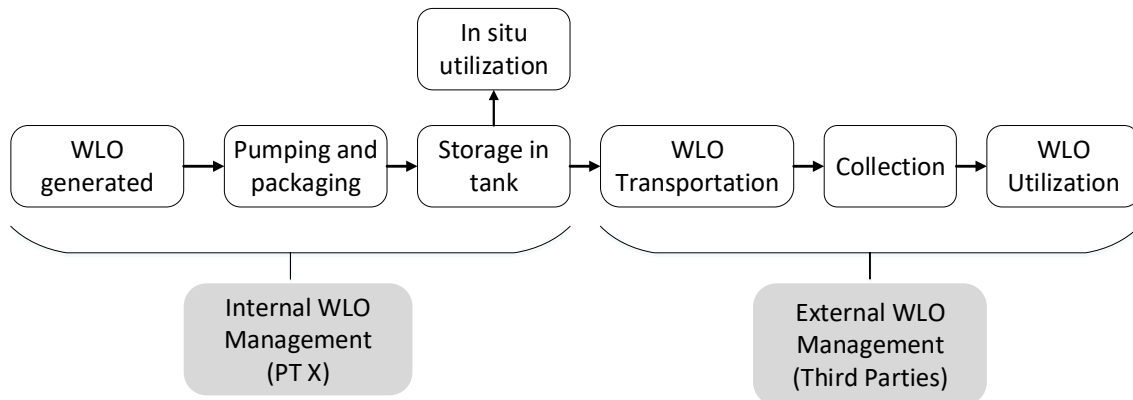


Figure 1. Waste Lubricant Oil Management in PT X

Figure 1 shows the internal management conducted by PT X starting from the transportation of waste lubricant oil to storage facility, packaging and storage at the storage facility, utilization of waste lubricant oil in situ. External management is conducted by PT X in combination with third parties in the activities of transporting waste lubricant oil from storage facility, collecting, treatment, and utilizing waste lubricant oil outside the PT X area.

1. Internal Waste Lubricant oil Management

PT X as a waste lubricant oil producer conducts internal management starting from the waste lubricant oil generated until the waste lubricant oil is stored in storage facility. Waste lubricant oil generated comes from repair and maintenance activities of heavy equipment, vehicles, and support units such as tower lamps and mine pumps carried out in the workshop area.

2. External Waste Lubricant Oil Management

External management is carried out by PT X in collaboration with third parties to manage some waste lubricant oil that cannot be utilized in situ. Third parties who cooperate are transporters as well as collectors, processors, and users who have a license from the Ministry of Environment and Forestry, specifically for waste lubricant oil transporters, permits are also given by Ministry of Transportation

Existing Conditions Evaluation of Waste lubricant oil Management

The management of hazardous waste including waste lubricant oil regulated in Government Regulation No. 22 of 2021 and Minister of Environment and Forestry Regulation No. 6 of 2021. In this study, the existing conditions of waste lubricant oil management starting from packaging, storage, utilization, collection, and utilization will be evaluated according to applicable regulations. The evaluation results of each management process are described in this sub chapter.

Waste Lubricant Oil Packaging and Storage

Waste lubricant oil packaging at PT X has been regulated in an internal procedure, namely the Hazardous Waste Management Procedure (P-ENV-02). This procedure is made based on Government Regulation No. 22 of 2021 and Minister of Environment and Forestry Regulation No. 6 of 2021. Waste lubricant oil is packaged in 2 container tanks, each with a capacity of 32.000 liters. The location of the tanks is in a hazardous waste site that has met the requirements in the technical details listed in the environmental permit.

The condition of waste lubricant oil packaging using container tanks at PT X is in accordance with the provisions required in Government Regulation No. 22 of 2021 and Minister of Environment Regulation No. 6 of 2021, the points of conformity include:

1. Packaging of waste lubricant oil according to standards or technical details integrated with environmental approval
2. Packaging is in good condition, meets technical requirements and is in accordance with the characteristics of hazardous waste
3. Labeling and symbolization in accordance with the characteristics of waste lubricant oil.

Based on the evaluation results, the percentage of regulatory compliance in waste lubricant oil packaging activities is 100%. Waste lubricant oil storage of PT has environmental permit from the Ministry of Environment and Forestry with the number SK.33/MENLHK/SETJEN/PLA.4/1/2023. PT X has a separate hazardous waste storage for solid and liquid waste due to facilitate the transportation process and minimize spills from the transfer process.

Waste lubricant oil storage location requirements that have been complied according to regulations:

1. The location of storage facility is flood-free and not prone to natural disasters. Storage facility is located at an elevation of +30, higher than the surrounding area thus it is free from flooding and inundation.
2. The design is in accordance with the type, characteristics, and amount of hazardous waste stored;
3. The building construction is fire resistant and equipped with emergency handling equipment, has undulating floor with a slope of <1%
4. Waste lubricant oil duration storage < 90 days due to schedule pickup by third parties at least 2 times each week.

Based on the evaluation results, the percentage of regulatory compliance in waste lubricant oil storage activities is 100%. Adequacy calculation of waste lubricant oil storage capacity in PT X is:

1. Waste lubricant oil produced by PT X in 2023 = 2.435 tons
2. Density of waste lubricant oil = 0.85 kg/liter
3. Total waste lubricant oil storage capacity = 64.000 liters

$$\text{WLO volume} = \frac{\text{WLO mass (kg)}}{\text{WLO density } \left(\frac{\text{kg}}{\text{liter}}\right)}$$

$$\text{WLO volume} = \frac{(2.435 \text{ ton} \times 1000)\text{kg}}{0,85 \left(\frac{\text{kg}}{\text{liter}}\right)} = 2.864.706 \text{ liter}$$

Based on Minister of Environment and Forestry Regulation No. 6 of 2021, the storage of hazardous waste in tank containers must leave at least 20% free space from total capacity of the tank and/or container, thus the storage capacity of waste lubricant oil can be used:

Usable storage capacity:

$$= 64.000 \text{ liter} - (20\% \times 64.000 \text{ liter}) = 51.200 \text{ liter}$$

Volume of WLO in 2023 = 2.864.706 liter

$$\text{Volume oli bekas per hari} = \frac{2.864.706 \text{ liter}}{365 \text{ days}} = 7.848 \text{ liter/day}$$

Storage capacity = 51.200 liter

$$\begin{aligned} \text{Storage duration} &= \frac{\text{Storage capacity (liter)}}{\text{Volume of WLO per day (liter)}} \\ &= \frac{51.200 \text{ liter}}{7.850 \text{ liter}} = 7 \text{ day} \end{aligned}$$

According to the calculation results, the container tank is able to store waste lubricant oil for 7 consecutive days without transportation activities. According to the existing conditions, waste lubricant oil transportation is carried out 2 times in a week or 1 times in 3 days.

The comparison shows that the waste lubricant oil storage capacity is greater than the existing conditions, so it can be concluded that the waste lubricant oil storage capacity is sufficient.

Waste lubricant oil Packaging and Storage

This study evaluated in situ utilization in operational area of PT X. The regulations that will be evaluated for utilization activities include Government Regulation Number 22 of 2021, Minister of Environment Regulation Number 6 of 2021, and waste lubricant oil utilization permit of PT X with number S.539/PSLB3S/VPLB3/ PLB.3/10/2021 Regarding Technical Permit in Hazardous Waste Utilization Activities of PT X.

Requirements for hazardous waste utilization activities that have been complied according to regulations:

1. Has a permit in terms of hazardous waste utilization;

2. Utilization activities have been tested and reported to the Ministry of Environment and Forestry;
3. Meet product quality standards and emission monitoring for the utilization activities carried out;
4. Reporting waste lubricant oil utilization activities electronically through reporting website of Ministry Environmental and Forestry.

Based on the evaluation results, the percentage of compliance in waste lubricant oil storage activities is 100%.

Collection and Transportation of Waste lubricant oil by Third Parties

Waste lubricant oil collection is the activity of collecting waste lubricant oil at a storage facility owned by third parties. The third-party collection permit is following Letter Number S.310/Menlhk/Setjen/PLB.3/5/2020. The hazardous waste collected does not only come from PT X, but also other companies located in Berau District. This collecting party also has a license as a hazardous waste transporter so that the collection and transportation activities are carried out by the same third party.

Hazardous waste collection requirements that have been complied with according to regulations:

1. Having a license in terms of hazardous waste collection including environmental approval, business license, and waste collection permit;
2. Collection activities consist of segregation or separation of hazardous waste according to waste type and characteristics and storage that does not exceed 90 days storage time;
3. Reporting waste lubricant oil collection activities electronically through reporting website of Ministry Environmental and Forestry.

Non-conformities of waste lubricant oil collection by third parties:

1. Solid hazardous waste is stored lengthwise without a block system without any distance hazardous waste should be arranged with a block system consisting of 2 (two) x 3 (three) and have an aisle width between blocks of at least 60 cm.
2. Solid hazardous storage and some waste lubricant oil drums were not palletized
3. Inconsistent provision of symbols and labels, some hazardous waste packaging, both solid and liquid, are not given symbols and labels, there is no marking on empty packaging, some have been given symbols and labels but not all of them.

Based on the evaluation results, the percentage of waste lubricant oil collection by third parties is 71%. The next process, the waste lubricant oil that has been collected at the third party's storage facility is then brought to the port to be transported by sea to a third party who will utilize the waste lubricant oil into base oil products.

Hazardous waste transportation requirements that have been complied according to regulations:

1. Having permits in terms of transportation of hazardous waste including recommendations from the Ministry of Environment and Forestry, transportation permits and electronic manifest as legal documents in the transportation of hazardous waste.
2. The transporting party has a conveyance that is in accordance with the technical specifications of the conveyance and the category of hazardous waste being transported and GPS Tracking has been connected to the Silacak application thus the transportation route can be traced and monitored by the Ministry of Environment and Forestry.
3. The transporter has procedures of waste loading and unloading, PPE for workers, hazardous waste emergency plan.

Based on the evaluation results, the percentage of compliance in waste lubricant oil transportation activities is 100%.

Regulation Compliance

Based on the evaluation results of waste lubricant oil management in PT X consist of packaging, storage, utilization, collection, and transportation, the percentage of regulatory compliance of each activity is shown in Table 1.

Table 1. Percentage of Compliance with PT X Waste Lubricant Oil Management Regulations

Activities	Location	Number of Compliance		Percentage of Compliance
		Comply	Not comply	
Packaging	PT X	3	0	100%
Storage	PT X	10	0	100%
Utilization	PT X	11	0	100%
Collection	Third Parties	5	2	71%
Transportation	Third Parties	10	0	100%
Total		39	2	95%

Source: Primary data, 2024

Table 1 shows that the total percentage of regulatory compliance for PT X's waste lubricant oil management is 95%. The 5% non-conformity comes from collection activities carried out by third parties including the storage of hazardous waste without pallet mats, hazardous waste not arranged in a block system, and inconsistency in the installation of symbols and labels on hazardous waste packaging. Follow-up in the form of corrective and preventive efforts have been described in point 3 regarding collection and transportation by third parties. This follow-up is expected to be a continuous improvement so that the percentage of regulatory compliance becomes 100% without any non-conformities.

According to the results of field surveys and interviews with collectors, non-conformity in the collection of hazardous waste is caused by several things including:

1. there are still hazardous waste generators and officers who do not have sufficient understanding of the provisions in handling hazardous waste so that procedures in storage, symbol and labeling are not considered.
2. officers have not conducted regular refresh training (at least 1 x 6 months) on hazardous waste management.

The next step is to determine the follow-up as an improvement action. The follow-up improvement action carried out is divided into 2, namely corrective action and prevention plan.

Corrective action are quick actions that need to be taken when the finding is discovered include:

1. Arranging and organizing hazardous waste storage with a block system, minimum aisle width of 60 cm, hazardous waste packaging is given a pallet base;
2. Giving symbols in accordance with the characteristics of hazardous waste and installing labels in accordance with the date of entry of waste recorded in the log book;
3. Implementing of hazardous waste management procedures and coaching to management staff.

Preventive action taken include:

1. Third parties provide training and certification in hazardous waste management to the officer in charge;
2. Supervisors conduct routine inspections and monitoring at hazardous waste storage facility;
3. Using practical guidance posted on the building of the storage facility regarding the correct way of packaging and storing hazardous waste so that it is more easily understood by field officers.

This improvement action is expected to be a continuous improvement so that the percentage of regulatory compliance becomes 100% without any non-conformities.

CONCLUSION

Based on the results of the evaluation of existing conditions, the internal management of waste lubricant oil in the PT X area is in accordance with the provisions and requirements stated in the regulations, however, external management of hazardous waste by third parties, there are still non-conformities, especially in packaging and storage activities. The percentage of regulatory compliance of waste lubricant oil management in PT X consists of packaging, storage, utilization, collection, and transportation is 95%. Corrective and preventive actions are needed as an improvement to comply with applicable regulations.

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