Design of Temporary Storage for Hazardous and Toxic Waste in a Rotogravure Cylinder Manufacturing Industry

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Abstract
PT APEB is a company that producing rotogravure cylinders. Company's management of hazardous and toxic waste, commonly referred to as B3 waste has been inadequate, particularly in regards to the temporary storage facility. The aim of this study is to analyse the types, characteristics, and quantity of B3 waste produced by the company. The results will be used to design a temporary storage facility for B3 waste that complies with Indonesian standards. The method used in this study is descriptive quantitative. All of the collected data, including information on fire extinguishers, storage tanks, aperture area, lighting, pallets, and packaging, has been determined to aid in the development of a temporary storage facility for B3 waste that adheres to the current regulations in Indonesia. The building has been designed using the Sketchup software. The available space for the temporary B3 waste storage facility is 10 m x 10 m x 4,5 m, and it is divided into three parts: warehouse A (WWTP sludge), warehouse B (grinding sludge and PPE, rags, and contaminated packages), and warehouse C (electronic waste, chemical ex-lab, and oil waste), which are divided according to the type and characteristics of the waste. One dry chemical powder fire extinguisher is required for the building, along with 9 armature lights. Up to 5 pieces of ventilation with a length of 40 x 50 cm are also proposed.

Keywords: armature light, b3 waste, design, rotogravure, temporary storage, ventilation

1. Introduction
According to Minister of Environment and Forestry Regulation Number 6 of 2021 [1], hazardous and toxic waste, abbreviated B3, is the residue of a business and/or activity that comprises hazardous and toxic material. Because of the hazardous and toxic material that is contained in B3 waste, it may have a detrimental effect on the surrounding ecosystem. The regulation re-explains that B3 waste is a substance, energy, and/or other component that due to their nature, concentration, and/or amount, either directly or indirectly can pollute and/or damage the environment, and/or can put the environment, health, and the survival of humans and other living things in danger. By appropriately handling B3 waste, it is possible to avoid the negative effects that are generated by this waste.

The regulation of the B3 waste management industry in Indonesia can be found in Government Regulation no. 22 of 2021 [2]. The management of B3 waste entails storing the waste, collecting it,
transporting it, putting it to use, processing it, and finally dumping it. Every individual or organization that produces B3 waste is responsible for managing that waste. B3 waste cannot be piled, burned, or simply discarded because it contains materials that can pollute the environment, imperil humans and other living things, and pollute the air [3]. Accidents involving direct skin contact, ingestion, inhalation, and other scenarios are possible to occur and may result in losses including first aid losses, injuries requiring medical treatment, LTIs (loss of time injuries), RDIs (restricted duty injuries), and fatalities [4].

Since 2003, PT APEB has been running its business as an industry that specializes in the production of rotogravure cylinders. It has cutting-edge and effective machinery and technology, like laser stream technology. PT APEB is broadly divided into twelve units, including Office, Lathe, Laboratory, Grinding, Copper Plating, Polish Master, Barco, OHIO, Laser, Chrome Plating, Proofing, Units Quality Control, and Packaging. All units’ activities have the potential to B3 and non-B3 waste. The production of gravure printing cylinders involves the use of various baths such as galvanic, chromium-plating, and dechroming baths. These baths have the potential to emit toxic compounds such as hexavalent chromium, hydrochloric acid, and isocyanates [5]. There are several significant concerns related to the cylinder manufacturing process, including the substantial emission of volatile organic compounds during printing, the electroplating of copper, nickel, and chrome, and the expenses associated with effluent treatment [6,7].

![Figure 1](image1.jpg)

**Figure 1.** Current condition of temporary storage facility for B3 waste

Despite operating for almost 2 decades, one area where PT APEB’s B3 waste management has fallen short is in the company’s handling of the temporary storage facility for B3 waste (Figure 1). The proper treatment of B3 waste requires that it be stored in accordance with the procedures and technical standards for storing B3 waste as outlined in Indonesian law. Therefore, the purpose of this study is to analyze the types and characteristics of the B3 waste produced by PT APEB, followed by an analysis of the amount of B3 waste generated in 12 units and to design a temporary storage facility for B3 waste at PT APEB so that the B3 waste produced can be stored in a location that meets Indonesian standards.

2. **Material and Methods**

This study was conducted in two stages: data collection and data processing. The process of data collection includes primary data, involving observation and documentation, as well as secondary data, which refers to the type, character, and quantity of B3 waste for 3-month period based on SNI 19-3964-1994 concerning methods for taking and measuring sample generation and composition of urban waste [8]. Meanwhile, the data processing method include calculation of storage facility for B3 waste following below aspects:

a. **Light fire extinguishers (APAR)**

   The determination of the type and number of fire extinguishers needed is in accordance with PerMenakertrans No. 04/MEN/1980 concerning installation and maintenance of light fire extinguishers [9] and SNI 03-3985-2000 concerning procedures for planning, installation and testing of fire detection and alarm systems for prevention of fire hazards in buildings [10].

b. **Storage tank calculation**

   The storage tank is designed using the calculation of drum volume, waste volume, and spillage volume per drum. The storage tanks for liquid waste are designed as follows:

   \[
   \text{Drum volume} = \frac{1}{4} \pi \cdot d^2 \cdot t
   \]
It is assumed that each drum holds 80% of the volume of waste from the drum, then:

\[ \text{Waste volume} = \text{Drum volume} \times 80\% \]

It is assumed that the waste spill is 30% of the volume of waste, then:

\[ \text{Spill volume per drum} = \text{waste volume} \times 30\% \]

c. Determination of aperture area

Based on SNI 03-6572-2001, that in class 7 buildings (warehouses) windows, openings, doors or other facilities with a ventilation area of not less than 10% of the floor area of the space to be ventilated, are measured not more than 3.6m above the floor [11].

d. Lighting calculation.

In this stage, the selection of the type of lighting source according to the needs of the building area is carried out. Based on SNI 03-6575-2001, the intensity of lighting (E) for warehouses is 100 lux. Furthermore, the calculation of the space index (k), lighting efficiency (ƞƿ), usage coefficient (ƙƿ), and the number of armatures needed (n) is performed [12].

e. Calculation of the dimensions of a B3 waste pallet and packaging

Calculations are carried out to determine the dimensions of the temporary storage facility for B3 waste based on the dimensions of the pallet and packaging used. The data required at this stage are data on the type, quantity, and density of B3 waste, as well as dimensions of pallets and packaging, which are then adjusted to the size of the temporary storage facility for B3 waste.

The all acquired data is intended to facilitate the design of a temporary storage facility for B3 waste using the Sketchup software. This involves adhering to the prescribed procedures and technical specifications for the storage of B3 waste following Regulation of the Minister of Environment and Forestry No. 12 of 2020 concerning storage of hazardous and toxic waste [13], Regulation of the Minister of Environment No. 14 of 2013 concerning hazardous waste symbols and labels [14] and Regulation of Minister of Industry No. 23 of 2013 regarding the global harmonization system of classification and labelling of chemicals [15].

3. Results and Discussion

Based on observations at the site, the temporary B3 waste storage facility has an available area of 10 m x 10 m x 4.5 m, which will be designed based on the capacity and amount of each B3 waste produced.

*Types, characteristics and Amount of B3 waste*

In this study, information regarding the types and characteristics of B3 waste was obtained from company document literature, specifically the UKL-UPL document, which refers to Appendix IX of Government Regulation No. 22 of 2021 on the Implementation of Environmental Protection and Management [2]. The generated B3 waste data is depicted in Table 1, which contains the type, physical form, characteristics, and category of B3 waste. That aforementioned information will be utilized to design the separator area between the B3 wastes and determine the containers to be used in the TPS based on their physical form and characteristics, as well as the facility's requirements.

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of B3 waste</th>
<th>Form</th>
<th>Characteristics</th>
<th>Category of B3 waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PPE (Personal Protective Equipment), used rags, contaminated package</td>
<td>Solid</td>
<td>Toxic, dangerous for the environment</td>
<td>2 (unspecified source)</td>
</tr>
<tr>
<td>2.</td>
<td>WWTP sludge, Grinding sludge, Polish Master</td>
<td>Semi-solid</td>
<td>Toxic, dangerous for the environment</td>
<td>2 (general specific sources)</td>
</tr>
<tr>
<td>3.</td>
<td>Oil waste</td>
<td>Liquid</td>
<td>Toxic, dangerous for the environment</td>
<td>1 (general specific sources)</td>
</tr>
<tr>
<td>4.</td>
<td>Electronic waste</td>
<td>Solid</td>
<td>Toxic, dangerous for the environment</td>
<td>2 (unspecified source)</td>
</tr>
<tr>
<td>5.</td>
<td>Chemical Ex lab</td>
<td>Liquid</td>
<td>Toxic, corrosive, dangerous for the environment</td>
<td>1 (general specific sources)</td>
</tr>
</tbody>
</table>

The amount of B3 waste

In the study, information regarding the quantity of B3 waste generation was obtained from the logbook of B3 waste produced over the previous three months and presented in Figure 2 as the amount, of
B3 waste generated by resources in the company’s various units. The information will be used to calculate the number of packages based on the available space and applicable regulations.

![Figure 2](image-url)  
**Figure 2.** Amount of B3 waste in each unit

For type of Personal Protective Equipment (PPE), rags, and contaminated package, a total of 1309.04 kg of waste was generated over three months; the unit that generated the most waste was the Proofing unit, which generated 1068 kg of waste, or approximately 82% of the total waste generated. The WWTP sludge waste generated over a period of three months was found to be 21,390 kg. The laboratory unit was identified as the primary contributor, accounting for the entire waste production at 100%. The laboratory unit receives WWTP sludge waste due to the fact that the laboratory supervisor is responsible for overseeing the WWTP. The cumulative amount of grinding sludge waste generated over the course of three months is 1620 kg, with the grinding unit being the primary contributor, accounting for 100% of the total waste produced. A number of other units generate minimal quantities of waste or are entirely waste-free. A third company will then transport the generated B3 waste. The transportation process is carried out by agreement, with one week's notice prior to its execution.

**Design of temporary B3 waste storage facility**

A calculation of the container packaging to be applied, and the design of the temporary B3 waste storage facility will be carried out based on data on the types and characteristics of the B3 waste and the amount of waste generated over the next three months.

**Determination of the type of fire extinguisher (APAR)**

Based on PerMenakertrans No. 04/ MEN/ 1980 concerning requirements for installation and maintenance of light fire extinguishers [9]. For buildings containing materials that cannot mix with water and materials that can mix with water, the type of fire extinguisher used is a chemical powder type or dry chemical powder fire extinguisher or dry flour (powder).

**Number of fire extinguishers required**

According to the requirements of PerMenakertrans No. 04/ MEN/ 1980 [9], the number of required fire extinguishers for temporary B3 waste storage facility that does not exceed a distance of 15 meters is one. The installation location must be plainly visible, readily accessible, and marked with an installation indicator. Each fire extinguisher must be hung on a wall with stirrup or other reinforcing construction or set in an unlocked cabinet or chest. The installation must allow chemical powder type or dry chemical powder fire extinguisher to be installed lower, with a minimum distance of 15 cm between the base of the fire extinguisher and the floor.

**Storage Tank Calculation**

The storage tank is designed using the calculation of drum volume, waste volume, and spillage volume per drum. From the pallet and packaging dimensions design above, the storage tanks for liquid waste are designed as follows:
Known: \( \pi = 3.14 \)
\[ d = 0.59 \text{ m} \]
\[ t = 1 \text{ m} \]

So, drum volume = \[ \frac{1}{4} \times \pi d^2 t \]
= \[ \frac{1}{4} \times 3.14 \times (0.59 \text{ m})^2 \times (0.9 \text{ m}) \]
= 0.246 m\(^3\) \approx 246 \text{ Liter} 

It is assumed that each drum holds 80% of the volume of waste from the drum, then:

Waste volume = drum volume \times 80 \%
= 246 \text{ Liter} \times 80 \%
= 196.8 \text{ Liters} 

It is assumed that the waste spill is 30% of the volume of waste, then:

Spill volume per drum = volume of waste \times 30 \%
= 196.8 \text{ Liter} \times 30 \%
= 59.04 \text{ Liters} 

In this study, four storage tanks are required: chemical ex-lab, oil waste, grinding sludge, and WWTP sludge. The storage area must be at least 110% of the tank volume's maximum capacity. Tanks must be situated in such a way that if one rolls over, it does not collide with another tank or move out of the embankment area. The dimensions of the storage tank can be estimated using a tank volume of 214 liters (0.214 m\(^3\)) as follows:

Chemical ex lab storage tank
Given:
Pallet container = 1 or 4 drums
Volume of the drum = 0.246 m\(^3\)
So, the total volume of four drums is 0.984 m\(^3\), so the container is made with a size of 1m x 1m x 2m = 2m\(^3\), which is still less than 110% \times 0.984 m\(^3\) = 1.082 m\(^3\)

Oil Waste storage tank
Given:
Pallet container = 2 or 8 drums
Volume of the drum = 0.246 m\(^3\)
So, the total volume of 8 drums is 1.968 m\(^3\), so the container is made with a size of 1m x 1m x 3m = 3m\(^3\), which is still less than 110% \times 1.968 m\(^3\) = 2.165 m\(^3\)

WWTP sludge and grinding sludge storage tank
For this type of waste in the form of solids, a container size of 1m x 1m x 2m = 2 m\(^3\) is provided to allow rinses in the case of spills.

* Determination of Aperture Area *

Based on SNI 03-6572-2001, class 7 buildings (warehouses) must have natural ventilation from windows, openings, doors, or other means with a ventilation area of not less than 10% of the floor area of the space to be ventilated and measured no higher than 3.6 meters above the floor [11]. The planned floor area is 100 m\(^2\), then 10% of 100 m\(^2\) is 10 m\(^2\). Ventilation is designed as many as 5 pieces with a length of 40 cm, and a width of 50 cm, which is obtained from the division of the area of the opening.

* Lighting calculation *

Based on SNI 03-6575-2001, the intensity of lighting (E) for warehouses is 100 lux [12]. Furthermore, the calculation of the space index (k), lighting efficiency (\( \eta \rho \)), usage coefficient (\( k \rho \)), and the number of armatures needed (n) is performed.

The calculation of the space index (k)
Given: \( p = 10 \text{ m} \)
\[ l = 10 \text{ m} \]
\[ t = 4.5 \text{ m} \]
So space index (k):

\[
k = \frac{p\times l}{10 m \times 10 m}
\]

\[
k = \frac{4.5 m}{100 m^2}
\]

\[
k = \frac{90 m^2}{100 m^2}
\]

\[k = 1.11\]

Calculation of illumination efficiency (\(\eta p\)) and consumption coefficient (\(\kappa \psi\))

The \(k\) value obtained is then used to calculate the value of \(\eta p\) by interpolating the \(k\) value. Then the minimum \(k\) value and its \(\eta p\) and the maximum \(k\) value and its \(\eta p\) will be obtained.

Given for \(k = 1\); \(\eta p = 0.30\)

\(k = 1.5\); \(\eta p = 0.46\)

so, \(k = 1.11\) is being interpolated

\[
\frac{1.5 - 1}{1.5 - 1.11} = \frac{0.46 - x}{0.46 - 0.30}
\]

\[x = 0.34; \text{ so for } k = 1.11; \eta p = 0.34\]

The depreciation factor for light soiling and planned cleaning every year is 0.85 so that \(\kappa \psi\) can be calculated.

\[
\kappa \psi = \eta p \cdot f_d = 0.34 \times 0.85 = 0.29
\]

Determining the number of armatures

Known:

- \(E = 100\) lux
- \(A = 100\) m\(^2\)
- \(\phi = 2500\) lumen multiplied by 2 because a direct lighting source TL 2 x 36 W is selected. Then,

\[
\eta p = \frac{1.25 \times E \times A}{\kappa \psi \times \phi}
\]

\[
n = \frac{1.25 \times 100 \times 100}{0.29 \times 2 \times 2500}
\]

\[n = 8.62 \approx 9\] armature

So, there are 9 armatures needed, which 2 armatures is installed in the room for electronic waste, chemical ex-lab, and oil waste, 2 armatures in the room for grinding sludge and PPE, rags, and contaminated package, and 5 armatures in the room for WWTP sludge.

*B3 waste packaging*

The pallet will be used as a base for the container used to store each B3 waste. The pallet’s dimensions used are 1.1m x 1.1m x 0.15m. Jumbo bags will be applied for B3 waste types of sludge, PPE, waste materials, and contaminated packages. The dimensions of the jumbo bag used are 1 m x 1 m x 1 m, so that one pallet will contain one jumbo bag. Drums are used as containers for liquid B3 waste, such as oil waste and chemical ex-lab, which will be put into a closed drum then placed on a pallet, as well as for electronic type B3 waste, which will be put into an open drum and then placed on a pallet. The drums are 0.59 meters in diameter and 0.9 meters in height, therefore one pallet can hold four drums (Figure 3).
Figure 3. Pallet, jumbo bag and drum used for storing B3 waste

The need for pallet for each type of B3 waste is determined by taking into account the dimensions of each packaging as well as the available area for temporary B3 waste storage facility, as shown in Table 2.

Table 2. Number of packaging for each type of B3 waste

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of B3 waste</th>
<th>Number of pallets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PPE (Personal Protective Equipment), used rags,</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>contaminated packages</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>WWTP sludge</td>
<td>14</td>
</tr>
<tr>
<td>3.</td>
<td>Grinding sludge</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>Oil waste</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Electronic waste</td>
<td>1</td>
</tr>
<tr>
<td>6.</td>
<td>Chemical Ex lab</td>
<td></td>
</tr>
</tbody>
</table>

Based on the design results from the above data processing, a temporary storage facility for B3 waste is developed, which is divided into three parts: Warehouse A (WWTP Sludge), Warehouse B (Grinding Sludge and PPE, rags, and contamination packaging), and Warehouse C (Electronic Waste, Chemical Ex-lab, Oil Waste), which are separated based on the type and characteristics of the waste so that it is not mixed and no reaction occurs (Figure 4). Based on the building’s construction, it is made in accordance with applicable regulations, such as drainage channels for each type of waste that has a reservoir and a dividing wall between warehouses is made to facilitate the placement of drainage channels and human mobility for the transportation process (hand lift) is not disturbed so that work accidents do not occur (Figure 5 and Figure 6).

Figure 4. Two-Dimensional (2D) layout of temporary storage facility for B3 waste
Figure 5. Three-Dimensional (3D) layout of temporary storage facility for B3 waste. (1) Front view; (2) Side view; (3) Back view

Figure 6. Three-Dimensional (3D) layout of temporary storage facility for B3 waste. (1) Room A from inside; (2) Room B from inside; (3) Room C from inside

4. Conclusion

Based on the results of the collected and processed data, the following conclusions can be drawn:

The waste management system at temporary storage facility for B3 waste is designed based on data obtained from the quantity of B3 waste generated over a three-month period. The facility has a total area of 10 m x 10 m x 4.5 m and is segregated into three sections based on the waste type and its properties, with 9 TL2 x 36 W armatures. A single dry chemical powder fire extinguisher is required for a temporary storage facility. The aperture area is designed as many as 5 pieces of ventilation with a length of 40 cm and a width of 50 cm.

5. References


