

A Study on the Prevention of Fire Korean in Waste Facilities

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〈Abstract〉

According to the National Fire Agency, there are 1,810 waste recycling facilities, 2,094 waste treatment facilities, and 223 waste minimization facilities in Korea. Waste fires are characterized by high severity and are prone to reignition, and it is difficult to timely detect them. Waste fires consequently demand many firefighters, equipment, and time to extinguish. Notwithstanding this reality, waste is excluded from the category of special combustible materials in the Act on Installation and Management of Firefighting Systems, 2021 (the Act). Therefore, this study proposes that special combustible materials, including waste, should be incorporated into the Act, that fire detectors and photoelectric smoke detectors should be installed to enable early detection of fires, and that the use of water and foaming agents as firefighting equipment should be enforced.

Keywords : Waste, Waste Facilities, Fire Severity, Fire Safety Control, Special Combustible Materials

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1. Introduction

On November 11, 2016, a fire broke out at a magnesium waste recycling facility in South Korea. The fire ignited when welding sparks spread to nearby magnesium waste. It was an unfortunate accident that resulted in one firefighter injured and three firefighters dead. The fire was extinguished after 30 hours of struggle, with 171 firefighters and 31 firefighting vehicles deployed.[1]

In general, fires at waste facilities require considerable manpower, equipment, and time to be extinguished because of the difficulty in initial fire detection and the severity of the fire. In addition, the lack of information on waste facilities and the different types of waste poses a significant risk to the safety of firefighters when extinguishing fires caused by waste.

Nevertheless, fire-related laws demonstrate serious fire prevention problems by requiring fire protection for waste treatment, storage, and recycling facilities that is similar to that required for general buildings. In addition, waste stored outdoors presents many problems because it is not properly regulated in the current fire codes.

Existing research results do not mention any special combustible materials inside waste facilities, and instead focus on fire prevention and management improvements for treatment facilities.[2,3]

This study analyzed the Act on Installation and Management of Firefighting Systems and

current problems regarding the prevention of fires and efficient extinction of fires in waste treatment facilities.

2. Waste Facilities and Firefighting Regulations

2.1 Waste Facilities

Waste is material that has become unnecessary for human life or business activities, such as garbage, combustible materials, sludge, waste oil, waste acids, waste alkali, and animal carcasses.[4] They are categorized as commercial waste, household waste other than commercial waste, designated waste that may cause environmental pollution or harm to the human body, or medical waste that may cause infection in the human body.

The Act defines waste-related facilities as resource cycling-related facilities. Waste-related facilities include waste recycling facilities, waste disposal facilities, and waste reduction facilities.[5] (Fig. 1).

According to the National Fire Agency's



Fig. 1 Types of waste facilities. (a) Waste recycling facilities (b) Waste treatment facilities (c) Waste minimization facilities

2022 statistics, there are 4,127 waste-related facilities in South Korea.[6] Facilities that collect, process, and transport waste that are registered as factory storage facilities rather than resource circulation facilities under the fire-related laws cannot be confirmed in statistical data, and it is assumed that many more waste-related facilities are scattered throughout the country. (Table 1)

Table 1. Number of waste facilities.(Unit: number)

Total	Waste recycling facilities	Waste treatment facilities	Waste minimization facilities
4,127	1,810	2,094	223

2.2 Fire Law Regulations

The minimum seniority level of the fire safety manager at a waste-related facility is Level 3 fire protection, which is a facility

Table 2. Installation status of firefighting systems

Division (Firefighting systems)	Total floor area (More than)	Quantity (More than)
Fire extinguishing apparatus	33 m ²	
Automatic fire detection systems	2,000 m ² (resources circulation facilities) 1,000 m ² (factories, warehouses)	500 times
Indoor fire hydrant systems	3,000 m ² (factories, warehouses)	750 times
Sprinkler systems	5,000 m ² (warehouses)	1,000 times
Outdoor fire hydrant systems		750 times

with an automated fire detection system or a Simplex sprinkler equipment.[7] Firefighting facilities installed in waste-related facilities must include fire extinguishing devices, automated fire detection equipment, indoor fire hydrants, sprinkler systems, and outdoor fire hydrants according to the total size of the area to be protected against fires or the specified quantity of special flammable materials allowed. Table 2 shows the installation status of firefighting facilities according to the total floor area and designated quantity of waste-related facilities.[8]

3. Fire Status and Characteristics

3.1 Fire Status

According to the National Fire Information System's analysis of the incidences of fires at waste facilities over the previous four years were 95 cases in 2017, 106 in 2018, 114 in 2019, and 121 cases in 2020. These statistical data exclude the fire status of waste stored in factories and warehouses as it is not included in the fire statistics of waste-related facilities among resource recycling facilities subjected to specialized firefighting.[9] (Table 3).

Table 3. Fire statistics. (Unit: number)

Division (Year)	Number of fires	Dead	Injury
2017	95	0	4
2018	106	0	7
2019	114	0	2
2020	121	1	9

A representative fire case is the fire that occurred at an outdoor industrial waste landfill in Gyeongsangbuk-do on April 10, 2021, requiring 48 hours to be completely extinguished. According to the report following the fire investigation, it started as a fuming fire that gradually expanded and was only sighted and reported to 119 by an officer after some time.

On December 19, 2016, a fire occurred at a synthetic resin industrial waste warehouse in Ulsan, which was caused by spontaneous combustion due to heat accumulation. According to the fire investigation report, the fire repeatedly reignited as surface combustion and surface fires, and it took several days to completely extinguish (Fig. 2).



Fig. 2 Example of a fire at a waste facility

3.2 Fire Characteristics

A waste fire is a mixture of an unspecified amount of waste and exhibits the characteristics of a smoldering combustion fire during the initial stages of ignition. It is very difficult to recognize whether a fire has started during the early stages of a surface combustion fire without a discernable flame.[10] Because of these characteristics, fires are often not discovered until they have been burning for a

considerable time. In addition, because of reignition, it may take several days to completely extinguish a fire, requiring substantial manpower and equipment.

The current firefighting acts do not have standards for waste storage and operation in factories, warehouses, and resource circulation facilities. Owing to the inadequacy of these acts, a large amount of waste is accumulated and stored compared to the prudent limits that should be acknowledged as firefighting targets.

A large amount of waste requires considerable effort from firefighters because of its characteristic of high fire severity. Fire severity is expressed in terms of fire load energy density and fire intensity as a function of duration and maximum temperature.[11]

Fire load is a factor that determines the number of minutes of extinguishing it with water and is a measure of the size of the fire. In other words, it is a quantitative concept that refers to the total amount of heat generated by the complete combustion of combustible materials.

It is expressed as the total mass of combustibles ($\sum(G_t \times H_t)$) per unit area (H_0) (Equ. 1) and is proportional to the area of the opening (A) and the square root of the height of the opening (\sqrt{H}) for compartmentalized room fires, and inversely proportional to the surface area of the room (A_T) (Equ. 2).

$$\frac{\sum(G_t \times H_t)}{H_0} \quad (1)$$

$$\frac{A\sqrt{H}}{A_T} \tag{2}$$

Fire intensity is a factor that determines the water discharge rate (ℓ/m²-min) of the extinguishing water and is a measure of the intensity of the fire. In other words, it is a qualitative concept that refers to the value of energy accumulated per unit area of a combustible material. In the case of a compartment fire, it is proportional to the floor area (A_F) and inversely proportional to the square root of the opening area (A) and opening height (√H).

$$\frac{A_F}{A\sqrt{H}} \tag{3}$$

4. Analysis and Suppression Methods

The causes of fires in waste-related facilities include arson, fermentation heat of organic materials, oxidation heat of organic materials, chemical reaction heat of inorganic materials, friction heat, and natural explosion heat.[12][13] Due to the characteristics of waste fumigation fires, the detection of fire occurrence is very late; therefore, it is necessary to introduce flame detectors and photoelectric smoke detectors that can detect a fire occurrence at an early stage.

To extinguish the fire, it is necessary to suppress the flames with a large volume of fire-extinguishing water by water supply equipment in the early stages of a waste fire

with high fire severity. However, the current Act does not provide for firefighting water equipment for waste-related facilities. It is necessary to amend the law to allow for effectively suppressing such fires. In addition, this study proposes that a foaming agent should be installed to prevent fires from reigniting by suffocation caused by the resultant air blockage.

Although posing many fire prevention risks, waste is not considered a special combustible. In particular, there are no regulations for waste stored outdoors at factories and warehouses under the current fire prevention legislation. According to the Act on Fire Prevention and Safety Control, waste loaded inside and outside industrial facilities such as factories and warehouses are classified as special combustibles (materials that spread quickly and are difficult to extinguish owing to the high heat of combustion in case of fire).[14] It is necessary to introduce measures

Table 4. Special combustible materials

Classification		Quantity (More than)
cotton products		200 kg
wooden shells, plane crumbs		400 kg
rags, paper crumbs		1,000 kg
types of thread		1,000 kg
straw products		1,000 kg
combustible solid products		3,000 kg
coal, charcoal products		10,000 kg
combustible liquid products		2 m ³
woodworking goods, wood crumbs		10 m ³
rubber, plastic products	fired up	20 m ³
	etc.	3,000 kg

to prevent fires by including waste management companies over a certain size in the fire safety management targets (Table 4).

5. Conclusion

Fires caused by waste are difficult to detect in their early stages and the intensity of these fires can be extremely high, requiring large firefighting forces and long firefighting times. In addition, it is difficult for firefighters at the scene to determine the extinguishing agents required for such fires because of the mixture of various types of industrial waste. In addition, hazardous waste and medical waste pose a high risk of injury and infection due to explosions while the fire is being fought. The rapid expansion of waste incineration generates many toxic gases with concomitant secondary threats to citizens' safety, such as air pollution and water quality problems.

This study analyzed the current status of waste-related facilities, fire codes and regulations, fire occurrences, fire cases, and fire characteristics in Korea. Based on the results of the analysis, the introduction of flame detectors and photoelectric smoke detectors for early fire detection in waste-related facilities and the introduction of water supply fire extinguishing facilities and fire extinguishing facilities, are proposed. It is further suggested waste should be designated as a special flammable material and that

waste management enterprises above a certain size should be classified as fire safety management enterprises. and The results of the analysis will be used as useful data for fire prevention and suppression at waste treatment facilities.

References

- [1] Nam, K.H., Lee, J.S., "Study on the effective response method to reduce combustible metal fire." *Journal of the Korea Academia-Industrial Cooperation Society*, Vol. 19, No. 12, pp. 600–606, 2018.
- [2] Myong In-Hoang, "A Study on the Fire Risk in the storage area in Waste treatment facilities." University of Seoul, 2022.
- [3] Moon Keun-O, Etc. "Study on the effective response method to reduce combustible metal fire." *Journal of Fire Investigation Society of Korea*, Vol. 12, No. 4, pp. 3–20, 2021.
- [4] Ministry of Government Legislation, "Wastes Control Act." Law No. 18853, April 27, 2023.
- [5] Ministry of Government Legislation, "Act on Installation and Management of Firefighting Systems, Attached Form 2" Wholly Amended by Presidential Decree No. 33321, March 7, 2023.
- [6] National Fire Agency, "Fire prevention and safety management statistics," 2022.
- [7] Ministry of Government Legislation, "Act on Fire Prevention and Safety Control, Attached Form 4." Presidential Decree, Law No. 33199, January 3, 2023.
- [8] Ministry of Government Legislation, "Enforcement Decree of the Act on Installation and Management of Firefighting Systems." Wholly Amended by Presidential Decree No. 33321, March 7, 2023.

- [9] Korea National Fire Agency, "National Fire Data System." [Online] Available from: <http://www.nfs.go.kr/>, [Accessed: May 23, 2023].
- [10] Oh, M.G., Ann, Y.D., Lee, D.H., Kang, D.M., "A Study on the Fire Possibility of Waste Fire." *Journal of Fire Investigation Society of Korea*, Vol. 12, No. 1, pp. 3–20, 2021.
- [11] Yang, S.C., Lee, J.S., "Investigation of Fire Resistance Performance Considering Fire Conditions in Compartments." *Journal of the Korean Society of Hazard Mitigation*, Vol. 19, No. 5, pp. 119–125, 2019.
- [12] Choi, H.H., Cho, B.H., Park, M.G., Lim, G.H., "An Experimental Study on the nature of industrial waste combustion." *Magazine of Fire Investigation Society of Korea*, Vol. 6, No. 2, pp. 109–114, 2015.
- [13] Jung, E.S., Kang, K.S., "A Study on Fire Risk & Countermeasure of RDF (Refuse Derived Fuel)." *Journal of the Korea Safety Management and Science Conference*, Vol. 2009, No. 1, pp. 17–25, 2009.
- [14] Ministry of Government Legislation, "Enforcement Decree of the Act on Fire Prevention and Safety Control, Attached Form 2," Amended by Presidential Decree No. 33199, January 3, 2023.

(Manuscript received April 4, 2024;

revised April 8, 2024; accepted April 15, 2024)