An Experiment on Apparent Specific Gravity and Settleable Degree of Fire Extinguishing Agent according to Durable Years of Regional Powder Extinguisher

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Abstracts: For powder extinguishing agents based on the useful life of the powder extinguisher, a powder extinguisher with a elapsed life of 6-10 years was collected from market, factory, and apartment houses to experiment with changes in volume by appearance and sedimentation, and to examine digestive characteristics. As a result of the study, the first, second, and third arithmetic mean analysis of the apparent specific gravity experiments from 6 to 10 years of use, showed that the total arithmetic average of three experiments in the market area with an 8-year useful life was 127mL. In 2012, the average arithmetic average of three experiments in multi-family housing with a 10-year useful life was 131mL, which was found to be inappropriate. Second, in the experimental value for sedimentation, it was found to be unsuitable in the 2012 sedimentation experiment on samples in the apartment area. In other words, the sedimentation test of the powder extinguishing agent should not occur within an hour, but the sample in the apartment complex area in 2012 was found to be defective. Third, the fire extinguisher needs to be strengthened to enable fire extinguisher maintenance and inspection because problems that cannot be used during initial fire suppression occur depending on the place of deployment, surrounding environment, age of use, and maintenance status.

Keywords: type 3, powder extinguisher, useful life, and physical properties test

1. INTRODUCTION

In case of fire, a fire extinguisher is the most effective means used for initial fire extinguishing [1]. According to ‘Article 3 Definition’ of fire safety standards for fire extinguishers and automatic fire extinguishing systems, they are classified into Class A, Class B, Class C, and Class K [2].

Powder fire extinguishing agents are classified into type 1 to type 4 powders, and in Korea, the type 3 of powder extinguishing agents are used the most. In the classification of fire, it is adaptable to Class A, Class B, and Class C fires, and is usually referred to as ABC powder extinguishing agent. Although the fire extinguisher using the third type powder extinguishing agent has excellent extinguishing power, problems such as damage from the powder and damage to objects due to metaphosphoric acid after using it occur as disadvantages. The use of a powder extinguisher can work greatly for the initial fire suppression and prevent the spread of fire by occupants before the fire brigade arrives in the event of a fire, and minimize damage to life and property. However, in the event of a fire, if the fire extinguishing agent solidifies due to moisture and humidity, and the radiation ability is reduced, damage to the human life and property will increase even more.

Powder fire extinguishers used to prevent the spread of combustion in case of a fire and to extinguish the initial fire are maintained and checked by fire safety managers and periodic internal inspections, but in most workplaces, they are checked by visual inspection. Also, depending on the location of the powder fire extinguisher, there is a situation where the powder cannot be used for fire-fighting activities because the powder is solidified due to moisture and humidity and cannot be emitted [3]. Accordingly, since 2017, the service life of the powder fire extinguisher has been applied to 10 years, and if there is no defect in the performance by sampling inspection, which is limited to only once, the powder fire extinguisher can be used for 13 years by extending it by 3 years. As a previous study related to powder fire extinguishers, Bok-Shik Son (2015) understood the process of making powder fire extinguishers by manufacturers to establish legal standards for recycling powder fire extinguishers and analyzed the current problems of powder fire extinguishers. In addition, by testing the possibility of recycling through the disassembling process of the powder fire extinguisher, a checklist of priority considerations was prepared and evaluated, and finally the powder fire extinguisher recycling standard to be used when recycling the fire extinguisher was analyzed [4]. Jinyoung Bae (2020) discusses the ripple effect of the powder fire extinguishing agent recycling

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system using the recycling device of the powder fire extinguisher and the legal technical standards for the extinguishing performance of the powder extinguishing agent, import substitution according to the development of eco-friendly powder extinguishing agents, cost reduction, industry, economic factors were quantitatively analyzed. In addition, recycling standards were presented by analyzing the performance of waste powder extinguishing agents using KS M 0016 and KS M 0032 methods [5]. Eui-pyung Lee (2012) analyzed the cases and causes of powder fire extinguisher rupture accidents. It proposed ideas about, the promotion and education on the dangers of corroded fire extinguishers, review of the introduction of a hydraulic inspection system for fire extinguishers after a certain period of time, establishment of a waste fire extinguisher recovery system, operation of counseling windows related to old fire extinguishers, indication of risk of rupture, mandatory service life indication, etc. for the training and education purpose [6]. In addition, in this study, there are a number of previous studies on the development of eco-friendly gas fire extinguishers and the study of powder fire extinguishers as it ages. Most of the preceding studies are limited to searching for fire extinguishing agent recycling methods, equipment, and recovery systems of powder fire extinguishers. It was not possible to analyze whether there was any actual change according to the service life of the powder fire extinguishing agent, the region, and the place of placement, the size of the change, and the extinguishing performance. Because of this recognition of this problem, in this study, in order to know the state of maintaining extinguishing performance according to the aging of the powder extinguishing agent in use, which was not covered in previous studies, the extinguishing agent was extracted from the powder extinguishers collected from the market area, factory area, and apartment complex area, and the volume by appearance, and whether there is a problem with the emittance standard and whether it maintains an appropriate performance state through the sedimentation test was analyzed. Through this, it is intended to be used smoothly in the initial response in case of fire.

2. TYPES AND CHARACTERISTICS OF POWDER FIRE EXTINGUISHING AGENTS

2.1. Types of powder extinguishing agents

There are 4 types of powder extinguishing agents, from type 1 to type 4. Type 1 has sodium bicarbonate as the main component, and uses silicone resin for surface treatment and metal stearate to prevent solidification by moisture and humidity. The main fire extinguishing effects are cooling digestion, chain reaction blocking effect, and suffocation effect. It is effective against electric fires and oil fires, but it is not generally used for general fires [7].

The main component of the second type is potassium hydrogen carbonate, and the main digestive effects are cooling digestion, chain reaction blocking effect, and suffocation effect. The main extinguishing effects are cooling digestion, asphyxiation digestion, blocking effect, and chain reaction blocking effect [8].

Type 3 is as known as the ABC powder extinguishing agent and is used for Class A fires, Class B fires, and Class C fires. The main ingredient is monoammonium phosphate, and the color of the agent is pink. The first ammonium monophosphate reacts with water and is classified into pyrophosphoric acid, metaphosphoric acid, and orthophosphoric acid according to a thermal decomposition reaction equation. Type 3 is also effective against Class A fires, and orthophosphoric acid produced by the thermal decomposition reaction of the first monoammonium phosphate dehydrates and carbonizes fibers constituting wood, fiber, paper, etc. to change it into flame-retardant carbon and water, which can block the chain reaction effect. Orthophosphoric acid, which is dehydrated and carbonized, is pyrolyzed again at high temperature to finally become the most stable glassy metaphosphoric acid. Metaphosphoric acid forms a glassy film on the surface of inflammables to block the inflow of oxygen required for combustion, so combustion is stopped.

The type 4 is mainly composed of a reactive agent of potassium hydrogen carbonate and urea, and the agent is colored gray. Currently, it is not in production [9].

2.2. Characteristics of powder fire extinguishing agents

The main components of powder extinguishing agents are substances such as potassium hydrogen carbonate, sodium hydrogen carbonate, and monoammonium phosphate, which are made into a fine powder and ejected to extinguish the fire. At this time, there is a difference in the extinguishing ability according to the size of the powder particles. The finer the powder, the greater this ability. On the other hand, if it is too fine, it also causes scattering

issues, so it should be emitted directly to the fire source while blocking the wind with one's back and standing at an appropriate distance [10]. Since powdered fire extinguishing agents react with moisture and humidity to cause solidification, moisture-proof processing with silicone resin and metal stearate is required [11]. Most of the powder fire extinguishers have been replaced the one with pressure accumulators, at present, and the main fire extinguishing effects are the auxiliary catalyst effect, the suffocation effect, and the blocking effect of radiant heat. In the case of type 3 powder extinguishing agent, it is used for general fires, electric fires, and oil fires [12].

3. EXPERIMENTAL METHOD

3.1. Extraction of digestive agents

As shown in Table 1, a total of 30 ABC powder fire extinguishers used in the experiment were collected; 10 from the market areas, 10 from the factory areas, and 10 from the apartment complex areas out of 10 years from January 2012 to January 2022 by production year. After a visual inspection, only 15 powder fire extinguishers with a service life of 6 to 10 years or less were used in the experiment. First, the condition of the environment with certain exposure to the collected fire extinguisher was checked, and the extinguishing agent was extracted while disassembling the valve part of the powder fire extinguisher and removing the storage container handling accessories for extracting the extinguishing agent. After sample extraction, it was visually checked whether the fire extinguishing agent was solidified. In addition, the characteristics of the volume by appearance and sedimentation tests were recorded based on 「Technical standards for type approval and product inspection of fire extinguishers」.

Table 1. Criteria for determining the physical property of a powder fire extinguishing agent.
Table 1. Criteria for Physical Property of Powder Extinguishing Agent.

Category	Volume by appearance	Sedimentation
Judgment Criteria	"Over 0.820 g/mL" (= Less than 120mL)	"If the powder is evenly sprayed on the water surface, it should not sink within an hour."

As shown in Figure 1, among the fire extinguishers, used in this experiment, using ABC powder extinguishing agents, collected from the market area, factory area, and apartment complex, 6 to 10 years old from January 2012 to January 2017 by production year, 15 fire extinguishers were classified and finally selected through storage conditions and visual inspection.

Figure 1. Experimental materials according to the years of use of powder fire extinguishers.
Figure 1. Experimental Materials according to Durable Years of Powder Extinguisher.

3.2. Volume by appearance test [13]

Based on 「Technical standards for type approval and product inspection of fire extinguishers」, "the experimental value of the volume by appearance of powder fire extinguishing agents should be less than 120 mL. Put (100 ± 1) g of sample into a 250 mL cylinder with a stopper (inside diameter of about 40 mm, minimum scale 1-2 mL), rotate it up and down 10 times per minute, store for 1 minute, and read the volume of the sample. The volume by

appearance is taken as the average value after 3 runs. Calculation of volume by appearance is the same as Equation (1)".

$$겉보기비중 = \frac{시료의중량(g)}{시료의용적(ml)} \quad \cdots\cdots\cdots\cdots(1)$$

Figure 2 is a measuring cylinder for the volume by appearance analysis experiment.

Figure 2. Volume by appearance test equipment.

Figure 2. Experimental Equipment for Apparent Specific Gravity.

3.3. Sedimentation test [13]

The sedimentation test is based on 「Technical standards for type approval and product inspection of fire extinguishers」, and it requires to "Pour powder fire extinguishing agent with 200 mL of water in a 200 mL beaker, spread 20 g of the sample evenly on the water surface, preserve for 1 hour, and then extinguish the powder to test whether the agent sinks".

Figure 3 is a beaker for the sedimentation test.

Figure 3. Sedimentation test equipment.

Figure 3. Settleable Experimental Equipment.

4. Experimental analysis and results review

4.1. Volume by appearance test

4.1.1 The first test of the volume by appearance

The experimental value of the volume by appearance of the powder fire extinguishing agent is 120 mL or less. As a result of analyzing the volume by appearance, as shown in Table 2, the first experimental values for the apparent specific gravity were 112 mL for the market area, 114 mL for the factory area, and 97 mL for the apartment complex area in the case of a service life of 6 years, and all of them were found to be suitable. In the case of a service life of 7 years, the first experimental values for the volume by appearance of the market area, factory area, and apartment complex area were 114 mL for the market area, 103 mL for the factory area, and 117 mL for the

apartment complex area, and all were found suitable. In the case of a useful life of 8 years, regarding the first experimental value for the volume by appearance of the market area, factory area, and apartment complex area, the market area value was found as 130 mL, which was found to be unsuitable. For the rest, the factory area was 116 mL and the apartment complex area was 113 mL, which was found to be suitable. In the case of a service life of 9 years, the first experimental values for the volume by appearance of the market area, factory area, and apartment complex area were 118 mL for the market area, 116 mL for the factory area, and 107 mL for the apartment complex area. In the case of a service life of 10 years, the first experimental values for the volume by appearance of the market area and the factory area were 115 mL for the market area and 112 mL for the factory area, that were found suitable. The first experimental value for the volume by appearance for the remaining apartment complex areas was 134 mL, which was found to be unsuitable. In other words, 2 out of 15 (13.3%) powder fire extinguishers had an volume by appearance that did not meet the standard, starting from 6 to 10 years of service life.

Table 2. First test analysis of the powder extinguishing agent's volume by appearance.

Table 2. Primary Test Analysis on Apparent Specific Gravity of Powder Extinguishing Agent.

Category		**Volume by appearance (Less than 120 mL)**	**Result**
Production Year	**Sample analysis area**		
2016 (Service life 6 years)	Market area	112	Suitable
	Factory area	114	Suitable
	Apartment complex area	97	Suitable
2015 (Service life 7 years)	a market-dominating position	114	Suitable
	Factory area	103	Suitable
	Apartment complex area	117	Suitable
2014 (Service life 8 years)	a market-dominating position	130	Inappropriate
	Factory area	116	Suitable
	Apartment complex area	113	Suitable
2013 (Service life 9 years)	a market-dominating position	118	Suitable
	Factory area	116	Suitable
	Apartment complex area	107	Suitable
2012 (Service life 10 years)	a market-dominating position	115	Suitable
	Factory area	112	Suitable
	Apartment complex area	134	Inappropriate
Subtotal/Defect Rate	15/(100%)		2/(13.3%)

4.1.2 The second test of the volume by appearance

The experimental value of the volume by appearance of the powder fire extinguishing agent is 120 mL or less. As a result of analyzing the volume by appearance, as shown in Table 3, the second experimental values for the apparent specific gravity were 113 mL for the market area, 114 mL for the factory area, and 107 mL for the apartment complex area in the case of a service life of 6 years, and all of them were found to be suitable. In the case of a service life of 7 years, the first experimental values for the volume by appearance of the market area, factory area, and apartment complex area were 112 mL for the market area, 107 mL for the factory area, and 116 mL for the apartment complex area, and all were found suitable. In the case of a useful life of 8 years, regarding the second experimental value for the volume by appearance of the market area, factory area, and apartment complex area, the market area value was found as 127 mL, which was found to be unsuitable. For the rest, the factory area was 114 mL and the apartment complex area was 113 mL, which was found to be suitable. In the case of a service life of 9 years, the first experimental values for the volume by appearance of the market area, factory area, and apartment complex area were 117 mL for the market area, 116 mL for the factory area, and 107 mL for the

apartment complex area. In the case of a service life of 10 years, the second experimental values for the volume by appearance of the market area and the factory area were 114 mL for the market area and 112 mL for the factory area, that were found suitable. The second experimental value for the volume by appearance for the remaining apartment complex areas was 128 mL, which was found to be unsuitable. In other words, 2 out of 15 (13.3%) powder fire extinguishers had an volume by appearance that did not meet the standard, starting from 6 to 10 years of service life.

Table 3. Second test analysis of the powder extinguishing agent's volume by appearance.

표 3. Second Test Analysis on Apparent Specific Gravity of Powder Extinguishing Agent.

Category		Volume by appearance (Less than 120 mL)	Result
Production Year	Sample analysis area		
2016 (Service life 6 years)	Market area	113	Suitable
	Factory area	114	Suitable
	Apartment complex area	107	Suitable
2015 (Service life 7 years)	Market area	112	Suitable
	Factory area	107	Suitable
	Apartment complex area	116	Suitable
2014 (Service life 8 years)	Market area	127	Inappropriate
	Factory area	114	Suitable
	Apartment complex area	113	Suitable
2013 (Service life 9 years)	Market area	117	Suitable
	Factory area	116	Suitable
	Apartment complex area	107	Suitable
2012 (Service life 10 years)	Market area	114	Suitable
	Factory area	112	Suitable
	Apartment complex area	128	Inappropriate
Subtotal/Defect Rate	15/(100%)		2/(13.3%)

4.1.3 The third test of the volume by appearance

The experimental value of the volume by appearance of the powder fire extinguishing agent is 120 mL or less. As a result of analyzing the volume by appearance, as shown in Table 4, the second experimental values for the apparent specific gravity were 112 mL for the market area, 110 mL for the factory area, and 100 mL for the apartment complex area in the case of a service life of 6 years, and all of them were found to be suitable. In the case of a service life of 7 years, the first experimental values for the volume by appearance of the market area, factory area, and apartment complex area were 115 mL for the market area, 101 mL for the factory area, and 118 mL for the apartment complex area, and all were found suitable. In the case of a useful life of 8 years, regarding experimental value for the volume by appearance of the market area, factory area, and apartment complex area, the market area value was found as 125 mL, which was found to be unsuitable. For the rest, the factory area was 118 mL and the apartment complex area was 110 mL, which was found to be suitable. In the case of a service life of 9 years, the first experimental values for the volume by appearance of the market area, factory area, and apartment complex area were 117 mL for the market area, 118 mL for the factory area, and 108 mL for the apartment complex area. In the case of a service life of 10 years, the second experimental values for the volume by appearance of the market area and the factory area were 116 mL for the market area and 115 mL for the factory area, that were found suitable. The second experimental value for the volume by appearance for the remaining apartment complex areas was 132 mL, which was found to be unsuitable. In other words, 2 out of 15 (13.3%) powder fire extinguishers had an volume by appearance that did not meet the standard, starting from 6 to 10 years of service life.

Table 4. Third test analysis of the powder extinguishing agent's volume by appearance.
Table 4. Third Test Analysis on Apparent Specific Gravity of Powder Extinguishing Agent.

Category		Volume by appearance (Less than 120 mL)	Result
Production Year	**Sample analysis area**		
2016 (Service life 6 years)	Market area	112	Suitable
	Factory area	110	Suitable
	Apartment complex area	100	Suitable
2015 (Service life 7 years)	Market area	115	Suitable
	Factory area	101	Suitable
	Apartment complex area	118	Suitable
2014 (Service life 8 years)	Market area	125	Inappropriate
	Factory area	118	Suitable
	Apartment complex area	110	Suitable
2013 (Service life 9 years)	Market area	117	Suitable
	Factory area	118	Suitable
	Apartment complex area	108	Suitable
2012 (Service life 10 years)	Market area	116	Suitable
	Factory area	115	Suitable
	Apartment complex area	132	Inappropriate
Subtotal/Defect Rate	15/(100%)		2/(13.3%)

4.1.4 Arithmetic mean analysis and review of volume by appearance

As a result of the apparent specific gravity analysis, as shown in Table 5, the 1st, 2nd, and 3rd results of the apparent specific gravity experiment were analyzed as the arithmetic mean results from 6 to 10 years of service life of the powder fire extinguisher. Based on that, it was analyzed as unsuitable in the market area with a use life of 8 years in 2014 and an apartment complex area with a use life of 10 years in 2012. In other words, the volume by appearance of the powder fire extinguishing agent should be managed below the standard value of 120 ml. In 2014, the average analysis in the market area with a useful life of 8 years was 130 mL in the first experiment, 127 mL in the second experiment, and 125 mL in the third experiment, that are considered unsuitable. In addition, the arithmetic mean of three experiments was 127 mL, which was found to be unsuitable. As a result of the average analysis in an apartment house with a useful life of 10 years in 2012, the result value of the volume by appearance experiments was 134 mL in the first experiment, 128 mL in the second experiment, and 132 mL in the third experiment, which was deemed unsuitable. The arithmetic mean of three experiments was 131 mL, which was found to be unsuitable as well. This means that the extinguishing agent in the powder state should not have any abnormalities such as hardening, lumps, or deterioration.

Table 5. Arithmetic mean analysis of volume by appearance.
Table 5. Arithmetic Mean Analysis of Apparent Specific Gravity.

Category		1st experiment	2nd experiment	3rd experiment	Average	Result
Production Year	**Sample analysis area**					
2016 (Service life 6 years)	Market area	111	113	112	112	Suitable
	Factory area	114	114	110	112	Suitable
	Apartment complex area	97	107	100	101	Suitable

2015 (Service life 7 years)	Market area	114	115	115	114	Suitable
	Factory area	103	107	101	103	Suitable
	Apartment complex area	117	116	118	117	Suitable
2014 (Service life 8 years)	Market area	130	127	125	127	Inappropriate
	Factory area	116	114	118	116	Suitable
	Apartment complex area	113	113	110	112	Suitable
2013 (Service life 9 years)	Market area	118	117	117	117	Suitable
	Factory area	116	116	118	116	Suitable
		107	107	108	107	
	Apartment complex area					Suitable
2012 (Service life 10 years)	Market area	115	114	116	115	Suitable
	Factory area	112	112	115	113	Suitable
	Apartment complex area	134	128	132	131	Inappropriate
Subtotal/Defect Rate	15/(100%)					2/(13.3%)

As shown in Table 5, the volume by appearance of powder fire extinguishers with a service life of 6 years was stable in the market area, factory area, and apartment complex area. Those with a small volume by appearance have fine powder particles, which are effective in increasing fire extinguishing ability, but the short emittance distance reduces the amount of effective chemical reaching the fire site. The emitted agent scatters upward by the rising airflow of heat, so it cannot reach the fire point and does not cover the flame, which causes the fire extinguishing effect not to be obtained.

As shown in Figure 4, the experimental value of the volume by appearance should be less than 120 mL, but it was found to be 131 mL, which is a bit more than the actual result. In the market area with a useful life of 8 years, the experimental value was 127 mL and the service life of 10 years, the experimental value of the apartment housing area was 131 mL, which was deemed unsuitable. If the volume by appearance is higher than the standard value, the extinguishing effect is reduced even if the powder fire extinguisher is emitted. Therefore, it is important that the distribution of powder particles is properly maintained.

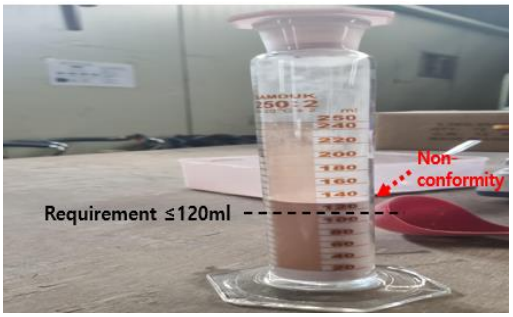

Figure 4. Determination of volume by appearance of powder fire extinguishers.

Figure 4. Judgment on Apparent Specific Gravity of Powder Extinguisher.

4.2. Test and review of sedimentation

The settling test value of the powder extinguishing agent is prescribed as a criterion for determining whether the powder of the powder extinguishing agent is precipitated. As a result of analyzing the sedimentation characteristics, as shown in Table 6, the experimental values for sedimentation properties for the market area, factory area, and apartment complex area were found to be suitable for all the areas. In the case of 7 years, the experimental values for sedimentation in the market area, factory area, and apartment complex area were found to be suitable for all the areas. In the case of 8 years, the experimental values for sedimentation in the market area, factory area, and apartment complex area were found to be suitable for all the areas. In the case of 9 years, the experimental values for sedimentation in the market area, factory area, and apartment complex area were found to be suitable for all the areas. In the case of 10 years, the experimental values for sedimentation properties in the market area and factory area were found to be suitable, but the experimental values for the apartment complex area were found to be unsuitable. In other words, 1 out of 15 (6.67%) of powder fire extinguishers were found to be unsuitable at the point between 6 to 10 years of service life. This is because powder fire extinguishing agents are not evenly distributed on the surface of the water due to other abnormalities such as hardening, lumps, deterioration, etc., due to long standing in an airtight container, depending on the progress of their useful life, exposure to the external environment, and management status. Based on the results, it seems that there can be a problem leading to falling or inability to radiate.

Table 6. Sedimentation Test Analysis of Powder Extinguishing Agent.
Table 6. Sedimentation Test Analysis of Powder Extinguishing Agent.

Category		Test result
Production Year	**Sample analysis area**	**Sedimentation**
2016 (Service life 6 years)	Market area	Suitable
	Factory area	Suitable
	Apartment complex area	Suitable
2015 (Service life 7 years)	Market area	Suitable
	Factory area	Suitable
	Apartment complex area	Suitable
2014 (Service life 8 years)	Market area	Suitable
	Factory area	Suitable
	Apartment complex area	Suitable
2013 (Service life 9 years)	Market area	Suitable
	Factory area	Suitable
	Apartment complex area	Suitable
2012 (Service life 10 years)	Market area	Suitable
	Factory area	Suitable
	Apartment complex area	Inappropriate
Subtotal/Defect Rate	15/(100%)	1/(6.67%)

As a result of the sedimentation analysis, as shown in Figure 5, a lump of agents, that is, sediments were generated. In the case of an apartment complex area, one (6.67%) of the 15 samples of the powder fire extinguishers with a service life of 6 to 10 years was analyzed as unsuitable with a service life of 10 years in 2012 as a result of the experiment. In other words, sedimentation is prescribed as a criterion for such determination of defects. This is because emittance problems occur depending on whether or not the powdered fire extinguishing agent settles. Therefore, it is judged that maintenance should be more depending on the location of placement in consideration of moisture and the surrounding environment. Therefore, it is judged that the systematical management plan for maintenance should be further strengthened so that the extinguishing performance of the powder extinguishing agent does not deteriorate according to the service life of the market area, factory area, and apartment complex area.

Figure 5. Sedimentation Judgment of Powder Extinguisher.
Figure 5. Settleable Judgment of Powder Extinguisher.

5. CONCLUSION

This study relates to the effectiveness of powder fire extinguishers, that is essential for preventing the expansion of fire sources and suppressing initial fires in case of fire. The service life of the powder fire extinguisher is 10 years, and in order to secure fire extinguishing performance according to the age of use, the extinguishing agent rule is extracted from the fire extinguisher collected from the market area, factory area, and apartment complex area, and volume by appearance and sedimentation test were conducted. Based on that, the following research conclusions were drawn.

(1) As a result of the volume by appearance the study first, second, and third arithmetic mean analysis of the apparent specific gravity experiments from 6 to 10 years of use, showed that the total arithmetic average of three experiments in the market area with an 8-year useful life was 127mL. In 2012, the average arithmetic average of three experiments in multi-family housing with a 10-year useful life was 131mL, which was found to be inappropriate. As a result of the arithmetic mean analysis of the 1st, 2nd, and 3rd experimental values of the volume by appearance, the volume by appearance in the market area of 8 years in 2014 was found to be unsuitable as 130 mL for the 1st experiment, 127 mL for the 2nd experiment, and 125 mL for the 3rd experiment., and the arithmetic mean of three experiments was 127mL, which was found to be inappropriate. As a result of the average analysis in an apartment house with a useful life of 10 years in 2012, the result value of the volume by appearance experiments was 134 mL in the first experiment, 128 mL in the second experiment, and 132 mL in the third experiment, which was deemed unsuitable. The arithmetic mean of three experiments was 131 mL, which was found to be unsuitable as well. In other words, if the powder extinguishing agent is exposed to high humidity air or left for a long time in an airtight container, it solidifies and turns into a lump, even if it is released by applying pressure, the extinguishing power may decrease or it may not be emitted. Therefore means that the extinguishing agent in the powder state should not have any abnormalities such as hardening, lumps, or deterioration.

(2) In the experimental value for sedimentation, it was found to be unsuitable in the 2012 sedimentation experiment on samples in the apartment area. In other words, the sedimentation test Sedimentation the powder extinguishing agent should not occur within an hour, but the sample in the apartment complex area in 2012 was found to be defective. In the case of powder extinguishing agents, the service life, exposure to the external environment, and management conditions are the causes of the low extinguishing power of the powder extinguishers. In particular, in the analysis of fineness, volume by appearance, and sedimentation test of powdered fire extinguishing agents from 6 to 10 years of service life collected from market areas, factory areas, and apartment complex area, some of the fire extinguishing agents were unable to be released due to solidification. Therefore, it is deemed necessary to consider reducing the service life of powder fire extinguishers from 10 years to 5 years.

(3) The fire extinguisher needs to be strengthened to enable fire extinguisher maintenance and inspection because problems that cannot be used during initial fire suppression occur depending on the place of deployment, surrounding environment, age of use, and maintenance status. Currently, functional inspection for operation and comprehensive detailed inspection are being conducted through self-inspection, but the operation status of fire extinguishers is not properly maintained in markets and factory areas. In other words, the inspection of the powder fire extinguisher is confirmed by visual inspection, and it is necessary to consider measures such as the application

of the service life according to external exposure and the replacement time of the powder fire extinguisher according to the maintenance status of each place of placement.

(4) In the manufacturing process, the charging method should also be reviewed in consideration of the workplace environment, humid season, and rainy weather. Due to the solidification phenomenon in which the extinguishing agent hardens with moisture, the volume by appearance and sedimentation properties may become suitable, so that it is impossible to release the extinguishing agent or the fire extinguishing performance turns to be poorer, so it cannot be used urgently in case of a fire.

This study is meaningful in that it conducted an experiment on the apparent specific gravity and sedimentation properties of fire extinguishing agents according to the service life of the powder fire extinguisher. However, the study has limitations, such as being biased to a specific region and a specific place, and lack of sample numbers. In future research, it is proposed to consider the service life and performance change of fire extinguishers placed in special environments such as beaches with high salinity and fire extinguishers on boats and ships.

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