Analysis of the Fineness Change Test of Type-3 Dry Chemical Powder with the Changes in Internal Pressure of Dry Chemical Extinguisher

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Abstracts: This study aims to analyze the fineness variance, one of the fire extinguisher's physical properties experiments, to confirm the maintaining state for fire extinguishing performance with changes in the internal pressure of the dry chemical extinguisher and the use periods, which were not covered in previous studies. The analysis results in fineness variance to examine the fire extinguisher's performance showed a difference in fineness variance with the change in internal pressure, whereas there was no difference in fineness variance with use periods. However, why sample 09-6-new in the recycled dry chemical powder with 13 elapsed years was found inappropriate was considered to result from poor maintenance, such as external environment and management status. So, it showed that fire extinguishers' maintenance proved an essential factor. Accordingly, it was suggested a need for practical training of fire safety managers and improving fire extinguisher inspection methods.

Keywords: Dry chemical extinguisher, Internal pressure, Fineness test, Durable years, Maintenance.

1. INTRODUCTION

Although the fire safety manager manages and inspects the dry chemical extinguishers used to prevent flame spreading and first-aid fire firefighting in the event of a fire, most workplaces only check them with the naked eye. In addition, depending on the location and management status of the dry chemical extinguishers, these cannot be emitted due to being solidified caused by moisture and humidity, so these may not be able to be used for fire extinguishing activity [1].

Dry chemical powders are classified into type-1 to type-4 powder, and type-3 dry chemical powders are used mainly in Korea. Depending on the classification of fires, they are adaptable to Class A, B, and C fires and are usually referred to as ABC dry chemical powder. Although fire extinguishers using type-3 dry chemical powder have excellent extinguishing power, inducing disadvantages, such as secondary damage caused by powder after use and damage to objects caused by metaphosphoric acid. The use of a dry chemical extinguisher prevents initial fire suppression and fire spreading. Also, it could minimize casualties and property damage by occupants using it before the fire brigade arrives in the event of a fire. However, if the dry chemical extinguisher's dry chemical powder deteriorates emitting capacity due to being solidified caused by moisture and humidity, it will cause human and property damage increase [2]. In Korea, the durable years of the dry chemical extinguisher have been applied to 10 years since 2017. In addition, if there is no defect in performance through a sampling test only once, it is permitted to use the dry chemical extinguisher for 13 years by extending three years.

B.S. Son (2015) understood the manufacturing process of dry chemical extinguishers and experimented with the possibility of recycling them through their decomposition process to establish legal standards for recycling dry chemical extinguishers. Moreover, the priority considerations for the dry chemical extinguisher recycling standards for recycling fire extinguishers were prepared as a checklist and analyzed through evaluation [3]. Y.B. Jin (2020) quantitatively analyzed various factors, such as the ripple effect of the dry chemical powder recycling system using the recycling device of the dry chemical extinguisher, legal-technical standards for the extinguishing performance of the dry chemical powder, substitution material importing with developing eco-friendly dry chemical powder, cost reduction, industrial and economic factors [4]. E. P. Lee (2012) analyzed the cases and causes of dry chemical extinguishers rupture and proposed risk publicity and education on corroded fire extinguishers, review of introducing an inspection system through water pressure test for fire extinguishers after a certain period, establishing an abandoned fire extinguisher recovery system, operating counseling counters related to old fire extinguishers, rupture

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hazard sign, mandatory indication of durable years [5]. A study by W.J. Lee et al. (2015) suggested that practical policies and support are needed to provide fire extinguishers in households, including apartments, to reduce casualties and property damage caused by fires [6]. Y.G. Shim's study (2015) experimented on three variables: the particle size of the fire-extinguishing component, the mixing ratio of the binder, and the blending ratio of the fire-extinguishing component and the binder. In addition, as the particle size of the extinguishing elements constituting the solid aerosol fire extinguishing agent decreases, the smoke density generated during the emitting fire extinguishing agent increases tendency was studied [7]. A study by A.V.Kunin et al. (2016) examined technology development for the production of fire extinguishing powder in which multifunctional ABCE dry chemical powder was composed of ammonium phosphate (mono-ammonium phosphate and ammonium phosphate) as the main ingredient [8]. Most previous studies have only been explored based on the recycling method for a fire-extinguishing agent, equipment, and recovery system of the dry chemical extinguisher, also have not been conducted further studies to analyze the change in the location's environment, durable years of fire extinguishing agent, and the fire extinguishing performance with the pressure change of the fire extinguishing container. Due to this recognition of the problems, this study aims to analyze the fineness variance, one of the fire extinguisher's physical properties experiments, to confirm the maintaining state for fire extinguishing performance with changes in the internal pressure of the dry chemical extinguisher and the use periods, which were not covered in previous studies.

2. RELATED LITERATURE

2.1. Theoretical Considerations

This study aims to research the sedimentation variance of the type-3 dry chemical powder with the change in the internal pressure of the extinguisher. The fire extinguishers used in the experiment were collected for dry chemical extinguishers aged 5, 10, and 13 years, which were manufactured between 2009 and 2017, and analyzed the sedimentation variance of the dry chemical extinguisher depended on the use periods when an internal pressure change of them, focusing on the usability issue of the fire extinguisher.

2.2. Experimental configuration

As shown in Table 1, this experiment configured the fire extinguishers manufactured between 2009 and 2017 divided into 0%, 50%, and normal state of internal pressure changes. In addition, in order to analyze the change in sedimentation variance with the internal pressure change and use periods of the fire extinguisher, a total of 40 samples were selected, 10 each from new dry chemical powder with 5 elapsed years, recycled ones with 5 elapsed years, new ones with 10 elapsed years, and new ones with 13 elapsed years, respectively.

Table 1. Experimental Configuration.

Changes in Internal pressure	Analysis of change in sedimentation status
0%	1. new dry chemical powder with 5 elapsed years
	2.. recycled dry chemical powder with 5 elapsed years
	3. new dry chemical powder with 10 elapsed years
	4. new dry chemical powder with 13 elapsed years
50%	1. new dry chemical powder with 5 elapsed years
	2. recycled dry chemical powder with 5 elapsed years
	3. new dry chemical powder with 10 elapsed years
	4. new dry chemical powder with 13 elapsed years
Normal	1. new dry chemical powder with 5 elapsed years
	2. recycled dry chemical powder with 5 elapsed years
	3. new dry chemical powder with 10 elapsed years
	4. new dry chemical powder with 13 elapsed years

2.3. Experimental Methods

2.3.1. Fineness judgment criteria

As shown in Table 2, the fire-extinguishing agent was extracted from ABC dry chemical extinguisher after

dismantling the valve part of the powder extinguisher and removing the accessories for handling the storage container to status check in the exposed environment.

After extracting the dry chemical powder sample, the characteristics of the fire extinguisher were examined through a fineness test based on 「Type Approval of Fire Extinguishers and Technical Standards for Product Inspection」 [9].

Table 2. Fineness judgment criteria.

	Fineness
Judgment criteria	"The residual amount that meets the technical standards when going through the KS A 5101-1 (Sieve for Test-Part 1: Metal mesh sieve) standard sieve"

2.3.2. Fineness determining criteria

For the fineness test, it used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by quantifying 100 g of a sample mixing powder based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>. Carefully put it in a 425 μm sieve of a multi-stage shaking apparatus and operate it 280 or 350 times a minute with an amplitude of 3 to 5 cm for 10 minutes, then quantify the residual amount of each specimen and base, and the residual rate is as shown in Equation (1).

$$\text{Rasidual ratio}(\%) = \frac{residual\ amount\ (g)}{specimen\ (g)} \times 100 \quad \text{.....Eq. (1)}$$

The average arithmetic value performed three times for each sample was set as the residual quantity rate. If the total amount of each specimen's residual quantity was less than 2% of the sample quantity, the test was not included in the number of tests. None of the submitted samples that meet the specifications was excluded. The relative humidity of the laboratory was 50% or less, and each supporting plate was brushed off with a brush. The fineness-determining criteria of the fire-extinguishing agent were analyzed, as shown in Table 3.

Table 3. Fineness determining criteria.

Standard sieve size(μm)	ABC Powder (Residual amount g)	
	Minimum	Minimum
425	0	0
150	0	10
75	12	25
45	12	25
Base	50	70

3. EXPERIMENTAL RESULTS

3.1. Changes in fineness of new dry chemical powder with five elapsed years

3.1.1. Changes in fineness of new dry chemical powder with five elapsed years

In the event of 0% internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 5 elapsed years were shown in Table 4. According to the results, in the case of the new dry chemical powder with 5 elapsed years, the mean experimental values for each sample number of the standard sieve size were 99.0 wt% on 17-1-new, 98.6 wt% on 17-2-new, 98.8 wt% on 17-3-new, 98.3wt% on 17-4-new, 98.5wt% on 17-5-new, 98.2wt% on 17-6-new, 99.2wt% on 17-7-new, 98.0wt% on 17-8-new, 99.3wt% on 17-9-new, 98.6wt% on 17-10-new, respectively, all of which were unsuitable. It came from showing all unsuitable results in the residual amount criteria for each standard sieve, such as no residual amount for ABC dry chemical powder in the 425 ㎛ sieves, the residual amount for ABC dry chemical powder in the range of minimum 0wt% to maximum 10wt% in the 150 ㎛ sieves, the residual amount for ABC dry chemical powder

in the range of minimum 12wt% to maximum 25wt% in the 150 ㎛ sieves in the 75 ㎛ sieves and 45 ㎛ sieves, and the residual amount for ABC dry chemical powder in the range of minimum 50wt% to maximum 70wt% in the 150 ㎛ sieves in the base.

Table 4. Changes in fineness of new dry chemical powder with 5 elapsed years.

2017(new dry chemical powder with 5 elapsed years		ABC Powder (Residual amount g)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
17-1-new	1	6.7	22.8	34.8	25.4	9.5	99.2	Unsuitable
	2	8.1	21.9	34.9	25.3	9.1	99.1	Unsuitable
	3	8.3	21.7	34.6	25.0	9.0	98.6	Unsuitable
	Avg	7.7	22.1	34.8	25.2	9.2	99.0	Unsuitable
17-2-new	1	0	15.2	24.6	36.2	22.8	98.8	Unsuitable
	2	0	14.8	25.1	37.0	22.0	98.9	Unsuitable
	3	0	14.6	25.2	36.3	21.9	98.0	Unsuitable
	Avg	0	14.9	25.0	36.5	22.2	98.6	Unsuitable
17-3-new	1	0	12.4	24.5	35.4	26.4	98.7	Unsuitable
	2	0	12.1	24.1	35.1	27.1	98.4	Unsuitable
	3	0	12.3	24.0	34.9	26.9	98.1	Unsuitable
	Avg	0	12.3	24.2	35.5	26.8	98.8	Unsuitable
17-4-new	1	0	6.3	26.1	31.2	35.1	98.7	Unsuitable
	2	0	6.1	26.1	31.1	34.8	98.1	Unsuitable
	3	0	6.1	26.0	29.8	36.2	98.1	Unsuitable
	Avg	0	6.2	26.0	30.7	35.4	98.3	Unsuitable
17-5-new	1	0	7.8	25.8	41.2	24.1	98.9	Unsuitable
	2	0	7.8	25.7	41.1	24.0	98.6	Unsuitable
	3	0	7.6	25.5	41.1	23.8	98.0	Unsuitable
	Avg	0	7.7	25.7	41.1	24.0	98.5	Unsuitable
17-6-new	1	0	7.3	18.9	32.6	39.5	98.3	Unsuitable
	2	0	7.1	18.7	32.6	39.6	98.0	Unsuitable
	3	0	7.0	18.7	32.4	39.9	98.0	Unsuitable
	Avg	0	7.2	18.8	32.5	39.7	98.2	Unsuitable
17-7-new	1	6.5	12.8	23.8	33.6	22.4	99.1	Unsuitable
	2	6.7	12.8	23.7	33.6	22.5	99.3	Unsuitable
	3	6.4	12.6	23.5	33.3	23.5	99.3	Unsuitable
	Avg	6.5	12.7	23.7	33.5	22.8	99.2	Unsuitable
17-8-new	1	0	12.3	23.5	32.7	29.5	98.0	Unsuitable
	2	0	12.2	23.4	32.6	29.8	98.0	Unsuitable
	3	0	12.2	23.4	32.5	30.2	98.3	Unsuitable
	Avg	0	12.2	23.4	32.6	29.8	98.0	Unsuitable
17-9-new	1	9.2	23.7	32.6	28.7	4.9	99.1	Unsuitable
	2	9.1	23.5	32.6	28.6	5.7	99.5	Unsuitable
	3	9.1	23.5	32.5	28.4	5.7	99.2	Unsuitable
	Avg	9.1	23.6	32.6	28.6	5.4	99.3	Unsuitable
17-10-new	1	0	5.4	27.8	30.5	35.2	98.9	Unsuitable
	2	0	5.3	27.6	30.5	35.3	98.7	Unsuitable
	3	0	5.4	27.5	30.3	35.1	98.3	Unsuitable
	Avg	0	5.4	27.6	30.4	35.2	98.6	Unsuitable

3.1.2. Changes in fineness of recycled dry chemical powder with five elapsed years

In the event of 0% internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the recycled dry chemical powder with 5 elapsed years were shown in Table 5. According to the results, in the case of the recycled dry chemical powder with 5 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.0 wt% on 17-1-recycled, 98.3 wt% on 17-2-recycled, 99.1 wt% on 17-3-recycled, 99.4wt% on 17-4-recycled, 99.4wt% on 17-5-recycled, 98.3wt% on 17-6-recycled, 98.5wt% on 17-7-recycled, 99.6wt% on 17-8-recycled, 98.1wt% on 17-9-recycled, 98.1wt% on 17-10-recycled, respectively, all of which were unsuitable. It triggered by showing all unsuitable results in the residual amount criteria for each standard sieve, such as no residual amount for ABC dry chemical powder in the 425 ㎛ sieves, the residual amount for ABC dry chemical powder in the range of minimum 0wt% to maximum 10wt% in the 150 ㎛ sieves,

the residual amount for ABC dry chemical powder in the range of minimum 12wt% to maximum 25wt% in the 150 ㎛ sieves in the 75 ㎛ sieves and 45 ㎛ sieves, and the residual amount for ABC dry chemical powder in the range of minimum 50wt% to maximum 70wt% in the 150 ㎛ sieves in the base.

Table 5. Changes in fineness of recycled dry chemical powder with 5 elapsed years.

2017(recycled dry chemical powder with 5 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
17-1-recycled	1	0	8.9	34.6	38.9	15.8	98.2	Unsuitable
	2	0	8.9	34.4	38.8	15.9	98.0	Unsuitable
	3	0	8.7	34.3	38.6	16.7	98.3	Unsuitable
	Avg.	0	8.8	34.4	38.8	16.1	98.0	Unsuitable
17-2-recycled	1	0	9.3	35.7	40.1	13.5	98.6	Unsuitable
	2	0	9.1	35.5	39.8	13.7	98.3	Unsuitable
	3	0	9.1	35.6	39.7	13.8	98.2	Unsuitable
	Avg.	0	9.2	35.5	39.9	13.7	98.3	Unsuitable
17-3-recycled	1	0	13.2	35.4	41.3	9.4	99.3	Unsuitable
	2	0	13.0	35.1	41.1	9.7	98.9	Unsuitable
	3	0	13.2	35.0	41.0	9.8	99.0	Unsuitable
	Avg.	0	13.1	35.2	41.2	9.6	99.1	Unsuitable
17-4-recycled	1	11.7	10.8	28.3	29.5	19.4	99.7	Unsuitable
	2	11.6	10.5	28.0	29.2	19.9	99.2	Unsuitable
	3	11.6	10.4	27.9	28.9	19.7	99.4	Unsuitable
	Avg.	11.6	10.6	28.1	29.2	19.7	99.4	Unsuitable
17-5-recycled	1	9.8	12.6	29.4	30.8	16.9	99.5	Unsuitable
	2	9.8	12.3	29.1	30.6	17.8	99.6	Unsuitable
	3	9.6	12.2	29.0	30.5	17.9	99.2	Unsuitable
	Avg.	9.7	12.4	29.2	30.6	17.5	99.4	Unsuitable
17-6-recycled	1	0	10.4	32.8	28.1	27.1	98.4	Unsuitable
	2	0	10.3	32.5	28.0	27.4	98.2	Unsuitable
	3	0	10.1	32.4	28.2	27.3	98.0	Unsuitable
	Avg.	0	10.3	32.6	28.1	27.3	98.3	Unsuitable
17-7-recycled	1	0	6.3	18.6	32.2	41.8	98.9	Unsuitable
	2	0	6.1	18.5	32.1	41.3	98.0	Unsuitable
	3	0	6.0	18.5	32.0	42.1	98.6	Unsuitable
	Avg.	0	6.2	18.5	32.1	41.7	98.5	Unsuitable
17-8-recycled	1	8.4	13.2	28.6	31.2	18.3	99.7	Unsuitable
	2	8.1	13.0	28.5	31.0	18.9	99.5	Unsuitable
	3	8.1	12.8	28.5	31.1	19.1	99.6	Unsuitable
	Avg.	8.2	13.0	28.5	31.1	18.8	99.6	Unsuitable
17-9-recycled	1	0	4.7	21.8	32.5	39.1	98.1	Unsuitable
	2	0	4.5	21.9	32.2	39.5	98.1	Unsuitable
	3	0	4.5	21.6	32.0	39.8	98.0	Unsuitable
	Avg.	0	4.6	21.7	32.2	39.5	98.1	Unsuitable
17-10-recycled	1	0	7.9	23.5	28.6	38.1	98.1	Unsuitable
	2	0	7.8	23.3	28.3	38.8	98.2	Unsuitable
	3	0	7.8	23.3	28.2	38.7	98.0	Unsuitable
	Avg.	0	7.8	23.4	28.4	38.5	98.1	Unsuitable

3.1.3. Changes in fineness of new dry chemical powder with ten elapsed years

In the event of 0% internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 10 elapsed years were shown in Table 6. According to the results, in the case of the new dry chemical powder with 10 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.3 wt% on 12-1-new, 98.3 wt% on 12-2-new, 98.3 wt% on 12-3-new, 99.5wt% on 12-4-new, 99.3wt% on 12-5-new, 99.5wt% on 12-6-new, 98.3wt% on 12-7-new, 99.7wt% on 12-8-new, 99.6wt% on 12-9-new, 99.7wt% on 12-10-new, respectively, all of which were unsuitable. It came from showing all unsuitable results in the residual amount criteria for each standard sieve, such as no residual amount for ABC dry chemical powder in the 425 ㎛ sieves, the residual amount for ABC dry chemical powder in the range of minimum 0wt% to maximum 10wt% in the 150 ㎛ sieves, the residual amount for ABC dry chemical powder

in the range of minimum 12wt% to maximum 25wt% in the 150 ㎛ sieves in the 75 ㎛ sieves and 45 ㎛ sieves, and the residual amount for ABC dry chemical powder in the range of minimum 50wt% to maximum 70wt% in the 150 ㎛ sieves in the base.

Table 6. Changes in fineness of new dry chemical powder with 10 elapsed years.

2012(new dry chemical powder with 10 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
12-1-new	1	0	4.3	23.8	34.2	35.9	98.2	Unsuitable
	2	0	4.1	23.7	34.2	36.3	98.3	Unsuitable
	3	0	4.0	23.5	33.9	36.8	98.2	Unsuitable
	Avg.	0	4.2	23.7	34.1	36.3	98.3	Unsuitable
12-2-new	1	0	7.9	27.5	35.2	28.2	98.8	Unsuitable
	2	0	8.0	27.3	35.1	27.7	98.1	Unsuitable
	3	0	7.7	27.2	35.1	28.1	98.1	Unsuitable
	Avg.	0	7.9	27.3	35.1	28.0	98.3	Unsuitable
12-3-new	1	0	10.5	28.5	38.8	20.6	98.4	Unsuitable
	2	0	10.1	28.3	38.7	21.3	98.4	Unsuitable
	3	0	10.2	28.4	38.5	21.1	98.2	Unsuitable
	Avg.	0	10.3	28.4	38.7	21.0	98.3	Unsuitable
12-4-new	1	10.9	16.7	28.9	32.9	10.3	99.7	Unsuitable
	2	10.6	16.6	28.8	31.8	11.4	99.6	Unsuitable
	3	10.6	16.4	28.5	32.1	11.8	99.4	Unsuitable
	Avg.	10.7	16.6	28.7	32.3	11.2	99.5	Unsuitable
12-5-new	1	13.7	19.6	29.3	28.9	7.9	99.4	Unsuitable
	2	13.5	19.6	29.5	28.9	8.2	99.7	Unsuitable
	3	13.4	19.4	29.2	28.3	8.9	99.2	Unsuitable
	Avg.	13.5	19.5	29.3	28.7	8.3	99.3	Unsuitable
12-6-new	1	7.2	22.5	30.3	31.8	7.8	99.6	Unsuitable
	2	7.0	22.3	30.2	31.9	8.1	99.5	Unsuitable
	3	6.9	22.2	30.1	31.5	8.9	99.6	Unsuitable
	Avg.	7.0	22.3	30.2	31.7	8.3	99.5	Unsuitable
12-7-new	1	0	11.3	29.5	38.6	18.7	98.1	Unsuitable
	2	0	11.0	29.1	38.5	19.7	98.3	Unsuitable
	3	0	11.1	29.0	38.6	19.2	97.9	Unsuitable
	Avg.	0	11.2	29.3	38.6	19.2	98.3	Unsuitable
12-8-new	1	18.2	21.6	31.6	27.3	1.1	99.8	Unsuitable
	2	17.9	21.3	31.4	27.1	1.9	99.6	Unsuitable
	3	17.8	21.4	31.2	26.9	2.4	99.7	Unsuitable
	Avg.	18.0	21.4	31.4	27.1	1.8	99.7	Unsuitable
12-9-new	1	10.9	23.7	32.5	29.6	2.9	99.6	Unsuitable
	2	10.5	23.6	32.3	29.5	3.8	99.7	Unsuitable
	3	10.7	23.1	32.4	29.1	4.4	99.6	Unsuitable
	Avg.	10.7	23.5	32.4	29.4	3.7	99.6	Unsuitable
12-10-new	1	3.2	21.7	30.2	31.5	13.2	99.8	Unsuitable
	2	3.0	21.6	30.2	31.2	13.7	99.7	Unsuitable
	3	2.9	21.8	30.1	31.2	13.6	99.6	Unsuitable
	Avg.	3.0	21.7	30.2	31.3	13.5	99.7	Unsuitable

3.1.4. Changes in fineness of new dry chemical powder with ten elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the summation of the experimental values.

In the event of 0% internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 13 elapsed years were shown in Table 7. According to the results, in the case of the new dry chemical powder with 13 elapsed years, the mean experimental values for each sample number of the standard sieve size were 99.4 wt% on 09-1-new, 99.2 wt% on 09-2-new, 98.2

wt% on 09-3-new, 98.2wt% on 09-4-new, 99.2wt% on 09-5-new, 99.3wt% on 09-6-new, 99.5wt% on 09-7-new, 99.2wt% on 09-8-new, 98.1wt% on 09-9-new, 99.4wt% on 09-10-new, respectively, all of which were unsuitable. It causes a problem in that the fire extinguisher cannot be used when 0% internal pressure of the fire extinguisher.

Table 7. Changes in fineness of new dry chemical powder with 10 elapsed years.

2009(new dry chemical powder with 13 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
09-1-new	1	9.8	12.8	23.7	32.5	21.0	99.8	Unsuitable
	2	9.7	12.9	23.5	32.6	20.7	99.4	Unsuitable
	3	9.5	12.6	23.4	32.3	21.7	99.5	Unsuitable
	Avg.	9.7	12.8	23.5	32.5	20.9	99.4	Unsuitable
09-2-new	1	13.2	15.5	27.8	34.5	8.3	99.3	Unsuitable
	2	13.0	15.6	27.5	34.4	8.9	99.4	Unsuitable
	3	12.9	15.3	27.4	34.1	9.5	99.2	Unsuitable
	Avg.	13.0	15.4	27.6	34.3	8.9	99.2	Unsuitable
09-3-new	1	0	18.6	29.6	30.5	19.3	98.0	Unsuitable
	2	0	18.5	29.5	30.5	19.8	98.3	Unsuitable
	3	0	18.5	29.1	30.8	19.9	98.3	Unsuitable
	Avg.	0	18.5	29.4	30.6	19.7	98.2	Unsuitable
09-4-new	1	0	9.2	32.5	31.6	24.8	98.1	Unsuitable
	2	0	9.1	32.4	31.4	25.5	98.4	Unsuitable
	3	0	9.3	32.2	31.3	25.4	98.2	Unsuitable
	Avg.	0	9.2	32.4	31.4	25.2	98.2	Unsuitable
09-5-new	1	16.2	18.3	29.5	32.6	2.8	99.4	Unsuitable
	2	15.8	18.2	29.1	32.5	3.5	99.1	Unsuitable
	3	15.9	18.0	29.2	32.4	3.7	99.2	Unsuitable
	Avg.	16.0	18.2	29.3	32.5	3.8	99.2	Unsuitable
09-6-new	1	13.5	15.6	30.8	32.6	6.8	99.3	Unsuitable
	2	13.3	15.6	30.6	32.5	7.2	99.2	Unsuitable
	3	13.2	15.5	30.5	32.3	7.9	99.4	Unsuitable
	Avg.	13.3	15.6	30.6	32.5	7.3	99.3	Unsuitable
09-7-new	1	3.7	12.9	28.5	37.2	16.9	99.2	Unsuitable
	2	3.6	12.5	28.3	37.3	17.6	99.3	Unsuitable
	3	3.6	12.4	28.6	37.0	17.8	99.4	Unsuitable
	Avg.	3.6	12.6	28.4	37.2	17.7	99.5	Unsuitable
09-8-new	1	8.7	15.2	31.5	28.9	15.3	99.6	Unsuitable
	2	8.6	15.0	31.2	28.5	15.9	99.2	Unsuitable
	3	8.5	14.9	31.3	28.4	15.8	98.9	Unsuitable
	Avg.	8.6	15.0	31.3	28.6	15.7	99.2	Unsuitable
09-9-new	1	0	11.3	28.4	32.8	26.1	98.6	Unsuitable
	2	0	11.0	28.1	32.7	26.4	98.2	Unsuitable
	3	0	11.1	28.3	32.5	26.2	98.1	Unsuitable
	Avg.	0	11.1	28.2	32.6	26.2	98.1	Unsuitable
09-10-new	1	9.2	16.5	29.8	32.2	11.2	99.5	Unsuitable
	2	9.0	16.3	29.5	32.1	12.6	99.5	Unsuitable
	3	8.9	16.2	29.4	32.0	12.7	99.2	Unsuitable
	Avg.	9.0	16.3	29.6	32.1	12.2	99.4	Unsuitable

3.2. Fineness variance in the event of 50% internal pressure

When 50% internal pressure of the fire extinguisher, fineness variance was analyzed by selecting 40 samples, ten each from a new dry chemical extinguisher with five elapsed years, a recycled dry chemical extinguisher with five elapsed years, a new dry chemical extinguisher with ten elapsed years, and new dry chemical extinguisher with 13 elapsed years, respectively.

3.2.1. Changes in fineness of new dry chemical powder with five elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by

quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the summation of the experimental values.

In the event of 50% internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 5 elapsed years were shown in Table 8. According to the results, in the case of the new dry chemical powder with 5 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.2 wt% on 17-1-new, 98.4 wt% on 17-2-new, 98.5 wt% on 17-3-new, 98.4wt% on 17-4-new, 98.2wt% on 17-5-new, 98.5wt% on 17-6-new, 98.3wt% on 17-7-new, 98.4wt% on 17-8-new, 98.2wt% on 17-9-new, 98.4wt% on 17-10-new, respectively, all of which were suitable.

Table 8. Changes in fineness of new dry chemical powder with 5 elapsed years.

2017 (new dry chemical powder with 5 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
17-1-new	1	0	3.2	15.6	21.7	58.1	98.6	Suitable
	2	0	3.2	15.5	21.4	58.2	98.3	Suitable
	3	0	3.3	15.2	21.5	58.0	98.0	Suitable
	Avg.	0	3.2	15.4	21.5	58.1	98.2	Suitable
17-2-new	1	0	2.8	16.2	22.3	56.8	98.1	Suitable
	2	0	2.9	16.4	22.5	56.8	98.6	Suitable
	3	0	2.8	16.5	22.4	56.6	98.3	Suitable
	Avg.	0	2.8	16.4	22.4	56.8	98.4	Suitable
17-3-new	1	0	3.8	20.4	21.8	52.3	98.3	Suitable
	2	0	3.9	20.7	21.4	52.5	98.5	Suitable
	3	0	3.9	20.8	21.5	52.4	98.6	Suitable
	Avg.	0	3.9	20.6	21.6	52.4	98.5	Suitable
17-4-new	1	0	4.1	19.7	20.6	54.2	98.6	Suitable
	2	0	3.9	19.5	20.5	54.7	98.6	Suitable
	3	0	3.8	19.6	20.6	54.1	98.1	Suitable
	Avg.	0	3.9	19.6	20.6	54.3	98.4	Suitable
17-5-new	1	0	4.8	16.8	19.2	57.6	98.4	Suitable
	2	0	4.5	16.7	19.0	57.9	98.1	Suitable
	3	0	4.7	16.8	18.9	57.7	98.1	Suitable
	Avg.	0	4.7	16.8	19.0	57.7	98.2	Suitable
17-6-new	1	0	6.9	18.3	19.2	54.2	98.6	Suitable
	2	0	6.8	18.1	19.1	54.8	98.8	Suitable
	3	0	6.5	18.0	19.2	54.3	98.0	Suitable
	Avg.	0	6.7	18.2	19.2	54.4	98.5	Suitable
17-7-new	1	0	7.1	17.6	18.7	55.2	98.6	Suitable
	2	0	7.0	17.5	18.5	55.1	98.2	Suitable
	3	0	7.1	17.2	18.4	55.7	98.4	Suitable
	Avg.	0	7.1	17.4	18.5	55.3	98.3	Suitable
17-8-new	1	0	7.6	15.7	16.8	58.3	98.4	Suitable
	2	0	7.3	15.8	16.5	58.8	98.4	Suitable
	3	0	7.4	15.4	16.6	59.1	98.5	Suitable
	Avg.	0	7.4	15.6	16.7	58.7	98.4	Suitable
17-9-new	1	0	8.3	16.5	17.2	56.4	98.4	Suitable
	2	0	8.1	16.1	17.0	57.0	98.2	Suitable
	3	0	8.0	16.0	16.9	57.3	98.2	Suitable
	Avg.	0	8.1	16.2	17.0	56.9	98.2	Suitable
17-10-new	1	0	7.9	14.8	15.8	60.1	98.6	Suitable
	2	0	7.8	14.7	15.5	60.4	98.4	Suitable
	3	0	7.6	14.9	15.6	60.2	98.3	Suitable
	Avg.	0	7.8	14.8	15.6	60.2	98.4	Suitable

3.2.2. Changes in fineness of recycled dry chemical powder with five elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the

summation of the experimental values.

In the event of 50% internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the recycled dry chemical powder with 5 elapsed years were shown in Table 9. According to the results, in the case of the recycled dry chemical powder with 5 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.8 wt% on 17-1-recycled, 98.5 wt% on 17-2-recycled, 98.1 wt% on 17-3-recycled, 98.3wt% on 17-4-recycled, 98.0wt% on 17-5-recycled, 98.6wt% on 17-6-recycled, 98.2wt% on 17-7-recycled, 98.1wt% on 17-8-recycled, 98.7wt% on 17-9-recycled, 98.1wt% on 17-10-recycled, respectively, all of which were suitable.

Table 9. Changes in fineness of new dry chemical powder with 5 elapsed years.

2017(recycled dry chemical powder with 5 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
17-1-recycled	1	0	8.9	16.7	21.3	52.2	99.1	Suitable
	2	0	8.7	16.8	21.0	52.3	98.8	Suitable
	3	0	8.6	16.5	20.9	52.6	98.6	Suitable
	Avg.	0	8.7	16.7	21.1	52.3	98.8	Suitable
17-2-recycled	1	0	8.1	17.4	19.6	53.3	98.4	Suitable
	2	0	7.9	17.2	19.5	54.1	98.7	Suitable
	3	0	7.8	17.2	19.8	53.8	98.6	Suitable
	Avg.	0	7.9	17.3	19.6	53.7	98.5	Suitable
17-3-recycled	1	0	4.9	16.4	19.8	56.9	98.0	Suitable
	2	0	4.6	16.5	19.8	57.3	98.2	Suitable
	3	0	4.7	16.3	19.7	57.5	98.2	Suitable
	Avg.	0	4.7	16.4	19.8	57.2	98.1	Suitable
17-4-recycled	1	0	6.6	17.2	19.7	54.6	98.1	Suitable
	2	0	6.5	17.0	19.8	55.2	98.5	Suitable
	3	0	6.7	17.3	19.9	54.3	98.2	Suitable
	Avg.	0	6.6	17.2	19.8	54.7	98.3	Suitable
17-5-recycled	1	0	9.2	16.3	18.4	54.3	98.2	Suitable
	2	0	9.1	16.2	18.2	54.8	98.3	Suitable
	3	0	9.0	16.4	18.1	54.1	98.1	Suitable
	Avg.	0	9.1	16.3	18.2	54..4	98.0	Suitable
17-6-recycled	1	0	6.3	15.9	17.1	59.2	98.5	Suitable
	2	0	6.0	15.8	17.0	59.5	98.3	Suitable
	3	0	5.9	15.6	17.3	60.1	98.9	Suitable
	Avg.	0	6.1	15.8	17.1	59.6	98.6	Suitable
17-7-recycled	1	0	3.9	16.4	18.1	60.1	98.5	Suitable
	2	0	3.8	16.5	18.4	59.4	98.1	Suitable
	3	0	3.8	16.4	18.2	59.9	98.3	Suitable
	Avg.	0	3.8	16.4	18.2	59.8	98.2	Suitable
17-8-recycled	1	0	2.6	15.9	17.3	62.5	98.3	Suitable
	2	0	2.6	15.7	17.0	62.9	98.2	Suitable
	3	0	2.4	15.6	17.1	63.0	98.1	Suitable
	Avg.	0	2.5	15.7	17.1	62.8	98.1	Suitable
17-9-recycled	1	0	7.6	19.3	21.8	50.1	98.8	Suitable
	2	0	7.5	19.2	21.5	50.3	98.5	Suitable
	3	0	7.8	18.9	21.6	50.4	98.7	Suitable
	Avg.	0	7.6	19.2	21.6	50.3	98.7	Suitable
17-10-recycled	1	0	8.2	16.9	19.2	53.8	98.1	Suitable
	2	0	8.1	16.8	19.1	54.0	98.0	Suitable
	3	0	8.2	16.5	18.6	54.9	98.2	Suitable
	Avg.	0	8.2	16.7	19.0	54.2	98.1	Suitable

3.2.3. Changes in fineness of new dry chemical powder with ten elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the

summation of the experimental values.

In the event of 50% internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 10 elapsed years were shown in Table 10. According to the results, in the case of the new dry chemical powder with 10 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.2 wt% on 12-1-new, 98.4 wt% on 12-2-new, 99.0 wt% on 12-3-new, 98.2wt% on 12-4-new, 98.4wt% on 12-5-new, 98.3wt% on 12-6-new, 98.2wt% on 12-7-new, 98.1wt% on 12-9-new, 98.3wt% on 12-10-new, respectively, all of which were suitable. In comparison, the 17-8-new sample was shown unsuitable at 98.9wt%. Although it should be from a minimum of 50 wt % to a maximum of 70 wt % at the base, 12-8-new was unsuitable as 45.5 wt %.

Table 10. Changes in fineness of new dry chemical powder with 10 elapsed years.

2012(new dry chemical powder with 10 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
12-1-new	1	0	7.6	15.4	17.8	57.5	98.3	Suitable
	2	0	7.5	15.6	17.6	57.3	98.0	Suitable
	3	0	7.4	15.7	17.5	57.8	98.4	Suitable
	Avg.	0	7.5	15.6	17.6	57.5	98.2	Suitable
12-2-new	1	0	4.8	14.8	16.7	62.3	98.6	Suitable
	2	0	4.5	14.9	16.5	62.5	98.4	Suitable
	3	0	4.4	14.8	16.4	62.6	98.2	Suitable
	Avg.	0	4.6	14.8	16.5	62.5	98.4	Suitable
12-3-new	1	0	6.9	16.2	18.3	57.6	99.0	Suitable
	2	0	6.8	16.5	18.4	57.2	98.9	Suitable
	3	0	7.1	16.4	18.6	57.1	99.2	Suitable
	Avg.	0	6.9	16.4	18.4	57.3	99.0	Suitable
12-4-new	1	0	8.1	15.6	17.8	56.8	98.3	Suitable
	2	0	7.9	15.4	17.8	57.1	98.2	Suitable
	3	0	7.8	15.3	17.9	57.3	98.3	Suitable
	Avg.	0	7.9	15.4	17.8	57.1	98.2	Suitable
12-5-new	1	0	9.8	17.1	18.3	53.3	98.5	Suitable
	2	0	9.6	17.0	18.2	53.6	98.4	Suitable
	3	0	9.5	16.8	18.2	53.7	98.2	Suitable
	Avg.	0	9.6	17.0	18.2	53.5	98.3	Suitable
12-6-new	1	0	6.3	16.5	17.8	57.8	98.4	Suitable
	2	0	6.2	16.4	17.5	58.2	98.3	Suitable
	3	0	6.0	16.5	17.6	58.0	98.1	Suitable
	Avg.	0	6.2	16.5	17.6	58.0	98.3	Suitable
12-7-new	1	0	6.9	17.4	19.2	54.7	98.2	Suitable
	2	0	6.8	17.2	19.0	55.0	98.0	Suitable
	3	0	6.7	17.2	19.1	55.4	98.4	Suitable
	Avg.	0	6.8	17.3	19.1	55.0	98.2	Suitable
12-8-new	1	0	8.2	21.4	23.9	45.5	99.0	Unsuitable
	2	0	8.3	21.6	23.8	45.2	98.9	Unsuitable
	3	0	8.0	21.3	23.8	45.7	98.8	Unsuitable
	Avg.	0	8.2	21.4	23.8	45.5	98.9	Unsuitable
12-9-new	1	0	3.6	15.6	17.6	61.5	98.3	Suitable
	2	0	3.7	15.5	17.6	61.2	98.0	Suitable
	3	0	3.6	15.8	17.3	61.6	98.3	Suitable
	Avg.	0	3.6	15.6	17.5	61.4	98.1	Suitable
12-10-new	1	0	6.7	18.2	19.5	54.1	98.5	Suitable
	2	0	6.6	18.0	19.1	54.5	98.2	Suitable
	3	0	6.4	17.9	19.0	54.8	98.1	Suitable
	Avg.	0	6.6	18.0	19.2	54.5	98.3	Suitable

3.2.4. Changes in fineness of new dry chemical powder with 13 elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by

quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the summation of the experimental values.

In the event of 50% internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 13 elapsed years were shown in Table 11. According to the results, in the case of the new dry chemical powder with 13 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.3 wt% on 09-1-new, 98.3 wt% on 09-2-new, 98.2 wt% on 09-3-new, 98.4wt% on 09-4-new, 98.3wt% on 09-5-new, 98.4wt% on 09-6-new, 98.2wt% on 09-7-new, 98.3wt% on 09-8-new, 98.5wt% on 09-10-new, respectively, all of which were suitable. In comparison, the 17-9-new sample was shown unsuitable at 98.9wt%.

It caused the experimental value should have the residual amount for ABC dry chemical powder in the range of minimum 0wt% to maximum 10wt% in the 150 ㎛ sieves, but it was indicated as 12.1wt%. Furthermore, the experimental value should have the residual amount for ABC dry chemical powder in the range of minimum 50wt% to maximum 70wt% in the base, but it was noted unsuitable caused of mean experimental value was 47.8 wt%.

Table 11. Changes in fineness of new dry chemical powder with 13 elapsed years.

2009(new dry chemical powder with 13 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
09-1-new	1	0	6.9	16.7	19.2	55.6	98.4	Suitable
	2	0	7.0	16.8	19.0	55.4	98.2	Suitable
	3	0	6.8	16.6	19.1	55.9	98.4	Suitable
	Avg.	0	6.9	16.7	19.1	55.6	98.3	Suitable
09-2-new	1	0	5.4	17.2	18.7	57.2	98.5	Suitable
	2	0	5.6	17.1	18.5	57.1	98.3	Suitable
	3	0	5.3	17.2	18.4	57.3	98.2	Suitable
	Avg.	0	5.4	17.2	18.5	57.2	98.3	Suitable
09-3-new	1	0	8.3	18.6	20.1	51.2	98.2	Suitable
	2	0	8.0	18.5	20.0	51.8	98.3	Suitable
	3	0	8.1	18.3	20.1	51.6	98.1	Suitable
	Avg.	0	8.1	18.5	20.1	51.5	98.2	Suitable
09-4-new	1	0	8.9	19.3	20.4	50.0	98.6	Suitable
	2	0	8.8	19.2	20.1	50.3	98.4	Suitable
	3	0	8.6	19.0	20.2	50.4	98.2	Suitable
	Avg.	0	8.8	19.2	20.2	50.2	98.4	Suitable
09-5-new	1	0	6.4	16.7	18.8	56.4	98.3	Suitable
	2	0	6.4	16.6	18.5	56.8	98.3	Suitable
	3	0	6.2	16.6	18.4	57.3	98.5	Suitable
	Avg.	0	6.3	16.6	18.6	56.8	98.3	Suitable
09-6-new	1	0	4.3	15.7	17.2	61.2	98.4	Suitable
	2	0	4.5	15.7	17.0	61.1	98.3	Suitable
	3	0	4.2	15.9	16.9	61.5	98.5	Suitable
	Avg.	0	4.3	15.8	17.0	61.3	98.4	Suitable
09-7-new	1	0	4.8	16.3	18.2	58.9	98.2	Suitable
	2	0	4.8	16.2	18.0	59.1	98.1	Suitable
	3	0	4.6	16.0	17.9	59.5	98.0	Suitable
	Avg.	0	4.7	16.2	18.1	59.2	98.2	Suitable
09-8-new	1	0	3.5	17.2	18.6	59.1	98.4	Suitable
	2	0	3.6	17.5	18.3	58.8	98.2	Suitable
	3	0	3.4	17.3	18.2	59.3	98.2	Suitable
	Avg.	0	3.5	17.3	18.4	59.1	98.3	Suitable
09-9-new	1	0	12.3	18.4	20.2	48.2	99.1	Unsuitable
	2	0	12.1	18.5	20.9	47.4	98.9	Unsuitable
	3	0	11.8	18.1	21.1	47.8	98.8	Unsuitable
	Avg.	0	12.1	18.3	20.7	47.8	98.9	Unsuitable
09-10-new	1	0	5.4	16.4	19.2	57.3	98.3	Suitable
	2	0	5.3	16.5	19.0	57.6	98.3	Suitable
	3	0	5.1	16.6	19.4	57.7	98.8	Suitable
	Avg.	0	5.3	16.5	19.2	57.5	98.5	Suitable

3.3. Fineness variance in the event of normal internal pressure

When the standard internal pressure of the fire extinguisher, fineness variance was analyzed by selecting 40

samples, ten each from a new dry chemical extinguisher with five elapsed years, a recycled dry chemical extinguisher with five elapsed years, a new dry chemical extinguisher with ten elapsed years, and new dry chemical extinguisher with 13 elapsed years, respectively.

3.3.1. Changes in fineness of new dry chemical powder with five elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the summation of the experimental values. In the event of normal internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 5 elapsed years were shown in Table 11. According to the results, in the case of the new dry chemical powder with 5 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.3 wt% on 17-1-new, 98.6 wt% on 17-2-new, 98.8 wt% on 17-3-new, 98.4wt% on 17-4-new, 98.9wt% on 17-5-new, 98.5wt% on 17-6-new, 98.9wt% on 17-7-new, 98.3wt% on 17-8-new, 98.2wt% on 17-9-new, 98.3wt% on 17-10-new, respectively, all of which were suitable.

Table 11. Changes in fineness of new dry chemical powder with 13 elapsed years.

2017(new dry chemical powder with 5 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
17-1-new	1	0	6.4	16.1	19.5	56.2	98.2	Suitable
	2	0	6.1	16.4	19.2	56.7	98.4	Suitable
	3	0	6.0	16.2	19.1	56.8	98.1	Suitable
	Avg.	0	6.2	16.2	19.3	56.6	98.3	Suitable
17-2-new	1	0	2.7	18.9	21.4	55.8	98.8	Suitable
	2	0	2.8	18.7	21.5	55.6	98.6	Suitable
	3	0	2.6	18.8	21.4	55.7	98.5	Suitable
	Avg.	0	2.7	18.8	21.4	55.7	98.6	Suitable
17-3-new	1	0	4.3	17.8	20.6	56.2	98.9	Suitable
	2	0	4.1	17.6	20.5	56.4	98.6	Suitable
	3	0	4.2	17.7	20.7	56.3	98.9	Suitable
	Avg.	0	4.2	17.7	20.6	56.3	98.8	Suitable
17-4-new	1	0	6.7	15.6	18.3	57.6	98.2	Suitable
	2	0	6.8	15.2	18.0	58.5	98.5	Suitable
	3	0	6.6	15.3	18.2	58.3	98.4	Suitable
	Avg.	0	6.7	15.4	18.2	58.1	98.4	Suitable
17-5-new	1	0	4.9	17.3	20.9	56.4	99.5	Suitable
	2	0	4.8	17.5	20.7	55.5	98.5	Suitable
	3	0	4.7	17.4	20.8	55.8	98.7	Suitable
	Avg.	0	4.8	17.4	20.8	55.9	98.9	Suitable
17-6-new	1	0	3.8	16.7	21.4	56.7	98.6	Suitable
	2	0	3.6	16.8	21.3	56.8	98.5	Suitable
	3	0	3.7	16.6	21.5	56.6	98.4	Suitable
	Avg.	0	3.7	16.7	21.4	56.7	98.5	Suitable
17-7-new	1	0	2.5	17.2	22.5	56.5	98.7	Suitable
	2	0	2.4	17.3	22.7	56.8	99.2	Suitable
	3	0	2.6	17.1	22.9	56.3	98.9	Suitable
	Avg.	0	2.4	17.2	22.7	56.5	98.9	Suitable
17-8-new	1	0	7.1	15.9	17.4	57.6	98.0	Suitable
	2	0	6.9	16.1	17.5	57.9	98.4	Suitable
	3	0	7.2	16.2	17.7	57.4	98.5	Suitable
	Avg.	0	7.1	16.1	17.5	57.6	98.3	Suitable
17-9-new	1	0	3.8	15.7	22.7	55.8	98.0	Suitable
	2	0	3.7	16.5	22.6	55.7	98.5	Suitable
	3	0	3.9	15.6	22.8	55.9	98.2	Suitable
	Avg.	0	3.8	15.9	22.7	55.8	98.2	Suitable
17-10-new	1	0	3.6	16.2	23.1	55.2	98.1	Suitable
	2	0	3.5	16.4	23.3	55.1	98.3	Suitable
	3	0	3.7	16.3	23.2	55.3	98.5	Suitable
	Avg.	0	3.6	16.3	23.2	55.2	98.3	Suitable

3.3.2. Changes in fineness of new dry chemical powder with five elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the summation of the experimental values.

In the event of normal internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the recycled dry chemical powder with 5 elapsed years were shown in Table 12. According to the results, in the case of the recycled dry chemical powder with 5 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.9 wt% on 17-1-recycled, 98.2 wt% on 17-2-recycled, 98.5 wt% on 17-3-recycled, 98.3wt% on 17-4-recycled, 98.4 wt% on 17-5-recycled, 98.4 wt% on 17-6-recycled, 98.8 wt% on 17-7-recycled, 98.1 wt% on 17-8-recycled, 98.5 wt% on 17-9-recycled, 98.3 wt% on 17-10-recycled, respectively, all of which were suitable.

Table 12. Changes in fineness of recycled dry chemical powder with 5 elapsed years.

2017(recycled dry chemical powder with 5 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
17-1-recycled	1	0	2.1	14.1	17.6	64.7	98.5	Suitable
	2	0	2.3	14.2	17.8	64.9	99.2	Suitable
	3	0	2.2	14.3	17.7	64.8	99.0	Suitable
	Avg.	0	2.2	14.2	17.7	64.8	98.9	Suitable
17-2-recycled	1	0	5.4	16.3	18.4	58.0	98.1	Suitable
	2	0	5.2	16.0	18.5	58.6	98.3	Suitable
	3	0	5.3	15.9	18.4	58.9	98.5	Suitable
	Avg.	0	5.2	16.1	18.4	58.5	98.2	Suitable
17-3-recycled	1	0	4.1	17.2	20.1	56.8	98.2	Suitable
	2	0	4.2	17.4	20.3	56.7	98.6	Suitable
	3	0	4.3	17.3	20.2	56.9	98.7	Suitable
	Avg.	0	4.2	17.3	20.2	56.8	98.5	Suitable
17-4-recycled	1	0	6.5	19.5	20.8	46.7	98.3	Suitable
	2	0	6.7	19.4	21.4	46.5	98.3	Suitable
	3	0	6.6	19.6	23.6	46.6	98.4	Suitable
	Avg.	0	6.6	19.5	25.6	46.6	98.3	Suitable
17-5-recycled	1	0	4.4	16.9	19.3	57.6	98.2	Suitable
	2	0	4.2	17.7	19.1	57.4	98.4	Suitable
	3	0	4.3	17.8	19.2	57.5	98.8	Suitable
	Avg.	0	4.3	17.4	19.2	57.5	98.4	Suitable
17-6-recycled	1	0	3.3	17.4	18.1	59.6	98.4	Suitable
	2	0	3.2	17.6	18.3	59.4	98.5	Suitable
	3	0	3.1	17.5	18.2	59.5	98.3	Suitable
	Avg.	0	3.2	17.5	18.2	59.5	98.4	Suitable
17-7-recycled	1	0	2.7	18.2	23.4	54.3	98.6	Suitable
	2	0	2.9	18.4	23.2	54.5	99.9	Suitable
	3	0	2.8	18.3	23.3	54.4	98.8	Suitable
	Avg.	0	2.8	18.3	23.3	54.4	98.8	Suitable
17-8-recycled	1	0	2.6	18.2	22.9	55.3	99.0	Suitable
	2	0	2.4	18.6	21.5	56.9	99.4	Suitable
	3	0	2.9	18.9	22.2	55.3	99.3	Suitable
	Avg.	0	7.1	16.1	17.5	57.6	98.3	Suitable
17-9-new	1	0	3.8	15.7	22.7	55.8	98.0	Suitable
	2	0	3.7	16.5	22.6	55.7	98.5	Suitable
	3	0	3.9	15.6	22.8	55.9	98.2	Suitable
	Avg.	0	3.8	15.9	22.7	55.8	98.2	Suitable
17-10-new	1	0	3.6	16.2	23.1	55.2	98.1	Suitable
	2	0	3.5	16.4	23.3	55.1	98.3	Suitable
	3	0	3.7	16.3	23.2	55.3	98.5	Suitable
	Avg.	0	3.6	16.3	23.2	55.2	98.3	Suitable

3.3.3. Changes in fineness of recycled dry chemical powder with ten elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the summation of the experimental values. In the event of normal internal pressure of the fire extinguisher, the results of the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 10 elapsed years were shown in Table 13. According to the results, in the case of the new dry chemical powder with 10 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.3 wt% on 12-1-new, 98.8 wt% on 12-2-new, 98.1 wt% on 12-3-new, 98.4 wt% on 12-4-new, 99.2 wt% on 12-5-new, 98.8 wt% on 12-6-new, 98.9 wt% on 12-7-new, 98.4 wt% on 12-8-new, 98.6 wt% on 12-9-new, 98.2 wt% on 12-10-new, respectively, all of which were suitable.

Table 13. Changes in fineness of recycled dry chemical powder with 5 elapsed years.

2017(recycled dry chemical powder with 5 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
12-1-new	1	0	2.3	14.5	17.1	64.3	98.2	Suitable
	2	0	2.4	14.7	17.2	64.1	98.4	Suitable
	3	0	2.2	14.5	17.3	64.2	98.2	Suitable
	Avg.	0	2.3	14.6	17.2	64.2	98.3	Suitable
12-2-new	1	0	2.6	14.7	18.7	62.4	98.4	Suitable
	2	0	2.8	14.9	18.6	62.2	98.5	Suitable
	3	0	2.7	14.8	18.8	63.3	99.6	Suitable
	Avg.	0	2.7	14.8	18.7	63.3	98.8	Suitable
12-3-new	1	0	5.1	18.7	21.4	52.9	98.1	Suitable
	2	0	5.3	18.6	21.6	52.7	98.2	Suitable
	3	0	5.2	18.6	21.5	52.8	98.1	Suitable
	Avg.	0	5.2	18.6	21.5	52.8	98.1	Suitable
12-4-new	1	0	4.1	17.4	21.1	55.9	98.5	Suitable
	2	0	4.3	17.6	20.9	55.7	98.5	Suitable
	3	0	4.2	17.5	20.8	55.8	98.3	Suitable
	Avg.	0	4.2	17.5	20.9	55.8	98.4	Suitable
12-5-new	1	0	4.7	17.3	19.6	57.3	98.9	Suitable
	2	0	4.9	17.2	19.8	57.5	99.4	Suitable
	3	0	4.8	17.4	19.7	57.4	99.3	Suitable
	Avg.	0	4.8	17.3	19.7	57.4	99.2	Suitable
12-6-new	1	0	3.7	17.9	18.6	58.6	98.8	Suitable
	2	0	3.8	17.7	18.8	58.7	99.0	Suitable
	3	0	3.6	17.8	18.7	58.5	98.6	Suitable
	Avg.	0	3.7	17.8	18.7	58.6	98.8	Suitable
12-7-new	1	0	3.2	14.1	20.2	61.3	98.8	Suitable
	2	0	3.1	14.3	20.3	61.4	99.1	Suitable
	3	0	3.3	14.2	20.1	61.2	98.8	Suitable
	Avg.	0	3.2	14.2	20.2	61.3	98.9	Suitable
12-8-new	1	0	6.2	20.6	21.8	50.2	98.8	Suitable
	2	0	6.2	20.5	21.5	50.3	98.5	Suitable
	3	0	6.0	19.9	21.4	50.8	98.1	Suitable
	Avg.	0	6.1	20.3	21.6	50.4	98.4	Suitable
12-9-new	1	0	5.1	19.8	21.3	52.2	98.4	Suitable
	2	0	5.2	19.9	21.5	52.3	98.9	Suitable
	3	0	5.3	19.7	21.4	52.1	98.5	Suitable
	Avg.	0	5.2	19.8	21.4	52.2	98.6	Suitable
12-10-new	1	0	3.9	16.9	19.1	58.4	98.3	Suitable
	2	0	3.7	17.0	18.8	58.7	98.2	Suitable
	3	0	3.8	17.2	18.9	58.5	98.4	Suitable
	Avg.	0	3.8	17.0	18.9	58.5	98.2	Suitable

3.3.4. Changes in fineness of new dry chemical powder with 13 elapsed years

Based on <Type Approval of Fire Extinguishers and Technical Standards for Product Inspection>, the fineness test of fire-extinguishing agents conducted used 425 μm, 150 μm, 75 μm, 45 μm, and base of KS A 5101 standard by quantifying 100 g of a sample mixing the powder, which defined as the determining criteria by 98% to 100% for the summation of the experimental values. In the event of normal internal pressure of the fire extinguisher, the results of

the first, second, and third arithmetic mean analysis of fineness variance of the new dry chemical powder with 13 elapsed years were shown in Table 14. According to the results, in the case of the new dry chemical powder with 13 elapsed years, the mean experimental values for each sample number of the standard sieve size were 98.7 wt% on 09-1-new, 98.9 wt% on 09-2-new, 98.7 wt% on 09-3-new, 98.2 wt% on 09-4-new, 98.0 wt% on 09-5-new, 98.0 wt% on 09-7-new, 99.2 wt% on 09-8-new, 98.9wt% on 09-9-new, and 98.8 wt% on 09-10-new, respectively, all of which were suitable. In comparison, the 09-6-new sample was shown unsuitable as 98.1 wt%. It caused the experimental value should have the residual amount for ABC dry chemical powder in the range of minimum 12 wt% to maximum 25wt% in the 45 ㎛ sieves, but it was indicated as 28.3 wt%. Furthermore, the experimental value should have the residual amount for ABC dry chemical powder in the minimum 50wt% to the maximum 70wt% in the base. Still, it was indicated unsuitable caused of an unsatisfied reference value as 45.4 wt%.

Table 14. Changes in fineness of new dry chemical powder with 13 elapsed years.

2009(new dry chemical powder with 13 elapsed years)		Standard sieve size (㎛)						Results
Sample No.	No. of times	425	150	75	45	Base	Sum	
		Residual amount (wt%)						
09-1-new	1	0	2.5	14.7	17.3	64.1	98.6	Suitable
	2	0	2.6	14.9	17.2	64.0	98.7	Suitable
	3	0	2.4	14.8	17.4	64.2	98.8	Suitable
	Avg.	0	2.5	14.8	17.3	64.1	98.7	Suitable
09-2-new	1	0	2.2	14.1	18.2	64.3	98.8	Suitable
	2	0	2.1	14.3	18.4	64.1	98.9	Suitable
	3	0	2.3	14.2	18.3	64.2	99.0	Suitable
	Avg.	0	2.2	14.2	18.3	64.2	98.9	Suitable
09-3-new	1	0	4.1	17.1	21.7	55.8	98.7	Suitable
	2	0	4.3	17.0	21.6	55.7	98.6	Suitable
	3	0	4.2	17.3	21.8	55.3	98.6	Suitable
	Avg.	0	4.2	17.2	21.7	55.6	98.7	Suitable
09-4-new	1	0	7.6	18.9	20.5	51.2	98.2	Suitable
	2	0	7.7	18.8	20.3	51.6	98.4	Suitable
	3	0	7.4	19.0	20.2	51.4	98.0	Suitable
	Avg.	0	7.6	18.9	20.3	51.4	98.2	Suitable
09-5-new	1	0	3.6	14.5	20.6	59.9	98.6	Suitable
	2	0	3.4	14.3	20.7	59.7	98.1	Suitable
	3	0	3.5	14.4	20.5	59.8	98.2	Suitable
	Avg.	0	3.5	14.4	20.6	59.5	98.0	Suitable
09-6-new	1	0	6.7	19.5	26.3	45.7	98.2	Unsuitable
	2	0	6.8	19.7	26.4	45.4	98.3	Unsuitable
	3	0	7.1	19.3	26.3	45.3	98.0	Unsuitable
	Avg.	0	6.9	19.5	26.3	45.4	98.1	Unsuitable
09-7-new	1	0	4.6	18.4	20.7	54.5	98.2	Suitable
	2	0	4.4	18.6	20.5	54.6	98.1	Suitable
	3	0	4.5	18.5	20.6	54.4	98.0	Suitable
	Avg.	0	4.5	18.5	20.6	54.4	98.0	Suitable
09-8-new	1	0	5.6	18.2	20.3	55.7	99.8	Suitable
	2	0	5.4	18.3	20.5	54.9	99.1	Suitable
	3	0	5.5	18.1	20.4	54.7	98.7	Suitable
	Avg.	0	5.5	18.2	20.4	55.1	99.2	Suitable
09-9-new	1	0	5.7	19.2	21.5	52.4	98.8	Suitable
	2	0	5.8	19.4	21.6	52.3	99.1	Suitable
	3	0	5.6	19.3	21.4	52.5	98.8	Suitable
	Avg.	0	5.7	19.3	21.5	52.4	98.9	Suitable
09-10-new	1	0	4.2	17.1	21.8	55.7	98.8	Suitable
	2	0	4.3	17.3	21.9	55.5	99.0	Suitable
	3	0	4.1	17.2	21.7	55.6	98.6	Suitable
	Avg.	0	4.2	17.2	21.8	55.6	98.8	Suitable

Experiments have shown that when the 0% internal pressure of the fire extinguisher, the dry chemical extinguishers for 5, 10, and 13 elapsed years have all failed to meet the fineness determining criteria. In contrast, when the 50% internal pressure, they all suitably met fineness determining criteria. When the internal pressure was normal, the dry chemical extinguishers for 5 and 10 elapsed years met fineness determining criteria, whereas one out of 10 new dry chemical powders with 13 elapsed years was noted unsuitable. In other words, it was confirmed that the results of determining the suitable or unsuitable fire extinguisher performance differed depending on internal pressure. In contrast, there was no difference in the use periods. However, it was found that one out of 10 recycled dry chemical powders with 13 elapsed years was considered unsuitable due to inadequate management of fire

extinguishers and poor storage conditions.

4. CONCLUSION

This study aimed to analyze the fineness variance, one of the fire extinguisher's physical properties experiments, to confirm the maintaining state for fire extinguishing performance with changes in the internal pressure of the dry chemical extinguisher and the use periods, which were not covered in previous studies.

(1) Measuring the change in fineness of the dry chemical powder for new of 5 elapsed years, recycled of 5 elapsed years, new of 10 elapsed years, and new of 13 elapsed years when the 0% internal pressure, all of them were shown as unsuitable.

(2) Measuring the change in fineness of the dry chemical powder for new of 5 elapsed years, recycled of 5 elapsed years, new of 10 elapsed years, and new of 13 elapsed years when the 50% internal pressure, all of them were shown as suitable.

(3) Measuring the change in fineness of the dry chemical powder for new of 5 elapsed years, recycled of 5 elapsed years, new of 10 elapsed years, and new of 13 elapsed years when the normal internal pressure, sample number 09-6-new, one of the new dry chemical powders with 13 elapsed years, was found unsuitable, whereas the rest were shown as suitable.

The analysis results in fineness variance to examine the fire extinguisher's performance showed a difference in fineness variance with the change in internal pressure, whereas there was no difference in fineness variance with use periods. However, why sample 09-6-new in the recycled dry chemical powder with 13 elapsed years was found unsuitable was considered to result from poor maintenance, such as external environment and management status. Since dry chemical extinguishers occurred fineness variance due to changes in the internal pressure of the dry chemical extinguisher depending on the external environment, management status, and use periods, it is essential to maintain the fire extinguisher daily. Accordingly, it was suggested a need for practical training of fire safety managers and improving fire extinguisher inspection methods.

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