

## An Experimental Study on the Non-Safety Pin Fire Extinguisher for the Elderly

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**Abstract:** In this study, an experiment was conducted to see how the ability of the elderly to use fire extinguishers is affected by simplifying the steps of using a fire extinguisher so that the elderly in elderly care facilities can easily use a fire extinguisher for initial fire suppression. In order to prevent the user from panic in a fire situation and to find out the effects of the fire extinguishing operation stage, the operation of the existing fire extinguisher and the newly developed non-safety pin fire extinguisher were compared and analyzed. The results are summarized as follows. First, the number of steps for using a fire extinguisher was reduced to two steps with the non-safety pin fire extinguisher. It was confirmed that the time was reduced as the fire extinguishing agent was immediately discharged by lifting the fire hose without removing a safety pin. Second, it was confirmed that the new fire extinguisher can be easily used by the elderly and women, and the initial fire suppression time is reduced to less than 10 seconds for discharging the fire extinguishing agent. Third, the satisfaction with fire suppression by using the non-safety pin fire extinguisher was “high”, and its safety was confirmed. In addition, this work is intended to contribute to the development of firefighting technology by developing fire extinguishers with practical applicability.

**Keywords:** Elderly care facilities, fire extinguisher, non-safety pin, fire extinguisher agent, initial fire suppressio

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## 1. Introduction

### 1.1 Research Background

Appendix 2 on nursing facilities of the 「Enforcement Decree of the Act on Fire Prevention, Fire-fighting Facilities Installation and Maintenance and Safety Management」 defines elderly care facilities.(1) Since the elderly care facilities are operated for the elderly, the level of awareness and facilities for fire-fighting are very low. Yoo (2) states that there is an urgent need for countermeasures from the dangers of fire and for increased accessibility of fire stations, as most of the people are elderly in elderly care facilities. It is very important to use fire extinguishers, which are fire fighting facilities for the initial fire suppression and safety of elderly care facilities. A fire extinguisher is the most convenient device that can extinguish a fire in the early stage when a fire occurs in the protected space or equipment facility of a fire-fighting target, and it can be directly operated by someone to discharge water or fire extinguishing agent, or it can automatically discharge the agent. Kang (3) said that one fire extinguisher, which is an actual initial fire response equipment, exhibits the ability of more than one fire truck.

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Depending on the type of fire extinguishing agent, there are water fire extinguishers, acid-alkali fire extinguishers, reinforced liquid fire extinguishers, foam fire extinguishers, CO<sub>2</sub> fire extinguishers, halon fire extinguishers, powder fire extinguishers, and there are pressurized fire extinguishers and accumulator fire extinguishers depending on the pressurization method. It is stated that a pressurized fire extinguisher is a fire extinguisher in which pressurized gas, which is the discharge source of the extinguishing agent, is filled in a special container separate from the main container of the fire extinguisher, and the extinguishing agents are discharged with gas pressure when the operating main plate of the pressurized gas container is destroyed. The accumulator fire extinguisher, which is the most commonly used type of fire extinguisher, compresses the fire extinguishing agents and air or non-combustible gas such as nitrogen and carbon dioxide inside the container, and then releases the agents with the pressure. Apart from carbon dioxide fire extinguishers, an indicator pressure gauge is attached to the extinguisher. Compression is approximately 81-98kg/cm<sup>2</sup> and when the indicator hand of the pressure gauge indicates red, it means there is an abnormal high pressure, and when the indicator hand of the pressure gauge indicates green, it means there is normal pressure.(5) The principle of fire extinguishing uses a method of removing and blocking the four elements of combustion such as combustibles, oxygen, ignition sources, and chain reactions.

Lee(6) states the reason why fire extinguishers are frequently used for initial fire suppression is because they are widely distributed and installed, and they are efficacious as early fire extinguishing devices. In the event of a fire, lighting equipment that can illuminate the surroundings can be disrupted due to power outages, making it difficult to see fire extinguishers that are normally visible, and even if an individual finds a fire extinguisher, they will likely be bewildered and unable to extinguish the fire effectively. In order to solve this problem, a fire extinguisher with a safety pin that can be quickly and easily removed is proposed. Specifically, a fire extinguisher which has a valve for opening the flow path of the fire extinguishing agent from the main body where the fire extinguishing agent is contained, and in which the fire extinguishing agent is discharged through a hose by the pressure of a lever coupled to the valve. Since the upper lever is characterized by maintaining a constrained state by a safety pin arranged in the same direction as the rotating direction of the lever, it makes it easier to remove the safety pin in an urgent fire situation. However, there remains a problem in many cases that the general public, who are not professional users, become bewildered in the event of a fire and are unaware of how to remove the safety pin. Kang(7) aims to identify problems in the use of fire extinguishers and seek alternatives that can be applied in reality so that the steps of using a fire extinguisher can be reduced, the elderly and women in elderly care facilities can easily operate and access them, and actual fire suppression can be achieved.

## 1.2 Research Objective

The purpose of this study is to enable the fire extinguisher to be operated without removing the safety pin in the event of a fire in the elderly care facility, to make it easier for the elderly to use.

First, to provide a fire extinguisher without safety pins so that the elderly can easily use fire extinguishers in case of fire.

Second, a control spin and a control side are formed on the cock valve and the link to provide a fire extinguisher that does not require a safety pin to prevent the cock valve from being easily opened.

Third, to provide a fire extinguisher that does not require a safety pin, which is able to discharge fire extinguishing agents by an unconscious movement of lifting the discharge hose.

The purpose of this study is to develop a fire extinguisher that does not require safety pins for the elderly in elderly care facilities, to reduce the steps required to operate a fire extinguisher during fire suppression.

### **1.3 Review of Previous Research**

Previous research data on non-safety pin fire extinguishers suitable for use by the elderly are as follows. Shim Young-geun (2014) confirmed the variables that should be considered for better suppression performance by identifying the effect of solid aerosol extinguishing agents on suppression performance. Park Yong-Hwan (2016) presented the current status of defects due to the filling of hand-operated fire extinguishers and their problems, and mentioned the unspecified durability of fire extinguishers and the decrease in new demand due to illegal filling of fire extinguishers. Lim Gyeong-beom and Yoon Jong-hyun (2019) expect the local economy to be revitalized and effects on new markets to be generated, such as public facilities, university labs, factories, housing, schools, vehicles and restaurants, by the improvement of the convenience of existing fire extinguishing equipment, and the development of a simple fire extinguisher with a sensor that uses a new concept of aerosol-type reinforced liquid, which provides various additional functions such as an alarm function and an evacuation induction function. In addition, they expect the simple fire extinguisher to contribute to reducing the damage to people and property by providing convenience with its multiple functions and enabling early extinguishing and early evacuation efficiently in the event of a fire. Joo-hee Oh and Jin-Jong Choi (2013) stated that if the technical standards of fire extinguishers are internationalized and the design concept is introduced to develop high-performance products, it is expected that international competitiveness can be sufficiently secured and furthermore, it will be of great help in the distribution of fire extinguishers. Se-Myung Lee (2013) evaluated the level of awareness of childcare teachers and infants on the correct way to respond and act in the event of a fire. In general, childcare teachers consider it important for infants and toddlers to alert others of the fire or evacuate to a safe place. Young-sam Lee (2016) was able to draw conclusions by conducting a fire extinguisher investigation and inspection analysis of fire extinguishers installed in underground parking lots. It was judged that the inspection status of the fire extinguisher checklist was found to be inadequate by 38%, and the inspection status and appearance of fire extinguishers were poor. In addition, it was decided periodic replacement was required in the case of powder fire extinguishers that were more than 5 years old, because the quality of the chemicals rapidly deteriorated. Yuji Nakamura, Taichi Usuki, and Kaoru Wakatsuki (8) mentioned the use of vacuum fire extinguishers which can extinguish fire cleanly without any damage to other items, as only oxygen is removed from the location of the fire. Instead of discharging water, the extinguisher sucks air in. Takashi Sana, Tetsuji Sugahara, Iwo Matsuki, and Koichiro Shiomori (9) presented the development of a liquid fire extinguisher using silicate polymer. It was stated that when liquid silicate is contained as the primary extinguishing component, the application surface swells at a temperature of 600°C to block oxygen from entering the fire source

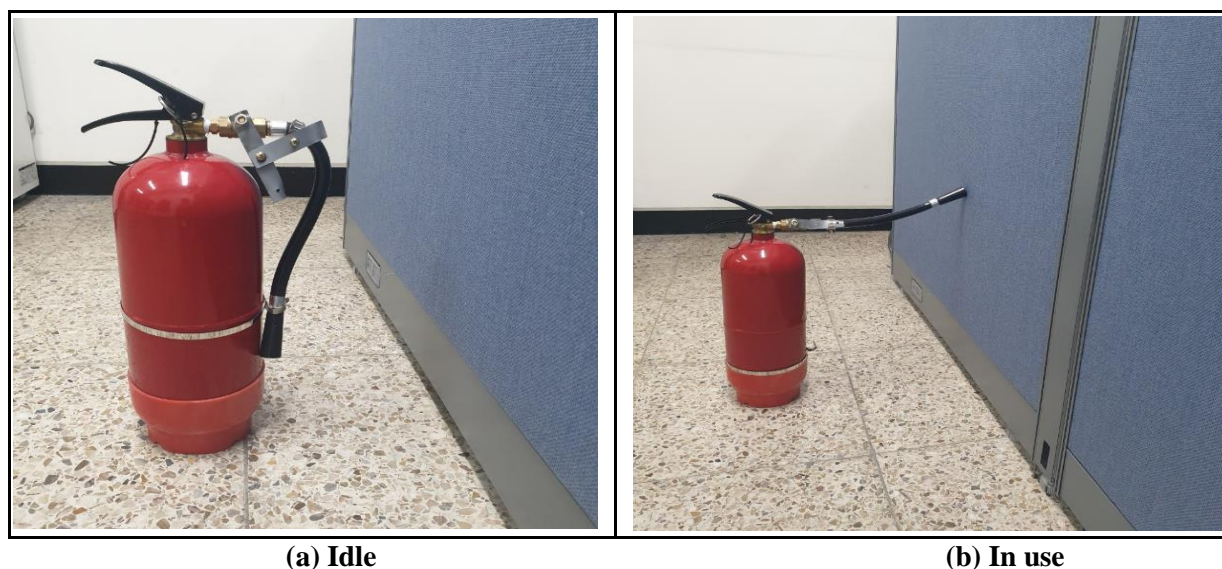
when liquid silicate is sprayed into the fire source, because of the high heat-resistant properties of liquid silicate. When the temperature of the fire source rises above 1,000°C, the substances change into a liquid, solidly bonded to each other and forming a water film, which prevents oxygen from entering the fire source, therefore causing strong extinguishing and retardant action. Jia-ming Jin; Feng-lin An; Yi Shou; Ren-ming Pan (10) analyzed the fire suppression characteristics through simulation according to the discharge of the filling gas in the Fireextinguisher.

## 2. Experiment Method

### 2.1 Fire Extinguisher Designing

There was no major difference in the appearance of the fire extinguishers, and the existing accumulator fire extinguisher was adopted as the basic type. Compressed gas is built into a container containing a fire extinguishing agent and compressed air, which work in a basic structure. The discharge hose that guides the release of the compressed gas and the fire extinguishing agent through the discharge pipe is attached at a right angle to move the extinguishing agent in a vertical direction and to move the cock valve wing in a horizontal direction. Therefore, when the hose is lifted, the connecting hose is made horizontal and the cock valve is opened to act as a safety pin. A link is attached between the clip located on the discharge hose and the top of the cock valve, and a control side is added to the end of the link to lift the discharge hose and at the same time, the link must rotate the cock valve while the control side passes over the control spin formed on the outside of the cock valve. Figure 1 shows the appearance of the fire extinguisher which was designed.

**Figure 1. The appearance of a fire extinguisher**



### 2.2 Conditions of the Experiment

This experiment on the use of fire extinguishers is designed with the elderly as test subjects, because the elderly who are slow to act when evacuating a fire in the elderly care facility are at high risk. This is an experiment to find out the ease of use through comparative analysis of existing fire extinguishers and a newly manufactured non-safety pin fire extinguisher, in order to allow the user to easily use fire extinguishers without panic in an emergency

fire situation. The age of the elderly group is limited to 65-70 years of age, with a total of 10 participants (5 male and 5 female). The experimental scenario type is the process of lighting a fire in a strange place, then extinguishing the fire in an emergency, and collecting the data from the existing fire extinguisher and the non-safety pin fire extinguisher on the operation stage, convenience of use, the time it takes to begin discharging, etc. The average value was analyzed by repeating the test 10 times for each participant. Prior to the experiment, the existing fire extinguisher and the non-safety pin fire extinguisher were sufficiently explained to the elderly about how to use the fire extinguisher and the operation stage, and the location of the flame was set differently and applied. The experimental results are shown in Table 1.

**Table 1. Fire Extinguisher Initial Discharge Time and Satisfaction by Experiment**

Participant	Gender	Age	Existing Fire Extinguisher		Non-Safety Pin Fire Extinguisher		
			Initial Discharge time (s)	Satisfaction level	Initial Discharge time (s)	Satisfaction level	Saved time (s)
A	Male	67	21	Medium	2	Medium	19
B	Male	66	24	Medium	2	High	22
C	Male	68	25	Low	3	High	22
D	Male	67	22	Low	2	High	20
E	Male	65	25	Low	1	High	24
Average		66.6	23.4		2.2		21.4
F	Female	68	39	Medium	3	High	36
G	Female	67	37	Medium	3	High	34
H	Female	69	38	Low	4	High	34
I	Female	66	36	Low	2	High	34
J	Female	67	37	Low	3	High	34
Average		67.4	37.4		3		24.4

### 3. Result of the Experiment

The results of the experiment, performed under the conditions of the experiment scenario, in which fire extinguishing agent was discharged from the existing fire extinguisher and the non-safety pin fire extinguisher are as follows. In the process of extinguishing a fire, most of the participants found that the “existing fire extinguisher” is complicated and were reluctant to use it even though they know how to use it through various information sources. It was observed in the experiment that there are three steps in operating the existing fire extinguisher. The

first step is to grab the handle of the fire extinguisher from the fixed place. The second step is to remove the safety pin and the third step is to squeeze the lever to begin discharging the fire extinguishing agent. On the other hand, the “non-safety pin fire extinguisher” was considered easy to use and the method was simple for most of the participants. There are two steps to use the non-safety pin fire extinguisher. The first step is to grab the handle of the non-safety pin fire extinguisher from the fixed place and the second step is to hold the hose horizontally.

Table 1 shows the results of the experiment, which consists of the time it takes the participants to begin discharging the fire extinguishing agent in the process of extinguishing a fire and their corresponding satisfaction level. In the “existing fire extinguisher experiment”, male participant A, 67 years old, had an initial discharge time of 21 seconds, which was the fastest among the male participants, and his satisfaction with the fire extinguishing agent discharge was “medium”. Participant C, 68 years old, had an initial discharge time of 25 seconds, which was the slowest among the male participants, and his satisfaction with the fire extinguishing agent discharge was “low”. Among the female participants, participant I, 66 years old, had the fastest initial discharge time of 36 seconds, and her satisfaction with the fire extinguishing agent discharge was “low”. Participant F, 68 years old, had an initial discharge time of 39 seconds, which was the slowest among the female participants, and her satisfaction with the fire extinguishing agent discharge was “low”. On the other hand, in the “non-safety pin fire extinguisher use experiment”, male participant E, 65 years old, had the fastest initial discharge time of 1 second, and his satisfaction with the fire extinguishing agent discharge was “high”. Male participant C, 68 years old, had an initial discharge time of 3 seconds, which was the longest time among the male participants, and his satisfaction with the fire extinguishing agent discharge was “high”. Among the female participants, participant I, 66 years old, had the fastest initial discharge time of 2 seconds, and her satisfaction with the fire extinguishing agent discharge was “high”. H, 69 years old, had the slowest initial discharge time of 4 seconds, and her satisfaction with the fire extinguishing agent discharge was “high”.

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