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Summary

Automatic water extinguishing systems are designed to detect and limit or control fires in their early stages and to control them so that people can safely evacuate the premises. Extinguishing systems are also meant to limit or control the fire either by improving the possibilities of it being put out by other means or until rescue department units can get to the site.

This study analysed all fires that activated automatic water extinguishers at care institutions or corresponding institutional residences from 2012–2019. Corresponding units refer to, among other things, residences fitted with automatic water extinguishing systems.

The study particularly aimed to establish:

- The number of fires that activated automatic water extinguishing systems in housing where support and assistance are needed (institutional residences).
- Whether the automatic water extinguishing systems helped minimise losses and, especially, injuries to people, and
- The reliability of the system, i.e. whether the systems operated as designed.

The information was compiled from the Finnish rescue services' accident and emergency statistics database PRONTO. In order to gather supplementary information on some of the fires the writers of the report contacted the rescue authorities dispatched to these fires as well as care operators and building owners.

This report was not commissioned; it was written in addition to other duties (IATOD). Since 2012 Tapio Stén, Fire Inspector (Engineer) at Tampere Region Rescue Department, who carried out the research, has written similar synopses regarding fires at institutional residences. The focus has been on the functioning of automatic water extinguishing systems. Lauri Lehto, Safety and Security Advisor at the Finnish National Rescue Association (SPEK), aided in writing this report.

1. Foreword

This report studied fires that were put out or limited and controlled by automatic water extinguishers at institutional residences from 2012–2019. In all, there were 77 fires studied that activated automatic water extinguishing systems.

Of these, automatic water extinguishing systems put out 60 fires and limited 15 fires. They would probably have extinguished even more fires had they had the time to operate longer. In these cases, either the local staff or the fire department put out the remaining, smouldering fire. In two cases the automatic water extinguishing systems could not extinguish the fire: In one the fire was inside a tumble dryer and in the other it was inside a washing machine. Even then, the system achieved its goal by limiting or controlling the fires and preventing their spread beyond the seat of fire, averting the onset of life-threatening conditions.

Of all of the fires 40 (52%) were considered to be arson. Two other major cause categories involved electric fires owing to malfunctioning devices or equipment (12 fires) as well as smoking and using matches or lighters (9 fires). There were 16 other types of fire.

Fifteen fires occurred in penal institutions. All of these were ruled arson. Of the fires (62 fires) that occurred outside of penal institutions, 25 (40%) were ruled arson.

The underlying cause of many of the intentionally set fires was apparent self-destructive behaviour. The arsonist's comments prior to the act as well as their behaviour during the fire implied this. The motives for arson at institutional residences and, especially, at penal institutions, should be more carefully studied in the future.

Altogether 400 people were involved in the fires. The number refers to the people who, when the fire broke out, were either in the room of origin or in a fire section to where the fire spread. Two people were seriously injured and one died. The number of deaths and injuries caused by fires from 2012–2019 is presented in Table 1.

Table 1. Fires, deaths and serious injuries at institutional residences 2012–2019.

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fires	7	4	10	9	5	19	14	9	77
Deaths	0	0	0	0	0	0	1	0	1
Serious injuries	0	0	0	0	0	1	1	0	2

2. Terms and definitions

Room of origin: The room or other space where the ignition occurred.

Rescue service response time: The time from when the first unit receives the alert until the rescue team (1+3 personnel) commences effective rescue action.

Effective rescue action: Is considered to begin when the nozzle team has a charged hose and is able to start fire suppression or, in the case of smoke diving, when the smoke diving supervisor is informed that smoke diving has begun.

Building fire: A fire which has spread from its seat of fire and ignited the building's structure or the movable property inside the building.

Self-extinguished building fires or building fires that died out are also categorised as building fires even though the fire department had no role in extinguishing at the site.

Potential building fire: A fire that did not spread from the seat of the fire to the structure or movable property, but which had the potential of doing so. For example, 'close calls' reported by automatic Fire Detection Systems, soot fires as well as 'singed' machines, devices or fluorescent lamps and garbage bin fires close to buildings, etc, are recorded as potential building fires even though they did not spread from the seat of the fire.

Also independently extinguished, small building fires or fires that died out are categorised as potential building fires even though the fire department did not have to suppress the fire at the site.

Automatic water extinguishing system: A fixed extinguishing system in a building that supports rescue action, intended to independently put out a fire in its early stages or at least limit and control the fire until final extinguishing is, if necessary, achieved by other means.

The operation of the extinguishing system is augmented by pre-rehearsed first extinguishing action and, when needed, by the rescue department's extinguishing operation. An extinguishing system markedly increases the time for action and provides more safe options for personnel during fires.

Automatic Fire Detection System (FDS): A system connected to the Emergency Response Centre (ERC) which detects a fire in its early stages and automatically reports it to the ERC. Fire Detection Systems constitute equipment which, for the most part, transmit the alarm to the ERC as soon as is possible and in the most reliable fashion, and so, the notification also reaches the rescue department as early as possible.

Fire Detection Systems play an important role in early detection and in providing more time for action to the staff. Automatic water extinguishing systems are connected through the FDS to the ERC in accordance with the EN 54 standard.

System-to-system control: Technical implementations presented in the examples where the Fire Detection System triggers the extinguishing system.

Automatic water extinguishing systems can also pre-action and deluge systems; in in these kinds of systems the FDS-controlled discharging system operates the main control valve. Then, for example, when the FDS detects a fire, it activates the automatic water extinguishing system and opens the main control valve. It must always be possible to manually or automatically discharge the extinguishing system.

When pre-action valves are being used, the extinguishing system activates normally when the direct influence of the fire reaches the nozzle, breaking its thermal element. In most fires only one nozzle will discharge, which is sufficient to extinguish, or at least limit, the fire. In pre-action and deluge systems the extinguishing system can, at least partly, incorporate open nozzles.

Institutional residence: Refers to housing facilities where support and assistance are needed for evacuation safety in the case of fire, for example care institutions and hospitals as well as correctional institutions. For the purpose of this synopsis, 'senior housing' service homes fitted with automatic water extinguishing systems are also included in this category.

3. Results: Fires put out or limited or controlled by automatic water extinguishers

The fires analysed in this report are divided into five categories:

- Fires resulting in fatalities.
- Fires occurring in dwellings or in the rooms of residents or patients. This category includes fires that occurred, for example, in housing units or in the patient rooms of care institutions, excluding hospitals.
- Fires that occurred in the public spaces of housing units and care institutions or similar institutional residences, excluding hospitals. Such spaces include lavatories located along corridors, kitchens or lounging areas in housing units.
- Fires that occurred in hospitals, and
- Fires that occurred in penal institutions.

The goal was to establish:

- The room of origin or other space where ignition occurred.
- The cause of the fire.
- The level of protection inside the room of origin.
- The number of people involved in the accident.
- The number of people in other fire sections at the time.
- Injuries and fatalities.
- The rescue service response time: The time from when the first unit receives the alert until the rescue team (1+3 personnel) commences effective rescue action.
- The position of the nearest able-bodied person at the time of the fire.
- The first extinguishing action, and
- An assessment of whether the automatic water extinguishing system impacted or prevented fire losses.

3.1. Injuries to people at sites with automatic water extinguishing systems

Automatic water extinguishing system normally discharge at around 68°C (154°F), which is often the temperature threshold set for protected spaces. The nozzle's thermal element breaks from the direct influence of the fire's heat. By the time this occurs, the fire has developed to the extent that it activates the extinguishing system.

In two instances the discharges could be considered as avoidable errors, even though the systems operated as designed. In the first case the mattress that was burning had just been carried outside when the system activated. In the second case the equipment was programmed to activate when the FDS detected smoke.

In three cases, however, the extinguishing system was unable to prevent injuries to people, even though it operated reliably and as designed. The fires resulted in one fatality and two serious injuries. Regarding the fatality the person was smoking in bed and the bedding caught fire. While the automatic water extinguishing system operated as designed and put out the fire, the resident had already sustained fatal burns, and the following day the resident died in hospital. When it comes to the fires where the victims sustained serious injuries, they had probably fallen asleep while smoking in bed and their bedding had caught fire.

Regarding the aforementioned two cases one must keep in mind that when the fires started, the victims were so close to the fire that they sustained severe burns before the automatic water extinguishing systems could react to the rising temperature inside the room. Without automatic water extinguishing systems, they probably would have died. Once a person's clothing or bedding catches fire, the victim sustains burns very quickly and the extinguishing system will not necessarily be able to prevent serious injuries. In all of the cases the automatic water extinguishing system functioned in the way it was designed to. It either put out or limited the fire so that the local staff or rescue services could then easily extinguish the fire.

It is highly likely that automatic water extinguishers saved at least 10 people from dying in a fire. These people were still inside the room of origin when the fire department arrived. The shortest rescue service response time until effective rescue action in these cases was 9 minutes and 26 seconds. Without automatic water extinguishing systems the conditions in residences and patient rooms normally become life-threatening within 2–3 minutes from the onset of the fire.

In addition to the aforementioned 10 people, automatic water extinguishing systems may have saved even more lives or prevented serious injuries. In two cases this conclusion was made on the assumption that the local staff was unable to safely evacuate all of the residents. Still, it is not possible to know what the sequence of events would have been in the absence of an automatic water extinguishing system.

Fire deaths at sites equipped with automatic water extinguishing systems

This part of the summary examines a fire in which a person perished as a result of a fire despite the activation of an automatic water extinguishing system.

The fire occurred in an eight-storey block of flats. The flat in question was a 25 m2 studio flat on the third floor.

Working inside the building were care operators who provided home care services to physically disabled people. Among other things, there were two studio flats in the building and the staff, in practice, only took care of the residents in these two units. The other flats in the building were rented. The studio flats were on the second and fifth floor of the building.

The flat in question was rented from the city's social psychiatric foundation. The occupant/victim was a physically disabled, 74-year old woman, who used mobility aids.

Responding to an unsafe housing conditions report, the rescue authorities visited the woman and explained the fire hazards of smoking in bed. Nonetheless, the occupant ignored this advice and kept smoking in bed, as was her custom.

The occupant was smoking in bed and her bedding caught fire. Judging by the FDS log the smoke detector reacted by issuing a pre-warning and, almost immediately thereafter, a fire alarm. The automatic water extinguishing system reacted to the rising temperature and activated within approximately three minutes from the pre-warning. The automatic water extinguishing system discharged and put out the fire but, even though it worked as designed, it could not prevent the occupant from sustaining fatal burns. As a result, she died in the hospital the following day.

The extinguishing system had a horizontally positioned sidewall head, at approximately 2.5 m from the bed.

3.2. Fires in rooms of residents or patients

This segment of the study analysed fires that occurred in dwellings or rooms of residents or patients. This group includes, among others, fires occurring in housing unit rooms as well as those in care institutions, excluding hospitals. In all, there were 41 such fires.

Causes of fire

Firefighting authorities deemed 17 out of 41 fires arson (Table 2). Most often the items that were intentionally set on fire were a bed, a sofa, an armchair, curtains, or loose items piled on the floor. Many such fires may have been associated with self-destructive behaviour on behalf of the arsonist. The arsonist's comments prior to the fire, as well as their behaviour during the fire, implied this.

Table 2. Causes of fires in dwellings or in the rooms of residents or patients.

Cause of fire	Fires	%
Arson	17	41,5
Smoking, lighters and matches	9	22,0
Use of an electric stove and items on it	3	7,3
Cathode-ray tube TV	2	4,9
Washing machine	1	2,4
Burning candles	1	2,4
Items close to the sauna stove	1	2,4
Ignition of a propane canister on the balcony	1	2,4
Ignition of a fridge during repairs	1	2,4
Ignition of cooking oil or fat	1	2,4
Cause unknown	4	9,8
Total	**41**	**100**

Room of origin

When it comes to fires in dwellings, the rooms of origin are presented in Table 3.

Table 3. Rooms of origin in dwellings or in the rooms of residents or patients.

Room of origin	Fires	%
Living room/lounge	12	29,3
Kitchen	9	22,0
Bedroom	7	17,1
Lavatory or bathroom	5	12,2
Hallway	4	9,8
Balcony	3	7,3
Sauna	1	2,4
Total	**41**	**100,0**

Automatic water extinguishing system operation

Automatic water extinguishing systems extinguished 32 fires and limited 9 fires. The following includes brief descriptions of the cases where they limited the fire:

- A burning bag which was ignited by the occupant activated the automatic water extinguishing system. When a staff member entered the flat the automatic water extinguishing system had almost completely extinguished the fire. The staff member put the fire out completely with a small portable extinguisher and evacuated the occupant from the room.

- In two cases the extinguishing system activated when the fire department was already at the site. The fire department completed the extinguishing.

- The fire department arrived at the site within approximately 1 minute from having received an automatic fire alarm. Prior to this an occupant had called the ERC and made threats and such. Because of this, the police and the fire department were dispatched to the site. This is why the (nominal) response time was only 1 minute. The firefighters put out the remaining fires after the automatic water extinguishing system had discharged. There were several fire pockets in the dwelling.

- A small smouldering fire in the occupant's bed.

- A propane gas canister was burning on the balcony and the automatic water extinguishing system was unable to completely put out the fire. However, the system cooled the canister throughout the event (there was a nozzle on the balcony).

- A washing machine caught fire in the lavatory/bathroom. Although the automatic water extinguishing system could not reach the flames inside the machine, it prevented the fire from spreading.

- Loose items on an electric stove caught fire. The automatic water extinguishing system did not completely extinguish the fire. The reason why the system only limited the fire remained unclear.

- The automatic water extinguishing system did not extinguish a fire in the kitchen. The reason why the system only limited the fire remained unclear.

When it comes to cases where the automatic water extinguishing systems limited fires, the systems would probably have completely extinguished them in a few cases, had they had the time to operate longer.

Altogether 150 people were involved in the 41 fires. Roughly twenty people were in the room of origin, i.e. in immediate danger, when the fire broke out. The rest were, among other things, in the other rooms of partitioned housing units.

Of the people who were in the room of origin, approximately 10 could not, or would not, escape on their own. In addition to them, there were several other people in other rooms who were unable to self-evacuate the premises.

Two people were seriously injured and 13 sustained minor injuries in these fires. In the fires that resulted in serious injuries the victims had fallen asleep, probably while smoking, and their bedding had caught fire. They had already sustained severe burns before the automatic water extinguishing systems extinguished the fire. Without automatic water extinguishing systems they would probably have died. It is highly likely that the extinguishing systems saved at least 10 people from dying or, at least, from sustaining serious injuries in a fire. This estimate is based on the fact that these people remained in the room of origin until the fire department rescued them. The shortest rescue service response time until effective rescue action in these cases was 9 minutes and 26 seconds. For the most part, the rescue service response times averaged at approximately 10 minutes.

Since the conditions in housing units and patient rooms normally become life-threatening within 2–3 minutes from the onset of a fire, it is quite safe to say that without automatic water extinguishing systems the people would have perished in their rooms.

In addition to the aforementioned people in the rooms of origin, automatic water extinguishing systems may have saved lives in a case where a staff member did not have the time to rescue two people before the arrival of the fire department. In this case the fire department's response time until effective fire suppression and rescue action was 11 minutes and 23 seconds.

In one case automatic water extinguishing systems possibly prevented a propane gas canister from exploding on the balcony. When the fire started at the canister's valve coupling, the automatic water extinguishing system was activated but was unable to extinguish the fire. However, water kept cooling the canister throughout the duration of the event, i.e. for at least 15 minutes. This, possibly, prevented the temperature from rising inside the canister and kept it from exploding.

In all of the cases automatic water extinguishing systems operated as designed. They either put out or limited the fires to the extent that the local staff or the fire department gained more time to complete the extinguishing. Moreover, the system prevented the creation of life-threatening conditions inside the spaces. For example, in one case a staff member rescued an occupant at the stage when the automatic water extinguishing system had almost completely extinguished the fire.

3.3. Fires in the public spaces of housing units or care institutions

This segment analyses fires that occurred in the public spaces of housing units, care institutions or the like, excluding hospitals. Such spaces include lavatories located along corridors, the kitchen or the lounge area of a housing unit. In all 13 fires were analysed in these locations.

Causes of fire

Firefighting authorities considered five out of thirteen fires to have been arson. Machines and devices caused six fires (Table 4). In addition to the aforementioned fires, hot work caused one fire and in one case a wooden trivet under a pot was smouldering.

Table 4. Fires caused by machines and devices in the public spaces of housing units, care institutions and the like.

Machine or device	Fires
Sauna stove and its connections	2
Tumble dryer	2
Washing machine	1
Freezer	1
Total	**6**

In two intentionally lit fires the curtains were set on fire. In one case a pram in a sectioned corridor was set on fire. In one case a mattress brought into the lounge was set on fire, and in one case loose material piled on the floor was ignited.

Room of origin

The rooms of origin were as shown in Table 5.

Table 5. The room of origin regarding fires in the public spaces of housing units, care institutions and the like.

Room of origin	Fires	%
Hallway or other lounging area	4	30,8
Communal kitchen	2	15,4
Laundry room	2	15,4
Sauna-washroom	2	15,4
Sectioned exit (corridor)	1	7,7
Heating oil tank space	1	7,7
Other	1	7,7
Total	**13**	**100,0**

All four fires in the hallway and other lounging areas were deemed arson.

Automatic water extinguishing system operation

Automatic water extinguishing systems put out seven fires and limited three fires. In two cases they did not reach the flames. In one case the fire was simultaneously being extinguished by the staff and the automatic water extinguishing system.

In cases where the fire was limited:

- The fire was inside a tumble dryer. The automatic water extinguishing system prevented the fire from spreading.
- A freezer in a housing unit's kitchen caught fire and the kitchen exhaust hood prevented the automatic water extinguishing system's water from reaching the seat of the fire. The system, however, prevented the fire from spreading beyond the freezer.
- When the sauna stove's electrical box caught fire, the fire spread into the air gap behind the wooden wall and the automatic water extinguishing system could not extinguish the fire. The fire did not spread beyond the sauna.

Fires in hospitals In two cases the system was unnecessarily activated: In the first case the extinguishing system was programmed to activate when the FDS detected smoke. The system was activated when a wooden trivet under a pot was smouldering, to which the smoke detector reacted. This was an avoidable, false alarm caused by human action.

The second case involved a burning mattress. The staff had just carried it outside when the automatic water extinguishing system activated. This being the case, the systems operated as designed in both cases but, owing to the staff's swift action, the activations were not needed.

Impact on human safety

In all, approximately 200 people were involved in these fires. Some of them were in the room of origin when the fire broke out and others were in the other premises of the housing units.

It is more difficult to estimate the impact of automatic water extinguishing systems to human safety in public spaces compared to fires occurring in dwellings. Nonetheless, automatic water extinguishing systems may have saved lives in at least the following two fires occurring in public spaces:

- During a freezer fire the staff managed to evacuate 17 out of the 39 residents before the fire department arrived. The rescue service response time in this case was 10 minutes and 25 seconds. Since the staff did not have the time to carry out first extinguishing, the freezer fire would probably have caused life-threatening conditions in this fire section within this timeframe.

- A resident suffering from memory disorder set the curtains on fire. The care facility operator said that, in all likelihood, it would have been impossible to evacuate all residents soon enough had they not had an automatic water extinguishing system at the site.

In all cases the automatic water extinguishing systems operated as designed. They either put out or limited or controlled the fires to the extent that the staff or the fire department could easily complete the extinguishing. Moreover, the system prevented the creation of life-threatening conditions in the rooms.

3.4. Fires in hospitals

There were altogether seven fires in hospitals (Table 6), three of which were deemed arson. They resulted in one minor injury. There were in all 55 people involved in the fires that broke out in the affected fire sections.

Automatic water extinguishing systems put out all seven fires. It is difficult to estimate the effect of automatic water extinguishing systems on preventing injuries or fatalities. In one patient room the mattress was on fire and the patient only evacuated the room once the automatic water extinguishing system discharged. It is difficult to surmise what the patient would have done in the absence of an automatic water extinguishing system.

In two cases where evacuation was required the staff managed to evacuate the patients well. However, they did not have the time to carry out first extinguishing. The rescue authorities estimated that the Fire Detection System and the automatic water extinguishing system played essential roles in rescue and evacuation.

Table 6. Type of building, room of origin and the action of patients/staff during hospital fires

Type of building. Room of origin	Cause of fire	Action of patients/staff
Psychiatric hospital. Public lavatory.	Automatic paper dispenser was set on fire. Arson.	"The Fire Detection System and the automatic water extinguishing system played essential roles in the rescuing and evacuating of people".
Forensic psychiatric hospital. Patient room.	The patient set the mattress on fire. Arson.	The patient in the room of origin left the room when the automatic water extinguishing system discharged.
Patient room lavatory in central hospital.	The patient set a fire in the lavatory. Arson.	Difficult to estimate impact on human safety.
Psychiatric hospital. Sauna on the hospital ward.	Loose items on top of the sauna stove caught fire.	Difficult to estimate impact on human safety.
Electrical room	Electrical appliance caught fire	No immediate impact on human safety
Electrical room.	Batteries were burning,	No immediate impact on human safety.
Transformer room.	A transformer caught fire.	No immediate impact on human safety.

3.5. Fires in penal institutions

This segment analyses 15 fires that occurred in prisons, jails and police cells. Each fire was deemed arson; most fires involved setting the mattress on fire. In three cases clothing was set on fire and, also, in three cases paper was set on fire.

Automatic water extinguishing systems put out 13 fires and limited one fire. In the latter case the fire was set behind the toilet seat in such a manner that the water discharged by the automatic water extinguishing system could not properly reach the fire pocket. In one case the guard used first extinguishing equipment in putting out the fire, which the automatic water extinguishing system had almost completely extinguished.

It is difficult to estimate the impact of automatic water extinguishing systems on human safety because the research material does not really elaborate on the sequence of events. However, it was apparent that the extinguishing systems at least made fire suppression and rescue action easier. The reports made it clear that the system kept the conditions safe in the entire fire section.

Prior research has shown that fires at similar sites without automatic water extinguishing systems created life-threatening conditions in the entire fire section already during the first extinguishing phase. And that the guards had to wear gas masks during first extinguishing (cf Stén, 2014). Toxic gases rapidly spread throughout the entire fire section because they had to keep the doors of the ignited space open during first extinguishing and evacuation. Furthermore, smoke also spread to other fire sections.

4. Evaluating the reliability of automatic water extinguishing systems

The aforementioned examples include cases where injuries and fatalities occurred even though the automatic extinguishing system functioned. In these cases the system worked as designed but, the fire developed so rapidly that the nozzle's thermal element, the pulp, did not have time to react and break in response to the rising temperature. In these examples, for different reasons, the victims were so close to the flames that they sustained burns before the automatic water extinguishing systems discharged.

Automatic water extinguishing systems have been found to be very reliable. When it comes to lifecycle reliability, meticulous system maintenance is paramount.

In his Master's thesis on the reliability of sprinkler systems Mikko Nieminen (2018, 43) stated that on the basis of information compiled from the PRONTO statistics system, they have been 98.1 per cent reliable. The study used statistics from building fires that occurred from 1996–2016.

To support everyday fire safety planning as well as the work of the authorities the research studied the reliability levels of sprinkler systems used in typical buildings. It also looked at the impact of system reliability regarding fire safety design based on theoretical fire spread models. The study included fires where the automatic water extinguishing system had the possibility to react to a fire. For example, fires that died out or fires which were extinguished before the ambient temperature rose to the level required for the system to activate, were omitted.

The research material exposed some cases where the automatic water extinguishing system did not discharge. The reasons for this were:

- The pipes were frozen.
- The system was deactivated at the time of the fire.
- Environmental impacts (e.g. the nozzle was covered with grease), and
- The electric supply was discontinued during operation and no backup power was available.

For one reason or another, no detailed information was available for the rest of the examples.

Comparable international statistics have also yielded similar results on the reliability of automatic water extinguishing systems. In the USA the National Fire Protection Association (NFPA) stated that from 2010–2014 automatic water extinguishing systems activated in 92 per cent of the fires where automatic water extinguishing systems were installed and when the fire was large enough to activate the system. (NFPA 2017, 5)

When it comes to the cases where the system failed to activate (8%, 660 cases/yr.), noteworthy aspects included issues with regular upkeep and neglecting to carry out required maintenance and overhauls that safeguard system reliability over its projected lifespan. The causes for the systems' non-activation are presented in Table 7.

(NFPA 2017). Table 7. Reasons for combined sprinkler failure in the United States.

Cause	%
System shut-off before fire	59
Manual intervention too soon	17
Lack of maintenance	10
System components damaged	7
Inappropriate system for type of fire	7
Total (660 fires/yr.)	**100**

The NFPA's report came to the conclusion that 'the lowest home fire death rate… is found in homes with sprinkler systems and hardwired smoke alarms or FDS'.

A similar percentage for reliability was also achieved in Sweden where, in 2008, the reliability of automatic water extinguishing systems was studied. The analysis demonstrates that automatic water extinguishing systems have been 92 per cent reliable in Sweden. The results were conclusions made on the basis of information compiled from official statistics. (Malm & Pettersson 2008, 35)

Sweden has also studied cases in which, according to official statistics, the automatic water extinguishing system did not work. This has raised questions and spurred debate regarding the true reliability of automatic water extinguishing systems. The Swedish Civil Contingencies Agency (MSB) analysed the cases that occurred from 2005–2014 in more detail. They concluded that automatic water extinguishing systems worked properly in most cases where they, owing to the size of the fire, should activate, and that they have been more than 99 per cent reliable. (Melin 2018)

The MSB's report aimed to study the reliability of automatic water extinguishing systems over a period of ten years, focusing on cases from buildings fitted with fixed automatic water extinguishing systems. The data make use of fire reports written by Swedish rescue departments.

The statistics discovered more than 3 000 instances where the automatic water extinguishing system did not activate. When the sites without automatic water extinguishing systems were removed from the scope of the study or when the conditions did not warrant activation the number of cases fell to 611 fires (19%). Further analysis found four instances in which the automatic water extinguishing system did not operate as designed. In other words, they were over 99 per cent, i.e. extremely, reliable.

The cases left outside the scope of the study, therefore, involved the authorities' recordings of sites where the automatic water extinguishing system had not activated simply because one did not exist or the conditions did not warrant the system's activation. Regarding the statistics, it must be noted that there was not any more detailed information available on all of the cases than that which could be presented on the basis of the reports. (Melin, 2018)

According to the Swedish Civil Contingencies Agency (MSB) the most typical causes for automatic water extinguishing system inaction were:

- The fire was extinguished by a person.
- There was very little smoke generation.
- The fire was too small to activate the automatic water extinguishing system, and
- The automatic water extinguishing system was not implemented pursuant to prevailing standards.

Situations where the automatic water extinguishing system did not activate also included many of the kinds of fires that were also analysed in this report, i.e. the victim was too close to the flames in which case the system could not save the person. From the technical viewpoint, it could be said that the system implementation did not comply with regulations or that maintenance had been neglected. Moreover, the fires may have been so small that the automatic water extinguishing system was not even designed to discharge because the fires did not generate enough heat or smoke to activate the system. When it comes to such cases the reports simply state that "the automatic water extinguishing system did not operate". This, in turn, distorted the statistics prior to taking a closer look at them, and also possibly resulted in different parties making intentionally biased conclusions regarding system operation and reliability. In reality, there were only four cases where system malfunction could not be excluded.

5. Conclusions

The conclusions make use of the material used in writing this report, deductions from different annual publications and relevant literature.

The goal was to establish the number of fires that activated automatic water extinguishing systems at institutional residences; find out whether the systems helped minimise, especially, injuries and fatalities; and determine the reliability of the equipment. The number of fires analysed in all of Finland over an eight-year period was 77. It was surprising that, taking into account all of the cases, more than half of the fires (40 cases, 51.9%) were estimated to be arson, often motivated by self-destructive behaviour. When classified by site, arson is remarkably prevalent at care institutions, service homes and assisted living facilities. What is more, all of the fires that occurred in penal institutions were deemed to be arson.

Approximately 400 people were involved in the fires analysed by this study. The number refers to the people who, at the onset of the fire, were either in the room of origin or in a fire section to where the fire spread. One person died and two people were seriously injured.

It is safe to say that automatic water extinguishing systems saved at least 10 people from dying in a fire. These people were still inside the room of origin when the fire department arrived. The shortest rescue service response time until effective rescue action in these cases was 9 minutes and 26 seconds. Without automatic water extinguishing systems the conditions in housing units and patient rooms normally become life-threatening within 2–3 minutes from the onset of the fire. Therefore, the conclusion can be considered to be justified.

The number of lives saved may be on the conservative side because every fire behaves differently and human action, especially successful evacuation, always includes unknowns. Compared to situations where automatic water extinguishing systems had not been installed, the systems also reduced fire losses.

Ever since the early 2000s automatic water extinguishing systems have been mandatory in care institutions, service homes and assisted living facilities if the evacuation safety assessment carried out at the facility required the introduction of such systems. Automatic water extinguishing systems have proved their worth in the aforementioned institutional residences. In Finland, too, the systems have a proven track record of reliability – not only limited to preventing economic losses at businesses, but also injuries and deaths at institutional residences as well as economic losses.

Automatic water extinguishing systems' impact on losses

In the fires that were analysed automatic water extinguishing systems saved lives and markedly prevented material losses and reduced costs to society arising from burn care. Flame burn care incurs the cost of approximately EUR 6 million to society each year. An individual victim's burn treatment may exceed EUR 400 000. Likewise, loss of production resulting from fire deaths may amount to nearly EUR 400 000. (Haikonen et al 2014, Haikonen et al 2017)

More fire deaths and injuries would have resulted from the absence of automatic water extinguishing systems. Likewise, injuries to people and loss of property would have been much greater compared to what they now were in premises which were fitted with automatic water extinguishing systems.

Since the functioning of automatic water extinguishing systems is reliable and also for the sake of human safety, it would make sense to also install automatic water extinguishing systems in normal homes. Increasingly older and frail people are living in their own homes. Owing to their reduced mobility they are unable to evacuate from a fire on their own. Should a fire break out, their only hope of escaping a fiery death is an automatic water extinguishing system.

The significance of conditions

It can be estimated that automatic water extinguishing systems have indirectly saved more lives than the statistics directly show. However, it is impossible to more precisely appraise the number of those saved because the figure depends on, among other things, how rapidly a fire spreads, smoke generation and the success of evacuation.

Automatic water extinguishing systems put out 60 fires and limited the fire in 15 instances. They would probably have extinguished even more fires had they had the time to operate a bit longer. In these cases either the local staff or rescue units finished extinguishing the smouldering fires.

Most of the examples demonstrate the fact that limited physical mobility, use of intoxicants as well as otherwise degraded ability constitute significant factors that contribute to deaths or burn injuries. Fires are often caused by smoking, cooking and electrical devices – when used inappropriately and without supervision. The results resemble those established by previous research (Kokki 2011, Kokki 2014). In the cases analysed in this report human action was responsible for the lion's share of all fires. More than half of the fires were deemed arson and a third were caused by carelessness.

In some instances the local fire authorities estimated that without an automatic water extinguishing system the fire would have resulted in fatalities. For example, this was the case when the occupant was not completely lucid and failed to fully appreciate the seriousness of the situation; without an automatic water extinguishing system the conditions would have rapidly become life-threatening.

Health and safety

Fires that broke out at institutional residences have caused, and continue to cause, danger to the staff as well. During first extinguishing and evacuation workers may sustain injuries from breathing toxic fire gases or sustain burns. Such fires can also be extremely traumatic to the workers and they may suffer a long time, even a lifetime, from their experiences, to the extent that they may no longer be able to continue in that line of work.

Automatic water extinguishing systems also significantly improve the staff's health and safety during fires. Not a single member of staff sustained injuries in any of the fires that were analysed. On the one hand the fires developed very rapidly, on the other hand, the staff immediately began to evacuate the residents without attempting first extinguishing. Even though a fire is rapidly detected and notified to the staff, they do not always have enough time to enter the space where the fire is burning to extinguish it and rescue the occupant.

Automatic water extinguishing systems, installed to augment the rescue department's action, markedly made rescue action and fire suppression easier and sustained safe conditions. Owing to the long (9–22 min) rescue service response time the fires would have progressed much more, causing much greater loss of life and property, had there been no automatic water extinguishing systems. Since the conditions in housing units and patient rooms normally become life-threatening within 2–3 minutes from the onset of a fire, it is quite safe to calculate that without automatic water extinguishers the occupants would have perished in their rooms.

Operating models at sites where the automatic water extinguishing systems activated

Each fire is one of a kind. In scores of fires the local staff was present when the fire broke out and the Fire Detection Systems were programmed to directly alert the ERC. The typical mode of operation for the staff was to evacuate occupants either out of the building or to some other space. However, the number of staff was inadequate for evacuation and first extinguishing. Automatic water extinguishing

systems, therefore, were instrumental in minimising injuries and fatalities and loss of property when the local staff did not have the time to carry out first extinguishing.

Many institutions only have a small or skeleton staff or there may be no night-time staff at all. Therefore, the only way to see to the fire safety of the residents is to install automatic water extinguishing systems. Despite the fact that a site would have the sufficient personnel, this synopsis still corroborates the prior view that staff will not always have enough time to carry out first extinguishing and evacuate all of the residents who are unable to escape on their own.

It is also worth mentioning that even though most fires occur during the day, in practice, it makes little difference at what time of day a fire breaks out, whether the site is fitted with an automatic Fire Detection System or whether the personnel is present; it is just a fact that the number of staff will not necessarily suffice. The problem is only exacerbated if first extinguishing, rescue and emergency evacuation have not been drilled.

Even though a site has an automatic Fire Detection System and personnel present, evacuation safety will not necessarily comply with the requirements of the Rescue Act. And in spite of the fact that the fire was soon detected and reported to the staff, they may still not necessarily have enough time to make it to the burning space for first extinguishing as well as rescue the occupant. If indeed the goal is to have no fire deaths at care institutions, service homes and assisted living facilities, all of them must absolutely be fitted with automatic water extinguishing systems.

Apparently, operators responsible for the maintenance of care institutions, service homes and assisted living facilities are overly optimistic about the abilities of their staff to rescue people from burning spaces. This fact also came up during the writing of this synopsis. Therefore, the rescue authorities must always take the words of care operators with a grain of salt when they claim that their staff members are fully capable of rescuing people from burning premises.

In the cases when the automatic water extinguishing system was activated, care operators acknowledged that it would have been very challenging to evacuate all of the occupants quickly enough in the absence of an automatic water extinguishing system. In most cases they did attempt to carry out first extinguishing, but in some cases this was only done after the system had nearly put out the fire.

In cases where first extinguishing was not attempted at all, the sites were fitted with automatic Fire Detection Systems. One must not ignore the importance of these systems alongside automatic water extinguishing systems.

In most cases automatic Fire Detection Systems were the first to transmit the alarm to the ERC. There being a rapid alarm in the first place is dependent on FDSs having been installed. Their use also makes it possible for staff to rapidly respond to the situation.

Even though a site would have been fitted with an automatic Fire Detection System and the local staff had been present, despite there having been rapid detection and an alarm the personnel would not have been able to extinguish any of the fires presented in the examples, aside from exceptional cases.

The significance of maintenance

In one case the automatic water extinguishing system saved the life of the occupant, even though the alarm signal could not be transmitted in the designed fashion. The sprinkler system was programmed to transmit the alarm through the FDS to the 24/7 manned security control room but, owing to a damaged SIM card, the connection was inoperative at the time of the occurrence. The extinguishing system preserved life-sustaining conditions in the dwelling for 30 minutes, until the time when the firefighters managed to remove the occupant from the space. The occupant had limited physical mobility. The automatic water extinguishing system put out the fire and saved the occupant. The elapsed time from fire detection until the onset of rescue in the dwelling was at least 30 minutes. Throughout this time the occupant remained in the residence.

Other safety and security

The research material also reveals shortcomings in other safety and security areas. Not only inadequate automatic water extinguishing system maintenance or testing, but also fires in, for example, hospitals' electrical rooms or transformers draw attention. Both areas should receive much more attention.

Another noteworthy issue in the material involves fires at correctional institutions. As each one of the 15 fires analysed in the material constituted arson, it is safe to say that penal institutions seem to be structurally safe. Attention should be paid to the action of the convicts. Research should be focused on the fires and their causes. In particular, it should focus on preventing fires set by self-destructive residents as well as on identifying and preventing self-destructive behaviour as such. Such research calls for a cross-disciplinary approach; the rescue services alone are unable to solve this problem.

Nonetheless, it must be stated that automatic water extinguishing systems are well suited to protect people in apparent cases of arson and even suicidal fires.

The results of this report provide a clear indication of this when set against all self-destructive fire deaths and injuries. Whereas the article Epidemiology of flame burn injuries and fire deaths in Finland (Haikonen and Kokki 2020, 13) showed that 16 per cent of all fire deaths were not caused by accident, the corresponding share at sites fitted with automatic water extinguishing systems was at most four per cent (one fire death). No similar difference could be seen with regard to injuries.

Staff competency and drills/training

Fire safety is an entirety which aims at supporting the options people have to act, especially the staff at the site. On top of technical systems, all sites should have a fire response plan. It is imperative that the entire staff has received safety training and is skilled in first extinguishing, is familiar with the local instructions and has been appropriately drilled. Proper safety culture is paramount. The site's own safety plan, methodical action as well as staff training and familiarisation play key roles.

Institutional residences may only have a small number of personnel present (cf Ojala 2020, 121) and they are unable to manage the required response unassisted if a fire breaks out. It is the task of the owner and operator of the property as well as the care operator to carry out safety planning, to train and familiarise their staff as well as distribute information as required among all interested parties. Safety managers along with the rest of the staff must be committed to improving the safety culture.

When an alarm sounds the personnel must be able to act in accordance with their instructions in all of the duties they have regularly drilled. Among other things, these include locating the source of the alarm, establishing its cause, possibly carrying out first extinguishing and evacuation as well as alerting the rescue department.

The staff must act during the fire, both when the FDS alerts and when the automatic water extinguishing system discharges. Drills, anticipation, preparedness as well as being able to operate and maintain the equipment are important elements for action during a fire. First extinguishing skills and regular evacuation drills are indispensable.

It is recommended that evacuation drills be organised on a regular basis. The goal of these drills, in addition to practicing efficient evacuation, is to identify fire safety hazards. While the evacuation drills can be independently carried out, the local rescue department can also provide support and participate in them, when asked.

Furthermore, the use of first extinguishing equipment is not self-evident to everyone; their use must be rehearsed and the staff must receive regular training. First extinguishing skills are crucial to limiting and suppressing fires. First and foremost, everyone must know where the first extinguishing equipment is kept.

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SPEK TALKS

This study analysed all fires that activated automatic water extinguishers at care institutions or corresponding institutional residences from 2012–2019.

Corresponding units refer to, among other things, dwellings fitted with automatic water extinguishing systems.

In the fires that were analysed automatic water extinguishing systems saved lives and markedly prevented material losses as well as reduced costs to society arising from burn care. More fire deaths and injuries would have resulted from the absence of automatic water extinguishing systems.

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