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History of the application of thermovision in the fire protection system in Poland

Abstract

The paper presents the most important events in the history of the development of the thermovision usage in Fire Services in Poland. The first attempts to use the thermal imaging cameras in fire protection in Poland and in the world have been described. Firefighting and Rescue Units were first equipped with thermal cameras for tactical operations in 1997. In the following years the Fire Service Units were continuously provided with more thermal equipment. Attempts have been made to use infrared pyrometers to detect fires. The paper also presents the current state of thermal imaging cameras equipment in Fire Services and information how the cameras are used. In order to present the usage of cameras in the actions of Fire Services, the statistics on thermal devices contribution in actions in the selected poviat has been drawn up. The data are presented in Table 1 and Table 2. The final conclusions show the directions for development of the thermovision usage in fire protection and rescue actions.

Keywords: fire detection, pyrometer, thermal imaging camera, fireman, firefighting, temperature.

1. Introduction

In 1997, the first field units of the State Fire Service were equipped with thermal imaging cameras. It's been 20 years since that moment. A rapid growth of interest in thermography was noticed at that time. Significant contributions to the development of thermography applications in Poland were made by the cyclic conferences on Infrared Thermometry and Thermography. Firefighters actively participated in these conferences. The origins of the development of the usage of thermal imaging in fire protection and rescue work coincide with the dates of the first ITT meetings. ITT conferences pose an excellent opportunity to meet and exchange the experiences for professionals from all walks of life who use infrared technology in their business.

2. The beginnings of the application of thermovision in firefighting

Fire Services all over the world have shown interest in thermography since its inception. The first example of its usage was noted in the 1970s when the British Navy employed such device to detect fires on ships [3, 10]. The United States was another country where the usage of infrared radiation detection for locating fire began.

Fire detectors worked on devices requiring cooling. It was difficult to adapt them to work in the field. Infrared devices were very expensive. They did not fit in the budgets of civilian Fire Brigades.

In the '90s, a TGS pyroelectric detector technology was developed that did not require cooling and was relatively inexpensive. They were used in surveillance cameras designed to detect fires. The cost of such a camera was about $20,000. The high price was the reason why only few Fire Service Units could afford such equipment. The high cost was even sometimes the reason of too high precaution. There were cases where, for fear of damage, the camera was kept in the commander's car instead of the fire engine [10]. Cameras offered to firefighters in the '90s were large, heavy and bulky. They included removable mechanical elements that reduced the cameras' resistance to shocks. However, they provided a well-visible thermal images. The minimum detectable temperature difference (MDTD) was less than 0.5 K. As an example we can mention the EEV P4428 camera manufactured by English Electric Valve, used by the British and German Fire Services.

3. Development of the application of thermovision in fire protection in Poland

The State Fire Service in Poland became interested in thermovision already in the '70s of last century. A number of activities on the possibility of using thermovision in rescue and firefighting actions were carried out at the Higher School for Fire Service Officers in Warsaw. The tests that were carried out referred to the usefulness of thermal cameras for observation under high smoke conditions.

The equipment used during those researches included Swedish cameras type Aga 750, available at that time in Poland. It was a portable battery powered camera, bulky and unsuitable for use in a fire environment. It weighed 6 kg. Prior to an operation, the detector cooling system was flooded with liquid nitrogen. In 1976 an experiment was conducted with such a camera at the Higher School for Fire Service Officers in Warsaw. There was even information about it in the newspapers. Firefighters enthusiastically referred to the camera despite its imperfections. It was believed that it could be adapted to work in difficult fire conditions. However the camera Aga 750 wasn't purchased due to its high price. In return, infrared pyrometers were bought and used for didactic purposes in the student lab.

In the '90s of last century a lot of factories were equipped with thermal cameras. Those industrial plants included petrochemical plants, fertilizer production plants, mines. Firefighters sometimes used their cameras. Such an event occurred in 1995 in Gdańsk after the collapse of an 11-storey residential building caused by a gas explosion. The Rescue Unit used a Marine P-4428 EEV camera, borrowed from a Marine Rescue Unit.

The Main School of Fire Service in Warsaw and the Scientific and Research Centre for Fire Protection –in Józefów near Warsaw have conducted researches, mainly theoretical, on the use of infrared technology in fire protection. In 1992, representatives of English Electric Valve were invited to present their products, in particular the P-4430 EEV thermal imaging camera. The presentation took place at the Main School of Fire Service in Warsaw, in the presence of the School Commander and representatives of the Headquarters of the State Fire Service. The Main School of Fire Service authorities showed high interest in the new technique. The camera was not purchased due to lack of resources, but funds were soon available for the purchase of other cameras and infrared pyrometers.

The School received two surveillance cameras specifically designed for rescue and firefighting operations. They were a Ficam-60 camera manufactured by the American company Thompson - CSF Group and a Talisman ISG camera manufactured by American Integrated Security Group (Fig.1). Cameras were working on LWIR long-term spectral range. They did not include any removable mechanisms. That fact was taken as an advantage asitcould only increase their insurance of reliability in field conditions. What is even more important, they were simple to operate. The test results were positive and firefighters were delighted with the new equipment. These were surveillance cameras so they did not measure the temperature. Firefighters suggested to equip them with infrared pyrometers. All the firefighters needed was the approximate temperature value and the ability to determine its change over time to determine whether the fire is developing or being extinguished.

Fig.1. Talisman camera being used by a firefighter

The Talisman ISG camera was recommended as the more modern and the one meeting the firefighters' expectations. Soon this type of cameras was included in the equipment of the State Fire Service Units.

4. Attempts to use infrared pyrometers

In the '80s and '90s, there were some examples of attempts made to persuade firefighters to use pyrometers during the firefighting actions. Unfortunately the attempts definitely failed. Camera prices of over $15,000 exceeded the capabilities of ordinary Firefighting and Rescue Units. Money was needed to meet more urgent needs. At that moment it should be mentioned that some camera functions could be taken over by infrared pyrometers. And this was the case in western countries, where firefighters used them as the cameras were very expensive. In contrast, the cost of a pyrometer was about $1,000, so it did not seem to be an issue.

In Poland, small electronic companies offered pyrometers at a lower price. It should be mentioned that some laboratory models of infrared pyrometers were developed at the Main School of Fire Service and designed for firefighting. Attempts were made to start their production but they were abandoned.

In 1995, three modern infrared pyrometers from Raytek were purchased. They were used for teaching and for popularizing the use of infrared technology in firefighting. Infrared pyrometers were given to the School Firefighting and Rescue Unit (The Main School of Fire Service) to be checked during real rescue and firefighting operations. The study was conducted over a 15-month period, 1995-1996. They were found useful for finding hidden fire sources, especially in chute vents and empty spaces between walls in buildings. They were also used to examine smoldering sites of fire. Temperature measurements taken at intervals allowed to determine whether the fire had been extinguished. Firefighters who tested the pyrometers during the activities carried out in Warsaw by the School Firefighting and Rescue Unit did not claim any objections to the equipment. However, firefighters working in the field units did not accept the pyrometers. They claimed the pyrometers were not worth the effort.

A firefighter entering a fire has got a lot of different types of equipment needed to carry out the firefighting action. The pyrometer is an additional object that could hamper. A rescuer works under the pressure of time and stress. His primary task is to check if there are any people in the fire zone and evacuate them safely. He must concentrate on this job entirely. The pyrometer is not very useful in such cases.

Unlike pyrometers, thermal imaging cameras have been accepted with enthusiasm. Firefighters quickly convinced themselves to them. The Fire Service is eager to buy thermal imaging cameras if they can afford them.

5. The first purchase of cameras for the Fire Service local units

The first purchase of thermal cameras for the local units of Fire Service was made in 1997. The State Fire Service Headquarters bought 13 Talisman ISG cameras. Their choice was based on the results of tests conducted at the Main School of Fire Service in Warsaw. The Talisman ISG camera was designed to work in a fire environment. At the special request of the ordering party, it was equipped with a system protecting the detector from overloading. What was considered to be its deficiency was the significant size and lack of ability of taking the temperature measurements. Information about the object's temperature was presented by shades of gray, which seems not to be satisfactory to firefighters. In the following years, individual fire departments made their own purchases.

The centralized purchase of cameras and transferring them to the field units in 1997 should be regarded as the beginning of the use of thermovision in the rescue and firefighting operations of Fire Services in Poland. It's been 20 years from that moment.

Another important decision accelerating the equipping local units with thermal imaging cameras was the Regulation of the Minister of Internal Affairs and Administration of 22 September 2000 on detailed rules of the equipment for the administrative units of the State Fire Service, specifying the minimum equipment in the area of operation of the State Fire Service Headquarters. According to this regulation, each province and poviat headquarters (in poviats with a population of more than 200,000 inhabitants) should have a portable thermal camera. This regulation was in force until 2014. It became obsolete because the number of cameras available for the State Fire Service Units significantly exceeded the requirements set out in the Regulation. The aim to be achieved is to ensure a thermal camera for etery fire service engine.

In addition, in 2011, the Chief Commandant of the State Fire Service imposed the obligation to equip the cars available for rescue operations with fire locators in first wave. These devices could be infrared cameras or infrared pyrometers. The record can be found in the guidelines for Standardization of equipment for fire engines and other means of transport of the State Fire Service.

6. Training

Training represents an important element of implementing infrared techniques. Cameras prepared for tactical purposes are very easy to use. This was taken care of at the design stage. However one cannot undermine the fact that the proper knowledge of the thermogram is essential. The sources where this kind of knowledge is available to firefighters are as follows:

- service instruction provided by the equipment supplier,
- internal training within the State Fire Service,
- specialized training in thermography and thermometry,
- studies at the Main School of Fire Service,
- literature.

Purchasing thermal equipment is usually combined with basic training in use and maintenance. At the request of the buyer the suppliers offer extended training. In special cases it is also possible to take advantage of expensive specialist trainings. They are organized by companies employing lecturers with the highest qualifications in the field of knowledge in the country. The State Fire Service regularly conducts training sessions to update and broaden the knowledge of firefighters. These training courses also cover the topic of thermovision.

The major role is played by the Main School of Fire Service. The school curriculum features content from the field of infrared radiation and the use of infrared technology in fire protection and rescue activities. Students apply theses on topics related to the use of thermal imaging cameras in rescue and firefighting operations, using cameras for temperature measurement in fire development studies, etc. The knowledge in the field of thermovision

applications can also be derived from articles published in periodical State Fire Service publications, thematic seminars and monographs.

7. Current status

The price is considered to be the main factor limiting the number of cameras included in the firefighters' equipment.

After 2000, cameras on bolometric detectors became popular as they do not require cooling. They also do not have movable mechanical parts, so they cannot be easily damaged by an impact. The other factor in favor is the fact they are relatively cheap.

Cameras are constantly refined and checked in actions [1, 2]. Currently manufacturers offer cameras designed specifically for tactical firefighting. These cameras meet the following requirements:

- they have been adapted to work in a fire environment,
- they are contained in housing protecting them from overheating, shock, dust and water,
- the cases, according to Polish Standard PN-EN 60529: 2003, provide IP66 degree of protection (dustproof and protection against a strong water jet of 100 l/min directed on the case from any place), IP67 (dustproof and protection against water immersion, within 30 minutes to a depth of 0.15 m above the top of the case or 1 m above the bottom for casesshorter than 0.85 m) or meet US NFPA 1801 (camera is inserted into a cylinder with a diameter of about 5.5 m (4 ft) and spinned for 30 minutes),

In addition, the latest cameras:

- they are small in size, light, handy,
- they are easy to handle, usually operated by fingers of the hand which holds it,
- they are powered by batteries providing enough energy to complete the action,
- measure the temperature at one point of the object,
- have a coloring function,
- provide the ability to record videos during the action.

The coloring function is very helpful. Bright color indicates high temperature. This makes it easy to recognize objects in difficult fire conditions. This option indicates more heated places and helps in finding fire sources, warns the rescuer of danger. The firefighter sees the heated spots on the floor where he should not walk.

8. Measuring cameras in the State Fire Service

Fire Service schools, Scientific and Research Centres for Fire Protection and selected specialist units possess high-end measuring cameras intended for researches on fire protection and civil security. The range of topics include the researches on burning behaviour of internal and external fires using the thermovision [8], researches on radiation emission in fires, detection and investigation the causes of thermal bridges in high power semiconductor lasers [5, 6], detection and identification of undersurface defects by active thermography methods, detection and analysis of burnt forest bedding areas by infrared detection methods [9].

There have also been researches conducted on the use of thermovision for the detection of infectious diseases to limit the spread of the epidemic. Some researches concerned the use of thermovision for crime detection.

9. Statistics on the use of thermal imaging cameras in firefighting and rescue operations

Having a thermal camera does not always mean it is used in action. It is not essential for all firefighting actions. The State Fire Service uses a national Decision Support System (SWD-ST) to record the number and type of events. Information about using the infrared cameras for firefighting actions can be found there. They are located in the descriptive part of the reports. The commander of action who draws up the report at the end of the action can decide what exact information and details are included in the report. And for that reason national statistics are unable to be created. This kind of data can be collected but for smaller areas, as for poviats. This condition ensures direct access to reports and known range of information included in them. In the poviat of Wadowice, there was a rule requiring entries for every use of a camera.

In order to compile statistics for the poviat of Wadowice, the Decision Support System was used to find all rescue and firefighting operations where the thermal imaging cameras were used. Next each action was analyzed individually to determine what was the purpose of using a thermal camera. The results are presented in Table 1 and Table 2. In 2012-2015, there was one camera available in Wadowice poviat and two cameras in 2016.

Tab. 1. Date and number of interventions to firefighting and local threats: in total and with using a thermal camera

Year	Fires	Local threats	Total
	total (with using a thermal camera)	total (with using a thermal camera)	total (with using a thermal camera)
2012	813 (36)	1561 (6)	2374 (42)
2013	364 (52)	1362 (5)	1726 (57)
2014	586 (53)	1533 (5)	2119 (58)
2015	566 (77)	1870 (9)	2436 (86)
2016	462 (97)	1280 (10)	1742 (107)
Total	2791 (315)	7606 (35)	10397 (350)

Source: own elaboration based on Decision Support System SWD-ST 2.5

Tab. 2. Percentage share of the number of interventions using a thermal imager in all interventions

Year	Fires	Local threats	Total
2012	4.4%	0.38%	0.8%
2013	14.3%	0.37%	3.3%
2014	9.0%	0.33%	2.7%
2015	13.6%	0.48%	3.5%
2016	21.%	0.78%	6.1%
Average	11.3%	0.46%	3.4%

Source: own elaboration based on Decision Support System SWD-ST 2.5

The data presented in the tables draw to the following conclusions:

1) the number of interventions including the usage of thermal cameras is systematically increasing;
2) thermal imaging cameras are mainly used in firefighting operations but occasionally they are used to eliminate local threats,
3) the percentage usage of cameras is too low.

Analysis of reports and conversations with firefighters engaged in firefighting division shows that the cameras are mainly used for:

- examining the smoldering burnt site,
- extinguishing the chimneys and ventilation shafts,
- searching for hidden sources of fire,
- assessment of the fire situation,
- making decision whether the fire is still developing or has been extinguished,
- searching the premises in strong smoke conditions,
- searching for victims in the dark, smoke and mist.

The most frequently mentioned actions were listed first. Firefighters prefer such types of actions as the camera facilitates them and reduce their efforts.

10. Conclusions

Firefighters have received thermal equipment that meets their requirements. Many State Fire Service Units do not have cameras yet, but they will soon receive them. It is strongly believed such equipment is needed.

Polish statistics in terms of the number of cameras in firefighting units against the neighboring countries, such as the Czech Republic, Slovakia, Hungary, Serbia, Ukraine, Belarus and Lithuania look satisfactory. In a few years each Firefighting and Rescue Unit in Poland will have a thermal camera.

In addition to the State Fire Service in Poland, there is also Voluntary Fire Service. Volunteers support professional firefighters. Some Volunteer Fire Service Units have been included in the National Rescue and Firefighting System. Volunteer firefighters play a vital role in rural areas. They are not as well equipped as professional firefighters. An infrared camera is rarely available to them. Such a camera is an expensive piece of equipment to look after. For many years it was obvious that only in the second shift there was an officer with a camera. Firefighters from the first group did not deal with this equipment. This is changing now. The camera is treated as a usual instrument to support action. It is also more and more often used in the first attack. And in this phase of action it can bring the greatest benefits. It is helpful to evaluate the fire situation, to search for fire victims, to search for a fire sources. In this phase the camera can save a life.

In rural areas, volunteer firefighters are usually the first to come to the site of fire. However, they do not have the camera that can do the most at the beginning of the action. The resources to enrich the equipment of Voluntary Fire Service should be mobilized as soon as possible.

The firefighter should have as much freedom of movement as possible. Camera is located in one hand [7]. Firefighters postulate placing the camera on the helmet. The rescuer should be equipped with a helmet integrated with a thermal camera and an image transmitter sending data from the camera to a command post ensuring telephone communications. This would allow to record the course of action. Camera manufacturers offer real-time video transmission. However, they do not provide good communication in cellar rooms. In such cases it is required to set antenna, which is time-consuming and impossible to perform. The State Fire Service is working on the design of an integrated helmet.

In many cases, it is difficult to interpret a thermogram without a photo in visible light. Thermal camera firefighters should be equipped with miniature cameras linked to the thermal cameras. This should not significantly affect the price of the entire device.

There are situations where it is not a firefighter that should work but a robot. Thanks to the infrared camera, the robot can operate in darkness, smoke and haze. Many centers in the world are nowadays developing such robots [4]. They will help to complete the most dangerous tasks.

Authors would like to thank Col. ŁukaszWalczak for his help in data collection on the use of thermal cameras in Firefighting and Rescue Unit activities in Wadowice.

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Received: 08.11.2016 Paper reviewed Accepted: 03.03.2017

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