ISSN:1306-3111
e-Journal of New World Sciences Academy
2012, Volume: 7, Number: 2, Article Number: 1A0323

NWSA-ENGINEERING SCIENCES
Received: February 2012
Accepted: April 2012
Series : 1A
ISSN : 1308-7231

Zuhal Şimşek
Nilüfer Akıncıtürk
Uludag University
Zumanav2002@hotmail.com
Bursa-Turkey

COMPARATIVE ANALYSIS OF TWO MAJOR HOSPITAL FIRES

ABSTRACT

Both in terms of their functions and occupancy characteristics, hospitals require special design criteria and safety measures. Protection of users and ensuring their safety is important during a fire and during the follow-up phases of to sustain treatment of patients. Hospital fire is a disaster that is frequently encountered today as was the case in the past. With advances in treatment and care conditions in hospitals it is considered that fire safety measures are more likely to develop in the light of technological advances in these buildings. Adapting the measures to be taken by examining the factors causing the start and spread of these fires to existing and new hospitals will help preventing new disasters and ensuring safety of hospitals and patients. For this purpose similar aspects of "Bursa Şevket Yılmaz Hospital fire" where 9 patients died and "Cleveland hospital fire" where 121 patients died are explained and the progress of the measures within this time period is discussed. This analysis will help to correct the deficiencies that affect the start and spread of fire and to design hospitals with fire safety.

Keywords: Fire Safety, Hospital, Smoke Control, Horizontal Evacuation, Evacuation Strategy

İKİ ÖNEMLİ HASTANE YANGININ KARŞILAŞTIRMALI ANALİZİ

ÖZET

Hastane yapıları gerek sahip oldukları fonksiyonlar gerekse kullanıcısının karakteristiği bakımından özel tasarım kriterleri ve güvenlik önlemleri gerektiren yapılar niteliğindedir. Yangın sırasında ve onu takip eden söndürme ve bakım evrelerinde, hastaların tedavilerinin sürdürülmesi kullanıcıların güvenliklerinin sağlanması ve korunması bakımından önem teşkil etmektedir. Hastane yangınları, geçmişte olduğu kadar günümüzde de sıklıkla karşılaşılan bir felakettir. Hastanelerdeki tedavi ve bakım koşullarının yıllar içinde gelişmesi ile birlikte, teknolojik ilerlemeler ışığında, bu yapılardaki yangın güvenlik önlemlerinde de aynı ölçüde geliştiği düşünülmektedir. Hastanelerin ve hastaların güvenliğinin sağlanabilmesi için bu yangınların çıkma, yayılma nedenlerinin incelenerek alınabilecek tedbirlerin mevcut ve yeni yapılacak olan hastanelere uyarlanması karışılabilecek yeni felaketlerin önüne geçilme konusunda yarar sağlayacaktır. Bu amaçla 2009 yılında Bursa'da 9 yaşamın sona erdiği "Şevket Yılmaz Devlet Hastanesi" yangını ile bu yangından 80 yıl önce gerçekleşmiş hastaların yarısının yaşamını yitirdiği "Cleveland Hastanesi" yangını arasındaki benzer yönler ve bu zaman dilimi içinde alınan tedbirlerin ne ölçüde geliştiği göz önüne serilmiştir. Yapılan analizler, hastane yapıların da yangının çıkmasını ve ilerlemesini etkileyen eksiklerin düzeltilmesinde ve yangın güvenlikli hastanelerin tasarlanması konusunda yarar sağlayacaktır.

Anahtar Kelimeler: Yangın Güvenliği, Hastane, Duman Kontrolü, Yatay Tahliye, Tahliye Stratejisi

1. INTRODUCTION (GİRİŞ)

In general hospital buildings are structures with medium level fire risk. However the fire risk increases due to the fact that patient treatment and care services are provided in these buildings and that they incorporate numerous support and service facilities with a high level of fire risk, which impose hazards. In addition the restriction of mobility in patients is another factor which makes evacuation difficult. However, despite all these adverse factors nowadays it is possible to prevent fires and to limit the spread of fires by making use of high-tech. products and safety of the users may be protected by designing horizontal evacuation zones. To this end the ***Cleveland Hospital Fire and the Şevket Yılmaz Hospital Fire in Bursa, Turkey*** and the measures taken prior to these fires are examined in detail.

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

Both in terms of their functions and occupancy characteristics, hospitals require special design criteria and safety measures. Protection of users and ensuring their safety is important during a fire and during the follow-up phases of to sustain treatment of patients. Hospital fire is a disaster that is frequently encountered today as was the case in the past. With advances in treatment and care conditions in hospitals it is considered that fire safety measures are more likely to develop in the light of technological advances in these buildings. Adapting the measures to be taken by examining the factors causing the start and spread of these fires to existing and new hospitals will help preventing new disasters and ensuring safety of hospitals and patients. For this purpose similar aspects of "Bursa Şevket Yılmaz Hospital fire" where 9 patients died and "Cleveland hospital fire" where 121 patients died are explained and the progress of the measures within this time period is discussed. This analysis will help to correct the deficiencies that affect the start and spread of fire and to design hospitals with fire safety.

3. THE CASE OF CLEVELAND HOSPITAL FIRE (CLEVELAND HASTANESI YANGINI)

When we look at the history of hospital fires we see that there were other fires which claimed more lives than the Cleveland Hospital Fire. However, the fact that almost half of the personnel and patients in the hospital have lost their lives in this fire makes this case one of the most significant hospital fires. This fire occurred in Ohio on the 15th of May, 1929. The hospital was erected in 1920. The clinic building was used for diagnosis and examination purposes without any research facilities, which also used to serve drug addicts.

The clinic building where the fire was started was a fireproof reinforced concrete frame building with two sections which was 4 stories high excluding the ground floor and the basement, located on the corner plot at the junction of two major streets. The construction comprised brick walls and a tile roof. There was a wire glass skylight extending through the 2. floor to the 4th floor. A smaller skylight is located over the front stairs provided for general use. There were 2 stairways and elevators in independent shafts providing horizontal ventilation. These shafts were connected to the corridors provided for general use with thick self closing metal doors fitted with wired glass panels. Fire extinguishers and fire hoses were provided on each floor of the hospital. However no locations in the hospital were fitted with sprinkler systems to help in controlling and automatically extinguishing the fire. The building is only 40 meters away from the

fire department, on a main street allowing fire engines to access and extinguish the fire easily [10].

- **General description of the X-ray archive where the fire originated:** The basement where the fire originated comprised the storage rooms for general supplies and pharmaceuticals, the machine room and the archive for X-ray films. The X-ray archive was adjacent to the elevator shaft. Two low pressure heating boilers were installed in the machine room but were no longer used. Steam for heating was piped to upper floors. The fire originated in the archive room in the basement where the X-Ray films were stored. This room was fitted with a class A fireproof door. The electrical installation for lighting in the archive room was new at the time and compliant with the requirements. Nevertheless smoking was not prohibited in this area where no fire warning or extinguishing systems were fitted. Yet there were portable fire extinguishers on the corridors. Only the upper floors were fitted with fire alarms [3].

This room, where the fire originated, was used also for the storage of iron pipes and fittings on wooden racks and old machine parts. Low pressure steam pipes were installed at the ceiling of this room. A coal chute opened into this room through a wooden door and no means of outside ventilation were provided [14].

- **Events preceding the fire:** A leak had been discovered in the high pressure steam line in the X-ray archive in the basement about 9 o'clock in the morning before the fire had started. This was reported to the technician in charge. After checking the piping the technician went to the power house to shut off the system in order to allow the line to cool and 2 hours later when he came back to the X-ray film archive he discovered a cloud of yellowish smoke in the room. He immediately secured a nearby fire extinguisher to control the fire and tried to get fresh air inside the room by opening the door. However the room neither had natural ventilation nor a mechanical system to let the fresh air in. The room neither had a window opening to the outside nor a mechanical ventilation system. Consequently two consecutive explosions have occurred after the gases that were accumulated inside the room with high pressure found their way to the roof and contacted oxygen. The fire alarm was activated by the personnel only after the explosion [3].
- **Start and spread of the fire:** The fire had started between 11.00 and 12.00 hours which is the busiest part of the day for the hospital. It is estimated that about 250 patients and employees were in the building at the time. 121 persons have lost their lives due to gas poisoning and about 50 others were treated in other hospitals. It was observed that the most convenient way for the patients to evacuate the building during the fire was through the front stairs or the front elevators. It was concluded that the main reason for most of the occupants of the building to lose their lives due to gas poisoning was this erroneous evacuation strategy. The shafts which were not ventilated adequately and not fitted with a pressurization system were filled with the fumes causing a high rate of poisoning. Inability to make horizontal evacuation and the use of elevators are among other factors which have contributed to the high death rate. Access to the rear stairs was cut off by the flames. Consequently the stairs provided for general use, which are not ventilated adequately were used for evacuation. However, patients and employees who were not able to find a way

to escape due to heavy smoke leaned out of the windows as a last resort until rescued. The fact that there was adequate space around the hospital building to carry out the rescue work and that the fire squad had responded to the the fire very quickly prevented a bigger disaster (Figure 1) [14].

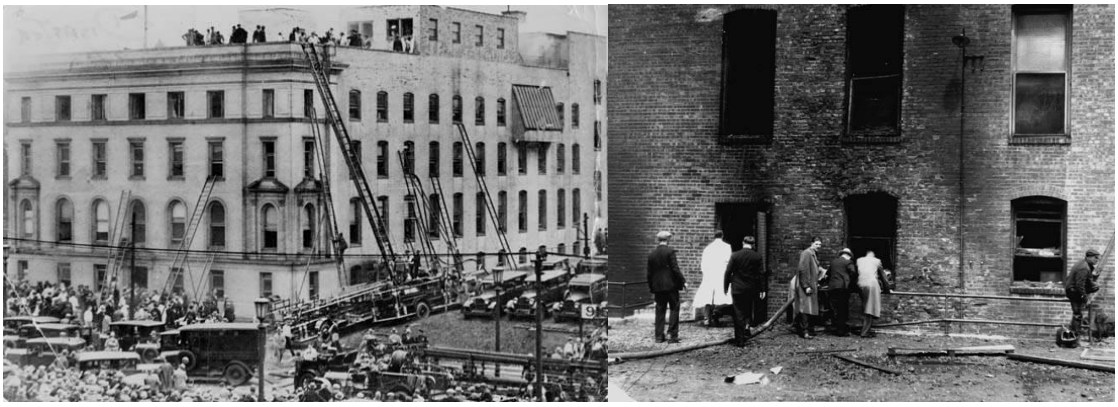

Figure 1. Fire extinguishing and rescue Works
(Şekil 1. Yangın söndürme ve kurtarma çalışmaları [13])

The authorities have developed three different theories as to the origin of the fire according to the Report on the Cleveland Fire. These theories are summarized here below:

- **Theory:** Decomposition of nitrocellulose film was caused by the rise in temperature brought about by the uncovered high pressure steam line in the room. Water leakage from the pipes located right above the film storage area in the archive room and concentration of the cloud of smoke in this area increases the possibility of correctness of this theory.
- **Theory:** The films were ignited by the heat radiated from an incandescent lamp.
- **Theory:** A lighted match or a cigarette stub was dropped on or near the films.

After the fire was noticed, 2 alarms were turned in to the fire department within 4 minutes and a third alarm was turned in 10 minutes later. The odor of burning nitrocellulose from the hospital was noticed before the fire squads were dispatched. The rescue work progressed very slowly due to the concentration of fumes and poisonous gases. This caused the rescue teams to go back and put on oxygen masks. Most of the employees and patients in the hospital who did not have oxygen masks have lost their lives due to poisoning at this stage. The fire had spread very quickly to six adjacent locations through combustible material and curtains (Figure 2). The elevator shaft adjacent to the archive room in particular, transmitted the smoke to all floors. Explosions have occurred at the roof when the fumes running through the ventilation and heating ducts under pressure contacted oxygen at the roof. The machine room which was adjacent to the archive room was also effective in these explosions by pressurizing the gases [13].

Figure 2. Patient evacuation and interior images of the explosion took place
(Şekil 2. Hasta tahliyesi ve patlamanın gerçekleştiği iç mekândan görüntüler [14])

4. THE CASE OF BURSA ŞEVKET YILMAZ HOSPITAL FIRE (BURSA ŞEVKET YILMAZ HASTANESI YANGINI)

Şevket Yılmaz hospital is a healthcare institution with a capacity of 514 beds, providing diagnosis, examination and treatment services. The hospital was constructed as an intelligent hospital through employment of new technologies [15]. Consequently it is required to be a building where all fire safety measures, both active and passive are designed and implemented better than other buildings.

The fire started on 26 May 2009 about 02.00 hours in the morning. The hospital building comprising a basement + 3 floors is located on a plot surrounded by empty car parking lots allowing fire engines to respond easily (Figure 3). The building is surrounded by open areas facilitating easy response by fire engines. However vehicles parked along the street obstruct the access of fire engines to the building.

Small galleries are provided in the entrance of the reinforced concrete building and also between the blocks. These galleries have access to the external environment through the glasses surrounding the stories. However these galleries are not equipped with funnels or mechanical smoke control systems to exhaust smoke. All floors of the hospital are equipped with fire extinguishers, fire hoses and smoke detectors.

Figure 3. Bursa Şevket Yılmaz Hospital
(Şekil 3. Bursa Şevket Yılmaz Devlet Hastanesi [15])

- **General information regarding the tomography center where the fire originated:** The basement where the fire originated comprises the tomography center, storage rooms, workshops and service rooms such as the heating center. The fire originated in the room where the tomography center is located. This room is specified as the storage room of the pharmacy on the architectural plans. After serving for this purpose for a while it was converted into a tomography center when the pharmacy was moved outside the building. The room is separated from the corridor with a glass door, the corridor is fitted with one security camera and smoke detector at each end and the floors and the room where the fire originated are fitted with fire extinguishers and fire cabinets, but the room which is not used continuously on a 24 hour basis and where no employees are on duty around the clock is not equipped with a security camera. The suspended ceiling is coated with rock wool which prevents the spread of flames. The piping shaft of the building opens into the tomography center through a wooden door, which opens into the corresponding rooms in other floors also through wooden doors. On the third floor this piping shaft opens into the surgery room and intensive care units where patients with no mobility, surviving through life support units are located, where specific fire measures must be taken. There are electrical panels inside the ducting shafts which should not be there and which are definitely incompliant with the fire regulations and oxygen piping also passes through these shafts. Moreover electrical wiring comprises easily inflammable cables emitting toxic gases when burnt, where halogen cables that delay combustion and do not emit toxic fumes were not used.
- **Events preceding the fire:** Smoke was noticed in the intensive care units, in other floors of Block A where these units are located and in Block B where the stairs for general use are located, at 02.00 o'clock in the morning. The fire was noticed only after the smoke was spread into the hospital through vertical ducting and ventilation shafts that open into the building due to the facts that the nurse on duty was not present at her office, the room was not equipped with smoke detection systems and security cameras and the detection systems in the building were not functioning.

The smoke was transmitted quickly to the intensive care units and other escape paths through unprotected vertical ducting shafts in Block A, reducing visibility, leading to unfavorable conditions.

- **Start and spread of the fire:** The patients were started to be evacuated vertically immediately after the fire was noticed, due to the lack of compartments for horizontal evacuation, and the entire hospital was evacuated within 15 minutes which is a very short period of time.

Figure 4. Şevket Yilmaz Hospital, Windows overlooking the gallery space
(Şimşek Archive 2009)
(Şekil 4. Şevket Yılmaz Hastanesi, galeri boşluğuna bakan pencereler)
(Şimşek Arşiv 2009)

The smoke had spread to all floors through vertical ducting shafts, the spaces between suspended ceilings, galleries, the stairwell and the elevator well. The cloud of smoke which has covered the entire building has reduced visibility making the evacuation process difficult. The windows facing the galleries were tried to be opened to discharge the smoke but due to the large distance between the floor and the windows, the windows could not be reached and it was not possible to discharge the smoke in the corridors (Figure 4). Evacuation was very difficult due to reduced visibility in the escape paths. The smoke which has covered the entire building not only obstructed evacuation but it was also the main cause of the deaths. Although the fire originated in the basement most of the casualties were experienced in the intensive care unit on the 3rd floor. All the smoke was spread into this unit as a result of the ducting shafts acting as a tunnel for transmitting the smoke between the tomography center and the intensive care units. The shafts were fitted with non-smoke proof wooden gates increasing the magnitude of the disaster (Figure 5). The non-smoke proof wooden shaft gates opening to the intensive care unit have caught fire due to high temperature and the fire had spread quickly in the intensive care units after the stretcher made from highly inflammable materials, which was located in front of the door was ignited. The coating of the stretcher emitted toxic gases increasing the magnitude of the disaster. Moreover the number of casualties was increased due to the fact that patients with no mobility, surviving through life support units were located in this room [8].

Figure 5. Sevket Yılmaz Hospital, CT center and plumbing shafts (Şimşek arşiv 2009)
(Şekil 5. Şevket Yılmaz Hastanesi, tomografi merkezi ve tesisat şaftları)

The fact that both electrical wiring and piping for vesicant gases such as oxygen, accelerating the burning process, were installed in the same ducting shaft with the dimensions of 165x65 cm is another important factor which contributed to the spread of the fire to the intensive care center which was located on the 3rd floor. Moreover the doors of fire escape stairs were locked for security purposes delaying vertical evacuation.

- **The theory developed by the authorities as to the origin of the fire:** It was asserted that the fire had originated in the area at the entrance of the tomography center where computers are located, due to electrical contact.

5. FINDINGS (BULGULAR)

The problems affecting the outbreak and spread of the fire are provided in table 4.1. Basic measures which are required to be taken in buildings which have experienced a fire are discussed in the recommendations column in this table.

Table 1. Problems affecting the outbreak and spread of the fire
(Tablo 1. Yangının çıkmasını ve yayılmasını etkileyen problemler)

		Problems	Cleveland Hospital	Şevket Yılmaz Hospital	Recommendations
Design	1	Architectural design	The locations of individual departments are not suitable for fire safety	The functionality of the building was altered as a result of the modification made following implementation of the architectural project. Fire measures suitable for the new locations were not taken.	The functions must be allocated by taking fire risks and loads into consideration during the design stage. All modifications and functionality alterations must be subjected to redesign.
Active measures	1	Smoke discharge	N/A	N/A	A project must be made and implemented for mechanical smoke exhaust, detection and warning to be monitored on a 24 hour basis through a control panel.
	2	Ventilation	Inadequate	Inadequate	
	3	Detection	N/A	Not functioning	
	4	Alarms	Inadequate	-	
Passive measures	1	Suitability of shaft gates	The gates were made from inflammable materials and smoke proofing was not made.	The gates were made from inflammable materials and smoke proofing was not made.	Shaft gates must be made non-flammable materials and smoke proofing must be made.
	2	Smoke barriers in the shafts	Barriers to prevent spread of the smoke were not used in the shafts.	Barriers to prevent spread of the smoke were not used in the shafts.	Smoke preventing mortar or barriers must be used and smoke detectors must be installed in all horizontal and vertical shafts and between suspended ceilings and stories.
	3	Suitability of suspended ceilings	-	Suspended ceilings were made from fire proof materials. However barriers to prevent spread of the smoke were not used and smoke detectors were not installed between suspended ceilings.	
	4	Suitability of fire escape stairs and escape paths	Fire escape stairs are not suitable for evacuation on stretchers. A pressurizing system to prevent spread of the fire was not installed.	Fire escape stairs are not suitable for evacuation on stretchers. A pressurizing system to prevent spread of the fire was not installed.	Fire escape stairs must be pressurized and made suitable for evacuation on stretchers.

	Tablo 1 more				
	5	Provision of horizontal evacuation zones	Horizontal evacuation zones or safe shelter areas are not provided.	Horizontal evacuation zones or safe shelter areas are not provided.	Fire and smoke proof horizontal evacuation zones (fire zones) must be provided.
	6	Emergency elevators	N/A	Not suitable	Emergency elevators
	7	Developing and enforcing a specific fire directive	-	Inadequate	A specific fire directive must be developed

6. CONCLUSIONS AND RECOMMENDATIONS (SONUÇLAR VE TARTIŞMA)

The Cleveland Hospital fire had occurred in 1929. Unfortunately we see that the same problems persist in our hospitals that are constructed 80 years later and that no lessons were learned from that major disaster. The fact that fire safety measures taken in most of the hospitals of today are similar to the measures taken in the "Cleveland Hospital" which was constructed in 1920, as reported by the fire prevention supervision board of the governorship of Bursa, suggests that we might face a similar disaster any moment.

The Cleveland hospital fire claiming 121 lives and the Şevket Yılmaz State hospital fire claiming 8 lives obliges us to ask the question "what kind of measures should have been taken to prevent these disasters?". The problems affecting the outbreak and spread of the fire are explained in table 4.1. The measures that are required to be taken are explained here below.

- **Design:**
  - All modifications that are made following implementation of the architectural project must be subjected to redesign and fire safety measures suitable for the location must be taken.
  - Many people have lost their lives due to the explosions in the boiler room in the Cleveland hospital fire. Consequently facilities with a high risk of explosion and fire such as the boiler room must be moved out of the building. If this is not possible due to functionality purposes, then these facilities must be designed as a separate compartment incorporating all fire measures.
  - It was seen that the X-ray film archive which was located near the boiler room had accelerated the Cleveland hospital fire. Consequently it is imperative to take fire risks into consideration when planning the functional layout of the facilities of an hospital.
- **Active measures:**
  - In both cases the fires have started at locations which are not used throughout the day preventing early detection of the fire. Consequently smoke detection and fire extinguishing systems must be installed at the X-ray film archive and at other locations where an employee is not on duty around the clock. These systems must be monitored on a 24 hour basis through a camera system and a control panel.
  - All ducting shafts must open to the corridors and fitted with smoke proof gates [9].

- The lack of ventilation in the archive had caused toxic gases to spread throughout the hospital. Natural ventilation must be provided in such locations and in places where chemicals are kept. Especially exhaust fans must be designed for suitable places [12].

- **Passive measures:**
  - Vertical evacuation of patients is very difficult and even impossible most of the time. In the Şevket Yılmaz hospital fire all casualties were patients in the intensive care units and no carbon monoxide was found in their blood according to the forensic report, which suggests that protection of the safety of these patients who are bedridden and dependant on medical devices, without moving them is more important than the discharge of smoke. Consequently places such as intensive care units and surgery rooms must be designed as smoke proof stand alone compartments with independent power supplies. If the patients are required to be evacuated, they must be taken to the nearest horizontal evacuation zone equipped with the same devices to sustain treatment of patients. Moreover fire and smoke proof horizontal evacuation zones must be provided in all hospitals. The horizontal evacuation zones must comprise an area of 1500 m^2 or 3000 m^2 if sprinkler systems are not provided, depending on the height of the building, resisting to the fire for a minimum period of 60 minutes. Floors for inpatients covering an area larger than 300 m^2 must be divided into compartments covering an area which is equal to the half of the entire floor area pursuant to article 49 of the Building Fire Code[4].According to NFPA codes(Health care facilities) Any smoke compartment organized in these circumstances may be at least 2100 m2 and at any point in the room containing the emergency escape smoke barrier distance may not exceed 61 m. Health structures are separated from each other by smoke compartments. To divide each floor, at least two smoke compartments are used. These compartments are used by hospitalized or ambulatory patients. With a load of 50 or more users on each floor is divided into at least two fire compartments. Also compartments are limited by 2100 m^2 atrium in the absence of the atria [11].
  - Ceiling lighting may heat up and ignite X-ray films. Thus the films must not be stored up to the ceiling.
  - Fire escape paths and stairs must be wide enough to allow for evacuation on stretchers and must be constructed from fire proof materials, smoke control must be provided and adequate lighting and signage must be provided [1]. It is imperative that the fire escape stairs open outwards with a panic bar, they are not locked and the escape paths and stairs are not obstructed with objects that might delay or prevent evacuation [4]. Hospital through all vertical shafts in both fires. Moreover vertical evacuation was not possible due to intensive smoke in the stairwells. Consequently a ventilation system to create positive pressure in the stairwells and even in the intensive care units and maternity wards must be operational in all hospitals [2].

- Vertical shafts and suspended ceilings must be sealed with materials that expand and prevent the passage of smoke through vertical shafts.
- All fire doors must be fitted with an automatic closing mechanism and must be smoke proof. All ducting shafts must open to corridors and be fitted with smoke proof gates. Electrical wiring and piping for vesicant gases such as oxygen accelerating the burning process must be installed in independent shafts. Flame retardant halogen free cables must be used in electrical wiring [4].
- A hospital specific emergency directive and plan must be prepared and evacuation practices must be made.

The measures to be taken against all these malpractices and problems must be adapted to all hospital buildings in accordance with the applicable fire codes and audits must be carried out to ensure that all the relevant provisions are implemented in order to avoid facing same results again.

REFERENCES (KAYNAKLAR)

1. Akdağ T., (2009). Bina kullanım Sınıflarına Göre Kaçış Yollarında Özel Düzenlemeler. Tüyak 2009 Yangın ve Güvenlik Sempozyumu, Sektörel F., İstanbul, s.38-43.
2. Anonim, (2006). Smoke in the Operating Room Complex: A Rare Incident of Internal Disaster. Anesth Analg, 102:326–35
3. Anonim, (1929). Report on the Cleveland Clinic Fire, Ohio,
4. Anonim, (2009). Türkiye Yangından Korunma Yönetmeliği. Teknik Yayıncılık, Tüyak, İstanbul, 97 s.
5. Bursa Şevket Yılmaz Devlet Hastanesi Yangın Raporu, (2009).
6. Bursa Şevket Yılmaz Devlet Hastanesi Yangın ön Raporu, (2009).
7. Bursa valiliği Yangın Önlem Denetleme Kurulu Raporları, (2009-2010).
8. Bursa Şevket Yılmaz Devlet Hastanesi Yangını Gözlem ve Mülakatları, (2009),
9. Klote, J.H. and Milke, J.A., (2008). Principles of Smoke Management. SFPE. 373 s.
10. Nfpa 101 life safety code (2012)
11. Nfpa health care facilites (2012)
12. Prince, L., (2012). The Fire Protection of Hospitals for the Insane,www.nfpa.org.
13. www.images.ulib.csuohio.edu, www.nfpa.org.2009
14. www.rootsourceweebly.com/the-cleveland-clinic-fire--hero-kin. 2009
15. www.sevketyilmaz.com.2009.