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Integrated Fire Safety Management at a Major Airport: The Istanbul Airport Case

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Abstract

IGA Istanbul Airport faces unique fire safety challenges due to its vast scale, high passenger traffic, and diverse operations. This paper examines the airport's integrated fire safety management strategies, with a primary focus on the terminal area and the critical role played by Aircraft Rescue and Fire Fighting (ARFF) teams. Key elements include rigorous inspection and maintenance programs, comprehensive hot work procedures, and advanced fire detection and suppression systems. These active measures are integrated with passive fire protection systems, such as fire-resistant materials, compartmentalization, and smoke management systems, to provide a holistic approach to fire safety.

A critical component of fire safety management is the Airport Operations Control Centre (AOCC), which serves as the centralized hub for monitoring and coordinating all operations, including emergency responses. AOCC integrates advanced technologies such as CCTV, dashboards, and communication systems, ensuring real-time oversight and rapid decision-making during crises. The fire alert management protocol further ensures that only real fire incidents prompt full-scale responses, minimizing unnecessary disruptions. Over 17,500 fire alerts were managed over a course of approximately 2 years, with only a very small percentage classified as actual fires, underscoring the success of these measures. Additionally, voluntary emergency response teams composed of non-ARFF personnel further enhance preparedness and response capabilities.

Although the study considers Istanbul Airport's overall fire safety framework, its main contribution lies in presenting detailed insights into terminal-level fire safety operations and the coordinated efforts of ARFF teams. The findings not only provide practical examples and insights that can be applied to other large-scale airports worldwide, but also contributes to the literature on fire safety management in modern aviation hubs.

1. Introduction

As global air travel continues to expand, the need to ensure the safety of airport terminals becomes more crucial. Airports, especially those in large urban centers, are particularly more vulnerable to fire risks due to their complex layouts, high passenger load, and the variety of functions they accommodate (Yildirim and Demirel, 2019). Istanbul Airport, renowned as one of the busiest and most advanced airports globally, serves as a good example of the challenges and opportunities in fire safety management within a large-scale terminal.

The critical importance of robust fire safety measures in the aviation sector is highlighted by the potential for devastating consequences when fire emergencies occur. Past incidents have demonstrated that incidents such as onboard fires necessitating emergency landings, post-crash fires engulfing aircraft and hindering rescue efforts (Wang et al., 2023), and terminal fires requiring mass evacuations can lead to significant loss of life, severe injuries, and widespread disruption. For instance, on May 24, 2006, the fire at Atatürk Airport Terminal C destroyed the cargo area and disrupted operations. It revealed significant fire safety shortcomings including missing sprinklers and detection systems, no fire zones, improper material selection, and insufficient cargo building protection (Yildirim and Demirel, 2019). These examples highlight the inherent risks and the absolute necessity of prioritizing fire safety across all aspects of airport operations.

Managing fire safety in airport terminals is a complex and multifaceted task, given their vast layouts and the constant flow of people. Istanbul Airport, renowned as one of the busiest and most advanced airports globally, serves as a good example of the challenges and opportunities in fire safety management within a large-scale terminal. Unlike typical buildings, the extensive size of airport terminals results in travel distances that are significantly longer, posing unique challenges for both firefighting and evacuation efforts (Edwards, 2004). In emergencies where every second counts, these long distances can delay the arrival of emergency responders and make it difficult for passengers, particularly those unfamiliar with the terminal layout, to locate safe exits

(Ng, 2003). Furthermore, large airports often handle 1,500 to 2,000 daily aircraft operations and accommodate thousands of passengers waiting inside for services. This underscores the critical importance of regional planning to effectively manage potential incidents and ensure safety in such dynamic and high-traffic environments.

Another critical factor that impacts fire safety in airport terminals is the extensive use of combustible materials (Ng, 2003). Modern terminals are often built with large amounts of plastic and other synthetic materials, which, when ignited, produce toxic smoke with limited buoyancy, leading to rapid smoke accumulation throughout enclosed spaces. This toxic smoke can quickly fill the terminal, creating hazardous conditions for everyone inside, including emergency responders trying to control the situation. The increased use of such materials necessitates ongoing research into smoke toxicity and the development of more effective smoke management systems (Chow, 2016). Additionally, the materials used in constructing and decorating terminals, including walls, ceilings, insulation, and furniture, can accelerate the spread of a fire if they are not carefully chosen and treated with flame retardants.

High fire load areas within terminals, such as retail shops, restaurants, hotels, sleep capsules, and baggage handling facilities, significantly heighten fire safety risks. Retail stores, in particular, pose significant risks because they often contain high fire load densities due to the storage of combustible items such as newspapers, magazines, alcohol, and upholstered furniture (Ng, 2003). Improper management of these areas, such as excessive storage of goods or blocking sprinkler systems, can significantly increase the likelihood and severity of a fire. Hotels and sleep capsules, which are increasingly common in modern airports, introduce additional complexities to fire safety management. These spaces often feature bedding, upholstered furniture, and electrical appliances, all of which contribute to a higher fire load. In the event of a fire, the presence of sleeping occupants also adds a layer of challenge to evacuation efforts, as individuals may be slower to respond or require assistance to evacuate safely.

Another major fire risk comes from airport parking facilities (Storesund et al., 2020), which accommodate thousands of vehicles of varying types, including electric vehicles (EVs), plug-in hybrids, LPG-powered vehicles, and traditional diesel or gasoline vehicles. EVs and hybrids, in particular, present unique challenges due to the presence of high-capacity lithium-ion batteries, which can ignite and sustain intense fires that are difficult to extinguish. The inclusion of EV charging stations further increases fire risks, as malfunctions or overloading of charging equipment can become potential ignition sources. LPG-powered vehicles also pose risks due to the flammability of the fuel. Besides, the sheer volume of vehicles stored in these facilities creates a dense fire load that can accelerate the spread of flames if a fire breaks out.

Baggage handling facilities remain another critical area of concern. These spaces are filled with conveyors, sorters, and other mechanical equipment, as well as luggage that acts as a moveable fire load (Yildirim and Demirel, 2019). The variety of contents in passenger baggage, such as electronics, flammable liquids, or compressed gases, can exacerbate fire conditions and make suppression efforts more complicated.

Given the diversity and density of fire risks in these areas, a comprehensive fire safety strategy is essential. Such a strategy must address the physical risks inherent in the terminal's design, including compartmentalization and fire-resistant materials, while also incorporating robust operational protocols for managing high-risk areas like hotels, sleep capsules, parking facilities, and baggage handling zones (Ng and Chow, 2005). Furthermore, regular inspections and maintenance as well as proper training for staff in handling fire incidents are critical for mitigating risks and ensuring passenger safety.

The need for effective fire safety measures in airport terminals is evident when considering the potential consequences of a fire ranging from severe flight delays to passenger safety risks and considerable financial losses (Chow, 2016). To minimize these risks, airports must implement a comprehensive fire safety management system that integrates both active and passive fire protection strategies, each playing a crucial role in ensuring the safety of the terminal (Lui and Chow, 2000).

Active fire prevention systems play a crucial role in detecting, suppressing, and controlling fires in their earliest stages, effectively preventing them from escalating into more severe situations. These systems operate in coordination as part of a comprehensive fire scenario. They include smoke detectors, heat sensors, fire alarms, and sprinklers, all of which work together to provide early warnings to occupants and emergency responders. This coordinated approach enables a swift and efficient response to fire incidents, minimizing potential risks and damages.

One of the most vital elements of these systems is the sprinkler system (Chow, 2016). They are engineered to automatically release water or other fire-suppressing agents when detecting high temperatures or flames. The sprinkler system is especially critical in expansive airport terminals, where fires can spread rapidly due to large open spaces and high fire loads.

In addition to traditional sprinkler systems, modern airports are increasingly employing advanced fire suppression technologies. For instance, gaseous suppression systems release inert gases to suffocate fires (Hu et al., 2020), making them particularly valuable in enclosed spaces like electrical rooms, control centers and IT rooms where water-based solutions might not be appropriate.

Furthermore, the vast and complex environments of airports demand continuous upgrades to firefighting equipment. For instance, portable breathing apparatuses of firefighters, typically limited to around 30 minutes of operation, need to be improved (Chow, 2016). These enhancements are crucial to ensure effective fire response and protection for emergency personnel working in such challenging conditions.

On the other hand, passive fire protection strategies are equally critical. These measures focus on containing fires and preventing their spread, which is critical for preserving the structural integrity of the building and giving people more time to evacuate safely. This strategy includes the use of fire-resistant materials in the construction of walls, floors, and ceilings, which can withstand high temperatures and prevent flames and smoke from passing through.

Compartmentalization is another key passive fire protection strategy. It involves dividing the terminal into separate sections or zones using fire-resistant barriers. In the event of a fire, these barriers help to contain the fire within a specific area, preventing it from spreading to other parts of the terminal and reducing the overall fire load (Ng and Chow, 2005). Fire doors, fire shutters, and fire-rated glass partitions are examples of elements used in compartmentalization.

Furthermore, the use of intumescent coatings and fire-stopping materials in joints and around penetrations, such as pipes and cables, is essential for maintaining the integrity of these compartments. These materials expand when exposed to heat and seal off any gaps and further prevent the spread of fire (Puri and Khanna, 2017).

The combination of active and passive fire protection measures ensures a holistic approach to fire safety in airport terminals. Active systems serve as the first line of defense by detecting and suppressing fires, while passive systems work to contain fires, protect structural elements, and give occupants more time to escape. This integrated strategy is essential for reducing the potential damage from fires, safeguarding passengers, and minimizing disruptions and financial losses for airport operations (Chow, 2001).

Istanbul Airport, with its vast infrastructure and strategic location, has implemented a robust and comprehensive fire safety strategy to protect its passengers, staff, and facilities. This strategy combines advanced detection and suppression systems, strict maintenance and inspection protocols, regular fire drills, and passive fire protection measures built into the design. Together, these measures address the unique fire risks associated with the terminal's layout, including extensive evacuation routes, large open spaces, and a diverse range of facilities.

A key component of this strategy is the Aircraft Rescue and Fire Fighting (ARFF) unit, which serves as the cornerstone of fire safety and emergency response within the airport environment. ARFF teams are specially trained and equipped to handle the specific hazards of aviation operations, including aircraft fires, terminal fires, fuel spills, and other critical emergencies. Their ability to respond swiftly to time-sensitive incidents is essential for minimizing casualties and operational disruptions (Herron et al., 2016). At a complex facility like Istanbul Airport, the ARFF unit plays an especially pivotal role, working in close coordination with other airport systems to ensure preparedness, containment, and rapid mitigation of fire-related incidents.

This paper aims to provide a comprehensive analysis of the fire safety systems and procedures at Istanbul Airport, with a particular focus on the terminal area and the integrated role of ARFF operations. By examining the current fire protection measures in place, this study aims to highlight Istanbul Airport's comprehensive approach to fire safety, offering valuable insights for other airports with similar characteristics. Additionally, the study contributes to a broader understanding of fire safety in modern airport terminals and provides practical recommendations that can be applied globally.

In the upcoming case study section, the various components of Istanbul Airport's fire safety program are presented, supported by real-world statistics to evaluate their effectiveness. This will be followed by the discussion section that not only analyzes these strategies but also explores avenues for future research on fire safety at Istanbul Airport.

2. Case Study: Fire Safety Strategies at Istanbul Airport

Istanbul Airport, one of the world's largest and most significant aviation hubs, is a vast and complex facility. Covering an area of approximately 76.5 million square meters, the airport is designed to handle up to 200 million passengers annually when all phases are complete. Currently, it operates with a capacity of 90 million passengers per year, supported by three main runways and two auxiliary runways, supporting a wide range of domestic and international flights to over 300 destinations. As of 2024, Istanbul Airport ranks as the second busiest international airport in Europe and the fifth globally, emphasizing its significance as a major hub in global aviation (OAG., n.d.).

The airport's infrastructure includes a massive terminal building, which covers 1.4 million square meters under a single roof, serving millions of passengers each year. In addition to the terminal, the airport also features extensive parking facilities with a combined capacity of 40,000 vehicles, and various support facilities spread across the expansive airport grounds (IGA Istanbul Airport, n.d.).

Given the size and scale of Istanbul Airport, managing fire safety is a critical aspect of its operations. With such a large and busy environment, the potential risks associated with fire hazards are significant, making it essential to have a comprehensive and well-coordinated fire safety management system. To achieve this, Istanbul Airport adheres to the international standards and recommended practices outlined in ICAO Annex 14, Volume I (2022), which provides guidance on the design and operation of aerodrome facilities to ensure safety. Additionally, the airport complies with the specifications in ICAO Doc 9137P1 (2015), which outlines the equipment and operational protocols necessary for effective fire safety management.

Fire safety at Istanbul Airport is integrated into both the design and operational aspects of its infrastructure. The airport strictly follows NPFA key regulations (NFPA 5000, 2024; NFPA 403, 2014) as well as the "Regulation on the Protection of Buildings from Fire" (Official Gazette, 2007) and the "Regulation on Health and Safety Requirements for the Use of Work Equipment" (Ministry of Labor and Social Security, 2013a). Compliance with these regulations is verified through the issuance of a Fire Brigade Report, which confirms that the airport's buildings, structures, and facilities meet the required fire safety standards.

This Fire Brigade Report is issued by a specialized and independent Fire Brigade Report Committee, which operates under the leadership of the IGA ARFF (Aircraft Rescue and Fire Fighting) Directorate but functions independently from it. This committee is composed of engineers with expertise in fields such as mechanics, fire detection and alarm systems, emergency management, construction, chemistry, and electronics, ensuring a thorough and comprehensive assessment of fire safety standards.

It's important to note that the issuance of the Fire Brigade Report is not a one-time process. Instead, it is part of a continuous commitment to maintaining and improving fire safety standards. The ARFF Fire Prevention Unit is central to this ongoing process, as it continuously monitors and inspects the airport's facilities to identify new risks and correct any emerging deficiencies. This proactive approach helps keep the fire safety measures at Istanbul Airport up to date. Moreover, all these reports and inspections are subject to external audits by accredited firms, ensuring an additional layer of scrutiny and accountability.

For a detailed flowchart of the Fire Brigade Report and inspection processes, please refer to Figure 1. This flowchart illustrates the comprehensive approach taken at Istanbul Airport, encompassing continuous monitoring and expert oversight, which is crucial in minimizing fire risks.

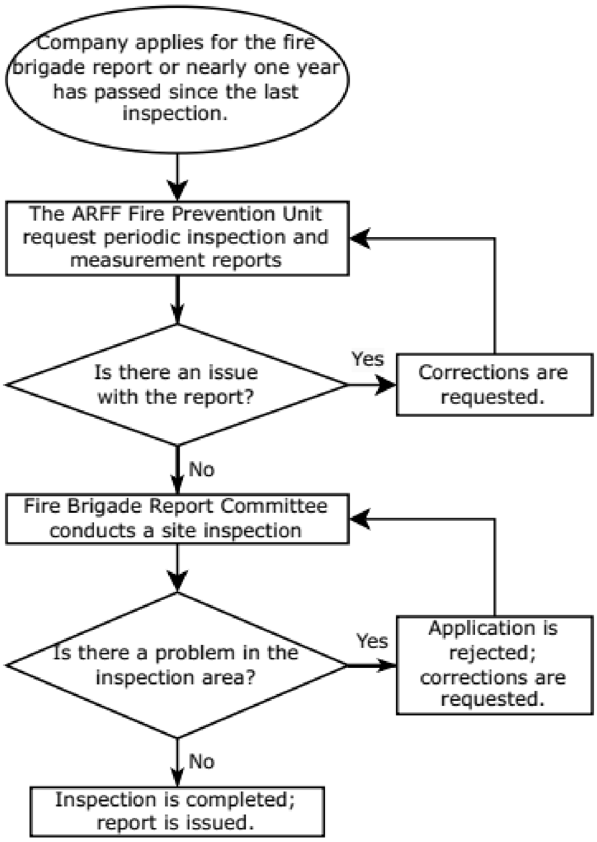

Figure 1. Fire Brigade Report and Inspection Process

2.1. Passive fire safety measures

At Istanbul Airport, comprehensive passive fire safety measures have been implemented to ensure the terminal building's protection. The structure is built in compliance with Type II (222) standards as specified in the 2024 edition of NFPA 5000 (NFPA 5000, 2024). Fire resistance classifications for the building's load-bearing structural elements are detailed in Table 1.

Table 1. Fire resistance classifications for the load-bearing structural elements

Description	Fire Resistance Rating
Exterior bearing walls: Supporting one or more floors, columns or other bearing walls	2 hours
Exterior bearing walls: Supporting roof only	1 hour
Interior bearing walls: Supporting one or more floors, columns or other bearing walls	2 hours
Interior bearing walls: Supporting roofs only	1 hour
Columns: Supporting one or more floors, columns, or other bearing walls	2 hours
Columns: Supporting roofs only	1 hour
Beams, Girders, Trusses, and Arches: Supporting one or more floors, columns, or other bearing walls	2 hours
Beams, Girders, Trusses, and Arches: Supporting roofs only	1 hour
Floor-Ceiling Assemblies	2 hours
Roof-Ceiling Assemblies	1 hour

To meet these structural fire safety requirements, load-bearing elements are reinforced with concrete cover thicknesses specifically chosen to achieve the necessary fire resistance durations. These thicknesses conform to both local and international fire codes, including Section 7 of the International Building Code (International Code Council, 2015), which covers Fire and Smoke Protection Features.

The electrical system has been equipped with various safeguards to mitigate fire risks:

• The distribution system incorporates ground fault circuit interrupters to prevent potential fires caused by short circuits, overloads, grounding faults, and leakage currents.

• All materials and equipment within the electrical system are selected based on short circuit calculations, with flame-retardant insulation materials utilized for cables and busbars.

• Supports, brackets, and hangers are designed to withstand seismic forces as per relevant standards.

• Cables supplying control modules are rated for 2-hour fire resistance.

• All penetrations in the electrical system between fire zones are sealed with fire-resistant mortar, epoxy, panels, or equivalent materials to prevent the passage of flames and smoke.

• Where the ceiling is utilized as a plenum, all cables passing through the plenum are housed within rigid metal conduits.

• Power cables serving emergency equipment, including fire pumps, smoke exhaust fans, pressurization fans, and jet-fans, are also rated for 2-hour fire resistance.

• Electrical shafts are insulated between floors and at floor entries to contain and control fire spread within a confined area.

• Electrical rooms, generator rooms, and transformer rooms are equipped with fire-resistant and smoke-tight barriers around cable penetrations and control panel entries to prevent fire propagation.

• Insulation materials are selected to maintain the fire resistance rating of the walls or floors to which they are applied.

• Shaft doors are designed to be fire-resistant and smoke-tight to prevent the spread of fire and smoke.

For smoke management, designated smoke accumulation areas have been established within the terminal building using smoke barriers, along with both mechanical and natural ventilation systems.

Smoke barriers are strategically installed within the terminal building and are utilized to prevent smoke migration between the Pier blocks and the terminal block. These barriers are engineered to effectively control smoke distribution and prevent fire spread throughout the building.

Smoke barriers are constructed from non-combustible materials and are designed to be lowered to up to 20% of the ceiling height. The minimum height of these barriers is 60 cm, and the clear height below them is maintained at a minimum of 2.1 m to ensure safe evacuation. The space above the ceiling is divided by walls with a minimum 1-hour fire resistance rating.

Hot Work Procedures:

The term "Hot Work" refers to tasks such as welding, cutting, grinding, or similar activities that generate sparks, heat, or other by-products capable of igniting fires. These activities are among the leading causes of fires, making it essential to adopt a systematic approach to ensure maximum fire safety before, during, and after such operations.

At Istanbul Airport, hot work procedures are carefully managed to reduce fire risks to a minimum. The process begins with the submission of an application to the Airport Operations Control Center (AOCC) by the unit or individual intending to perform hot work. The application is then reviewed by IGA ARFF and other relevant airport units. If the application is found to be incomplete or unsuitable, feedback is provided, and the necessary corrections must be made before resubmission. Upon approval, ARFF is informed, and preparations for the task begin.

Before the work can commence, an ARFF unit visits the designated area to inspect the safety measures in place. If the precautions are deemed insufficient, work cannot proceed until the identified deficiencies are corrected. Once all safety requirements are satisfactorily met, permission is granted, and the hot work is carried out under strict safety precautions. This includes measures such as isolating potential fire hazards by using fire-resistant barriers or removing flammable materials from the vicinity of the work area.

After the completion of the hot work, the ARFF unit is contacted once more to re-inspect the area. If any potential threats are identified during this inspection, immediate interventions are carried out, and the area is monitored until it is declared safe. In cases where no threats are detected, the area is deemed secure, and the process concludes. As an additional safety measure, the area is monitored for at least 30 minutes following the completion of the work to address any delayed risks. This structured, systematic approach, which is also depicted in Figure 2 ensures a high level of fire safety across the airport.

2.2. Active fire safety measures

The airport's operations are closely monitored and coordinated through the AOCC. This central hub excels in integration of all parts of the airport complex, including numerous external firms, into a single operational framework. This is made possible by the extensive use of fiber optic connections that link every part of the airport to AOCC. This infrastructure ensures that both routine operations and crises are managed in a coordinated and efficient manner from a single center, enhancing the efficiency of the airport's operations.

AOCC is equipped with advanced technological systems, such as application platforms, video walls, CCTV monitoring, and dashboards. These tools provide AOCC with a real-time, comprehensive view of airport activities to oversee daily operations and quickly respond to any disruptions. This ability is crucial for minimizing operational risks and ensuring smooth, uninterrupted service.

Within AOCC, there is a dedicated room called the Crisis Center, which is specifically designed for managing emergencies according to the Emergency Plan (EP). This center works within the AOCC framework to ensure effective communication and coordination among various agencies and organizations. This setup allows for the quick deployment of personnel and resources during emergencies. A key component of this communication system is the Red Line Phone, which enables direct conference-style communication between AOCC, ARFF, medical teams, Air Traffic Control (ATC), and the Police Communication Center without the need for dialing. This rapid and direct communication between key units is vital during crises, where every second is critical.

This seamless integration of operations and emergency management at AOCC not only differentiates Istanbul Airport from many others but also enhances its capacity to handle both routine and extraordinary situations with precision and speed.

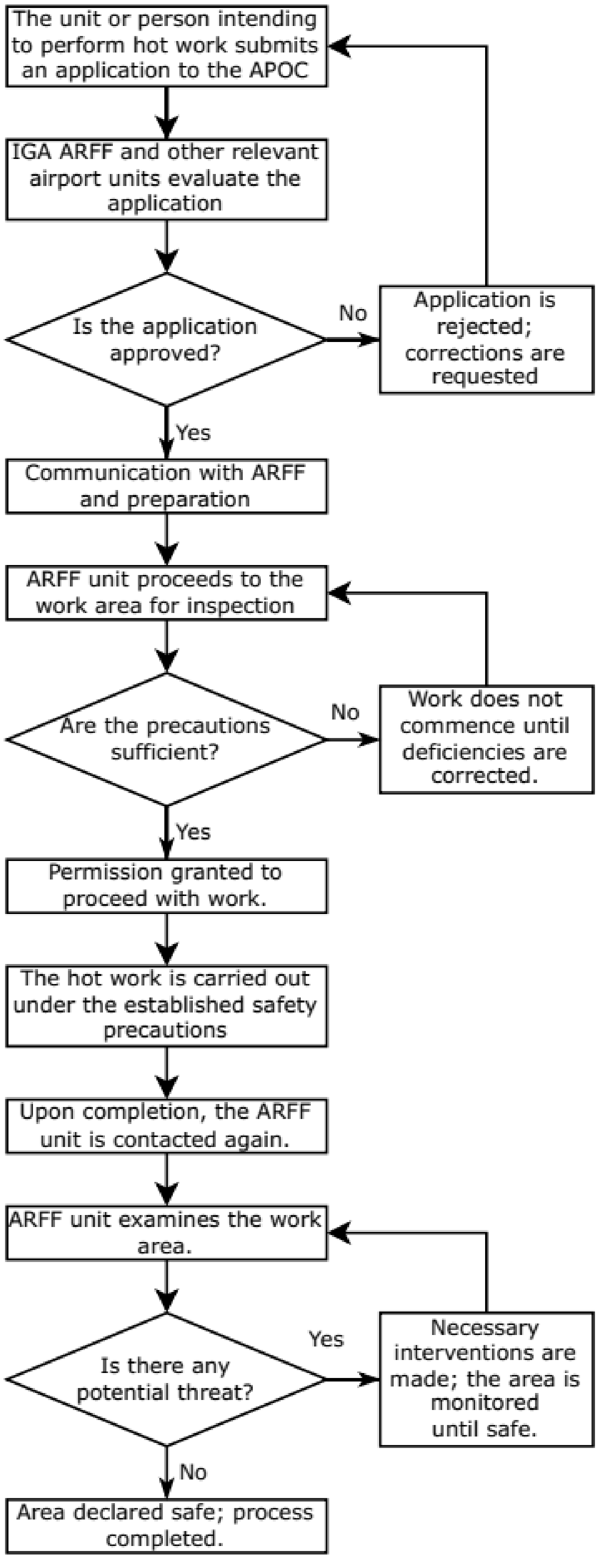

Figure 2. Flowchart of Hot Work Procedure in Istanbul Airport

In the event of a fire alert, whether triggered by detectors, flow switches or manual call points, Istanbul Airport follows a structured procedure to ensure that only real fire incidents lead to a full-scale emergency response. Like in similar airports (Howarth and Kara-Zaitri, 1999), many alerts turn out to be false alarms, and even when an incident is classified as a fire, it is often quickly extinguished without the need to activate the full fire scenario or initiate evacuation. The protocol, which is detailed in Figure 3, is followed for every fire alert, preventing unnecessary activation of the full fire scenario.

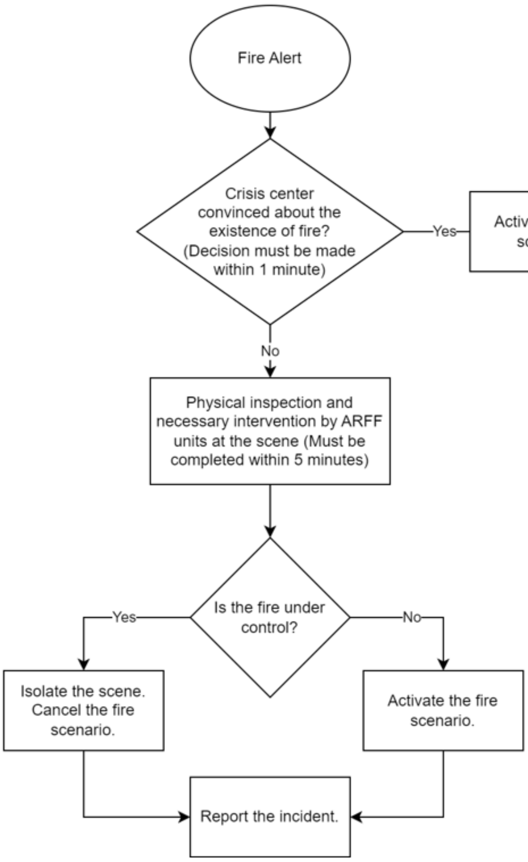

Figure 3. Fire Alert Protocol at Istanbul Airport

The decision-making process starts with the Crisis Center, which must decide within one minute whether the alert is likely to indicate a real fire. If there's any doubt, the ARFF Fire Prevention units are required to perform an on-site inspection and intervention if necessary. This process must be completed within five minutes. The initial response and fire suppression tasks are carried out by the ARFF Fire Prevention Unit, which is staffed by 50 personnel working in four shifts to provide 24/7 coverage. These tasks are supported by the use of aerosol-equipped mobile vehicles, as shown in Figure 4.

If the fire is found to be under control after this initial assessment, the area is isolated, the fire scenario is canceled, and the incident is documented. However, if the fire is not under control, the fire scenario is activated immediately. This systematic approach minimizes unnecessary disruptions while ensuring a rapid and effective response to real fire incidents.

Between January 2021 and March 2023, Istanbul Airport received a total of 17,552 fire alerts. However, only 175 of these alerts were confirmed as actual fire incidents. Almost all these fires were managed and extinguished through the initial intervention of the ARFF Fire Prevention Unit using the aforementioned mobile vehicles, without requiring the activation of the full fire scenario. Only a few incidents required minor regional evacuations. This demonstrates the effectiveness of the initial response procedures as this approach not only ensures safety but also minimizes unnecessary disruptions to airport operations.

Here, the effectiveness of the airport's automatic fire detection system might be questioned, given that only 175 out of 17,552 fire alerts (approximately 1%) were confirmed as actual fire incidents. However, this apparent discrepancy should be interpreted in the context of the system's design philosophy. The fire detection infrastructure at Istanbul Airport consists of over one million distributed sensors positioned throughout the airport, including ceilings, concealed spaces, underground voids, and beneath furnishings. These devices are intentionally calibrated to be highly sensitive and cost-effective, with an emphasis on early detection even at the risk of false positives over the potentially severe consequences of a false negative.

Figure 4. An ARFF Fire Prevention Staff Member with His Aerosol-equipped Mobile Vehicle

Each alert, even when not triggered by a real fire, often signals a deviation from normal operating conditions that requires verification. For instance, a mist from a pipe leak may be detected as smoke, but such an anomaly still necessitates inspection to ensure safety. In this context, the system's sensitivity is a feature rather than a flaw, contributing to the airport's high safety standards through early intervention and preventive action.

Istanbul Airport has implemented a comprehensive fire safety strategy, largely centered around the operations of its ARFF teams. These specialized teams are crucial for managing emergencies at the airport such as fires, accidents, or other critical incidents involving aircraft and airport facilities. ARFF personnel receive extensive training beyond basic firefighting, equipping them with the skills to address the unique challenges posed by the aviation sector. The ARFF teams regularly conduct drills, enforce fire safety protocols, and provide rapid, effective responses to emergencies.

As illustrated in Figure 5, Istanbul Airport's ARFF services are strategically positioned at three stations located near the runways to ensure rapid response to aircraft-related emergencies. These stations are staffed by 246 personnel who work 24/7 in rotating shifts to maintain constant readiness for any fire or emergency. Each station is equipped with specialized firefighting vehicles, including P-type fire trucks and ladder trucks designed for high-rise rescues in building fires. For fires within the terminal, a member of the ARFF Fire Prevention team, known as the dispatcher, stationed within AOCC, is responsible for monitoring fire alarms and coordinating response efforts through the AOCC.

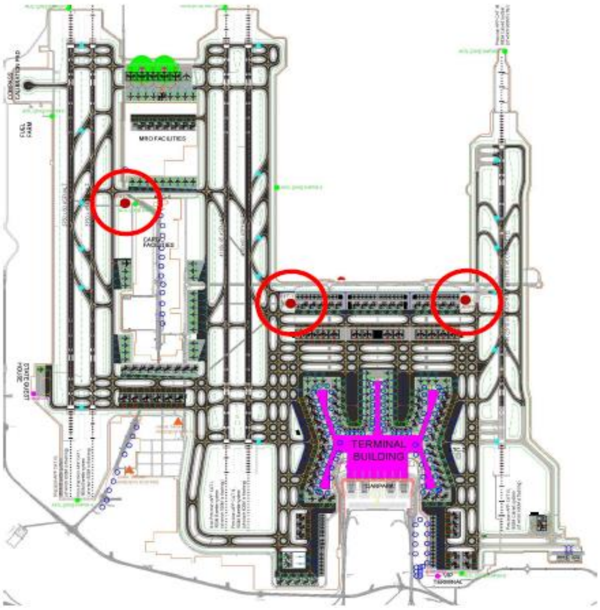

Figure 5. Location of ARFF Stations in Istanbul Airport

In responding to fires, the ARFF Unit primarily uses water as an extinguishing agent but also relies on ICAO-approved Class C AFFF foam and Class BC dry chemical extinguishing powder for more specialized needs. For fires inside buildings, the unit utilizes ABC-class dry chemical extinguishing powder. To ensure reliability, the foam and the equipment using it undergo annual testing, with foam samples evaluated in a laboratory by a qualified specialist.

In addition to professional ARFF teams, Istanbul Airport has established emergency response teams under the "Regulation on Emergency Situations in Workplaces" (Ministry of Labor and Social Security, 2013b) and the "Regulation on the Protection of Buildings from Fire" (Official Gazette, 2007), composed of employees whose primary duties are not related to firefighting. These teams are composed of personnel trained to quickly identify and address risks during emergencies. To enhance the visibility and sense of responsibility of these team members, specially designed lanyards and badge reels have been designed for them, each color is coded to represent different teams as seen in Figure 6: First Aid (blue), Firefighting (red), Search and Rescue (green), and Protection (yellow).

Figure 6. Specially Designed Lanyards and Badge Reels for Emergency Response Teams at Istanbul Airport

In summary, Istanbul Airport has implemented a comprehensive and well-coordinated fire safety strategy that spans both active and passive measures. Through the integration of highly trained ARFF teams, fire brigade report committee, advanced fire detection and suppression systems, and dedicated emergency response personnel, the airport has built a robust framework to address a wide range of fire risks and emergencies.

3. Discussion

Istanbul Airport's fire safety strategies are characterized by their thorough integration into every aspect of the airport's design, operations, and emergency planning. The effectiveness of these measures is clear from both real-world incidents and statistical data. Between January 2021 and March 2023, the airport received 17,552 fire alerts, yet only 175 of these were actual fire incidents. Importantly, nearly all of these fires were quickly managed by the ARFF Fire Prevention Unit without activating the full fire scenario or disrupting airport operations. During that same period, the ARFF Fire Prevention Units also conducted 1,034 fire inspections, ensuring the airport consistently met fire safety standards. These numbers highlight the effectiveness of Istanbul Airport's fire safety measures that allow quick and precise responses to real threats while minimizing unnecessary interventions.

A recent incident on May 8, 2024, further highlights the strength of Istanbul Airport's emergency response capabilities. When a FedEx cargo plane experienced a malfunction with its nose landing gear while approaching the airport, the ARFF teams, already positioned on the runway, responded within just 15 seconds after the plane came to a stop. Their quick and coordinated actions prevented any fire and ensured the safety of the plane's cargo. Throughout this event, all other runways, including backup ones, continued to operate without disruptions. This incident serves as proof of the preparedness and effectiveness of Istanbul Airport’s ARFF teams, demonstrating the airport's capacity to handle emergencies while maintaining safety and operational continuity.

While this study focuses on the fire safety measures at Istanbul Airport, the strategies and protocols outlined serve as a valuable model for other airports, both within Turkey and globally. This systematic approach can provide valuable insights into how large-scale aviation hubs can maintain high safety standards while efficiently handling millions of passengers annually.

While Istanbul Airport's current fire safety measures seem to be effective, continuous improvement is essential to maintain and elevate safety standards at such a vast and complex facility. To achieve this, it is recommended to establish a Fire Risk Analysis Committee composed of experts from various fields. This committee should conduct a comprehensive risk assessment across all airport departments, using risk analysis techniques that consider the three key dimensions of risk: severity, occurrence and detectability. By accurately evaluating and quantifying the risks, the airport could implement targeted measures to further reduce the likelihood of fire-related incidents. This proactive approach to risk management would help Istanbul Airport stay ahead of potential challenges and ensure it continues to be a safe and efficient global aviation hub.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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