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Influence of Compliance with Fire Safety Standards and Regulations in Fire Safety Management Performance at International Airports in Kenya

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Abstract

Purpose: Fire outbreak is a global hazard with a potential to cause injuries, loss of life and damage to properties. To mitigate against these fires, fire safety of the building should to be considered from the design, construction phases of the building and through effective implementation of fire safety management which plays an important role in enhancing safety of buildings against unforeseen fires in complex occupancies like airports. This study aimed to assess whether compliance with fire safety standards and regulations affected implementation of fire safety management at International airports in Kenya.

Materials and Methods: Stratified and simple random sampling methods was employed to determine employees and management to be included in the study. The study was a cross-sectional descriptive survey, involving 270 employees and 120 Management respectively at International airports in Kenya. Questionnaires and observation were used to collect data from respondents. The data collected was coded, tabulated and analyzed using SPSS version 20 and presented in a descriptive statistics inform of arithmetic means, standard deviation and frequencies while inferential statistics was carried out using t-test and results presented using tables and charts. Findings: Regression coefficients showed strong negative relationship between fire safety compliance and obstacle to implementation of fire safety management. The prediction factor was -0.67, $p<0.05$; showing that a unit increase in fire safety compliance predicted a decrease of 0.67 units of hindrance in fire safety management implementation. The null hypothesis, failed in favour of the alternative hypothesis.

Findings: The study concluded that non-compliance with fire safety standards had impact on implementation of fire safety management in the study areas and recommends installation, inspection and maintenance to ensure availability, serviceability and reliability and management to exercise their obligations geared towards improving fire safety within International Airports in Kenya.

Implications to Theory, Practice and Policy: This study is supported by utilitarian theory which emphasizes on fire safety in an occupancy where the employer is mandated to comply with fire safety regulations and standards through provision of serviceable and reliable fire protection system (Ibrahim *et al.,* 2020) and training occupants on operations of fire protection and evacuation system and encouraging everyone in the workplace to practice safety culture (Alao *et al.*, 2021). However, fire safety regulations and standards do not provide guidelines regarding human behavior and conduct in fire emergency (Endang &Dadan, 2024). This has necessitated establishment of evacuation procedures, training occupants and testing the procedure through conducting fire safety drills in the workplace to evaluate its effectiveness and adequacy.

Keyword: *(Influence, Compliance with Fire Safety Standards and Regulations, Fire Safety Management Performance, International Airports, Kenya)*

K32: Energy, Environmental, Health and Safety Laws

1.0 INTRODUCTION

Fire safety is a set of practice that focuses on avoidance of fire outbreaks and mitigation of direct and consequential damages within the workplace through training (Lawretta, 2022), provision of fire systems to protect and detect fire incidences, maintenance of fire systems and encouraging everyone in the workplace to observe fire safety in accordance with fire safety regulations and standards (Venkatesh & Muhammad, 2020). It is a major concern and integral part in workplaces all over the world as a result of increase in quantities of hazardous materials in processes, storage and transport, (Zack, 2018) and therefore require cooperation between workers, employers, and governments to ensure successful prevention and control of fire in the workplaces (Munir *et al* (2018).

The Chicago convention of 1944 which aims at promoting and developing a safe and orderly International Civil Aviation requires all contacting States to provide Rescue and Firefighting Service and equipment at an airport and to ensure that firefighters are adequately trained and rescue equipment properly maintained to save lives in the event of an aircraft accident or incident at or within the vicinity of an aerodrome (ICAO annex 14 volume 1(2022).

Airports are complex sociotechnical systems within civil aviation (Ivano *et al.*, 2019) making air transport a crucial system for any country especially for its ability to promote the development of both national and local economy, including employment opportunities, industrial upgrading, and social welfare improvement and interconnectivity (International Civil Aviation Organization [ICAO], 2023) but with numerous potential hazards (Brian, 2020) which include mixed use and occupancies, uneven distribution of occupant density, high fuel load and a considerable number of passengers with different mental and physical abilities almost every day irrespective of time, carrying combustible loads in the form of luggage (Brian, 2020). Therefore, it is prudent that lives and properties within airport terminal buildings are protected against unforeseen fire outbreaks through provision of adequate, serviceable and reliable fire protection system, and trained personnel to operate fire protection system (Ibrahim *et al.*, 2020).

Fire incidences in Europe involving airport terminal buildings include Dusseldorf airport (1996) which claimed 17 lives and injuring 62 people, Fiumicino airport (2015), Alicante airport (2020), Catania airport (2023) (Szeto, 2022). In Asia, Hong Kong International airport air cargo terminal (November 2017) and terminal 1 (December 2017) (Szeto, 2022). In Kenya, the most recent airport fires include Moi International airport (2012) and Jomo Kenyatta International Airport terminal building (2013) threatening both infrastructure and safety (Amboka, 2015).

Maintenance of firefighting system plays a vital role in fire safety within the workplace in ensuring effective performance of the firefighting system when required (Alao *et al*., 2020). The Fire Risk Reduction Rules (GOK-FRRR, 2007) which aims at ensuring that employers provide a safer working environment for all employees and those who might be affected by their activities while in the workplace through provision of serviceable and reliable fire protection systems stipulates that maintenance of fire protection system be done by qualified and competent persons at interval of one year.

Statement of the Problem

Kenyan Government and International Civil Aviation Organization (ICAO) through Fire Risk Reduction Rules (FRRR) and Standards and Recommended Practices (SARPS) respectively

mandates occupier to ensure and maintain high standards of fire safety in a workplace. However, even with the provision of these relevant legislation and guidelines in design and installation of fire safety systems; fire incidences still persist within the airport terminal presenting a risky situation in a possible fire outbreak (Brian, 2020). This is a pointer to non-compliance on the part of the occupier for proper and timely maintenance of the installed fire safety equipment (Sobral, 2017). According to Ongoro & Muiya (2023), losses as a result of property damage due to fire between 2014 and 2022 in Kenya was estimated at 600,000 USD, with the most recent fire outbreaks occurring at Jomo Kenyatta international Airport (Berre, 2023). It is on this background that this research was conducted to identify some of the gaps within international airports and the prevailing fire safety management systems; and publish the outcome to serve as a source of knowledge.

Research Gaps

There are few studies published to elucidate impact of compliance with fire safety standards and regulation on fire safety management performance at international airports. This situation has resulted in knowledge gaps which this research attempted to fill using Kenyan International airports.

2.0 MATERIAL AND METHODS

Study Design

The study was a descriptive cross-sectional research design conducted on approximately 1900 airport workers at international airports in Kenya. The target population was divided into two groups; namely the employees and management comprising of 1600 and 300 respectively.

Likert-scaled questions in the form of positive statements were administered to respondents where they were asked to indicate their level of agreement with each of the listed statements in a scale of 1-5 where (5-Strongly agree; 4-Agree; 3-Neutral; 2-Disagree; 1-Strongly disagree). For each of the statements, the respondents were requested to indicate the extent to which in their opinion each of the practices affected implementation of fire safety management at their airport, using the scale of 1-5; where (1-Very small extent, 2-Small extent, 3-Moderate extent, 4-Large Extent, 5-Very large extent).

Cronbach's alpha to assess the validity of the tools and consistency of the instruments in achieving the study objectives was computed from the results of the pilot study. Checklists and photography were used to record observations at the airports the data collected was coded, tabulated and analyzed. T-test was used to test research null hypothesis.

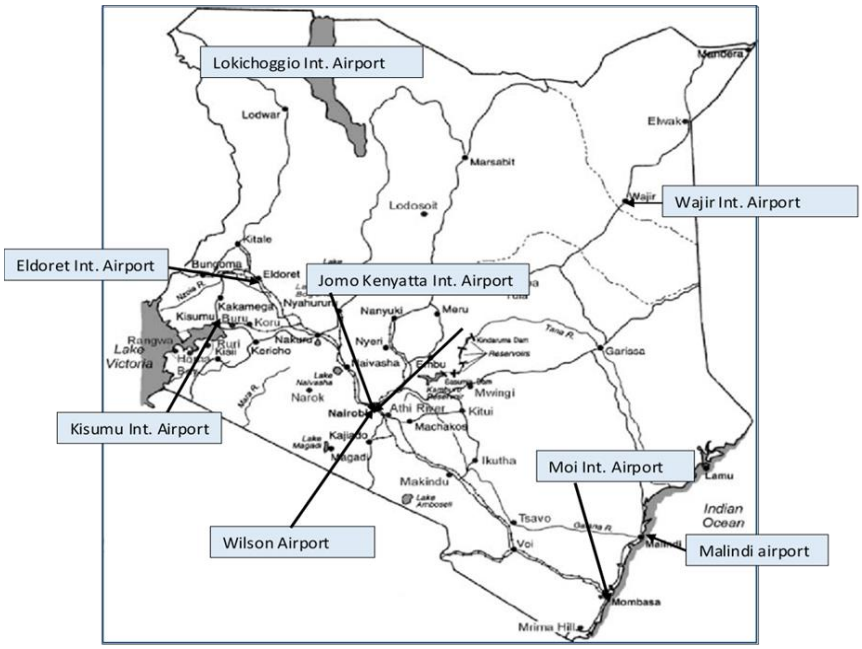

Figure 1: Map Showing Study Areas

Source: https://www.google.com/

Sample and Sampling Techniques

The study used stratified and simple random sampling in selecting respondents to ensure that sample size is distributed proportionately between the employees and management of Kenya Airports Authority.

Sample Size Determination

In determining the sample size Krejcie and Morgan (1970) formula was used.

s= X 2NP (1− P) ÷ d 2 (N −1) + X 2P (1− P)

Where:

s= required sample size.

X2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841) = [1.96x 1.96]

N = the population size (1600). The population of airport employees.

P = the population proportion (assumed to be 0.5 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (0.05).

Therefore:

s= X 2NP (1− P) ÷ d 2 (N −1) + X 2P (1− P)

=3.841 x 1600 x 0.5(1-0.5)/ [0.052 (1600-1) + 3.841 x 0.5 (1-0.5)]

=1536.4 / 4.95775

=310

To get the sample size of each study area use

n1= Xn/N*n

Where:

n = desired sample size in the whole population

Xn= the number of the targeted population in the category

N= the total study population in the study area.

In determining the sample size of the management population (300), Krejcie and Morgan (1970) formula was used.

s= X 2NP (1− P) ÷ d 2 (N −1) + X 2P (1− P)

Where:

s= required sample size.

X2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841) = [1.96x 1.96]

N = the population size (300).

P = the population proportion (assumed to be 0.5 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (0.05).

Therefore:

s= X 2NP (1− P) ÷ d 2 (N −1) + X 2P (1− P)

=3.841 x 300 x 0.5(1-0.5)/ [0.052 (300-1) + 3.841 x 0.5 (1-0.5)]

=288.075 / 1.70775

=169

3.0 FINDINGS

Table 1: Compliance with Relevant Sections of BOWEC, FRRR and ICAO SARPS

Statements	5	4	3	2	1	Mean	SD
Fire protection systems (smoke, heat and sprinkler systems) are installed at the airport	10	45	23	132	60	2.31	0.725
Inspection of fire protection systems are done as stipulated by FRRR LN No. 59	14	20	33	113	90	2.09	0.760
Fire hydrants installed at the airport	18	34	25	93	100	2.17	0.841
Fire safety audits conducted annually at the airport by competent and qualified fire safety auditors	24	20	27	112	87	2.19	0.822
AEP established at the airport	34	35	21	93	85	2.39	0.889
Aerodrome Emergency Plan tested periodically	25	18	10	91	126	1.79	0.956
ARFFS established is commensurate with the airport category	18	16	20	98	118	1.96	0.829
Emergency Access roads provided where terrain conditions permit	29	34	13	123	71	2.36	0.837
ARFFS personnel trained to perform their duties efficiently	102	113	27	18	10	4.03	0.517
ARFFS personnel participate in live fire drills including pressure-fed fuel fires	15	21	34	86	114	2.03	0.819
Aggregate						**2.33**	**0.799**

(1=Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly Agree)

Installation of Fire Protection System and Fire Hydrants

As shown in Table 1 above, 3.7% of the employees strongly agreed that fire protection systems were installed at the airport, while 22.2% strongly disagreed. The respondents who agreed and disagreed that fire protection systems were installed at the airport were 16.7% and 48.9% respectively. According to the results, installation of fire protection system at the airport among employees recorded a mean and a standard deviation of 46.2% (2.31) and 0.725 respectively. Again, 6.7% of the employees strongly agreed that fire hydrants were installed at the airport. The respondents who agreed and disagreed that fire hydrants were installed at the airport were 12.6% and 34.1% respectively while 37.0% strongly disagreed. From the results, installation of fire hydrants at the airport among employees recorded a mean and a standard deviation of 43.4% (2.17) and 0.841 respectively. Physical inspection of the airport facilities revealed absence of fire protection systems and those available were unserviceable including dry fire hydrants. These finding were not compliance with ICAO Doc 9137 Part 1, (2015) and BOWEC in relation to provision of fire hydrants at the airport for expeditious replenishment of foam tenders to ensure continuous application of the media, maintenance of survival conditions and installation of fire protection systems respectively.

Regular Inspection of Fire Protection System as a Requirement by Law

As shown in Table 1 above, 5.2% of the employees strongly agreed that fire protection systems were regularly inspected. The respondents who agreed and disagreed that fire protection systems were regularly inspected were 7.4% and 41.9% respectively, while 33.3% strongly disagreed. From the results, regular inspection of fire protection system as a requirement at the airport among employees recorded a mean and a standard deviation of 41.8% (2.09) and 0.760 respectively which, is an indicator of good agreement of the results among the respondents. Based on the result, inspection of fire protection system was below average, hence not done as required by Fire Risk Reduction Rules, 2007, document review revealed inspections were done though with inconsistent records.

Annual Fire Safety Audits Conducted by DOSH Approved Persons

From Table 1 above, 8.9% of the employees strongly agreed that fire safety audits are done by approved persons while 32.2% strongly disagreed. The respondents who agreed and disagreed that fire safety audits are done by approved persons were 7.4% and 41.5% respectively. From the results, annual fire safety audits recorded a mean and a standard deviation of 63.0% (2.19) and 0.822 respectively which, is an indicator of good agreement of the results among the respondents. Documents review, showed fire safety audits were done by approved Directorate of Occupational Safety and Health Service (DOSHS) persons. However, there were inconsistent implementation of the audit findings. The researchers deduced that non implementation of audit findings affected fire safety management.

Establishment of Aerodrome Emergency Plan and Periodic Testing of the Plan

As illustrated in Table 1 above, 12.6% of the employees strongly agreed that aerodrome emergency plan is established at the airport while 31.5% strongly disagreed. The respondents who agreed and disagreed that aerodrome emergency plan was established at the airport were 12.9% and 34.4% respectively. From the results, establishment of aerodrome emergency plan at the airport among employees recorded a mean and a standard deviation of 47.8% (2.39) and 0.889 respectively which, is an indicator of good agreement of the results among the respondents. ICAO Doc 9137 part 7, 1991) requires airport management to establish an emergency plan commensurate with the activities of the airport to minimize the effect of emergency. Again, 9.3% of the employees strongly agreed that aerodrome emergency plan was periodically tested while 46.7% strongly disagreed. The respondents who agreed and disagreed that aerodrome emergency plan was periodically tested at the airport were 6.7% and 33.7% respectively. According to the results, periodic testing of aerodrome emergency plan at the airport among employees recorded a mean and a standard deviation of 35.8% (1.79) and 0.956 respectively which, is an indicator that Airport Emergency Plan was not periodically tested.

ICAO Annex 14 volume 1 (2022) requires airport operators to test Aerodrome Emergency Plan by conducting a full-scale aerodrome emergency exercise within a period of two years, partial emergency exercises in the intervening year and a series of modular tests starting in the first year at intervals not exceeding three years to correct any deficiencies found during such exercises. The periodic tests are done to check for adequacy of the plan, adequacy of the response of each responding agencies, communication systems and concentrated effort on specific components of the emergency plan. According to Zamal *et al* (2023), full-scale emergency exercise by virtue of being comprehensive, is the best one to evaluate multi-agency and multi-jurisdictional readiness.

Documents review revealed availability of records of periodic aerodrome emergency drills previous done at 37.5% airports with inconsistency as stipulated by KCARS, 2013. These results showed that periodic testing of aerodrome emergency plan is not done as required. The lack of consistence periodic testing affected implementation of fire safety management.

Establishment of ARFFS Commensurate with Declared Airport Category

From Table 1 above, 6.7% of the employees strongly agreed that the established ARFFS was commensurate with the declared airport category while 43.7% strongly disagreed. The respondents who agreed and disagreed that the established ARFFS was commensurate with the declared airport category were 5.9% and 36.3% respectively. From the results, establishment of ARFFS commensurate with declared airport category recorded a mean and a standard deviation of 39.2% (1.96) and 0.829 respectively which, is an indicator of good agreement of the results among the respondents. Physical inspection of the airport facilities and equipment revealed that none of the airports had established ARFFS commensurate with the declared category and they operated below the declared category. ICAO Annex 14 volume 1 (2022) requires airport operators to provide rescue and firefighting equipment and services at the airport used for commercial air transport and the level of protection provided to be appropriate with the declared and published airport category and that all airports conducting international operations must be certificated and have adequate number of qualified and skilled ARFFS personnel to perform airport activities.

According to KCARS (2013), airport operator is obligated to provide rescue and firefighting facilities that are commensurate with the declared and published airport category. Document review revealed that 37.5% of the international airports hold valid aerodrome certificate issued by KCAA. Additionally, none of the eight international airports assessed met the minimum requirements in terms of adequate number of staff to operate the equipment at maximum capacity and be deployed in a way to ensure continuous agent application is fully maintained. These results are indicators to non-compliance with ICAO SARPS and KCARS, 2018 in relation to provision of adequate fire cover and certification of airports. Failure to meet the minimum requirements was construed to affect implementation of fire safety management.

Provision of Emergency Access Roads where Terrain Conditions Permit

As shown in Table 1 above, 10.7% of the employees strongly agreed that emergency access roads were provided at the airport where terrain permits while 26.3% strongly disagreed. The respondents who agreed and disagreed that emergency access roads were provided at the airport where terrain permits were 12.6% and 45.6% respectively. From the results, provision of emergency access roads at the airport among employees recorded a mean and a standard deviation of 47.2% (2.36) and 0.837 respectively which, is an indicator of good agreement of the results among the respondents. Physical inspection revealed presence of emergency access roads within 50% of the airports though not all weather hence affecting response time especially during rainy seasons when the emergency access roads are rendered impassable. ICAO Annex 14 volume 1 (2022) requires airport operators to provide all weather emergency access roads at airport where terrain conditions permit their construction and capable to support the heaviest vehicles using them. The results showed that lack of all-weather access roads resulted in delayed response hence affecting principle objective of saving lives of occupants and overall implementation of fire safety management.

Training of ARFFS Personnel Including Pressure Fed-Fuel Fires

From Table 1 above, 37.8% of the respondents strongly agreed that ARFFS personnel were adequately trained to perform their duties and 3.7% strongly disagreed. The respondents who agreed and disagreed that ARFFS personnel were adequately trained to perform their duties were 41.9% and 6.7% respectively. Training of ARFFS personnel among employees recorded a mean of 80.6% (4.03) an indicator that fire safety training among employees was above average. Document review during interview revealed that ARFFS personnel had been trained within the levels to perform their duties and copies of certificate provided. Further, 5.5% of the respondents strongly agreed while 42.2% strongly disagreed that ARFFS personnel were adequately trained including training on pressure fed-fuel fires to perform their duties. The respondents who agreed and disagreed that ARFFS personnel were adequately trained including training on pressure fed-fuel fires to perform their duties were 7.8% and 31.9% respectively. ARFFS Pressure fed-fuel fires training recorded a mean of 40.6% (2.03).

Document review during interview revealed that 1.9% of ARFFS personnel had attended training on pressure fed-fuel fires outside Kenya. ICAO Annex 14 volume 1 (2022) requires airport operators to effectively train Aerodrome Rescue and Firefighting Service (ARFFS) personnel and participate in live fire drills that included pressure fed-fuel fires commensurate with the types of aircraft and firefighting equipment in use at the airport. The results showed that Aerodrome Rescue and Firefighting Service personnel have no training in pressure fed-fuel fires commensurate with the types of aircraft and firefighting equipment in use at the airport. The researchers concluded that lack of pressure fed-fuel fires affected endurance of firefighters as a prerequisite for firefighting in extreme conditions and therefore affecting overall implementation of fire safety management. These findings were in agreement with Nelson *et al* (2019) who concluded that specialized training is vital to air transport performance at Kenyan airports as effective rescue depended on the training received and the speed in which firefighters and firefighting equipment can be deployed (ICAO Doc 9137 Part 1, 2015).

Linear Regression Analysis

Simple linear regression results confirmed existence of a direct and positive relationship between compliance with relevant sections of BOWEC, FRRR and ICAO SARPS and implementation of fire safety management. The prediction factor was 0.67, $p < 0.05$; an indicator that one-unit increase in compliance with relevant sections of BOWEC, FRRR and ICAO SARPS resulted in an increase of 0.67 units in the implementation of fire safety management. Equally, the results also showed an existence of a direct and negative relationship between compliance with relevant sections of BOWEC, FRRR and ICAO SARPS and hindrance in the implementation of fire safety management with a prediction factor of -0.67, $p < 0.05$. This implied that a unit increase in compliance with fire safety standards resulted in a decrease of 0.67 units of hindrance in the implementation of fire safety management.

Hypothesis Testing

The null hypothesis (H_o), fire safety management at international airports in Kenya is not affected by compliance with relevant sections of BOWEC, FRRR and ICAO SARPS ((H_0: $\mu - 2.5 = 0$), failed in favour of the alternative hypothesis ($HA: \mu - 2.5 \neq 0$). The result of the computed *t*-statistic was 3.498 compared to 1.645 at $\alpha = 0.05$; this was more than right-tailed critical value of the *t*-distribution.

4.0 CONCLUSION AND RECOMMENDATIONS

Conclusion

Lack of compliance with relevant sections of BOWEC, FRRR and ICAO SARPS affected implementation of fire safety management at International airports in Kenya. The Aggregate mean for compliance with fire safety standards was 2.33 representing 46.6% on level of compliance. Fire hydrants were dry, sprinkler and alarm systems were not installed at the airports, Airport Emergency Plan were not tested periodically, emergency access roads provided were not all weather, ARFFS provided at the airport was not commensurate with published airport category and ARFFS personnel did not participate in live fire drills that included pressure fed-fuel fires. Results of the regression analysis results showed that a change of one unit in compliance with relevant sections of BOWEC, FRRR and ICAO SARPS predicted a change of 0.67 units in Implementation of Fire Safety Management. The null hypothesis "Implementation of Fire Safety Management is not affected by compliance with relevant sections of BOWEC, FRRR and ICAO SARPS" failed in favour of the alternative hypothesis.

These findings were in agreement with Ricky (2023) who concluded that insufficient fire hydrants within the airports hindered effective provision of rescue and firefighting service. They were consistent with Windisch *et al.* (2017) who concluded that firefighting is a unique occupation that requires physical fitness because it is characterized by sudden high intensity workloads hence requiring endurance as a prerequisite for firefighting in extreme conditions similar to those experienced in pressure fed-fuel fires mock simulators.

They also concurred with Adedayo (2021) who concluded that Nigeria's Aerodrome Rescue and Firefighting Service (ARFFS) plays an important role in rescue operations but grossly affected by inadequacy of skilled and qualified ARFFS personnel and firefighting facilities. Further, they agreed with Venkatesh & Muhammad (2020) who alluded that many developing countries have challenges in providing adequate firefighting service due to inadequate resources (both human and capital) and poor state of existing firefighting facilities and Shokouhi *et al* (2019) who concluded that lack of adequate equipment for rescue and firefighting operations affected implementation of fire safety management.

Recommendations

The airport management should ensure that: -

a) Installation of adequate fire protection systems in all occupied floors at the airport to enhance fire safety within the terminal buildings as well as surrounding structures;
b) Implementation of periodic inspections and maintenance schedules of fire protection systems is adhered to and done by approved persons to ensure availability, serviceability and reliability of the same at all times at the airport;
c) Sufficient emergency water supply is available within fire protection systems for use
d) Periodic testing of airport emergency plan is done as required by law
e) All weather emergency access roads where terrain conditions permit are provided.
f) Aerodrome Rescue and Firefighting Service (ARFFS) provided at the airport is commensurate with published airport category and that the ARFFS personnel participate in live fire drills including pressure fed-fuel fires.

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Conflicts of Interest Declaration

None

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