Noise Levels Around Queen Alia International Airport

[1]Hana Naghawi,
Civil Engineering Department, University of Jordan, Amman, Jordan
hana_naghawi@yahoo.com
[2]Taqwa Hadidi,
Civil Engineering Department, University of Jordan, Amman, Jordan
taqwa.hadidi@yahoo.com
[3]Esra Oran,
Civil Engineering Department, University of Jordan, Amman, Jordan
esraorankoo@yahoo.com

***Abstract*— In recent years there has been enormous increase in the air travel. For communities living around airports, noise is obviously the most environmental impact of aviation which has a great effect on the quality of life of people living close to airports. In this paper, noise levels were calculated to formulate an objective assessment of the noise impact caused by aircrafts on the airport's surrounding areas. This research describes one of the first attempts to calculate noise levels not only in Jordan but also in the Middle East. Three types of noise levels were calculated; day, evening, and night. It was found that the noise pressure level varied from 83.1 db (A), 89.3db (A), and 94.7db (A), for day, evening and night time respectively. The percentages of people affected by this noise were also calculated, it was found that 72.08%, 92.1%, 96.7% people were affected for the three contour types respectively.**

***Keywords*- noise, airport noise, noise levels.**

I. INTRODUCTION

Noise is the most perceptible impact of an airport. Due consideration is required for all community factors affected by the airport activity including social, economical, ecological and environmental factors [1, 2].

Aircraft noise initiates from both the engines and the airframe of an aircraft, but engines are by far the most significant source of noise. Meteorological conditions affect the propagation (or transmission) of sound through the air. Wind speed, direction, temperature and aircraft elevation immediately above ground level cause diffusion and displacement of sound waves. Humidity and temperature materially affect propagation of air-to ground sound through absorption associated with the instability and viscosity of the air [3, 4]. The International of Civil Aviation Organization (ICAO) states that aircraft produces in 2007 are about 75% quieter than ones produced 40 years ago and that the number of people revealed to significant levels of aircraft noise has fallen by approximately 30% in 2006, when compared to 2000 levels. However, a recent analysis shows that the global population exposed to significant aircraft noise levels will increase by 78% from 2005 to 2025 due to the projected increase in number of aircraft operations [5].

The International Civil Aviation Organization (ICAO) has realized the potential effect of implementing sophisticating technology of flight guidance to decrease aircraft impact noise. ICAO developed a Noise Abatement Operating Measures Group (NAOMSG) with the following tasks [6]:

1. Describe the effective recession operational procedures and strategies of the current noise.

2. Evaluate the critical components of aircraft flight procedures which may reduce the emissions of aircraft noise community exposure.

3. Identify emerging and future airport systems technologies in flight management field.

4. Recognize new operating procedures to minimize noise exposure of the community taking into account the emerging and future technologies identified in 3.

Noise levels are calculated in order to be able to make an objective assessment of the noise impact caused by an airport in the adjacent areas. These noise levels reflect changes and events that can have an impact on the noise production by air traffic during landing and departure, and as such, can be used to describe the situation as well as to evaluate the effects of changes in the aircraft fleet, changes in numbers of flights and any actions taken.

This paper illustrates noise levels at different distances for Queen Alia International Airport (AMM), the major airport in Jordan, located at Aljeza distinct. This was done by measuring and modelling the sound pressure levels around the airport and its effects on the population of the surrounding areas.

II. Measuring Aviation Noise

Sound is defined as the energy passing through the air in the form of small fluctuations in air pressure. These fluctuations are detected by the ear or the microphone on a noise monitor. The rate at which these fluctuations occur is the 'frequency' of the sound. While the human ear responds to sound over a wide range of frequencies but with different sensitivities (for example, very high pitched noises are often not picked up by the human ear). A variety of frequency weightings have been developed to align with the way the human ear hears. The most commonly used is the A-weighted sound level, which is widely used to quantify sound from all modes of transport [7] Table 1 shows approximate sound pressure levels for different activities or situations.

TABLE I
APPROXIMATE SOUND PRESSURE LEVEL (LPA) FOR DIFFERENT ACTIVITIES OR SITUATIONS [6]

Situation	Sound pressure Level LpA dB(A)
Threshold of pain	130
Threshold of discomfort	120
Chainsaw,1m distance	110
Disco , 1 m from speaker	100
Diesel truck pass-by , 10 m away	90
Curbside of busy road,5 m away	80
Vacuum cleaner, distance 1 m	70
Conversational speech , 1m	60
Quiet office	50
Room in quiet , suburban area	40
Quiet library	30
Background in TV studio	20
Rustling leaves in the distance	10
Hearing threshold	0

III. Methodology

To obtain an overall picture of the annoyance around the airport, it is usually chosen not to use the equivalent sound pressure level over 24 hours or LAeq, 24h. For the purpose of this study, three types of LAeq,T levels were calculated:

- *Lday*: the equivalent sound pressure level for the daytime period, defined as the period between 7.00 and 19.00.
- *Levening*: the equivalent sound pressure level for the evening period, defined as the between 19.00 and 23.00.
- *Lnight*: the equivalent sound pressure level for the night period, defined as the period between 23.00 and 07.00.

The Lden (level day- Evening-Night) is the A-weighted equivalent sound pressure level over 24 hours, with a (penalty correction of 5 dB(A) being applied for noise during the evening period, which rises to 10 dB(A) during the night. Noise during the evening or night period is always perceived as more annoying than the same noise during the daytime period.

A. *Input Data*

Noise levels around AMM airport were calculated based on average 24 hour period. Based on data for a complete year, an average of twenty-four hour period was determined, by considering all air traffic movements in that year, then dividing it by the number of days of the year.
To take a movement into consideration, data required are aircraft type, nature and time of the movement (landing and takeoff).

Table 3 and 4 depict aircraft movements at Queen Alia International Airport for the landing and takeoff movements respectively.

TABLE 2
DATA OVER 24 HOUR LANDING MOVEMENTS AT AMM AIRPORT

Time	AC Type	Time	AC Type	Time	AC Type
0:02	B737-800	11:50	A320	18:45	A320
0:05	A320	11:59	A320	18:55	A319
0:20	A321	12:06	A320	19:20	A320
0:35	E175	12:30	A320	19:27	E195
0:50	A320	13:00	A320	19:30	A320
1:05	A321	13:10	A320	19:50	E195
1:15	A320	13:30	A320	19:53	A320
2:05	E195	14:33	A320	19:53	A319
2:22	A320	14:34	A320	19:55	E175
3:00	A319	14:42	A320	20:00	A319
5:15	A330	14:49	A320	20:05	E195
5:44	A319	14:49	A320	20:10	E195
6:15	A320	15:26	A319	20:15	A320
9:17	E195	15:33	E195	20:20	A321
9:30	A319	15:41	A321	20:30	A320
9:38	E175	15:41	E175	20:30	A320
9:41	E175	16:00	A321	20:45	A319
9:42	B777-200	16:05	E195	20:45	A320
9:45	E175	16:10	A320	20:45	A320
9:45	E195	16:23	A320	21:05	A319
9:51	A321	16:25	A321	21:25	A320
9:55	E175	16:30	B777-700	21:30	A320
9:58	E195	16:30	A320	21:30	A320
10:06	E195	17:35	A320	21:45	A320
10:18	A321	17:45	E175	22:05	E175
10:24	A319	17:45	A319	22:05	E195
10:31	A320	17:50	A340	22:15	A321
10:47	B777-200	18:04	A340	23:00	E195
11:15	B737-800	18:20	B737-800	23:10	A320
11:43	E195	18:30	A340		
11:48	A321	18:45	B737-800		

TABLE 3
DATA OVER 24H TAKE OFF MOVEMENTS AMM AT AIRPOT

Time	AC Type	Time	AC Type	Time	AC Type
1:05	A320	11:30	A319	17:10	A321
1:00	E195	11:35	E175	17:15	A321
1:05	E195	11:45	A320	17:30	A319
1:25	A320	12:05	A330	17:40	A319
1:30	B747-400	12:15	E175	17:50	B777-700
1:30	A320	12:20	A319	18:30	E195
1:35	A320	12:30	E195	19:05	B777-800
2:30	A320	12:50	A330	19:10	A320

5:58	E195	13:15	E175	19:40	E175
6:15	E195	13:30	A320	19:50	B777-800
6:30	E175	13:50	A320	20:00	A320
7:37	A321	14:00	A320	20:10	A320
7:55	A319	14:20	A320	20:15	A319
8:13	E195	14:30	A330	20:30	A320
8:24	A320	15:40	E195	20:35	A319
8:58	A319	15:50	A320	20:40	A321
9:51	E175	15:55	A320	20:50	A320
10:00	A321	16:00	B777-200	21:05	A320
10:30	E195	16:25	A319	21:30	B777-800
11:15	A319	16:55	B777-200	22:10	A320
11:20	A321	17:00	A320		

B. *Population Data*

The most recent data available from the Jordan Department of Statistics was used to determine the number of people potentially highly annoyed within the noise level zone.

A noise zone is the zone delimited by two successive noise levels. For example, the noise zone 60-65 dB (A) is the zone delimited by the noise level of 60 and 65 dB (A).

C. *Data Analysis*

Based on the data collected from AMM which was summarized in Tables 2 and 3, each aircraft has its own Weighted Equivalent Sound Pressure Level in dB (A) categorized into two movements, takeoff and landing. Table 4 summarizes the Weighted Equivalent Sound Pressure Level in dB (A) for aircrafts at AMM international airport according to Federal Aviation Administration (FAA) advisory circulation (AC) 36-3H Appendix 2 [8].

TABLE 4
A-WEIGHTED SOUND PRESSURE LEVEL DB (A) FOR AIRCRAFTS AT AMM AIRPORT (TAKE OFF &LANDING) (7)

A-Weighted Sound Pressure Level dB(A) (Landing)	A-Weighted Sound Pressure Level dB(A) (Take off)	Aircraft Type
92.5	98	B 747-400
89.6	83.3	B 777-300
89.1	82.5	B777-200
86.7	76.5	B 737 -800
88.8	75.1	B737 -700
84.3	73.3	A 319
85.6	73.7	A 320
86.7	77.1	A 321
87.6	80.2	A 330
88.5	80.5	A 340
86.7	85.3	E 175
87.9	86.1	E 195

Then the weighted equivalent sound pressure over 24 hour (LAeq,24) was plotted for each aircraft and movement as shown in Figure 1.

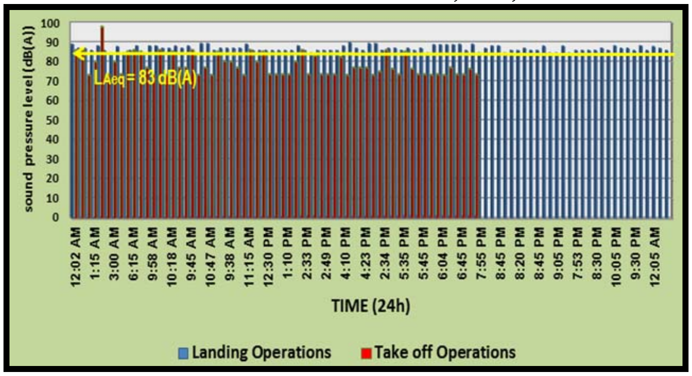

Figure 1: A-Weighted Equivalent sound pressure level for 24 h (LAeq,24).

It can be seen that the A-Weighted Equivalent sound pressure level for 24 h (LAeq,24) was 83 dB(A),While the max value of equivalent sound pressure over 24 hours was equal 98 dB(A) and 89.6 dB(A) for takeoff and landing respectively.

The weighted equivalent sound pressure for Lday (7:00 - 19:00) was plotted as shown in Figure 2. Also it can be seen that the A-Weighted Equivalent sound pressure level for Lday was 83.1dB (A).

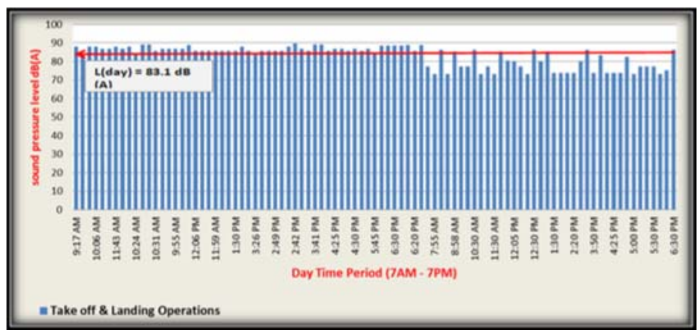

Figure 2 the equivalent sound pressure level for (Lday).

The weighted equivalent sound pressure for Levening (7:00 pm -11:00 am) was plotted as shown in Figure 3. Also it can be seen that the A-Weighted Equivalent sound pressure level for Levening was 89.3 dB (A).

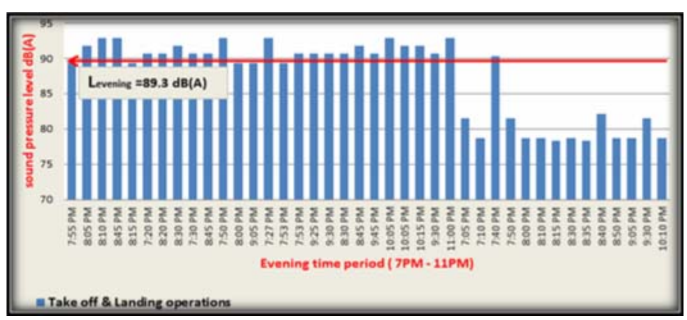

Figure 3: A-Weighted Equivalent sound pressure level for (Levening)

The weighted equivalent sound pressure for Lnight (19:00 -23:00) was plotted with a correction of 10 dB (A) for each aircraft and movement as shown in Figure 4, to obtain the L night equivalent sound pressure.

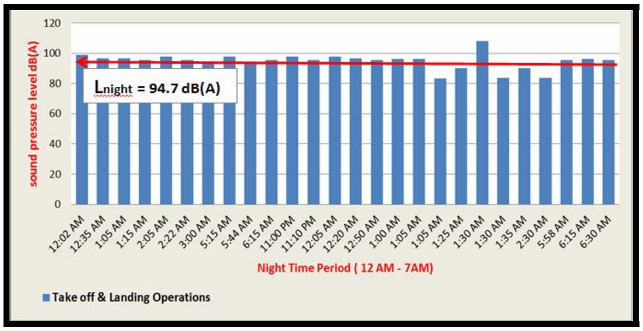

Figure 4: A-Weighted Equivalent sound pressure level for (Lnight)

It can be seen that people annoyance is higher and much detected at night. The A-Weighted Equivalent sound pressure level for Lnight was 94.7dB (A) which is the highest value and far away from the threshold of Jordan which is 83 db (A), this is due to the propagation of 10 db (A) for each movement.

D. Noise Levels

When measuring noise levels, the distance should always be stated. A distance of one meter from the noise source is frequently used. Noise levels were calculated using equation 1.

Lp2 = LP1+ 20*Log10 ( ) ….equation 1 [9]

Where:
L_{p2} is the Equivalent sound pressure level at distance r_2.
L_{p1} is the Equivalent sound pressure level at distance r_1.
r_2 and r_1 distances from the sources.

For the purpose of this study the noise levels where calculated at the following distances (10m, 30m, 50m, 100m, 500m and 1000m). Table 5 shows the equivalent sound pressure at the selected distances for L day, evening and night.

Table 5
Equivalent sound pressure level with distance dB (A)

Distance (m)	10	30	50	100	500	1000
Lday (dB)	63.1	53.6	49.0	43.1	29	23.1
Levening (dB)	69.3	59.7	55.3	49.3	35.3	29.3
Lnight (dB)	74.7	65.2	60.7	54.7	40.7	34.7

Table 5 shows that sound level decreases as the distance from the source increase. For instant the maximum sound level for night at 10 m was 74.7 dB. While the L equivalent for night at source was 94.7 dB as found in Figure 4.

E. Number of people potentially highly annoyed

To determine the number of people potentially highly annoyed within each noise zones for Lday, Levening, and Lnight, the effect ratio is incorporated in the following formula.

Seriously affected% = -9.199*10^-5 (Lden-42)³ + 3.932 *10^-² (Lden-42)²+0.2939(Lden -42) ……. equation 2 [10]

Number of people potentially highly annoyed during day:

= -9.199*10^-5 (83.1-42)³ + 3.932 *10^-² (83.1-42)²+0.2939(83.1 -42) = -6.39 + 66.4 +12 = 72.08%

Number of people potentially highly annoyed during evening:

Seriously affected% = -9.199*10^-5 (89.3-42)³ + 3.932 *10^-² (89.3-42)²+0.2939(89.3 -42) = -9.7 + 87.9 +13 = 92.1%

Number of people potentially highly annoyed during night:

Seriously affected% = -9.199*10^-5 (94.7-42)³ + 3.932 *10^-² (94.7-42)²+0.2939(94.7 -42) = -13.5 +95.2 +15 = 96.7%

This shows that number of people potentially highly annoyed are (78.08%, 92.1%, and 96.7 %) for day, evening, and night respectively.

IV. CONCLUSION

This study describes one of the first attempts to calculate noise levels. Noise levels were calculated for Queen Alia International Airport (AMM) in Amman, Jordan. Three types of levels were calculated for day, evening, and night. It was found that the noise pressure level ranged from 83.1 db (A), 89.3db (A), and 94.7db (A) for different day time; evening and night respectively. These values were higher than threshold of Jordan of 83 db (A) in the three cases. The percentages of people potentially highly annoyed by this noise were 72.08%, 92.1%, 96.7% for day, evening, and night respectively.

In order to mitigate the noise emitted from aircraft operations at Queen Alia International Airport, some countermeasures are proposed through providing:

- Noise proof walls for the purpose to shut noise in the airport
- Buffer green forest area between the airport and the surrounded residential areas to attain environment protection.
- Constructing noise matching facilities which have little concerns of receiving disturbances to its function from aircraft noise.

V. REFERENCES

[1] Lambert J "Perception and attitudes to transportation noise in France: a national survey", 2008, The 9th Congress of the ICBEN, Mashantucket.

[2] C. V. Robart, "Environmental Considerations in Airport Planning," Course Notes for Airport Planning and Design Short Course, University of California, Berkeley, Calif. June 1977.

[3] Horonjeff Francis X. McKelvey William J. Sproule Seth B. Young, 2011, Planning and Design of Airports , fifth edition
[4] Salah Khardi "Environmental impact reduction of commercial aircraft around airports. Less noise and less fuel consumption", 2013.
[5] Maurice, L. Q., and D. S. Lee D. S. (Eds.), "Assessing Current Scientific Knowledge, Uncertainties and Gaps in Quantifying Climate Change, Noise and Air Quality Aviation Impacts", final report of the International Civil Aviation Organization (ICAO) Committee on Aviation and Environmental Protection (CAEP) Workshop, Washington DC and Manchester U.S. Federal Aviation Administration and Manchester Metropolitan University, 2009.
[6] Aerodromes and operations-Noise and Emissions, Attachment c to the Report on Agenda Item 7, Terms of Reference of Working Group 2, ICAO, 1993.
[7] Discussion Paper 05:Aviation Noise July 2013
[8] Federal aviation administration (FAA) advisory circulation (AC) 36-3H Appendix 2
[9]http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/design/design00.cfm access on 21/7/2014.
[10] Good practice guide on noise exposure and potential health effects. EEA Technical Reports No 11/2010.

AUTHORS PROFILE

Dr. HANA NAGHAWI is an Assistant Professor in the Department of Civil Engineering at the University of Jordan. She holds a Bachelor of Science degree in Civil Engineering and a Master of Science degree in Civil Engineering (highway and traffic) from the University of Jordan, and a PhD in Civil Engineering from the Louisiana State University, USA. Her research interests lie within the broad area of transportation engineering, with a specific interest in traffic operation and congestion prevention. She is a member of the Jordan Engineers Association, the Jordan Road Society, and the Institute of Transportation Engineers, Washington DC, USA. Dr. Naghawi has also been awarded a number of honoraries.

Eng. Taqwa Al Hadidi is a master student in the Department of Civil Engineering at the University of Jordan. She holds a Bachelor of Science degree in highway and bridge engineering from albalqa applied university. Her research interests lie within the broad area of transportation engineering, with a specific interest in traffic operation. She is preparing her master thesis in improving traffic operation. She is a member of the Jordan Engineering Association.

Eng. Esra Oran was born in Tafila in 1990. She earned her B.Sc. degree in Civil Engineering in June 2012 from Tafila Technical University and now she is preparing for her thesis on M.Sc. degree in transportation.
Eng. Oran worked as TEACHER ASSISTANT (TA) in the University of Jordan.

.