Proceedings of 20th International Congress on Acoustics, ICA 2010

23-27 August 2010, Sydney, Australia

Noise exposure of the ramp's operators in airport apron

Franco Gugliermetti, Fabio Bisegna, Anna Carmela Violante and Cristina Aureli

Department of Fisica Tecnica – University of Rome "La Sapienza", Via Eudossiana n. 18, 00184 Rome, Italy

PACS: 43.50.Qp Effects of noise on man and society

ABSTRACT

The current regulation regarding noise exposure protection of workers cannot consider the peculiarities of some work environments. The study here presented concentrates on one of these peculiar site, the airport apron, where there are many difficulties in performing measurment, owing to the risks associated with the airport activities, and in selecting and evaluating each noise source. In this environment, where hard works are carried on, the dosimeter cannot be easily used and different methods must be considered and applied. Several kinds of operations and operators have been considered. A procedure is here proposed for evaluating the noise exposure of ramp's operators starting from acoustical measurements of sound pressure levels produced by ramp equipments. Measurements have been carried out with a multichannel and multiprocessing sound analyzer placed as much as possible near the source. Simultaneously the peak level and other index are registered. A method for cleaning the experimental data during the data analyzing process is here considered to compute through the noise exposure time the daily equivalent level of exposure. Afterwards obtained $L_{EX,\ 8h}$ are compared with the limits imposed by the current regulations.

INTRODUCTION

Occupational exposure to noise is one of the most significant health risk for workers being able to determine irreversible hearing damages. Exposure for a long time to high noise levels, greater than 80 dB(A), may lead to a permanent increase in the Noise Induced Permanent Threshold Shift. The risk of noise-induced hearing loss involves the ramp's operators who perform various tasks in the airport.

Following the placement of the aircraft in the apron, "turn around" phase begins and consists of operations to support the aircraft. In this peculiar environment operators perform their tasks in the presence of noise from many sound sources, equipments normally using to carry out specific activities but also aeronautic noise, and follow precise security procedures. It is therefore necessary to identify the characteristics of places and the types of work activities, operators, equipments, other sound sources present, typical working days.

There are not many available data on the assessment of the daily noise exposure level for these workers and are usually considered as one homogeneous group [1] [2]. Ramp workers instead belong to several professional groups with a wide diversity of tasks, experience, working time, information and training regarding to noise exposure. Different searches were conducted to characterize the noise emitted by aircraft in ramp and outside of ramp, considering how sound sources propulsion engines and the Auxiliary Power Unit for different types of airplanes [3] [4] [5].

The study here presented has the goal to develop a procedure for evaluating the noise exposure of workers starting from acoustical measurements of sound pressure levels produced by ramp equipments. The daily equivalent level of exposure is so determined by considering the noise exposure times and is compared to the limits imposed by the current regulations.

REGULATIONS

The current regulation in the European Union regarding protection of workers is based on the Directive 2003/10/CE [6]. In Italy the safety act D. Lgs. 9 April 2008, n°81 [7] and the following revisions are in force. This directive and the national decree state a set of minimum disposals with the aim of protecting the workers from the risks for their safety and health, caused or that may be caused by the noise exposure.

The indexes used for assessing the noise level in each workplace are the daily equivalent level of exposure $L_{EX,8h}$ and the peak level L_{peak}. In no case the real exposure of a worker may overpass the limit values of $L_{EX,8h}$ = 87 dB(A) or L_{peak} = 140 dB(C), even considering the attenuation given by the personal hearing devices used by each worker. When the daily equivalent level is over 80 dB(A) and/or the peak level exceeds 135 dB(C) the following measures have to be applied in the workplaces: to provide each worker with a proper information, and, when applicable, a proper training regarding to noise exposure assessment and potential risks for hearing, preventive measures, use of personal hearing devices, results of the medical hearing checkup; to carry out a medical hearing checkup of the workers that demand them; to give personal hearing devices to the workers that demand them. When the daily equivalent level is equal or over 85 dB(A) and/or the peak level exceeds 137 dB(C) a program of technical and organisational measures to reduce the exposure must be established; the previous measures are medical hearing checkup of workers usually once a year and personal hearing devices given to all the workers exposed. Areas where workers may be exposed to noise above the upper exposure action values are indicated by appropriate signs and shall also be delimited; the access to them is restricted where this is technically possible.

Whenever possible and according to the current regulations, measurements must be done in absence of the affected worker by placing the microphone at the same height as his ear. If the worker has to be present, the microphone will be placed preferably in front of his ear, approximately at a distance of 10-40 centimetres. Measurements should be performed in according with ISO 1999:1990 [8], ISO 9612:1997 [9] and the Italian technical standard UNI 9432:2008 [10]. The daily equivalent level of exposure is defined by ISO 1999.
Nevertheless, standards cannot consider the peculiarities of some work environments, that present difficulties and in general risks in performing measurements.
The study concentrates on one of these peculiar environments, the airport apron, where there are many difficulties in selecting grids of measuring points, owing to the risks associated with the airport activities, and in selecting and evaluating each noise source. In this environment, where hard works are carried on, the dosimeter cannot be easily used and different methods must be considered and applied.

Italian law provides that the employer takes into account the measurement inaccuracies determined in accordance with metrological practice.
The overall uncertainty on the L_{Aeq} is composed of four elements:
- instrumental ε_S, due to inaccuracies which suffers the measurement chain, deduced from calibration certificate or assumed to be 0.5;
- by sampling ε_A, where the measurement is not continued throughout the exposure time, averaging the equivalent levels of N measurements on a single event ($N \geq 3$) and the standard deviation of the distribution of levels;
- by positioning the instrument ε_P, linked to disturbances induced by the presence of the subject during the measurement to be taken equal to 1 as suggested by the UNI 9432:2008;
- temporal, due to inaccuracies in the definition of exposure time (not determinable).

If the measurement lasts for 8 hours, in this case the equivalent level coincides with the daily equivalent level of exposure of workers and therefore it will be accompanied from the same random error (being zero the temporal and environmental uncertainty) . If the measurement is held for shorter periods, the $L_{EX,8h}$ will be affected by an unknown uncertainty that is necessary to determine. The uncertainty on the peak noise level is influenced by the same contributions, but in this case the contribution of environmental uncertainty is considered zero. For other uncertainties the following values are assumed: ε_P is 1 and ε_S is half expanded uncertainty, value indicated on the certificate of the instrument or, failing this, equivalent to 1.2 dB (A).

NOISE SOURCES AND “TURN AROUND” OPERATIONS

This study is centered on workers operating in the air-side for the “turn around” of the aircraft during the stop in apron of an international airport. For the determination of occupational noise exposure it is important to define, first of all, the noise sources and the workers engaged in ramp.

It is possible to divide the several noise sources in two types: aeronautic source and ramp equipments. When the aircraft arrives in apron and during the departure there is the noise caused by turbofan engines in slow running. During the stop the noise caused by Auxiliary Power Unit, when the aircraft is close to departure, must be considered.

After the landing the aircraft moves through fixed and defined runs said "taxi-way" to the platform of standstill (apron). The parking with positioning the anterior cart in a well defined point happens using onboard propulsion engines under a very low thrust. The exit from the apron of the aircraft can be made using the thrust of the propulsion engines or, in the case of platforms with loading bridges, using a special operation called push-back: the draw back of aircraft using a tractor, acting on the anterior cart, takes him on a taxi-way to prepare for takeoff. Upon departure from the apron, engines must be started in advance to reheat, for checking of the aircraft and for connection to the control tower.
The APU, coupled with a small gas turbine lodged in the back extremity of the fuselage, is able to produce the electric energy for the airplane and the compressed air for conditioning on board during the stop and for the starting of the engines. Therefore the APU must have put into operation a few minutes before departure. Other sources of noise are the ventilation system positioned under the belly of the fuselage.

Following the placement of the aircraft in the apron, “turn around” phase begins, a series of operations to support the airplane. The equipments of ramp are arranged radially to the airplane, to guarantee everyone an escape route in case an accident. The ramp workers belong to many professional groups with a wide diversity of tasks. Generally, manual operators shall perform the duties of loading and unloading of baggage and cargo in the holds of the aircraft, the supply of potable water and fuel, the treatment of toilets, the catering service and the transport of the baggage from the land-side to aircraft and vice versa. They also set wheel blocks (denominated heels and cones) to the arrival in ramp of the airplane, they operate the loading bridge and they develop the operation of the push-back. The ramp employees are responsible for coordinating and directing all operations conducted in proximity of the aircraft on the parking area to ensure the safety and departure time.

This research examines these operations:
- baggage loading/unloading,
- cargo loading/unloading,
- aircraft fuelling,
- air conditioning supply,
- potable water service,
- toilet service,
- catering service,
- loading bridge,
- push-back.

In every operation specific equipments are used as conveyor belt loader, cargo loader, transporter, container dolly, aircraft fuelling equipment, aircraft movement equipment (push-back), potable water service equipment, toilet service equipment, air conditioning equipment.

The operations that are developed in presence of aeronautical noise are:
- the positioning of wheel blocks (heels and cones),
- the positioning of loading bridge,
- the control of the ramp operations from the employee,
- the push-back.

When the airplane is in position on the apron, the engines are shut off and heels are applied in front and behind the wheels of the anterior cart, to make an additional security locking aircraft beyond that provided by the brakes. These wedges are then removed during the departure of the airplane and that operation is usually performed after starting the engines. The worker that assures the positioning and the removal of the heels can also develop the operation of baggage loading and

of signaling during the arrival or the departure of the aircraft from apron.
The operator that has the assignment to operate the loading bridge, during the arrival and the departure of the aircraft from apron, and the operator who performs the entire phase of push-back, from the locking of equipment on to front carriage until the leaving of the airplane from the ramp, are also exposed to noise of jet engines of the aircraft.

The operations that are developed in presence of APU noise are:
- toilet service,
- baggage loading/unloading.

DESCRIPTION OF THE PROPOSED METHODOLOGY

The airport apron, where operations of "turn around" are carried out to provide assistance to aircraft in ramp, has several peculiarities compared to other workplaces. The entire handling process must follow precise and complex security procedures in which groups of workers performing heavy manual tasks or operations that require high expertise. Moreover most of the work takes place outdoors even under adverse environmental conditions.

Each activity follows a specific protocol in particular as regards the positioning of the equipment in ramp than the airplane and the other machines and its handling in the air-side. Each employee takes a job with highly variable over time during the working day both as a task both as a location: for example is responsible for the movement of the equipment in apron between parking area and the platform of standstill of aircraft; to approach equipment to aircraft and to move it in ramp; to perform specific processing which may require heavy manual work; to load to and unload from the cargo bay.

Moreover, the multiplicity of the type of sources, some temporarily fixed and some movable, leads to great variability of noise levels in the different positions on ramp, requiring therefore a large number of measurements and a very accurate analysis of tasks performed by employees and of the organization of work. Because of the preponderance of some sources over others and the high noise levels they produce, in the assessment of noise exposure the simultaneity among the different situations must be considered.

To allow smooth functioning of working and to ensure the safety of operators and persons engaged in the test, there is a real difficulty in performing measurements with the dosimeter or selecting grids of measuring points. This study proposes a procedure for determining the daily exposure levels to identify in the first instance preventive measures to enforce current regulation. The methodology for the assessment of noise exposure of workers/employees of the ramp, is divided into several stages.

1. First of all an analysis of tasks, performed by workers of the ramp, and of used equipments must be done during a typical day.

2. Then it is necessary to performe measurements, at or near the site operator, so that it is possible to characterize the noise sources to which the employee is subject in different operating conditions. The parameters needed for subsequent analysis are: equivalent continuous A-weighted sound pressure level refers to the sampling time $L_{Aeq,Ti}$, the peak level L_{Peak} in dB (C), analysis of sound pressure level for frequencies. During each measurement it is useful to record the audio signal.

3. The measurements should be related to different contexts in which workers are to be working throughout the day: when there is a single source and when there are various sources simultaneously including aeronautic source. Sometimes in addition to that there is the contribution due to sources located outside the ramp in use, such as the effect of an airplane entering the adjacent ramp.

4. Thus, it is possible to calculate a single value of L_{Aeq}, for each operator, determined as the average of noise levels in the different operating conditions. This allows to reconstruct the real acoustic environment to which the worker is subjected during the working day. The definition of the exposure time to different sound sources and the number of operations carried out are also essential to identify a typical day, including pauses of inactivity in acoustically protected locations or periods used to work in office.

5. The last step is the calculation of the daily exposure level, whereas the value of the total uncertainty (by sampling, instrumental and by positioning the instrument) and the upper bound of the unilateral interval corresponding to a confidence level of 95%.

MEASUREMENTS

For this study, a multichannel and multiprocessing sound analyzer (01dB Italia), of class 1, has been used for the measures in external environment, complying with the IEC 61672-1; EN/IEC 60651; EN/IEC 60804; DIN 45657; ANSI S1.4; ANSI S1.43. It's equipped with four microphones connected to a PC ti process the data in real time. For each measure can be recorded simultaneously the audio signal and several indexes as equivalent continuous A-weighted sound pressure level $L_{Aeq,T}$ in dB(A), peak level L_{peak} in dB(C), spectrum from 12.5 Hz to 20 kHz registered along the whole measurement. The data acquisition software dBFA Suite (01dB Italia) processes all acoustic parameters simultaneously. The analysis of environmental noise is made using the dBTRAIT32 application; it derives the sound pressure levels for definite periods, thus allowing to isolate individual operations carried out in the ramp.
While the measures inside equipments cab (transporter and push-back) were performed through a portable analyzer (Bruel & Kjaer 2250), modular precision integrating sound level meter, of class 1, with an immediate user interface.
Before and after each set of measurements the instrument was checked by the calibrator provided (ensuring that the deviation from the acoustic calibration level did not exceed 0.5 dB).

The measurements were performed with the worker present, located at the usual workplace, and with the microphone positioned near him during the execution of the activity or instead of him. In any case the measurement points were identified for safeguarding the health of the workers and the employees to the phonometric test and to allow the correct carrying out of the "turn around". The measurements were performed from July to September 2009 when air traffic is more intense, during "turn around" on different aircrafts (Boeing 767/300, Boeing 747, Airbus 310). Operations under board and equipments that are used are the same for the aircrafts investigated.

For the evaluation of the daily equivalent level of exposure it is necessary to consider all the possible situations in which the operators could be to operate within the working turn.
The possible operating situations can be:
A) operator of the single equipment or of the single working, with the background noise only;

B) operator of the single equipment or of the single working, with the background noise influenced by the entry in adjacent ramp of an aircraft;
C) more operators engaged simultaneously, influenced by the noise produced by the equipments, by the noise sources of the assisted aircraft and by the entry in adjacent ramp of an aircraft.

The Figure 1 shows the results of the measurements taken in situation A) for the following groups of workers:
– group 1 - toilet service, potable water service, aircraft fuelling, air conditioning supply;
– group 2 - catering service;
– group 3 - transporter (operation always contemporary to the cargo loader);
– group 4 - cargo loader (operation always contemporary to the transporter);
– group 5 - conveyor belt loader;
– group 6 - wheel blocks, loading bridge, push-back, ramp employee (operations that are developed in presence of aeronautical noise);

in situation B) for group 1 and in situation C) for group 5.
The operations that take place in the presence of aerodynamic noise (group 6) are characterized by an equivalent level in dB(A), integrated throughout their duration, greater than 87 dB (A).
For the user employed to push-back in Figure 1 level reported was measured during the phase in which the operator is working outside of the vehicle. During the removal of the aircraft form the ramp, which takes place with the operator inside the vehicle, $L_{Aeq,T}$ is 90 dB(A) and L_{peak} is about 118,5 dB(C). The equivalent levels measured in the vicinity of the equipment for loading and unloading baggage or cargo (groups 3, 4 and 5) are between 80 and 85 dB(A). For activities of the group 1 and 2 were detected equivalent levels below 80 dB(A). For group 1, during the entry in adjacent ramp of an aircraft the equivalent level (in figure indicated with 1*) is about 84 dB(A). Therefore it is essential to evaluate not only the situations where the different operations take place without particular environmental events, but also those in which an aircraft is approaching the adjacent ramp.

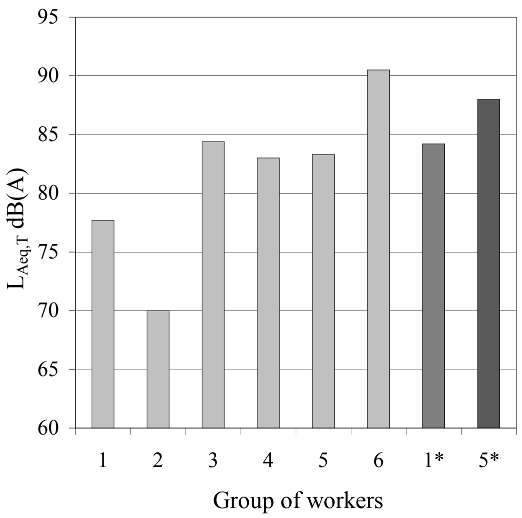

Figure 1. Equivalent level measured for single operation, for group 1 with adjacent aircraft (1*) and for group 5 with contemporary operations (5*)

Other measures were performed to identify the effect of simultaneous multiple operations on some workers, particularly for the operator on the conveyor belt loader, doing his job for the most part outside the vehicle when loading or unloading baggage between the baggage dolly and the conveyor belt, is also subjected to noise from equipments operating in their vicinity as the transporter and the cargo loader. In this case the equivalent level (in figure indicated with 5*) is 88 dB(A) instead of 83.3 dB(A). The level remains the same even when the operation is performed with APU running.

In Figure 2 the drawing shows the plan with the type and the position of the equipments and with the measuring point to detect the equivalent level at which the operator of conveyor belt loader is exposed, working together with cargo loading/unloading and with APU running.

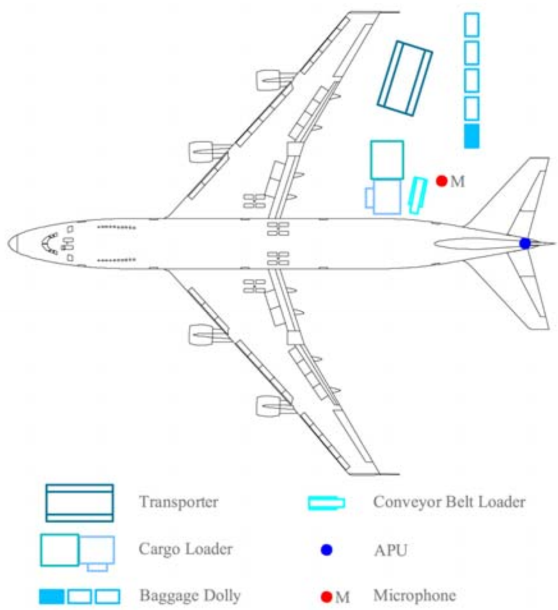

Figure 2. Plan showing the position of the equipments and the microphone during a measurement

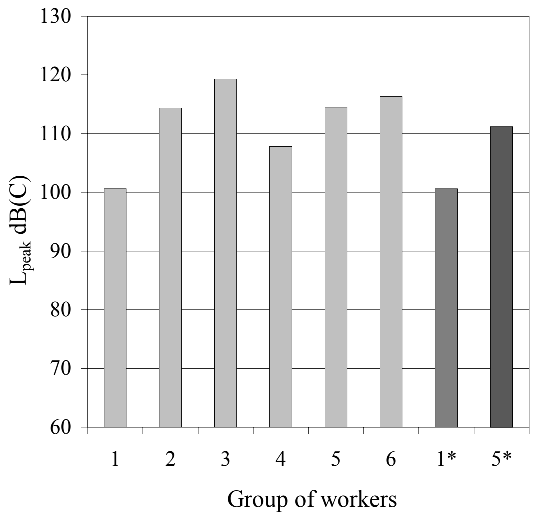

Figure 3. Peak level measured for single operation, for group 1 with adjacent aircraft (1*) and for group 5 with contemporary operations (5*).

The Figure 3 shows the peak levels measured in the same situations evaluated in Figure 1. The maximum values are approximately 120 dB(C) and do not increase with the entry of an aircraft in adjacent ramp or during contemporary operations.

APPLICATION OF THE PROPOSED METHODOLOGY

The proposed methodology for determining daily equivalent level of exposure was applied to ramp operators, considering the multiple contexts in which they conduct their activities. For each group of workers was identified a typical day during which alternate different environmental situations, linking equivalent levels to their exposure times. These levels were evaluated based on the data measured in the vicinity of the various sound sources, combining them appropriately with each other to represent all possible situations, and on the effects of noise on individual operators.

First of all the equivalent level was assessed for the cargo loader and the conveyor belt loader during the entry of an aircraft in the adjacent ramp. It was then performed a calculation starting from the equivalent level in dB for frequencies of the individual operation, of the background noise in the absence of special events and of the noise due to the entrance of a plane in the adjacent ramp. For example, for cargo loader (group 4) to the equivalent level in dB for frequencies was subtracted on a logarithmic scale the level of background noise for frequencies and then was added in logarithmic scale the spectrum of noise emitted by the approach of an aircraft in the adjacent ramp, obtaining at the end the value of 86 dB(A), greater than 3 dB(A) than that measured for the individual operation in the absence of special events (Figure 4). For the conveyor belt loader (group 5), applying the same methodology, the equivalent level is 87 dB(A), 3,7 dB(A) higher than that measured for single working (Figure 4).
Considering the regularity and frequency with which these situations are repeated throughout the working day and their impact on the level, were included in determining daily equivalent level of exposure.
Other possible situations that may arise in the "turn around" were then analyzed: the contemporaneity among different activities and the entrance of an aircraft in the adjacent ramp.

The equivalent level was determined for the worker of the cargo loader (group 4) whereas the presence of the operation of loading and unloading baggage with the conveyor belt loader and an aircraft approaching the adjacent ramp; for worker of conveyor belt loader (group 5) whereas the contemporary with the cargo loader, with the catering service and APU running; for worker of potable water service or fuelling (group 1), whereas the contemporary with the cargo loader in addition to the entry of an airplane in adjacent ramp. L_{Aeq} values obtained are 88 dB(A) for group 4 and 90 dB(A) for group 5 and group 1. For Group 4 (cargo loader) and Group 5 (conveyor belt loader) is reported in Figure 4 the measured value during the single operation, that calculated by considering an aircraft entering in adjacent ramp and that calculated by considering the contemporary with other operations.

For the employee to push-back were considered a representative level of the work conducted outside of the equipment during the waiting and preparation (coupling tractor to the front carriage of the airplane) and a level measured inside the equipment throughout the operation from the ramp to the taxi-way and from there to ramp.

The ramp employee with the task of controlling the "turn around" is exposed to noise due to all activities that take place in ramp and follows the entire operation of the push-back for most of the time outside of the equipment.

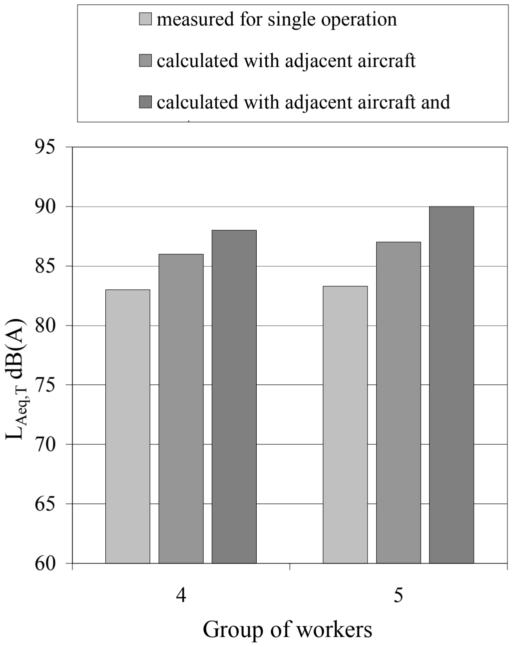

Figure 4. Equivalent level for some operations measured and calculated in different work situations

Therefore, a single value of $L_{Aeq,T}$ was calculated for each operator, calculated as the average of noise levels for the different working conditions (Figures 5 e 6 show L_{Aeq} for operator of conveyor belt loader and for operator of potable water service or aircraft fuelling).

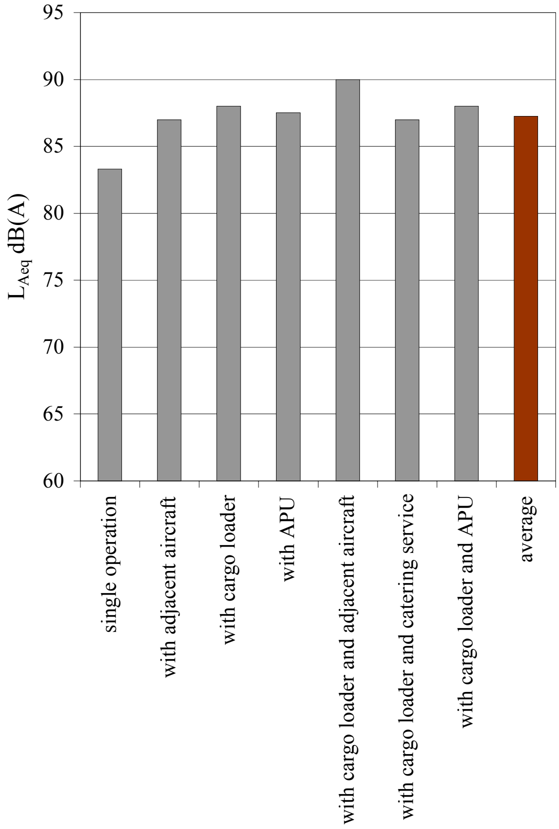

Figure 5. Equivalent level calculated for operator conveyor belt loader

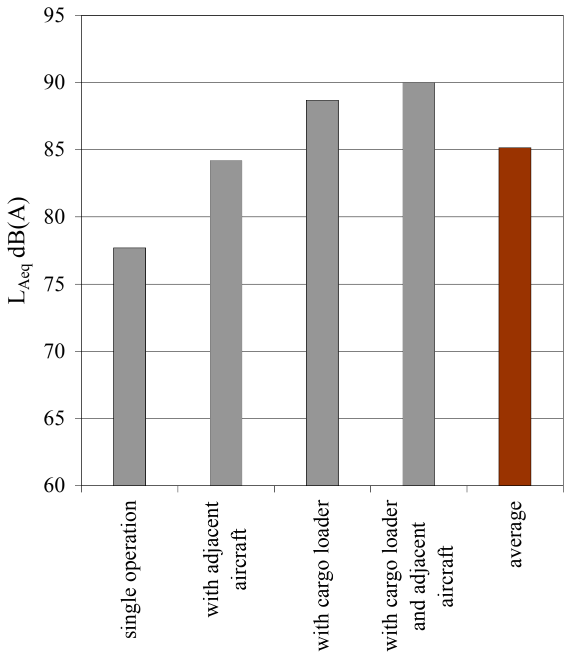

Figure 6. Equivalent level calculated for operator potable water service or aircraft fuelling

Even the data obtained from measures inside the rest rooms located near the apron were used; the equivalent level is assumed to be equal to 69 dB(A). The next stage was that of calculating the daily noise exposure level as specified by law and previously reported.

Two categories of workers were identified based on the type of contract:

- temporary seasonal operators who work in periods of intense activity 4 hours daily (3 hours and 30 minutes dedicated to the operations of the ramp and 30 minute to the physiological pause in the rest room); this category does not include workers employed to push-back to control the “turn around”;
- permanent operators who work throughout the year 6 hours daily (5 hours in ramp and an hour in the rest room).

Table 1 shows the daily exposure level values for the first category of workers and Table 2 those for the second category; Table 3 shows the peak level.

Table 1. Daily noise exposure level for operators - 4 h daily

Operator	$L_{EX,8h}$ dB(A)	$\varepsilon(Lex_{,8h})$	$\varepsilon_A(Lex_{,8h})$	$L^*_{EX,8h}$ dB(A)
Toilet service	80,0	2,2	2,1	84,0
Potable water service and aircraft fuelling	82,0	3,0	3,0	87,0
Catering service	67,0	1,4	1,3	69,0
Transporter	81,0	1,2	1,1	83,0
Cargo loader	82,4	1,5	1,4	85,0
Conveyor belt loader	84,0	1,5	1,4	86,5

Table 2. Daily noise exposure level for operators - 6 h daily

Operator	$L_{EX,8h}$ dB(A)	$\varepsilon(Lex_{,8h})$	$\varepsilon_A(Lex_{,8h})$	$L^*_{EX,8h}$ dB(A)
Ramp employee	85,1	1,2	1,1	87,0
Push-back	88,2	1,2	1,0	90,5
Toilet service	81,4	2,2	2,1	85,0
Potable water service and aircraft fuelling	83,2	3,0	3,0	88,0
Catering service	69,0	1,3	1,2	71,0
Transporter	82,4	1,2	1,1	84,5
Cargo loader	84,0	1,5	1,4	86,5
Conveyor belt loader	85,2	1,5	1,4	88,0

Table 3. Peak level for operators

Operator	Lpeak dB(C)	ε(Lpeak)
Ramp employee	116,3	1,56
Push-back	118,2	1,56
Toilet service	100,6	1,56
Potable water service and aircraft fuelling	100,6	1,56
Catering service	114,2	1,56
Transporter	117,0	1,56
Cargo loader	108,0	1,56
Conveyor belt loader	114,5	1,56

The catering service operator is exposed to levels smaller than 80 dB(A). The values for operator assigned to the transporter and to toilet service (4 hours daily) exceed 80 dB(A) but below 85 dB(A). Workers who perform the task of push-back, potable water service and fuelling, baggage loading/unloading for 6 hours daily are exposed to higher levels of 87 dB(A). For all other operators values are between 85 dB(A) and 87 dB(A).

CONCLUSIONS

Considering the influence on worker’s health and well-being of the effects caused by noise exposure in certain working sectors, the research aims to investigate this issue in an area not yet sufficiently analyzed and characterized by specific aspects, in order to evaluate the hearing loss and to propose preventive solutions.

The workplace investigated is the airport apron, where operations of “turn around” are carried out to provide assistance to aircraft in ramp in accordance with precise safety procedures, characterized by several peculiarities compared to other workplaces and in which there are many difficulties to perform an extensive measurement campaign in all operating conditions.

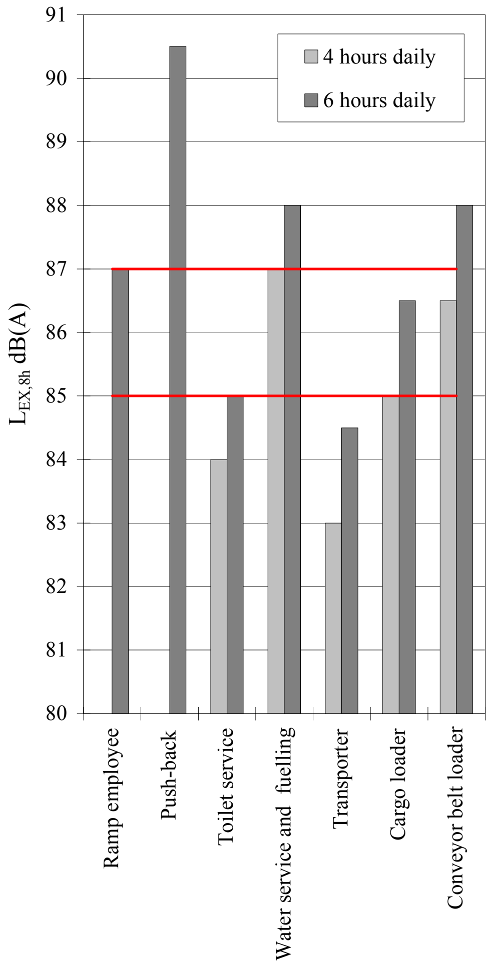

Figure 7. Daily exposure level calculated for each operator compared with the limits of the regulation

Within this research, the study presented here suggests, therefore, a methodology for assessing the daily noise exposure levels that has been applied to workers employed at an international airport in activities of baggage and cargo loading/unloading, fuelling, preparation and control of the aircraft at departure. The procedure allowed to characterize all possible operating situations, considering the variety of sound sources and activities which, in most cases, are performed simultaneously. By equivalent levels calculated for each operator, it was possible to determine $L_{EX,8h}$ after identifying the typical day and time of exposure, considering the periods of inactivity in the rest rooms.

From reading the daily exposure levels to noise evaluated including uncertainty, it is possible to notice that the only ramp's operators exposed to a level below 80 dB(A) are the workers of the catering service. The levels for the operators assigned to the transporter and to toilet service (4 hours daily) exceed 80 dB(A) but are below 85 dB(A); so these workers are not required to wear ear protection devices. All other workers are exposed to $L_{EX,8h}$ greater than or equal to 85 dB(A) and must use the protective devices. For some operators who work six hours a day together with other activities and other sound sources or are subjected to aerodynamic noise of the aircraft (operators of push back, potable water service and conveyor belt loader), the level is greater than 87dB(A); in this case, specific preventive measures should be taken. Particular attention should also be given to seasonal workers, engaged in manual work for which no special expertise is required, who are exposed to high noise levels.

The procedure, in the study applied to a specific international airport, can be applied to other airports where there may be other types of aircraft, equipment and security protocols in carrying out "turn around" operations.

The evaluation of daily noise exposure levels through the proposed methodology could be used to calculate the risk of auditory damage and to identify suitable preventive and protective measures such as:

– identification of appropriate personal hearing devices,
– optimization of the "turn around" procedures and working shifts,
– use of equipments with lower emission levels,
– improving the acoustic comfort in rest rooms,
– more information about the risks from noise in particular for temporary seasonal workers.

REFERENCES

1 R. L. Tubbs, "Noise Exposure to Airline Ramp Employees" *Applied Occupational and Environmental Hygiene* **15(9)**, 657–663 (2000)
2 A. Farina and L. Rocco, S. Solange, "L'esposizione al rumore degli aerie negli impianti aeroportuali" dBA '94 *Rumore e Vibrazioni – Valutazione, prevenzione e bonifica in ambiente di lavoro Modena, 20/22 ottobre 1994*, 409–416 (1994)
3 W. Krebs and M. Balmer, E. Lobsiger, "A standardised test environment to compare aircraft noise calculation programs" *Applied Acoustics* **69**, 1096–1100 (2008)
4 C. Asensio and I. Pavon, M. Ruiz, R. Pagan, M. Recuero, "Aircrafts' taxi noise. Sound power level and directivity frequency band results" *Applied Acoustics* **70**, 986–1008 (2009)
5 C. K. W. Tam and N. N. Pastouchenko, "Combustion Noise of Auxiliary Power Units" *11th AIAA/CEAS Aeroacoustics Conference 23-25 May 2005, Monterey, California*, 1–24 (2005)
6 EU. Directive 2003/10/CE of the European parliament and of the council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (2003)
7 Gazzetta Ufficiale del 30 aprile 2008, n°101, *Decreto Legislativo 9 aprile 2008, n°81 - Attuazione dell'articolo 1 della legge 3 agosto 2007, n°123, in materia di tutela della salute e della sicurezza nei luoghi di lavoro*. Gazzetta Ufficiale del 05 agosto 2009, n° 180, *Decreto Legislativo 3 agosto 2009, n. 106 - Decreto integrativo e correttivo del D.Lgs. n°81*
8 ISO. International standard, *ISO 1999:1990 Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment* (1990)
9 ISO. International standard, *ISO 9612:1997 Acoustics – guidelines for the measurement and assessment of exposure to noise in a working environment* (1997)
10 UNI. Ente Nazionale Italiano di Unificazione, *UNI 9432:2008 Determinazione del livello di esposizione personale al rumore nell'ambiente di lavoro* (2008)