

MEASUREMENT METHODS AND ANALYSIS OF AIRPORT NOISE

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APAT

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1 – TECHNICAL NORMS FOR THE EXECUTION OF THE MEASUREMENTS ACCORDING TO THE ITALIAN REGULATIONS

The evaluation index of the airport noise, in order to the determination of the iso-level curves, is the evaluation level of the airport noise (L_{VA}).

The level of the airport noise is defined by the following expression:

$$L_{VA} = 10 \log \left[\frac{1}{N} \sum_{j=1}^N 10^{L_{VAj}/10} \right] dB(A)$$

in which:

L_{VA} represents the evaluation level of the airport noise;

N is the number of the days of the period of phenomenon observation and

L_{VAj} is the daily value of the evaluation level of the airport noise.

The number of the days of the period of phenomenon observation **N**, must be twenty-one, equal to three weeks, each one chosen within the following periods:

1 OCTOBER - 31 JANUARY;

1 FEBRUARY - 31 MAY;

1 JUNE - 30 SEPTEMBER.

The week of observation inside every period must correspond to the week with the greatest number of flights, according to the data supplied by the Ministry of Transports and of Navigation, or detected by the installed monitoring systems. The noise measurement, during every week of observation, will have to be performed continuously in time.

The daily value of the evaluation level of the airport noise (L_{VAj}) is determined through the following relationship, considering all land and of overflight operations occurred during the whole day (00:00 and 24:00 hr):

$$L_{VAj} = 10 \log \left[\frac{17}{24} \cdot 10^{L_{VA_d}/10} + \frac{7}{24} \cdot 10^{L_{VA_n}/10} \right] dB(A)$$

where L_{VA_d} and L_{VA_n} represent respectively the evaluation level of the airport noise in the diurnal (06.00 - 23.00 hr) and nocturnal (23:00 – 06:00 hr) period.

The evaluation level of the airport noise in the diurnal (L_{VAd}) period is determined by the following relationship:

$$L_{VAd} = 10 \log \left[\frac{1}{T_d} \sum_{i=1}^{N_d} 10^{SEL_i/10} \right] dB(A)$$

in which $T_d = 61.200$ s is the duration of the diurnal period, N_d is the total number of aircraft flights in the same period, SEL_i is the level of the i^{th} sound event associated to the single flight.

The evaluation level of the airport noise in the nocturnal (L_{VAn}) period is determined by the following relationship:

$$L_{VAn} = \left[10 \log \left(\frac{1}{T_n} \sum_{k=1}^{N_n} 10^{SEL_k / 10} \right) + 10 \right] dB(A)$$

in which $T_n = 25.200$ s is the duration of the nocturnal period, N_n is the total number of aircraft flights in the same period, SEL_k is the level of the k^{th} sonorous event associated to the single flight.

The level of the i^{th} sound event associated to the single movement of aircrafts SEL_i is determined by the following relationship:

$$SEL_i = 10 \log \left[\frac{1}{T_0} \int_{t_1}^{t_2} \frac{p_{A,i}^2(t)}{p_0^2} dt \right] = \left(L_{Aeq,Ti} + 10 \log \frac{T_i}{T_0} \right) dB(A)$$

in which:

- $T_0 = 1$ s is the reference time
- t_1 and t_2 represent the initial and final instants of the measure, or the duration $T_i = (t_2 - t_1)$ of the event i in which the level L_A results greater than the threshold $L_{AFmax} - 10dB(A)$;
- $p_{Ai}(t)$ is the instant value of the “A” weighted sound pressure of the event i^{th} ;
- $P_0 = 20$ μ Pa represents the reference sound pressure;
- $L_{Aeq,Ti}$ is the equivalent continuous level of “A” weighted sound pressure of the i^{th} sound event.
- L_{AFmax} is the maximum level of the sound pressure in “A” weighting curve, with the time constant "Fast", related to the event.

2 – Instrumentation and methods of measure

2.1- Measure Systems

The measuring system of the airport noise must be distinguished into:

- a) Assisted system;
- b) No-assisted system.

The assisted system is specific for measurements carried out using mobile instrumentation in which a noise meter or integrator of class 1 with characteristics foreseen by the reference EN norms can be used. The noise meter must be able to measure the **SEL** at least, and must allow to memorize in numerical form, on a graphic recorder or on an electronic computer, the L_{AF} (Level of “A” weighted sonorous pressure in time constant Fast) of aircraft flights. The assisted measuring system must be able to keep EN specifications also in the worst climatic conditions.

The no-assisted system is specific for fixed monitoring measurements. It must be a levels analyzer type, equipped with microphone for outdoor measurements with autocalibration system. It must have the possibility to characterize automatically the profiles of the overflights and also the possibility to assign the corresponding value of SEL to each one of these profiles.

No-assisted survey systems must be able to determine:

- 1) The level of the sonorous event **SEL**;
- 2) The interval of time in which the prefixed threshold has been exceeded;
- 3) The time in which it verifies;
- 4) Graphical representation of L_{AF} .

In the assisted systems, the operator determines the interval of time in which, during an overflight, the SEL has to be measured.

2.2 – Microphone position

In the cases of assisted and no-assisted systems, the microphone must be located so that the view line between the microphone and all the possible routes of overflight is not interrupted by some solid obstacle. The microphone will have to be located on an acoustic reflecting solid surface, at an height not lower than 3 meters from the ground level in the case of free surfaces, or from the base of a building. The distance of the microphone from any vertical reflecting surfaces must be at least equal to their height referred to the same microphone.

2.3 - Microphone Characteristics

In the assisted measuring systems, it must be used a microphone with characteristics of precision meeting requirements of EN norms in the field, and equipped with anti-wind cap. In no-assisted systems, the microphones of the phonometric chain must be able to maintain the specific demand for precision in the most unfavorable climatic conditions. The microphone must moreover be protected using an anti-wind cap and an anti-bird protection.

2.4 - Meteorological conditions

In the final report, the meteorological conditions during the phonometric measurements and the measured values of temperature, pressure, humidity and wind speed will have to be quoted.

2.5 - Verification of stability and calibration

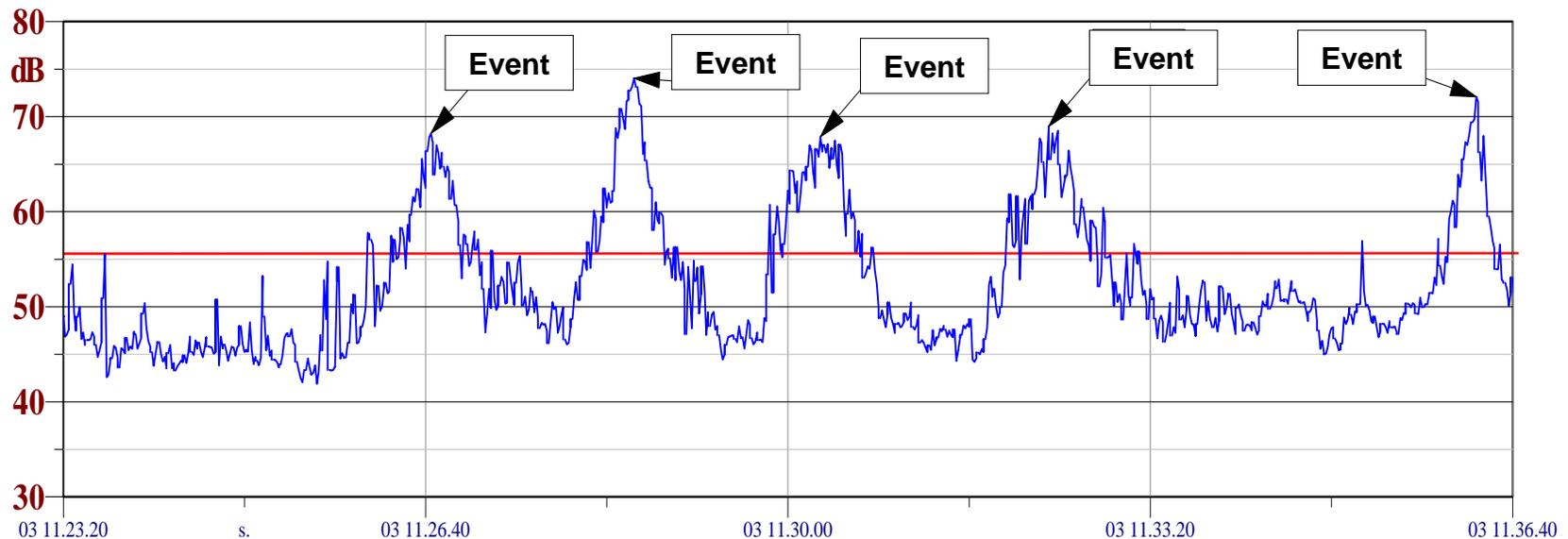
In the no-assisted systems, the stability of the entire phonometric chain (from the microphone to the acquisition and reading data device) must be verified at least every 24 hours by means of a sonorous source with known level. Moreover, calibration by using a standard source complying at least with class 1 of EN norms must be performed each time a technical intervention on the same chain has been executed. This information is valid also for the assisted systems, with the difference that the calibration has to be carried out before and after each measuring campaign.

2.6 – The use of previsional models

For the definition of anti-noise procedures and acoustic characterization around airport, previsional models can be used. The results of the application of such models must supply the values of the indicator of airport noise L_{VA} as requested by Annex A.

Acknowledgment of the sonorous events

Example of identification of the sonorous events based on the determination of a noise threshold (red line) and a minimum time duration of the event



For each event it has been derived the value of the SEL and all these events have contributed to the determination of the acoustic indicators:

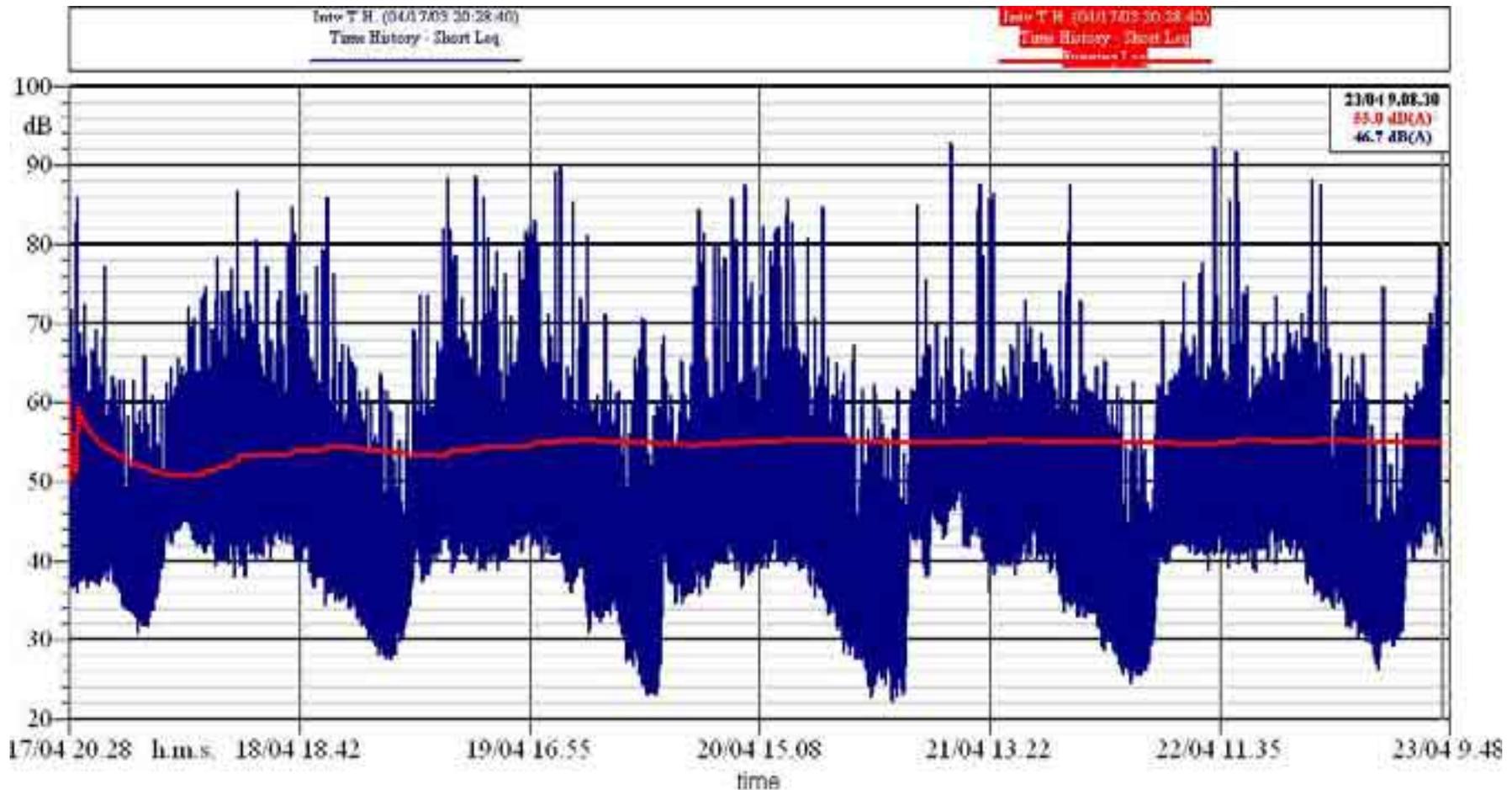
$L_{VA,d}$ “diurnal events evaluation level” (06:00-23:00 hr) (dBA) ;

$L_{VA,n}$ “nocturnal events evaluation level” (23:00-06:00 hr) (dBA);

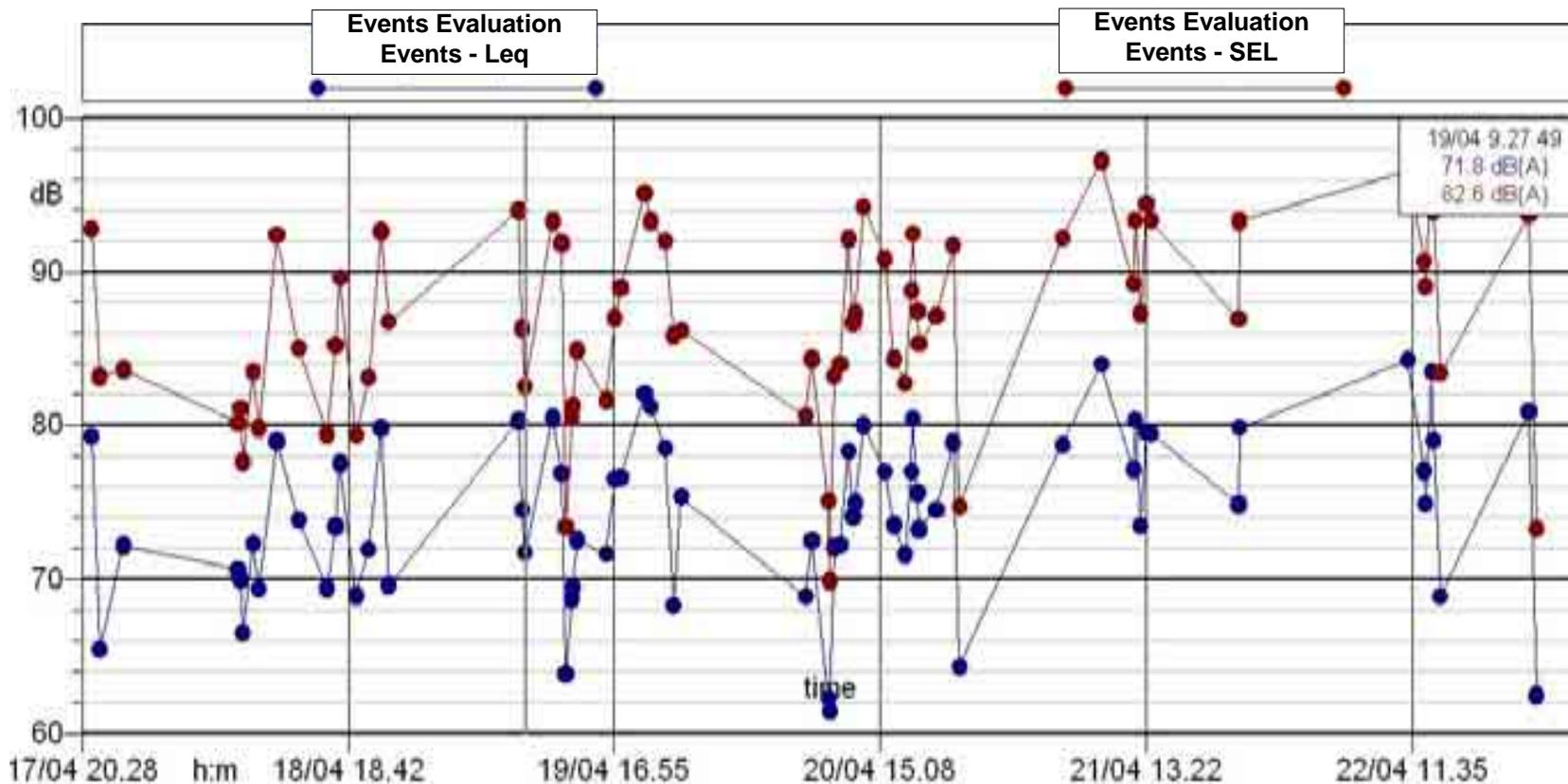
$L_{VA,j}$ “daily events evaluation level” (00:00-24:00 hr) (dBA);

L_{VA} “Annual value”.

Example of the airport noise monitoring carried out for 24 hours.



Example of post-elaboration of the acquired data from monitoring of the airport noise carried out for 24 hours and with the identification of the events



N.diurnal events : 316 N.nocturne events : 10 N. total events: 326

$L_{VA,d(6-23)}$: 54,5 dB

$L_{VA,n(23-6)}$: 44,5 dB

3 – Acoustic characterization round about airport

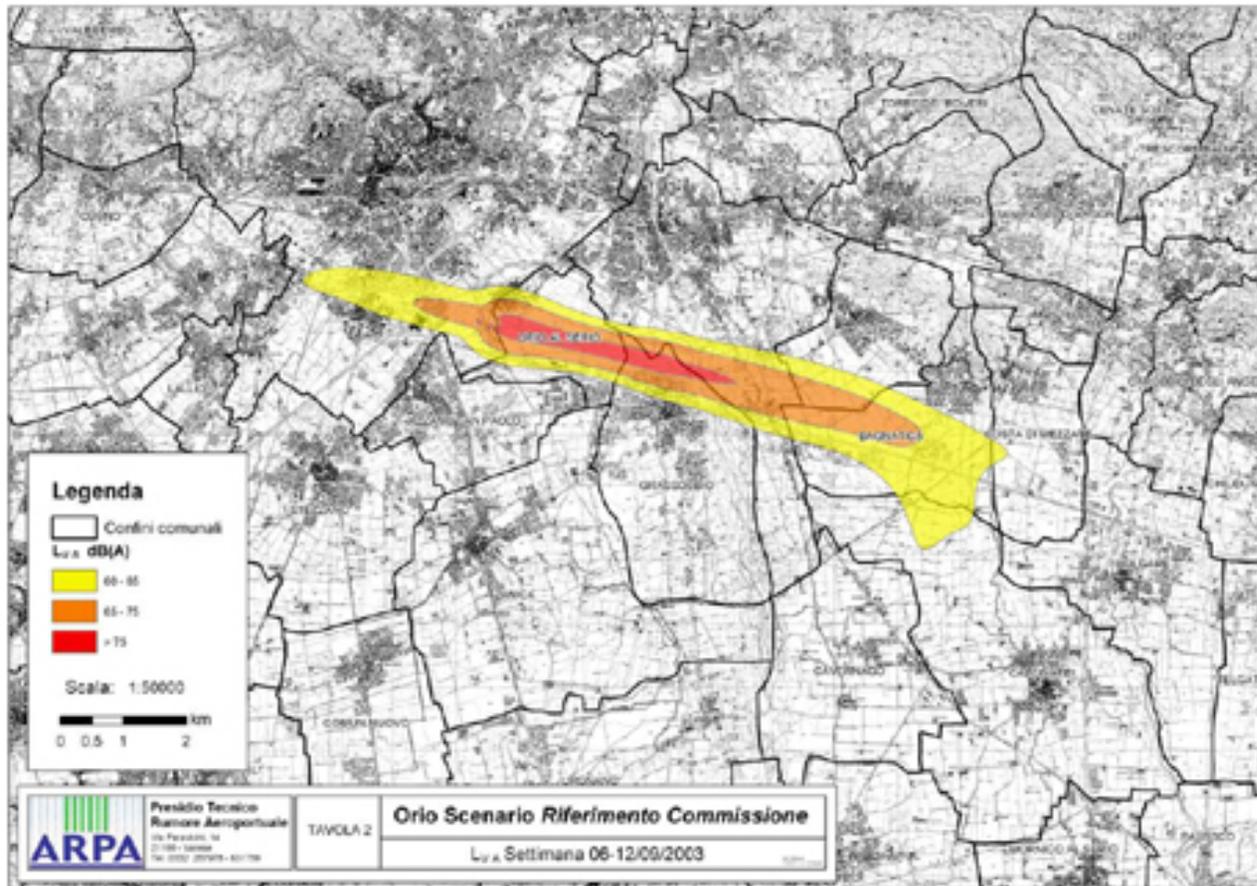
1. The commissions foreseen by article 5, paragraph 1, of the present Decree, by taking into account the airport regulatory plan, the instruments of enforced territorial planning and urban planning and of the adopted antinoise procedures, define around airports the borders of the following restricted areas: zone A, zone B, zone C.

2. Into these zones the following limits for the noise produced by the airport activities as defined by article 3, paragraph 1, letter m), point 2), of the law n. 447 of 26 October 1995, are in force:

- zone A: the index L_{VA} must not be greater than 65 dB(A);
- zone B: the index L_{VA} must not be greater than 75 dB(A);
- zone C. the index L_{VA} must not be greater than 75 dB(A).

3. Beyond zones A, B and C the index L_{VA} must not be greater than 60 dB(A).

Example of restricted zones delimitation



Source: Arpa Lombardia – Maurizio Bassanino

Radar Tracings - Malpensa (MI)



Source: Arpa Lombardia – Maurizio Bassanino

4 – ITALIAN LEGISLATION IN THE FIELD

- Law n. 447 of 26 October 1995,– *“General policy law on acoustic pollution;*
- Decree of the Ministry of the Environment 16 March 1998 - *“Techniques of survey and measurement of acoustic pollution”;*
- Decree of the Ministry of the Environment 31 October 1997 - *“Methodology of measure of the airport noise”;*
- Decree of the Ministry of the Environment 3 December 1999 - *“Antinoise procedures and restricted zones in the airports”;*
- Decree of the Ministry of the Environment 20 May 1999 - *“Planning Criteria of monitoring systems”;*
- Decree of the President of the Republic n. 496 of 11 December 1997- *“Concerning banning of nocturnal flights”*