Brüel Acoustics

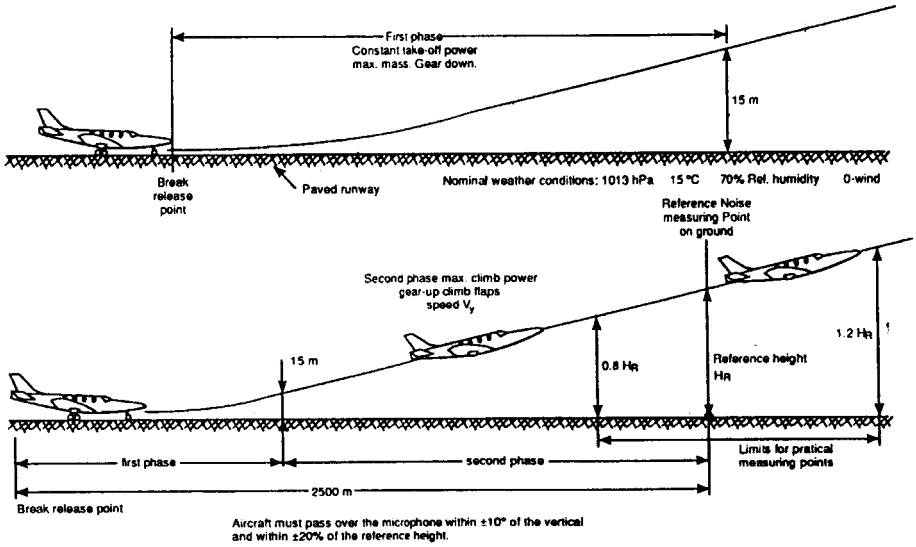
99-01

Technical Review

To Advance Techniques in Acoustical and Noise Abatement Services

Noise Evaluation of Small Airfields

Presented at the First International Symposium on Recreational Noise, its Effects on Man and the Environment. 1998 Nov. 20th, Queenstown, New Zealand.



Dr. Per V. Brüel received his post-graduate M.Sc. in 1938, with electronics and acoustics as his specialised subjects of study. PVB was drafted to the army in 1939 and at the military radio laboratory he constructed the first acoustic analyzer in the world (using RC feedback). PVB was responsible for the acoustics at the Danish broadcasting house while it was being built. He became Associate professor at Chalmer's Technical University in Gothenburg, Sweden in 1942. Here the prototype of the famous Level Recorder was developed, based on a logarithmic electrodynamic principle. PVB became a Doctor of Science in 1944. Co-founder of world-renowned acoustics company Brüel & Kjær in 1944, Dr. Brüel has developed many advanced measuring instruments for acoustical use, including the first stable condenser microphone (crystalline connection of the diaphragm). PVB is an honorary member of several acoustical societies, has received many medals from scientific societies, and has received honorary doctorate degrees from seven universities.

PVB is at present working on a special research project: For a long time there has been an inexplicable paradox. Industrial workers who are exposed to noise suffer irreparable damage to auditory nerves in the frequency range 5-7 kHz, but the noise they have been exposed to is loudest in the range 500-1000 Hz. The damage thus occurs at frequencies about 3 octaves higher than the range in which where the sound is strongest. In 1973 PVB explained the paradox and for this work received the Lord Rayleigh Gold Medal 1974. Work on the problem now continues together with Ålborg University and the US Army Laboratory for Small Arms. The goal is to develop an instrument which shows the risk of induced hearing damage at places of work, schools, orchestras and also from leisure activities such as flying, motoring and shooting.

Brüel Acoustics is an international development company engaged in research and construction of prototypes within acoustics, noise control and speech intelligibility. Brüel Acoustics (BA) uses the acoustical, electronic and physical knowledge which the world-renowned company Brüel & Kjær has built up throughout 50 years. Brüel & Kjær was sold to a German concern in 1992 and during a subsequent rationalisation, many knowledgeable and experienced engineers became redundant. Brüel Acoustics now makes use of these engineers' knowledge and experience.

B&K only makes measuring instruments whereas Brüel Acoustics develops acoustical absorbers, distributors, and production systems as well as measuring systems.

In co-operation with the newest of Italy's university hospitals, a minor division of BA in Rome carries out research on induced hearing loss.

Brüel Acoustics receives its income through the sale of licences and development of prototypes. Furthermore, some research and development is paid or partly paid by the EU. Brüel Acoustics has also had PhD students from European universities who have worked in Denmark on their final thesis. In this way, research papers which normally are done at the universities get a practical touch which make them useful to industries and national institutions.

The results, which are obtained in Denmark and Italy, are published in the periodical *BA Technical Review*, which is issued 4-6 times a year. It is published in English, but if there is a need it may also be issued in other languages.

Noise Evaluation of Small Airfields

Dr. Per V. Brüel, Brüel Acoustics, Denmark

Aircraft noise from small airfields and airstrips irritates many people living nearby. Although the noise from a small airfield is a thousand times less than that from a large commercial airport, many people want the small airfield to be closed or at least activities drastically reduced. The arguments offered for closing the airfield are not only the noise, but also other factors such as:
1) Flying small aircraft is unnecessary and only a toy for well-to-do people.
2) Small aircraft use valuable fuel which contains toxic chemicals and lead.
3) Flying is dangerous and the aeroplanes may crash on houses and property.

These arguments are often exaggerated, but noise itself is a problem we have to do something about. Flying has many advantages, particularly for young people and therefore also for society.

1) Flying small aircraft is the easiest and cheapest way to learn to fly. Society needs pilots. Both the military, police, and commercial air companies prefer young people who have shown an interest in flying light aircraft, ultralights or gliders.
2) Most small airfields are owned or at least run by a local flying club. The members of the club must exercise a strict discipline not only for safety reasons, but also for environmental reasons.
3) In most cases a small airfield has restricted areas which are closed to dogs and non-authorised persons. In these areas we often see interesting wildlife and vegetation which cannot survive in open parks. (Ref. 1).
4) In many flying clubs, the members do all kinds of maintenance and handwork such as painting, welding, mechanical overhaul, in addition to learning physics, aeronautics and meteorology at a fairly high level. All very useful later in life.
5) As flying activities do not go together with alcohol and drugs, members of a flying club will not be tempted to these dangerous and tragic habits which ruin and end many young peoples' lives (approx. 1000 times as many as by fatal flying accidents).
6) When disasters, accidents, or sudden illness happen at remote places or islands, helicopters and light aeroplanes are the only way to bring help and save lives. We therefore need small landing strips both at remote places and close to hospitals or main roads.
7) Last but not least, it is a dream of most children to fly. Boys and girls like to go to the nearby airfields just to watch the planes, gliders, ultralights or model aeroplanes, and when they grow up they can actively participate and their dreams turn into reality.

For all of these reasons we have to preserve the present small airfields and landing strips. We should also build new ones. On the other hand, all unnecessary noise and consumption of fuel should be avoided. It should be a pleasure to be a neighbour to a small airfield.
The population's attitude to aviation in general varies and can be divided into different categories. By far the largest group of about 80% enjoy travelling by air and about 50% of them are interested in aviation matters. This interest may arise

from the physics of both birds and aeroplanes, or how the airlines manage the business or how air travel influences our daily business and life. But at the same time, there are many people who like to travel by air, but do not like to be disturbed by the noise from small aeroplanes. And there is a very small group which hates aeroplanes so much that the sight of an aeroplane or glider is enough to incite morbid fanaticism. It is the goal of this paper to suggest a method, which satisfies the majority of people.

The method is to make it profitable for manufacturers to produce low-noise light aeroplanes, ultralights, motorised gliders, hot-air balloons etc.

The technical skill to develop low-noise flying equipment already exists, but manufacturers need some motivation to produce low-noise aircraft (ref. 2.). The motivation will come if we can make some sensible rules or regulations that give manufacturers an economic incentive.

The Federation Aeronautique Internationale, Paris (FAI) (now Lausanne in Switzerland), which is the umbrella organisation for most aeroclubs world-wide, has realised that something has to be done to preserve small airfields (ref. 3.). The FAI makes suggestions and recommendations to all flying clubs for making as little noise as possible, not to fly over sensitive areas and to use authorised corridors etc. But experience shows that recommendations are not enough. Many young aviators like the sound of light aircraft too much. Therefore we must have some fixed legal rules to control and guide development. The rules must be the same in all countries, be clear and logical, and not too expensive to implement. The long-term goal is that on the whole low-noise equipment is manufactured, sold and used in future.

For the time being local authorities make their own rules, which vary for each individual airfield. The most common rules or restrictions are:
1. Only a certain number of operations can take place at the field per year or during a three month period. Operations include both take-offs and landings, or 2. No school flights are permitted at weekends, or 3. No heavy aircraft or twins-engine aircraft are permitted, or 4. Only business and taxi flying are permitted, or 5. No tows of gliders or lifting of parachutists are permitted, or 6. No operations permitted at all at weekends, or evenings after 6 p.m., or only on Wednesdays, or any other combination.

If the purpose of such measures has been to reduce noise, none of the above-mentioned regulations are of any use, mainly because there is no benefit to either the manufacturer to make or the user to buy low-noise equipment. All regulations should involve noise and fuel consumption.

Therefore, a simple and direct way to regulate the noise from an airfield is to add up the noise from every aircraft taking off. Careful studies have shown that most of the complaints are generated by the starting and climbing of aircraft (ref. 4). Light planes flying across country do not seem to trouble anyone. So if we can control the starts, we can control 95% of the noise.

There is a great variation in noise emission from different light aircraft. For example, a Cessna FR 172, noise no.77.4 dB is about ten times as noisy as a Cessna

150, noise no. 67.8 dB. Such a remarkable variation in noise emission proves that a drastic reduction of noise is possible.

We therefore need rules and procedures in accordance with which the total noise around an airfield can be determined. These rules should be worked out as an international standard issued by ISO or as a recommendation from ICAO (ref. 5.) No limits should be mentioned in this standard procedure. It must be up to local authorities to lay down sensible limits. The limits can be different according to local circumstances. When technical developments permit, the limits can be lowered. With fixed procedures and predetermined limits, we can avoid many uncertainties and discussion. If the noise from an airfield exceeds the limit, the airfield or flying club is fined, but if it operates below the limit, operations can continue and complaints should be rejected.

For light propeller-driven aircraft, the ICAO has required that all light aircraft, according to weight, must comply with a certain noise limit before they can be registered in an ICAO country (ref. 6). Every light aircraft must have a certificate onboard indicating the maximum noise it radiates to the ground. We call this noise level the "noise no." of that particular aircraft. The noise no. is very accurately determined and given in dB with an accuracy of ±0,1 dB. When suggesting a sensible procedure for evaluating small airfields therefore, we should use the aircraft noise no. If we do this, we can avoid all noise measurements at small airfields.

We would like to have one single figure which represents the total noise in a given space of time, e.g. an hour, a day, a weekend, a week or a month. We could imagine that we, as indicated on fig.1, have placed a ring of microphones around the airfield. We can then measure the noise on the ground for every aircraft leaving the field. We add the noise from the individual aircraft and get one single figure. This figure gives us a measure of the total noise which the airfield is responsible for during the time of observation.

This is not simple because aeroplanes of all kinds with different speeds and heights are coming from the airfield and going in different directions. With a large commercial airport the problem is much simpler as the takeoffs and landings all occur in one or only a few directions, and all planes have almost the same speed and climb profile. So a few points of observation are sufficient to describe the total noise. But if we use the same method at a small airfield, we must use at least 12 microphones arranged in a circle. We have to choose the distance, R, from the field at which the microphones should be placed. When that is done, we must find the noise, or more correctly the noise dose, that every aircraft start produces. The noise must be evaluated in the same way as we evaluate the noise from industries and roads, i.e. the integral of the squared sound pressure multiplied by the time duration. Fig. 2 shows an aircraft flyover in which the sound pressure is measured in dB_A and a "Slow" time-weighting is used. The integral of the entire flyover therefore has to be found by converting the log values to linear values. Then for every second the sound pressure must be squared and summed. We could also use an integrating sound level meter, which integrates the entire flyover curve. In this way we obtain the noise dose for every aircraft start, normally expressed in Pa^2s (ref. 7). A powerful low-flying aircraft will contribute with a large dose, whereas a high-flying low-noise aircraft will contribute with only a very small dose.

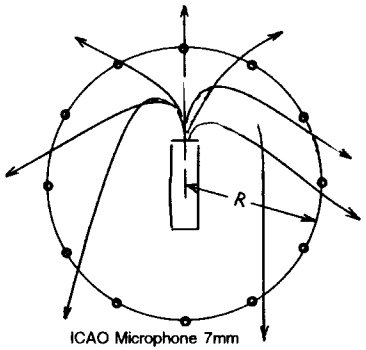


Fig. 1: Light aircraft flying in all directions. Therefore a min of 12 microphones are needed. Distance R is 2.5 km.

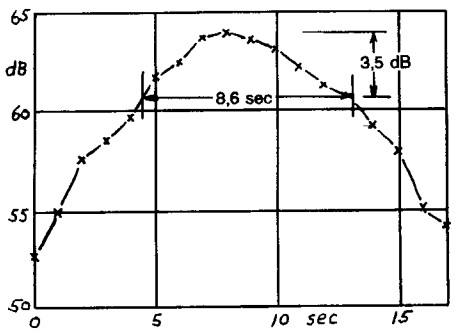


Fig. 2: Noise from light aircraft measured by a fixed microphone on the ground.

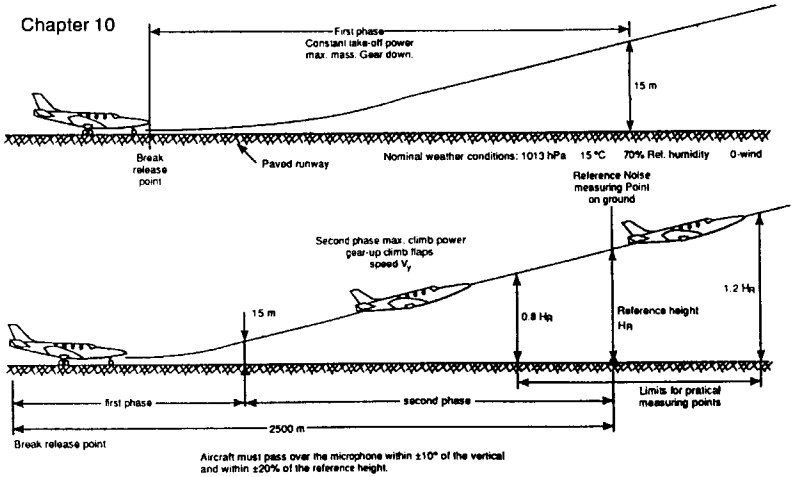


Fig. 3: Procedure for measuring and obtaining the noise no. for light aircraft according to ICAO Annex 16, Chapter 10.

When adding all aircraft starts together from all 12 microphones, we obtain the total dose for a day, week, or a year, normally expressed in Pa^2s. If we want the average noise level, L_{eq}, we can simply divide by the total time and convert to dB.

The electronics required are not quite as simple. Only one microphone at a time must be selected and the others suppressed. The electronics must only measure the aircraft noise and not other noise sources. We have experienced that not only other traffic, but also insects make a terrible noise when they are active close to the microphone diaphragm. We have also experienced that if the pilot knows the location of the microphone, he has flown at full power until he is in the vicinity of the microphone and then slowly cuts power to a minimum. Full power is again applied once the aircraft has passed the microphone. We have also seen people trying to make false noise by placing a transportable radio near the microphone site. So all in all, measuring the aircraft noise from a small airfield is both complicated and extremely expensive. Evaluation of the total noise has the following advantages:

1) One single figure only can express the noise impact on the surroundings. So different airfields can easily be compared.
2) The total noise evaluation uses the same basic elements as used for evaluating noise from industry and road traffic.
3) The evaluation can be used by local authorities to regulate the noise simply by requiring a certain limit for the total noise expressed in Pa^2s or in L_{eq}.
4) But by far the most important value of this procedure is the motivation of manufacturers to develop low-noise equipment and the users of light aircraft to buy it. If a user can fly 20 times as much with a low-noise aircraft as with today's noisy aircraft from one particular airfield, he will choose the low-noise equipment and maybe be prepared to pay slightly more for the new equipment. In this way, the noise from the light aircraft can be drastically reduced and at the same time the number of operations increased.
5) The owners of airfields can decide if they want to have many starts and landings with low-noise aircraft or fewer starts and landings with noisy aircraft.
6) In many places we do not like noise during the night. A good regulation is to impose a penalty for night operations by adding 10 dB to the noise during the period from 10 p.m. to 7 a.m.

We can see that the expense of measuring the noise from a small airfield as outlined above is very high. No flying club or airfield owner can afford to buy and operate such an installation. It is the purpose of this paper to show how the noise evaluation can be drastically simplified using the very accurately measured noise no., which is required in all aircraft registered in an ICAO country.

We could express the noise using many parameters, but extensive investigation of most of the literature reported by Dr. Henning van Gierke, (ref. 8) has shown that the noise dose expressed as Pa^2s or L_{eq} is the most appropriate unit. Consequently to suggest something else would require extensive and careful investigation.

The Sound Level Meter (SLM) should read L_A, which is also used for measuring noise from indoor and outdoor industry, noise from roads, railways, ships, and practically everything else. The SLM is set to frequency weighting curve A (L_A). Around larger airports a special weighting called the D-weighting is often used, but we should stick to the A-curve and be in line with measurements of other traffic noises.

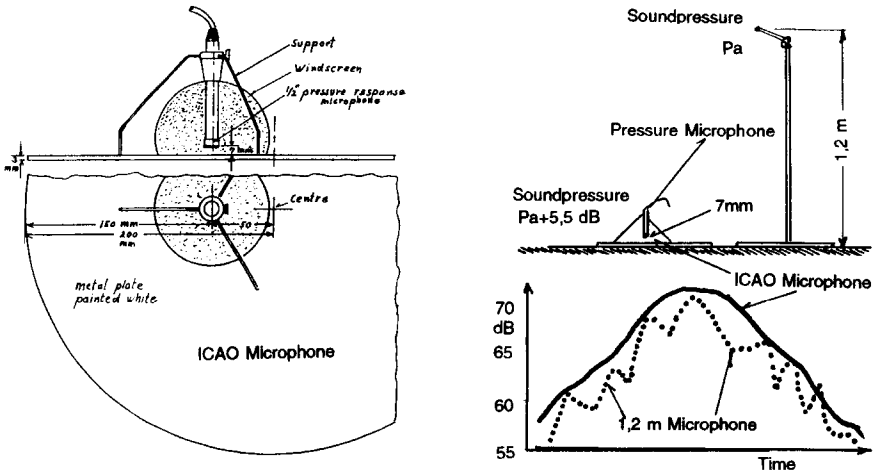


Fig. 4: Left: Microphone arrangement for measuring aircraft noise according to ICAO, Chapter 10. To the right is shown the standard microphone position for measuring noise from industry, road traffic, railway. By measuring at the ground level the aircraft noise is about 3 dB higher than for a microphone at a height of 1.2 m.

In industry and on roads we use the "Fast" (F) time-weighting, but for aircraft noise where the level variation is low, it is customary to use the "Slow" (S) time-weighting, and we suggest that is done here when we express a noise level. After careful investigations the FAA has found that the noise from aeroplanes climbing is most disturbing, which is natural as the aircraft is at maximum power when climbing (ref. 4). Also the distance from the airfield has been discussed. Very close to the field, people expect some noise, whereas people further away do not want to be disturbed by a higher noise level than that from normal road traffic, wind turbulence, and other natural sounds. The FAA has suggested a distance of 2.5km, which has been adopted by ICAO (ref. 5) for certification purposes (ref. 6).

Noise Certification

Fig. 3 shows a schematic representation of the procedure that is in use according to ICAO, Annex 16, Chapter 10. It is seen that measurement of the aircraft when it is climbing is made on the ground 2.5 km from the starting point. The aircraft is measured with full load, at max. permissible power and at standard atmosphere (15°C and 1013.2 hPa). This means that the measured level is the maximum noise which that particular aircraft can produce. The microphone set up is also well described. The microphone is close to the ground and therefore indicates about 6 dB more than if it were 1.2m above the ground (fig. 4).

To measure the sound from a light aircraft at ground level means that the measurement results are smoother than if the microphones are placed some distance from the reflecting ground. The sound from the aircraft is measured as the direct sound mixed with the reflections. As the aircraft moves, the reflections will be added and subtracted alternatively from the direct sound which results in very irregular measurements (Fig. 4). By having the microphone at a reflecting plane on the ground, a smooth result is obtained. All reflections are added and the results are theoretically 6 dB higher. In reality the difference is only 5.5 dB, (see 9). Fig. 5 shows the present limits for noise radiation for propeller-driven aircraft up to 9 ton MTOM (refs. 6 and 10). It is seen that the permissible noise depends on the mass of the aircraft. Aircraft over 1500 kg may produce 12 dB more noise than an aircraft with a mass of 600 kg. This is very liberal for the heavier aircraft, but often difficult to comply with for the lighter category of aircraft. ICAO is now proposing a 6 dB lower limit for light aeroplanes and 3 dB lower for aeroplanes lower than 1500 kg. That will make it difficult for the manufacturers of light equipment. Many small home-built and experimental aircraft will never be able to be registered. FAI has therefore suggested that the new limit curve should be reduced by 3 dB, including the very light aircraft. This means maintaining 12 dB difference for all categories.

It has to be stressed that the rules recommended by ICAO operate as a law in all member countries, i.e. no aircraft can be registered in a member country if the noise emission is higher than that recommended by ICAO. But a country can exercise stricter limits. Germany has done this, so German aircraft must have a noise no that is 4 dB lower than that required by ICAO. The German government has published its intention to further tighten these limits. It is unclear if such a step is legal for a EU country. In any case it will be the best solution if all countries have the same requirements. If it is different in the EU countries, it is a hindrance to free trade.

Suggested Method for Evaluation of Small Airfields

In our proposal here for the evaluation of smaller airfields we will use the measured noise numbers, which exist for most aircraft, as a basis for how the noise is measured and heard on the ground.

The procedure is very simple, no measurements have to be performed. It is as follows:

1) For every aircraft start, note the noise no. for the individual aircraft given in dB, and using a table, convert the noise no. to a dose in linear units (Pa^2s). Aeroplanes of the same type have usually the same noise no. and fly-over time.
2) After the desired period of time (one day, a week or a month) add all the linear dose values together and you have the total dose for the given period of time as a linear value (Pa^2s).
3) If the value is required to be expressed on a log scale, simply calculate the average of the linear values over the period of time and take the log to obtain L_{eq} in dB. This conversion is also done in accordance with some simple tables.

The method has the following advantages:

1) The procedure is very accurate — far better than using a lot of measuring points which always will be disturbed by other noises.
2) The method is cheap, as no expensive instruments are required. The ICAO procedure has already made the measurements.
3) It is very simple for anybody to control and verify the correctness of results, simply by looking at the list of starts.

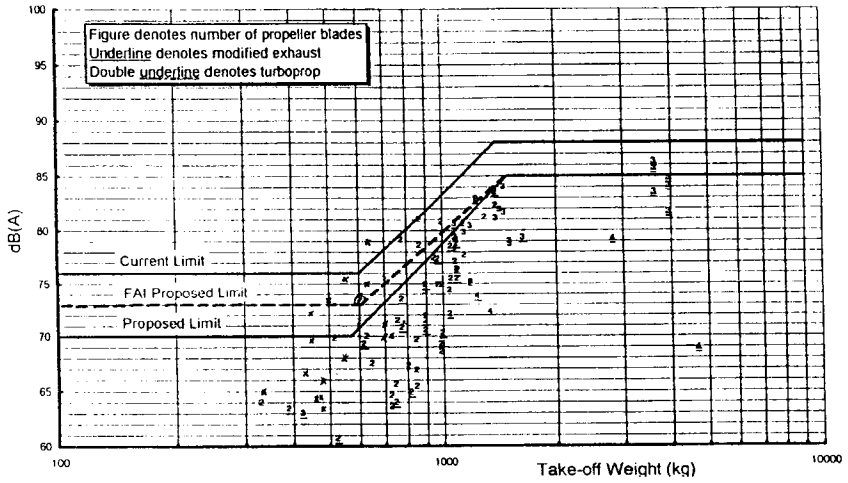


Fig. 5: Max. Noise limit for a propeller-driven aircraft below 9 t MTOM (ref. 6). An aircraft radiating more than indicated on the curve cannot be registrated in an ICAO country. The upper curve is the present limits, below the proposed new requirements. Very light aircraft are required to have extremely low noise radiation.

4) It is feasible to predict the total noise from a field with high accuracy if the aircraft types and number of starts are known. It is also possible to calculate the dose retrospectively, so that the situation e.g. a year ago can be determined.
5) The real great advantage is, however, that everybody will ask for low-noise equipment, as it is possible for an aircraft with a small dose to make many more operations. So manufacturers have to make low-noise equipment otherwise they cannot sell anything.
6) Of course, people operating noisy aircraft will suffer as their starts and landings will load the airfield with a larger dose.

Flyover Time:

The noise no. of the aircraft is the max. noise level heard on the ground at the reference point. But an important factor is also how long we hear or feel disturbed by the noise. So we have to multiply with the time — the duration of the aircraft flyover. If we, as mentioned before, record the whole flyover level as shown in fig. 4 and 6, by integrating we can obtain the total dose in Pa^2s. But as we only have the noise no. we need to either measure or estimate the flyover time.

If in future, when the aircraft is certified, we can get not only the L_A max., but also the dose in Pa^2s it would solve the problem.

The procedure for finding just the effective flyover time is simple. Using an integrating Sound Level Meter (SML), the L_{eq} is measured during the period which the aircraft is just heard and until the sound again fades away. In the example shown in fig. 6 this duration could be from 0 to 25 seconds. With a normal SLM the aircraft noise no. L_A max is found. Then simply calculate how long time is required to obtain the same L_{eq} if the sound was constant with a level of L_A max. The dB level must be

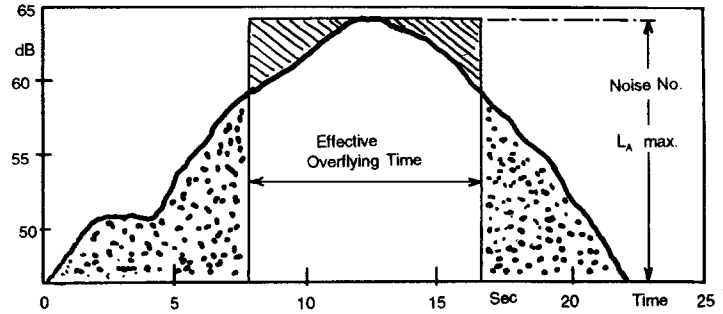


Fig. 6: Definition of effective flyover time. The dotted area contains the same energy as the hatched area, even if it does not appear so. The reason is the logarithmic scale for sound pressure (dB).

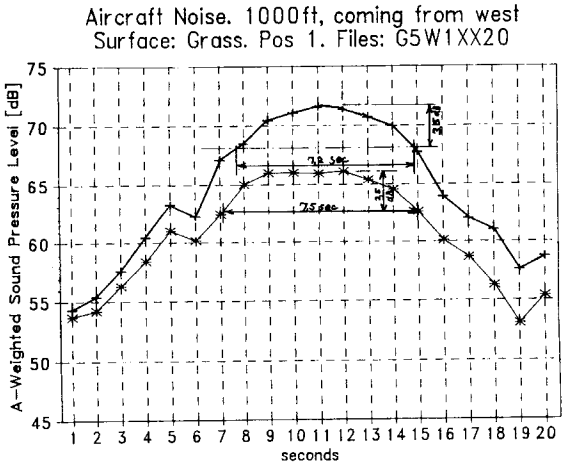


Fig. 7: Noise profile for two light aircraft, Falco LV8 and Piper PA28.

converted to a squared linear sound pressure to find the balance. We have measured many single-engine and twin-engine aircraft and have found that in most cases the effective flyover time is about 7-9 sec., fig. 7. If the flyover time is not known we suggest a value of 10 sec is used. It is reasonable to use a time which is slightly above the average since we are not taking noise from landing into consideration in dose determination. The landing noise from propeller-driven aircraft is already insignificant compared with starting noise (less than 1/10).

The most important factor is to have an accurate L_A max as this value goes into the dose with the square of the value whereas the flyover time comes in linearly. When a tow plane tows a heavy glider, it is still low 2.5 km from the starting point and then the effective flyover time can be 5-7 sec, but as the noise is high due to the short distance from the plane to the microphone, the dose will still be high. Some examples are shown in fig. 8.

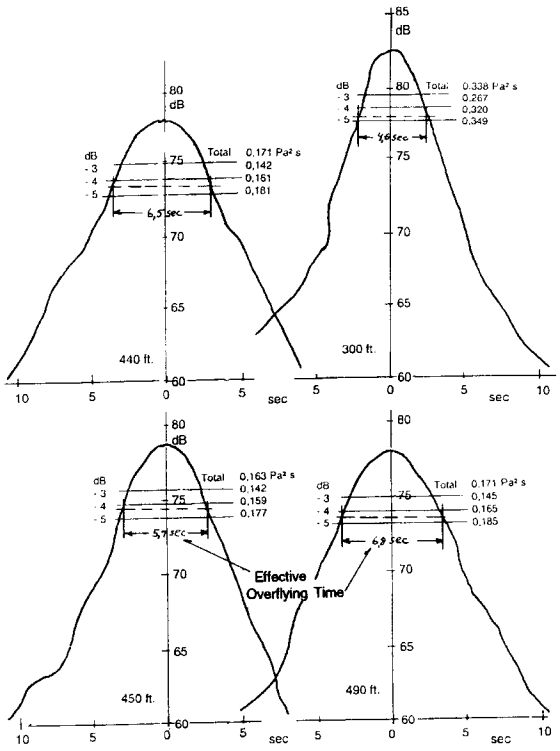


Fig. 8 : Noise profile for overflying aircraft towing a glider.

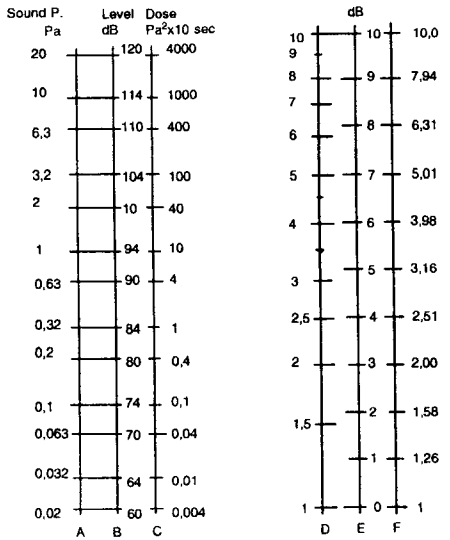


Fig. 9: Conversion noise level in dB to linear value in Pa²s. Sound Pressure (A) and A-weighted level in dB re 2x10 Pa (B) and corresponding dose in Pa²x10 sec for 10 sec duration (C).
Right: help scales for transferring dB 0-10 to power ratio (D) and (F).

Fig. 9 below shows how much noise dose is emitted from one start, when the aircraft has a certification value of $L_A$max dB. Since the certification value for aircraft is shown in 1/10 dB, the intention is to interpolate for the 0.1 values. Fig. 9 gives some scales, which make the conversions easy.

The most simple way to operate at a small airfield is to have a list of all the different aeroplane types which may operate from the particular field. The list should indicate type no., ICAO noise no. in dB, and the dose in Pa²s. The landing noise should be incorporated in the dose, so only aircraft starts are counted. This list can be prepared by the national flying clubs. Tow-planes for gliders have therefore two dose values — one dose when the plane flies alone and another when the plane tows a glider (or even a third dose if the plane tows two gliders).

Helicopters, Hot-Airballoons, some Ultralights, and Model Planes often do not use airfields and are in any case normally not flying 2.5 km out to the reference distance. Consequently the noise from these planes should not be added to the fields' noise dose. Their noise should be regulated by measuring max L_A "Slow" on the ground with full power when the plane is at minimum legal altitude. But up to now there is no international suggested procedure. It would be desirable to have international rules.

Chapter 6 to Chapter 10.
When ICAO first introduced noise nos. for light aircraft (below 5.6 tons), Ch 6, ref. 11, the measuring method was: Full power in horizontal flight 300 m over the ground. The microphone was placed on short cut grass 1.2 m above the ground. The method was changed about ten years ago and is described in ref. 6.

Ch 10 measures the aircraft during climbing and the microphone is placed on a metal plate on the ground. The changes make a difference in the results with the consequence that the limit curves are different for the two methods. Ch 10 normally gives a higher noise no. than Ch 6. Some countries still use Ch 6, but will soon change to Ch 10. But in any case, an aircraft registered according to Ch 6 will not be required to be measured according to Ch 10. We suggest that for evaluation of small airfields we should only use noise no. measured according to Ch 10, ref. 6. Consequently the Ch 6 numbers have to be converted to Ch 10 numbers. Careful study (ref. 9) has shown that this can be done with an acceptable accuracy by following the following steps for converting Ch 6 figures to Ch 10 values:

1. Correct the height difference between Ch 10 reference point and 300 m using the formula difference in dB= 22 log H . Both H and 300 are in m (ref. 9) Add the figure to the Ch 6 to get the Ch 10 value. ref ref
2. If the aircraft has a fixed pitch propeller, subtract 2.5 dB (ref. 9).
3. For moving the microphone from 1.2 m to ground add 5.5 dB (ref. 9). After that, we have converted the Ch 6 value to Ch 10 figure which should be used for evaluation of the noise from small airports.

Hints for measuring aircraft according to Chapter 10.

According to Ch 10, the noise should be measured 2.5 km from rolling point. In most cases, that is not possible because there may be a forest, many houses, places with much noise, or the place might be at a different level to the runway.

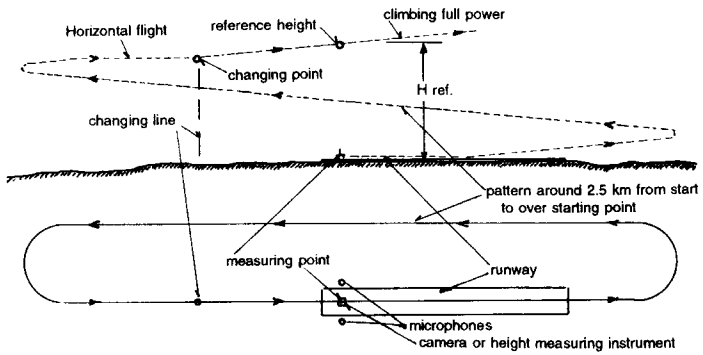


Fig. 10: Measuring the noise no. for a simulated flight 2.5 km from rolling point. Start and fly with normal climb power the 2.5 km pattern. If the pattern is longer than 2.5 km you have to incorporate a changing point at a height below the reference point. Before changing point fly horizontal with reduced power, but maintain climbing speed. At changing point apply climb power and reach reference point close to the calculated value.

But the measurements can be made over the runway. The reference height 2.5 km away has been calculated from official papers for the aircraft. Now you can establish a flight profile where you fly horizontal e.g. 100 m over the ground with climbing speed (reduced power). At a calculated point before the runway you give full power and start climbing. If the calculation has been correct you will reach the reference height just over the microphone. DLR in Braunschweig has used and described the method (ref. 11).

A few remarks about future aircraft:

Developments will possibly go in two directions. We shall see the Burt Rutan types.

Fast moving aircraft with short wings. Engine 100 HK. The aircraft can only operate from airfields with a hard surface. This kind of aircraft makes a moderate noise during start, but in the air it makes very low noise. Due to low drag, it uses little fuel. The other type looks like today's gliders with long wings, very low drag and produce only moderate noise. It can operate on small grass airfields. This kind of aircraft can be made so that it is both economical in initial expenditure and in use.

Low-noise aircraft sometimes cause other problems. A Swedish tow plane with a Volvo engine is dangerous on the ground when the propeller is running. The noise is so low that people inadvertently walk into the propeller. It has therefore been necessary to install an acoustic warning signal to avoid tragic accidents.

If we evaluate small airfields by using the actual noise emission, light and economical aircraft will benefit and we will see a number of new low-noise aircraft types. Future development will not only take place solely on account of a request for low-noise aircraft, but also because we want to save fuel. Fuel saving is strongly connected to noise. Noise is always a sign of bad efficiency.

In the near future we shall see motorised gliders starting and landing in small fields and making little noise. This kind of aircraft will use less fuel than even today's small cars.

Later on we shall see solar-driven aircraft starting on batteries. One aircraft has already flown from coast to coast in US. So let us not stop that development by destroying our small airfields or our young peoples' dreams of flying.

References:

[Ref. 1]: Wildlife. Statement made in Paris, FAI meeting 24 Jan 1997 by Dr. Wolfgang Scholze from the German Aero Club.
The author of this paper has participated in two congresses where the influence of aircraft noise on human beings and wildlife was discussed: 1) International Symposium on Recreational Noise, Queenstown 20 Nov. 1998, New Zealand. 2) 7th International Congress on Noise as a Public Health Problem, ICBEN, Sydney 22-26 Nov, 1998. In the proceedings from both congresses the remarkable statement was made that both birds and wild animals like to nest and stay at areas with high noise levels e.g. close to a highway or at an airport. According to the researchers the explanation is that in noisy areas there are no dogs, cats and few human beings. Many wild birds do not like the human voice. They regard human beings as their enemies. The astonishing conclusion is if you want a park or area where wild birds can nest and wild animals can rest it should be a place without dogs and cats and human beings walking and bicycling. But driving a car or motorbike or even flying low over the area should cause any harm. People who are seriously interested in protecting our wild life should study the ICBEN proceedings. There are also many references to earlier work on the subject.

[Ref. 2]: US Army converted some standard Cessnas 172 into very low-noise aircraft which could fly just over the top of the trees and not be heard even a few hundred meters away. In Sweden a small association has installed an engine from a Volvo car on a Piper Pawnee and a slow rotating four-blade propeller and has got a very low-noise towplane.

[Ref. 3]: Decision to set up a FAI Environment Commission was taken at the FAI General Assembly in 1994. FAI supports all aerosports such as ballooning, light aviation, gliding, rotorcraft, parachuting, flying with model planes, aerobatics, astronautic records, hang gliders, microlight flying. FAI have furthermore commissions for aerospace education, amateur built aircraft including solar powered craft, medico-physiological problems, and now also an environmental commission where the goal is to reduce noise and fuel consumption. FAI pursues its goals by collaboration with local air authorities and ICAO in Montreal. FAI can talk with some weight as the organisation represents several million members spread all over the world.

continued page 16...

References

continued...

[Ref. 4]: Private Communication from Alan H.Marsh, DyTecEng. CA92649. AM is used by FAA as a consultant in aircraft noise matters.

[Ref. 5]: ICAO: International Civil Aviation Organization in Montreal. The organisation is dealing with and co-ordinating the air rules. Members are the governments of the member countries. Today about 150 states are members.

[Ref. 6]: ICAO Annex 16, chapter 10, Montreal.

[Ref. 7]: Pa^2s is Pascal squared second where Pa is the international unit for pressure (1 Newton per m^2). Pa^2s is often called "Pasques".

[Ref. 8]: Henning von Gierke and Kenneth M. Eldred: Effects of Noise on People. Noise/News International, June 1993. It is an overview of papers and books dealing with the problems.

[Ref. 9]: Per V. Brüel: Noise Evaluation of Light Propeller-Driven Aircraft, 14th Aeroacoustics Conference, May 1992, Aachen. DGLR/AIAA - Bericht 92-03. The author's company has during 15 years installed more than 1000 microphones for aircraft monitoring. Experience shows that accurate measurements are difficult and require permanent attention.

[Ref. 10]: ICAO "Prop 3" Task Group. Last meeting of the group was in 1997 in Paris.

[Ref. 11]: H. Dahlen & H. Heller: Comparison of the ICAO Annex 16, Chapter 10 and 6, Noise Certification Procedures on the Basis of Flight Noise Measurements of Ten Light Propeller-Driven Aeroplanes. DLR-Mitt 90-17, Braunschweig.

[Ref. 12]: MTOM is maximum take off mass of an aircraft.

Brüel Acoustics	Office	Research Centre	Stock & Shipping	Brüel Acoustics S.r.l.
Address	Gl. Holtevej 97	Venlighedsvej 6	Ågerupvej 25	V.le. C. Pavese 304
Zip Code	DK-2840	DK-2970	DK-3200	I-0014
Town	Holte	Horsholm	Helsinge	Roma
State	Denmark	Denmark	Denmark	Italy
Phone	+45 45 80 00 50	+45 45 76 05 10	+45 48 71 34 12	+39 6 505 10 797
Fax	+45 45 80 04 70	+45 45 76 05 70		+39 6 505 10 797