Motorsport and Noise

1. Introduction

Car and motorcycle racing are forms of motorsport that are highly likely to produce noise annoying to those living nearby. This noise is often variable in level and intermittent, making it difficult to quantify with a single measurement. The courses used for competition are often several kilometres in length and cover large areas, which can also make it difficult to predict and/or monitor noise exposure at every potentially sensitive receiving location.

For spectators, the noise of a motorsport event can add to the excitement. But for some of those living near a venue it can be annoying or even alarming. How to balance the competing views is perceived as difficult, and although achievable for an individual track , it is clearly more difficult to develop standards that can be applied nationally and internationally to give fairness and certainty to all concerned (3).

Several factors contribute to the degree of acoustical annoyance caused by the exploitation of a racing track:

- the level of noise emitted by the vehicles, mechanical, engine and exhaust
- the number of events throughout the year
- the periods during which these events are held (day, evening, night)
- public address systems
- increased traffic locally to and from the event

One of the most important aims of operating a motorsport venue is to maximise its use for obvious commercial reasons, but this is always at odds with noise disturbance in the community. For many venues in the UK this means restrictions in the number of days that they can operate and also may mean restrictions on the type of events that they are allowed to run. The question really is how can one fairly and accurately assess the degree of noise intrusion, or indeed is any noise intrusion or pollution fair in the first place? The motorsport industry will talk at great length about the uniqueness of motor sport noise from other sources, the inadequacies of assessment methods, the need for more guidance etc. (3), but motorsport noise is still intrusive noise **however** you look at it.

In the summertime, living next to a motorsport venue makes it difficult to open a window or even enjoy the garden because of the noise levels from racing events. Indeed, the term *secondhand noise* is increasingly used to describe noise that is experienced by people who did not produce it (10). Anti-noise campaigners will say it's effects on people is similar to that of secondhand smoke, ie. it is put into the environment without people's consent and then has effects on them that they have no control over. The effects of sound don't stop with the ears either, nonauditory effects of noise exposure can result in elevated blood pressure, aggression, increased heart rate, high stress levels and other harmful effects for example. Thus racing tracks that are located near housing developments can influence the health conditions of the inhabitants by uncontrolled noise pollution (27). Good neighbours keep their noise to themselves.

People who are keen on motor racing will say that if you take the noise away, you take away the enjoyment, that noise is an integral and exiting part of the activity. (3). The level close to the traffic at the start of an unsilenced race at Goodwood might be, say, 120dB. If you drop if to 110dB, will that make a difference? Does it stop the enjoyment? For somebody some distance away, dropping it by 10dB at source might be the difference between being annoyed by it or not. One problem is clearly the motorsport industry itself in 'encouraging' vehicle modifications, one of which can involve replacement of the standard silencers in the case of cars or their complete removal and substitution of a "straight through " pipe in the case of motor-cycles. The object is partially to increase the power output of the engine but also to add the *thrill* of noise to the racetrack, which is desirable to the spectators but undesirable to anyone not directly involved (6). A good deal of information is already available on the noise levels produced by properly silenced road vehicles but this is quite inadequate for assessing community noise problems from racetracks. It is also interesting to observe just ***how noisy*** vehicles can be if they are not properly silenced. Thunderous noise is often associated with stock car racing for example (24) and to a certain extent is part of the sport appeal.

There is a growing literature which draws attention to the way in which many towns and cities seek to enhance their image and enable implied economic benefits locally through the pursuit of motor sports and mega-events. Motorsport all over the world, is as much a commercial activity as a sporting activity. Advertisers eager to associate themselves with racing spectacles fund and promote races. The speed, power, masculine daring and excitement of motor racing are used as marketing tools for products ranging from newpapers to beer and alcohol,
from shock absorbers to the motor vehicles themselves as well as the promotion of the 'good life' that motorsport culture celebrates. Business and cultural elites should not simply accept the argument that motorsport events are 'good for the city' or 'good for the town', they should consider an alternative perspective: that the location of motorsport events is a crucial consideration with implications (8).

2. Existing Racing Circuit Restrictions

In this section we look at whatever noise expectations are published in various countries regarding residential areas. As such we can only find specific legislation from Australia but the applicable legislation elsewhere relies on associated regulations that encompass the noise aspect and which directly relate to residential areas.

Motor sport activities are sometimes subject to an environmental impact analysis (E.I.A.), especially for noise emissions, when people are living in the surrounding area of a racing track. In this case, a reasonable compromise should be found between the acoustical comfort of these people and the desire of *petrol heads* to enjoy their sport (1). In this respect, the E.I.A. must first define objective criteria to characterize the annoyance in the neighbourhood. Limit values must then be proposed and compared to the noise emissions of the future racing track. However, only few scientific studies have been published on that topic. Legislation exists in some regions or countries, but it is not really harmonized at the European level and certainly not at the worldwide level. (2)

In Germany, there's no specific legislation for racing tracks and motor sports activities but an E.I.A. must be carried out for all projects of this type, and the exploitation is submitted for authorization. In France, there's also no specific legislation for racing tracks. They are submitted to the general regulation concerning neighbourhood noise and installations having an area greater than four hectares are subject to an E.I.A. and public enquiry. The situation is similar in the United Kingdom, where an E.I.A. is required where the area of development exceeds 1 hectare. In Belgium, the legislation concerning environmental matters has been transferred to the Regions. A general regulation defines the noise limit values which must be applied to the installations which are subject to an E.I.A. In residential areas, at more than 500m from the zone of activity, the equivalent level LA_{eq} must be less than 55 dB(A) in daytime (07h-19h), 50 dB(A), in the evening (06h-07h and 19h-22h) and 45 dB(A) during night-time (22h-06h). The equivalent level is an $LA_{eq,1hr}$, measured during the "nosiest hour" in the considered period, and it must be corrected in the presence of tonal components or impulsive noises. It is also the "particular" noise level, i.e. generated by the activity only. See the particular sections on this site for the Goodwood noise restrictions and also the noise restriction currently in place on other motor circuits in the UK.

The aim of the European Noise Directive (END) (34), is to define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to exposure to environmental noise. It applies to environmental noise to which humans are exposed in particular in built-up areas, in public parks or other quiet areas in an agglomeration, in quiet areas in open country, near schools, hospitals and other noise sensitive areas. The term 'annoyance' in this context means the degree of community noise annoyance as determined by means of field surveys where a community 'limit value' shall mean a value of L_{den} (day-evening-night level) or L_{night} (nightime noise indicator – 8 hrs.), and where appropriate L_{day} (day noise indicator – 12 hrs.) and $L_{evening}$ (evening noise indicator), as determined by the Member State, the exceeding of which causes competent authorities to consider or enforce mitigation measures. Limit values may be different for different surroundings and different noise sensitiveness of the local population. The Environmental Noise (England) Regulations 2006 and the Environmental Noise (Identification of Noise Sources) (England) Regulations 2007 implement the END in England (33). There are no relevant formal limit values in force, or under preparation, in the UK. However, the UK does have guideline values and bands in regulations and guidance currently in force and in Northern Ireland they are currently derived from levels which equate to those areas below the L_{den} 55dB and L_{night} 50dB noise bands. Quiet areas must have a L_{day} noise level of less that 55dB, which generally correlates to a $L_{evening}$ of less than 50dB.

In the 27 member stated of the EEC, only 6 (including the UK) do not have noise value limits in force. For residential areas in some other countries the following limits apply:-

- Germany: 64dB(A) day; 49dB(A) night
- Estonia: 55 dB(A) day; 45 dB(A) night
- Luxembourg: 59 dB(A) day; 49 dB(A) night
- Italy: 50 dB(A) day; 40 dB(A) night
- Lithuania: 55 dB(A) day; 45 dB(A) night
- Latvia: 50-55 dB(A) day; 40-45 dB(A) night

There have been several initiatives in Australia and New-Zealand (Refs 1,6,7 in 2) concerning the management of motor sports noise. Noise limit values are again proposed, together with additional measures, such as the "credit system" in which each motor sports activity is attributed a number of "credits", depending on the amount of noise emitted. This system allows the venue operators to program the different events, in order to respect an annual maximum total credit accorded to the racing track. A similar approach of noise management adopted in the US is also cited in (Ref 1 in 2). In Australia, limiting values have been set with a view to minimising environmental noise (5). Noise impact limits are 95 dB for cars at 30m, *ie* at the edge of the spectator areas.

3. Nature of the Noise; Testing and On-Site measurements

Noise emissions by motor sports activities do not generally create hearing damage to people living at reasonable distance from the track (1), but they can cause discomfort and annoyance. They can therefore be considered as a health problem, in the sense defined by the W.H.O. (2) In particular, noise interference with speech communication "results in a large number of personal disabilities, handicaps and behavioural changes" (22). An indicative limit value is 55 dB(A), for which "sentences may be 100% intelligible with increased vocal effort". The W.H.O. report (22) also analyses the effects of noise on residential behaviour and annoyance. Several studies express the correlation between the number of highly or moderated annoyed people and the equivalent levels $LA_{eq,\ 24hr}$ or L_{dn} . During daytime, only few people are highly annoyed if $LA_{eq} \geq$ 55dB(A), while only few are moderately annoyed if LA_{eq} < 50dB(A). These values should be decreased by 5 dB(A) during the evening, and 10 dB(A) during the night. Limit values (for daytime) are included as $LA_{eq,16\ hr}$ (9) No maximum LA_{max} values are specified for daytime, but they could be justified for intermittent noise emissions. Night-time limit values in dwellings, measured indoors (window open), are $LA_{eq,\ 8hr}$ <35 dB(A) and LA_{Fmax} <45 dB(A).

Of the publications in the acoustical scientific literature concerning the noise emissions by motor sports activities, some of them analyze the annoyance of technicians and spectators, but only a very small number are interested by the annoyance of residents (2). Noise indicators used to characterize noise emissions and immissions are often either the maximum A level and/or the equivalent A level. However, and especially for the last one, the corresponding duration of the measurement may vary from one track to the other (sometimes even not specified). Also, the position of the microphone (distance to the track) is far from uniform. Meteorological conditions (especially wind) significantly influence remote measurements (in the immission zones) and special care must also be accorded to the loudspeakers used during the races, a fact often overlooked (18). The PA system speakers can often be as loud as the racing vehicles themselves.(17) Finally, the information available to residents about the noise management procedure, the results of the measurements (especially in their residential area), the programming of events organized on the racing track, is very important (18).

Three methods have been identified to characterize these noise emissions (7):-

- static measurements
- track-side or on-track measurements (also called dynamic tests)
- remote measurements (in the residents' zone).

The traditional test for vehicle noise is a static one, taken prior to racing. It can give control over individual vehicle noise levels, though by itself cannot guarantee control of community noise, which is also influenced by other factors. Under MSA and ACU regulations, static noise testing is compulsory before a vehicle is allowed on the track. The test is simple, which is important for technical regulation which may result in a vehicle being banned from the event (18). Although far from perfect, the static test has been successful in bringing down overall vehicle noise levels throughout the years that it has been in use. Its advantages are its simplicity and minimum investment in instrumentation, but it only provides a snapshot of stationary vehicle noise and is open to cheating. The test can be invalidated by modern engine management systems that allow the static vehicles to be run at the required rpm but at a much reduced power output resulting in much lower noise emissions. The test does not adequately measure the potential for noise emissions when the vehicle is moving (3). Many have tried to correlate the static test with the noise emission from a moving vehicle without much success. One difficulty of the test is that the limits arc based on 75% or maximum revs, but there is no technical requirement for vehicles to be equipped with a rev. counter. Static tests are often performed according to the procedure adopted by the M.S.A. (Rule 5.18). Limit values for static tests depend on the vehicle type but they are generally comprised between 98 and 110 dB(A), at 0.5m and 45° from the exhaust (1).

Dynamic tests or "drive-by" tests are generally preferred over static ones in the literature, because they allow real-time control of noise emissions, including all components of noise (motor, tyre/road interaction and aerodynamic), and they offer the possibility to disqualify too noisy vehicles (7). However, it is usual to suggest a combination of static and dynamic controls but there is correlation between both types of measurements for the same vehicle (18). Drive-by noise testing usually takes place at a point where the vehicles are going fast and at maximum acceleration. It may generally be carried out in conjunction with time and date-stamped videos so that results can be checked against an individual vehicle. Readings may also be taken at track boundaries or sensitive locations (3).

Because of interference from other vehicles on the track, it can prove difficult to identify individual vehicles but not impossible. There is still the problem of repeatability and the fact that the noise has already occurred before action can be taken. However, development in instrumentation and systems means that it may be possible to resolve some of the problems with trackside testing and use this method on more events (3). For dynamic tests, a limit value of LA_{Fmax} = 95 dB(A) at 30m from the track has been proposed (7) (the vehicle running at full acceleration). Other values have been cited (1). It has been suggested that noise for a particular type of racing might be defined effectively by an LA_{eq} measurement related to a single lap (3). The temptation is to assess the received noise levels in the community but there may be a long propagation path with other sources of ambient noise that affect the readings. Another approach might be to quantify the noise at the source and use software to relate it to results at a distance for different wind conditions.

Many venues now have to comply with noise conditions that limit the levels of noise produced at the site and this usually means period LA_{eq} levels in the community as well. This is a fair and reasonable system, but it is considered ‘inconvenient’ to try and operate effectively by monitoring the noise levels in the community. It is difficult to produce results that will accurately measure the contribution from the venue. However, it may be useful, for noise control purposes, to **predict** sound levels arising from motor racing. This has been theoretically predicted for circular and elliptical track models (4).

Obviously, some vehicle types will not be able to respect the above limits, for example most F1 cars and unsilenced vehicles. This already suggests that other limitations should be adopted, especially for tracks hosting these noisy vehicles. As will be seen later, limitations of the number of racing days and their distribution over the year could then be defined as a complement to noise emission limits. Also, as far as the residents’ comfort is concerned, it can be accepted that some racing tracks authorize higher noise levels (at emission), depending on the distance between the venue and the closest dwellings. A special attention should however be accorded to the spectators.

So what of the noise itself. Fig 1 (6) is typically some Category 2 results for the start of a race at 10m, (a), and during the race (b) at the same microphone position and (c) at 120m from the track. This shows bunched engine revving at the start of the race and subsequently the noise peaks once the field is more spread out.

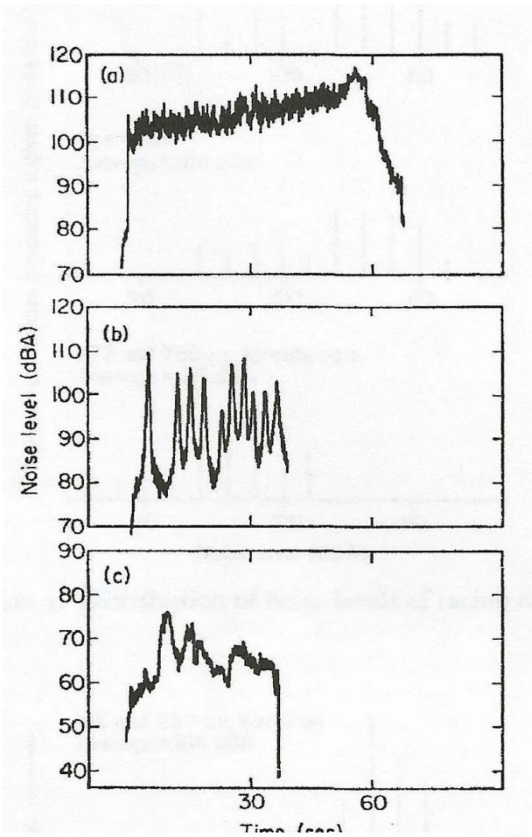


Fig 1. Race Noise results for 19 vehicles

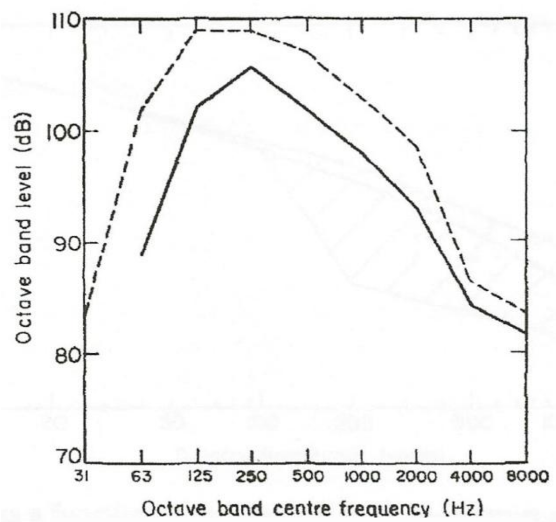
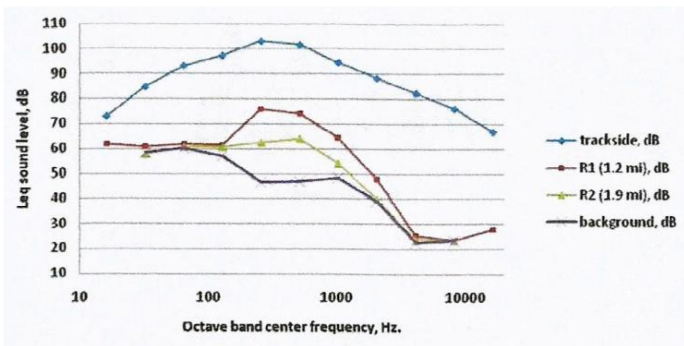


Fig 2. Octave Band Noise Levels for Racing Cars (solid line) and Motorcycles (dotted line)

Fig 2 (Fig 4 Ref 6) shows the octave band average noise levels for both racing cars and motorcycles. There is in fact little variation and nearly all the important energy is in the 125, 250, 500 and 1000 Hz octave bands.

This is also illustrated in Fig 3 which is from Tampa Bay in Florida.

Fig 3. Octave Band Noise Levels for V8 cars at Trackside, 1.2 miles and 1.9 miles



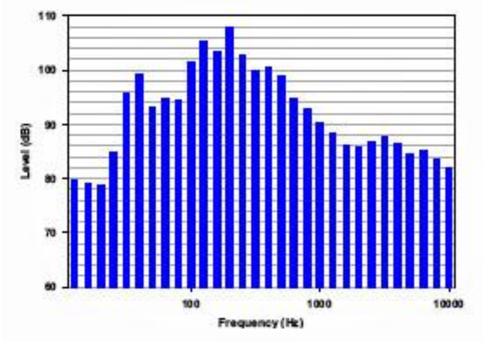


Fig 4. (fig3 ref24) A Stock Car noise Spectrum

Fig 4 shows the noise spectrum for a stock car but in this case there is an additional noise frequency peak around 30Hz

Fig 5 (fig 6 Ref 6) Noise as a function of distance from the trackside

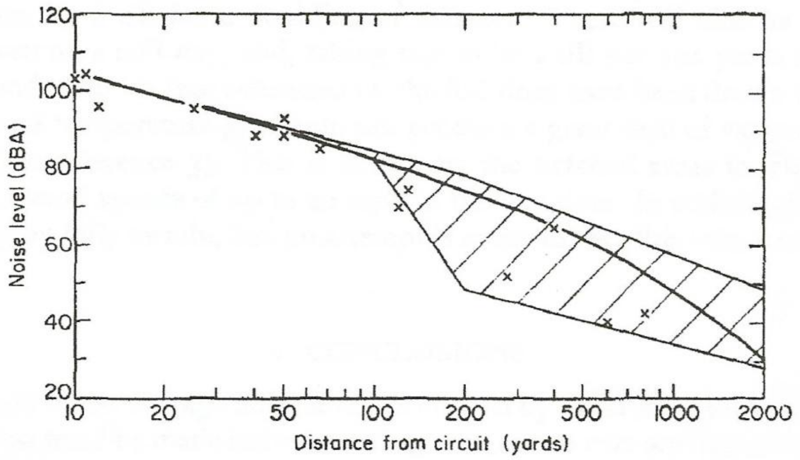


Fig 5 shows noise level measurements made at up to 800 yards from the track during car racing as a function of distance. No allowance has been made for wind or terrain differences but the hatched area in Fig 3 illustrates the divergence that occurs over 100 yards due to these effects.

As anyone living around the Goodwood motor racing circuit on an unsilenced day will tell you, it is far better to have the track downwind of you since sound refraction effects of an upwind location are difficult to bear. This is the difficulty of living in the immission zone and something not viewed sympathetically by Chichester District Council Environmental at all. The effects of wind on noise levels in the immission zone have been studied (9) and can result in a 23dB difference 2 miles from the source. Measurements also showed that the wind direction several hundred metres above ground level play a significant role in sound wave refraction.

4. Regulation of the Noise in Immediate Neighbourhoods

Some immission zone reference noise limits are as follows (2):-

- Industrial noise regulation in southern Belgium: $LA_{eq,1hr}$ is limited to 55 dB(A) during daytime in residential areas.
- W.H.O. $LA_{eq,16\ hr}$ is limited outdoor to 53 dB(A), during the day and 45 dB(A) during the evening period, in residential areas.
- In Germany and Austria, the noise emitted by sporting installations is limited to a maximum level, comprised between 50 dB(A) and 60 dB(A) during daytime. Otherwise, the activities are limited in number of days.

The term *immission zone* is used when referring to noise levels measured at the point of reception, typically residential areas adjacent to a noise source. Various studies estimate that the acoustical **annoyance** starts at an L_{den} value of 55 dB(A). Moreover, this level is the minimum threshold of the zones of intervention around the airports in Belgium and the minimum threshold of the noise zones defined by the Directive 2002/49/CE of the European Parliament of June 25, 2002 (34) relating to the evaluation and the management of the noise in the environment. Consequently, it is suggested that the *regular* activities of a motor racing circuit should respect an immission level of $LA_{eq,1hr}$ = 55 dB(A) during any *sliding* hour of the day, in the residential zones surrounding the circuit. The activities which cannot respect this criterion must be restricted in terms of a number of days per year, in order to respect an annual L_{den} level of 55 dB(A). In an ideal situation, these criteria should be controlled using acoustical monitoring placed at the limit of the residential surrounding area, in the zones which are the most exposed to the circuit noise. To satisfy the acoustical criteria at the immission, it would be clearly necessary to limit the noise of the vehicles on the track and/or the number of events per year. However, there would be problems carrying out this management, because form the practical point of view it is difficult to distinguish the i*ndividual* noise from the various vehicles when the microphones are at great distance from the racing track. Consequently, motor circuit management prefers to control the noise levels at short distance (near the track), during each passage of every vehicle. This *dynamic* method is preferred to *static* tests, for the reasons already explained earlier. In a simple simulation (including the number of vehicles during the race and the attenuation of sound intensity with distance), indicated that to respect the $LA_{eq,1hr}$ of 55 dB(A) in residential areas *close* to the circuit, the maximum level LA_{max} should be limited to 90 dB(A) (2). This relation is typical of a particular immission zone, and may not be applicable to other racing tracks

However, the control of the noise levels near the track need to respect the immission criteria ($LA_{eq,1hr}$ and L_{den}). To determine the relation between the maximum noise levels measured near the track and the equivalent noise levels, a number of measurements made in real conditions (18,17).

An analysis showed that the difference between the maximum level LA_{max} and the corresponding equivalent level LA_{eq} fluctuates. It essentially depends on the type of vehicle, as well as the distance between the source and the microphone position. The average value of the difference between LA_{max} (drive-by) and LA_{eq} was about 15 dB(A), with a standard deviation of 4 dB(A). In the Goodwood case it is 18dB(A) for Category 3, 19dB(A) for Category 2 and for Members' Meetings (Category1) it is 16dB(A) or less. With a measurement distance of 10m to the track centre line, one study showed that the difference was 25dB(A) and 21.4dB(A) at 34m(26).

One proposal put forward , not untypical of the type of the Goodwood approach, is to consider three categories of activities having different limitations (2):-

- Category A:
  - no noise limit would be imposed for these competitions, ie unsilenced
  - the annual number of days of this type of competitions should be very limited to respect the condition of $L_{den,1year}$ less than or equal to 55 dB(A).
- Category B:
  - LA_{max} (measured at 15m from the track) is limited to 100 dB(A), for all vehicles running during this activity.
  - the annual number of days of this type of competitions should be limited to respect the condition of $L_{den,1year}$ less than or equal to 55 dB(A).
- Category C:
  - LA_{max} (15m) is limited to 90 dB(A), for all vehicles running during this activity;
  - the annual number of days would not be limited, for the events in this category.

Furthermore, the night-time activities must remain "exceptional", strongly limited and clearly announced to the residents. The suggested limit value of 90 dB(A) is based on a simplified approach which enabled us to estimate that if the vehicles respect this limit, the $LA_{eq,1hr}$ will be less than 55 dB(A) in the residential zones near the circuit. The suggested limit value of 100 dB(A) results from the distribution of the competitions in the categories A and B, to ensure the respect of the $L_{den,1year}$ of 55 dB(A) in the residential area close to the circuit.

5. The Buffer Zone

Buffer Zones are particularly important as a measure to separate (new) developments and an environmental sensitive area from sources of major noise pollution. This has been belatedly applied by local Councils once they realise their potential liabilities from the legal effect of more recent Noise Regulations in allowing housing developments too close to racetracks, despite pressure from Developers. This of course is not new, just common sense. It has been suggested that a minimum buffer distance of 300m should be maintained between a motor racing venue and nearest residential areas over flat terrain with favourable weather conditions. (17) Some locations such as Brands Hatch in particular are far less than this. However, Chichester District Council have recently started quoting 400m minimum (28) which did not appear as an issue in any of the Goodwood noisy raceday relaxation approvals granted by them in 2010.

6. Noise Dosage

This is a different approach to looking at racetrack noise and one not usually considered even though racetrack noise is *industrial* in origin as Goodwood is a commercial business and arguably should be treated as such. Therefore industrial noise regulations could be deemed to apply so we will consider the implications here. The Control of Noise at Work Regulations 2005 (the Noise Regulations) (30) are based on a European Union Noise Directive 2003/10/EC requiring similar basic laws throughout the Union on protecting workers from the risks caused by noise. They replace the Noise at Work Regulations 1989, which have been in force since 1990. They do not as such apply to members of the public exposed to noise from their non-work activities, but householders close to Goodwood have no choice in the matter, they are exposed to industrial noise whether they like it or not. The duties in the Noise Regulations are in addition to the general duties set out in the Health and Safety at Work etc Act 1974 (the HSW Act). These general duties extend to the safeguarding of the health and safety of people who are not your employees, such as students, voluntary workers, visitors and **members of the public**. The main differences from the 1989 Noise Regulations are: (a) the two action values for daily noise exposure have been reduced by 5 dB to 85 dB and 80 dB; (b) there are now two action values for peak noise at 135 dB and 137 dB; (c) there are new exposure limit values of 87 dB (daily exposure) and 140 dB (peak noise) which take into account the effect of wearing hearing protection and which must not be exceeded; (d) there is a specific requirement to provide health surveillance where there is a risk to health. The lower exposure action values are (a) a daily (or weekly) personal noise exposure of 80 dB (A-weighted); and (b) a peak sound pressure of 135 dB (C-weighted). (2) The upper exposure action values are (a) a daily (or weekly) personal noise exposure of 85 dB (A-weighted); and (b) a peak sound pressure of 137 dB (C-weighted).

As an example of daily noise exposure, consider the published **trackside** data from one days racing activity in the States (31), see Fig 7. If we take the 8 highest levels of $LA_{eq\ 1min.}$., these range from 100 to 92dBA and apply the HSE calculator (32), the result is a daily exposure of 93dB and 659 exposure points. The hearing of any observer without ear protection is clearly at risk. Whilst we do no suggest these numbers are likely at the extents of the buffer zone, they are very likely to occur at the circuit on Category days 1 and 2. However, it will be interesting to see how close the number are (or possible exceed?) the lower limits for Category days 1 and 2 in the future.

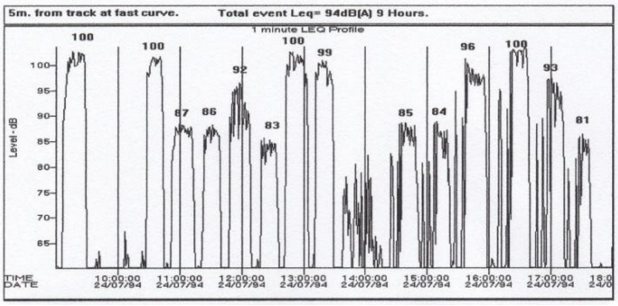


Fig 7: F1 Trackside Noise

Interestingly, regulation 7 (30) regarding hearing protection states that without prejudice to the provisions of regulation 6, an employer who carries out commercial 'work' which is likely to expose any employees to noise at or above a lower exposure action value shall make personal hearing protectors available upon request to any employee who is so exposed. However, it should not be used as an alternative to controlling noise by technical and organisational means.

7. Theoretical studies

A good noise indicator must thus integrate all these various parameters to be representative of the nuisance undergone by the surrounding community. The various possible indicators are (2):-

- $LA_{eq,\,1hr}$: standard indicator, used for example in the Walloon region of S.Belgium regional government noise legislation.
- $LA_{eq,30min}$: Goodwood
- $LA_{eq,8hr}$: indicator mentioned, for example, in the standard ISO R1996.
- $LA_{eq,16hr}$: indicator used by the W.H.O. to represent the annoyance in outdoor living area, for the period including the day and the evening.
- $LA_{eq,15'}$: indicator used for some circuits in Australia.
- LA_{max} : indicator used by the W.H.O. to specify noise levels guaranteeing the quality of sleep, it doesn't take into account the number of noisy events.
- L_{den}: indicator derived from the equivalent levels LA_{eq}, with a minimal reference period of 24 hours, often longer (up to one complete year). It is usually used to evaluate the annoyance due to airport noise. This indicator is recommended by the noise directive of the EC for the noise mapping of the European cities.

In addition to this equivalent levels above, one approach (2) has been to suggest the use of the L_{den} indicator which will permit a characterisation of the annoyance over one year, and then can be applied in order to limit the number of activities during one year. L_{den} is calculated according to the following formula (23): -

$$L_{den} = 10 \log \left(\frac{1}{24} \left\{ 12.1^{\,Ld/10} + 4.1^{\,Le+5/10} + 8.1^{\,Ln+10/10} \right\} \right)$$

where:

L_d is the average noise level determined on the day period (between 7h00 and 19h00);
L_e is the average noise level determined on the evening period (between 19h00 and 23h00), together with a penalty of 5 dB(A);
L_n is the average noise level determined on the night period (between 23h00 and 07h00), together with a penalty of 10 dB(A).

A theoretical study of a circular racetrack (4), with identical cars, has calculates the equivalent level at:-

$$LA_{eq} = L_{WA} + 10\log_{10} n - 10\log_{10}(c^2 - a^2) - 10\log_{10} 2\pi$$

where:- $$L_{WA} = 10\log_{10} \left(\frac{W_A}{W_{ref}} \right) \text{dB}$$

$W_{ref} = 10^{-12}$ W
N = number of cars
c = distance of receiving point from centre of track on extended diameter
a = track radius
L_{WA} = A weighted sound power level

In the derivation of the equations it has been assumed that the sound power of a car remains constant as it goes round a circuit and furthermore that all the cars in a race have the same value of W_A. Realistically, the sound power of a car is likely to vary continuously as it moves round a circuit. Consequently W_A should be replaced by $W_A(t)$.

Without a knowledge of the form of $W_A(t)$, however, the best that can be done is to replace W_A by a value $\hat{W}_A$ which is an average sound power for all the cars taking part in a race, on all sections of the circuit. Practically, $\hat{W}_A$ can be estimated from sound level measurements at representative points round a racetrack. The procedure does not take into account air and ground absorption. So for a circular track,

$$LA_{eq} = L'_A + 10\log_{10} n - 10\log_{10}\left(d_0^2/(c^2 - a^2)\right)$$

Where d_0 is a standard reference distance from the race track (10m)
L'_A is the logarithmic average level as each car passes by at representative points around the track

Race tracks are rarely circular but in fact, for large distances from the centre of a track, noise contours are approximately circular anyway. Clearly this is quite a basic model and we are not going to attempt modelling at this time but it will be done once real time numbers are available in the future.

In an investigation of the effect of wind direction on sound refraction from a motor circuit, a long range propagation model has been proposed (9) such that:-

$$LA_{eq,\ 1min} \approx L_o + 25\log_{10}(D_{ref}/D) + 1.254\cos(\Theta).shear$$

where L_o = reference LA_{eq} level ($LA_{eq,\ 1min}$) at distance D_{ref}
D = distance to receiver
Θ = wind direction angle (deg) between source and receiver (0 deg. is downwind)
shear = change is wind speed (m/s) between ground level and 1km above surface

This model does not take into account any atmospheric absorption losses which are estimated only to be of a few dB. Also the model does not account for background sound levels so this should be added on. This analysis does not however adjust the upwind/downwind sound levels received for the atmospheric conditions experienced on different days. A method of adjustment is thought possible (9, 25) based upon wind roses, if available, for the noise producing location together with the time the noise source is active. This then produces adjusted received sound levels to compare against agreed community noise targets.

8. Health Issues

Whilst noise is conventionally defined as 'unwanted sound', it is generally accepted that excessive 'wanted sound', such as music or sporty cars, will also cause hearing loss (5). It is assumed that the sound energy associated with recreation activity noise has the same effect on hearing as does the sound energy produced by workplace noise. Many people inadvertently (or deliberately) expose themselves to high levels of noise during recreational activities (see Section 7).While acknowledging that some spectators may be exposed to higher levels, it is reasonable to assume that a spectator at a range of motor sports activities could be exposed to at least an LA_{eq} of around 90 dB or more over the time of the event.

While individuals are at work, they come under the jurisdiction of various workplace occupational health and safety legislation and codes of practice where responsibilities are well defined for both individuals and organisations. However, when the individuals are away from the workplace, they need to be responsible for their own health and safety. In relation to immediate physical dangers this responsibility is usually obvious, but with respect to future health difficulties individuals often do not necessarily know they must act or how to act in their own best interest. This may be due to a number of factors including optimistic bias ("it won't happen to me"), ignorance of the health consequences of their actions or through generally unsafe practices(5).

In the workplace, regulations require the implementation of noise management strategies with the goal to ensure no workers have noise exposure levels $LA_{eq,8hr}$, greater than 85dB or peak levels, LC_{peak}, greater than 137 dB. These levels represent 'maximum risk', not 'risk free'. For recreational noise exposure, there are no legally binding noise exposure criteria. However, popular recreational activities have been shown to produce noise levels, LA_{eq}, well in excess of 85 dB. In fact, it has been shown that for an F1 race, one lap at any of 3 track positions can easily exceed the safe daily noise exposure (29).The combination of time spent in a controlled workplace plus time spent in a noisy recreational activity can lead to an overall noise exposure that may be considered as posing a risk to hearing health. To minimise the risk of hearing loss from such activities, individuals need to take responsibility and minimise or control their exposure to excessive recreational noise. Simple strategies, similar to those for mitigating workplace noise exposure, can be applied in recreational pursuits and in many situations this will require a change in both attitude and behaviour of all those involved with the recreational activity. Noise levels from unsilenced cars are similar to that produced by a jet planes taking off, Such noise can easily penetrate buildings in residential areas and the impact is heightened in the more densely populated urban areas.

Air pollution is another health impact from motorsport. Drivers, spectators and officials are exposed to high pollution levels from the racing vehicles, and this can be exacerbated where pollution is trapped by surrounding buildings (8). Motor racing also produces fine black carcinogenic dust from skidding tyres. The glorification of motor racing indicates that our society privileges speed, movement, power, private profit, energy wasteful activity and spectacular consumption. The glorification of motorsport events by allowing their location in significant places undermines the values of sustainability and the promotion of public health.

9. Summary

The planning system should contribute to and enhance the natural and local environment by preventing both new and existing development from being put at unacceptable risk from, or being adversely affected by unacceptable levels of noise pollution (28). It is accepted that noise from a motor circuit is different to road noise or other more or less continuous noises. However, a noise measure based only on energy summation and expressed as an Leq, is not enough to characterise most noise environments. This is very important issue since it is generally held in the racetrack community that noise below a absolute decibel level is acceptable regardless of its character content which is certainly not the case. Goodwood has traditionally relied on $LA_{eq30min}$ to justify it's existence to the environmentally acceptability of it's commercial activities. That is no longer good enough. Apart from the fact that most householders didn't understand a number which apparently was allowed yet causing significant impact and annoyance by virtue of it's special noise characteristics. It is equally important to measure the maximum values of noise fluctuations combined with a measure of the number of noise events. Whilst sound can be measured with the help of acoustical instruments such as sound level meters the actual extent of noise nuisance cannot be measured in this way. Non-acoustical factors, including personal factors such as noise sensitivity, and social factors can have as much effect as the sound level.

Because of wind and terrain issues, the noise expected in Summersdale during category 2 days is likely to be anywhere between 40 and 70 dB(A). Category 1 days will be higher.

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