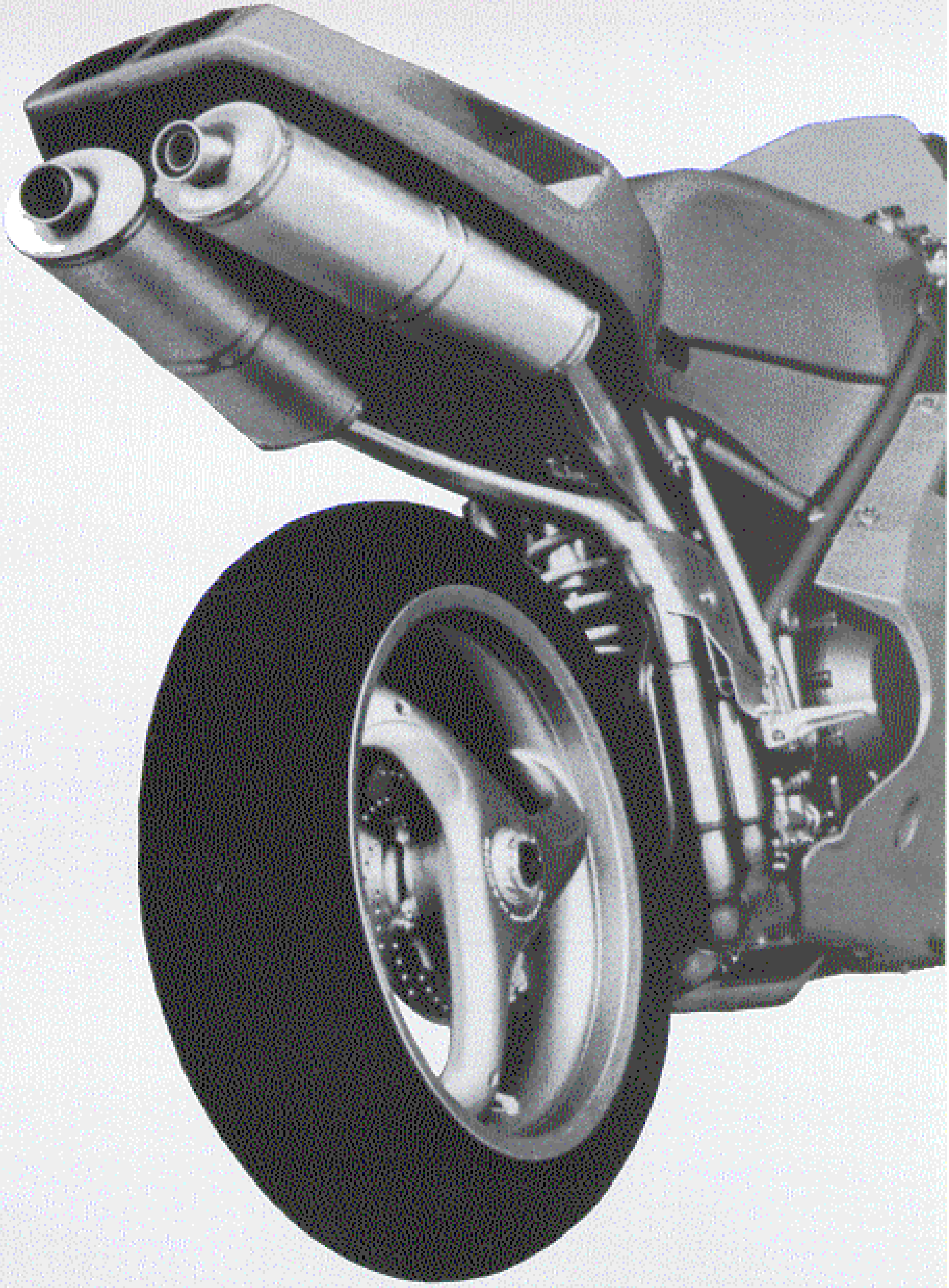

MOTORCYCLE NOISE: THE CURIOUS SILENCE

A REPORT BY THE MOTORCYCLE INDUSTRY

Preface

The noise made by motorcycles* excites interest and sometimes strong emotions in almost every developed market. It can rekindle memories of a past youth, represent part of a current self-image, be an everyday irritation or a political headache. In the studies presented in this report it has become clear that the same basic causes of this interest are at work.

The origin of this report was in the discussions of the future legislation to be applied in the European Union in the late 1990s. However, very similar discussions were also held in the USA in the late 1970s and early 1980s prior to establishing the legislation which has been in place since 1983. Research in Japan has also shown the same mechanisms in operation.

The issues raised in this report are therefore truly international and provoke fundamental vehicle design challenges and profound public policy questions related to the law and its enforcement. The review and analysis in this document provide a status report of the present situation using the specific case of the region with the toughest noise legislation for new vehicles. Due to the general nature of the issues, the conclusions are valid for any developed market.

* In this report the term motorcycle, when used generally, includes mopeds.

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Executive Summary

The motorcycle noise question arouses strong feelings amongst users and non-users and presents many challenges to the industry, the regulators and the law enforcement agencies. Unfortunately, discussions of the issues involved have in the past tended to be divided with different aspects being treated within different organisations. The result has been a piecemeal approach to a problem which needs to be solved by approaching it from many different angles. The purpose of this review document has been to collect together, for the first time, a complete picture of the issues involved in trying to find a satisfactory and lasting solution to the motorcycle noise question.

In summary the research reviewed in this paper leads to the following conclusions:

- powered two wheelers (mopeds and motorcycles) in original condition are quiet
- the public perceives powered two wheelers as noisy because either the environment is quiet (at night) or the vehicle is equipped with an illegal exhaust
- illegal replacement exhausts are promoted heavily in advertisements and glamorised editorial coverage
- overall there is a 35 % (motorcycle) and 65 % (moped) penetration of illegal exhausts in the parc of vehicles: implying that over 2 million motorcycles and 7,5 million mopeds have illegal RESS*. The majority of these are 10 - 15 dB(A) over the limit. At this level the increased noise is the equivalent of adding 25,6 million 'standard' motorcycles to the existing parc of 6.8 million motorcycles and 79,8 million 'standard' mopeds to a parc of 12.3 million: it is the direct result of law-breaking on an enormous scale.
- when compared with a hypothetical parc which meets the legal limits exactly, the presence of so many illegal systems raises the average noise output 7 times
- 2/3rds of riders consider excessive noise on the public highway is inappropriate and 73 % believe the rider has a responsibility towards the environment
- aftermarket replacement exhausts are mainly bought for general performance (driveability, response etc.), price and image (sound quality etc.). The importance of performance and sound will ensure that riders will expect to ride motorcycles with appropriate driveability and image characteristics.
- tests were run in five different European cities to document typical motorcycle usage. The conclusions were that riders maintain their riding style in different situations, the gearbox is used to keep the motorcycle with the traffic flow and that the larger the engine capacity, the lower the engine speed used and the smaller the range of rpm needed.
- legislation exists to control the new vehicle but little has been done, until recently, to control replacement exhausts or vehicles in use. There is a lack of control at the point of sale (particularly for the 'racing use' loophole) and of powers, procedures, equipment and priority for the police to act effectively.
- control of individual imported vehicles (25% of the large motorcycle market) is also necessary to prevent individual nuisances with higher noise levels being produced in the environment
- the technical options for making new motorcycles and mopeds quieter are limited, as known noise reduction technologies are already applied to meet existing limits. Therefore, there is no single solution since the contribution of each noise source differs depending on the type of motorcycle.

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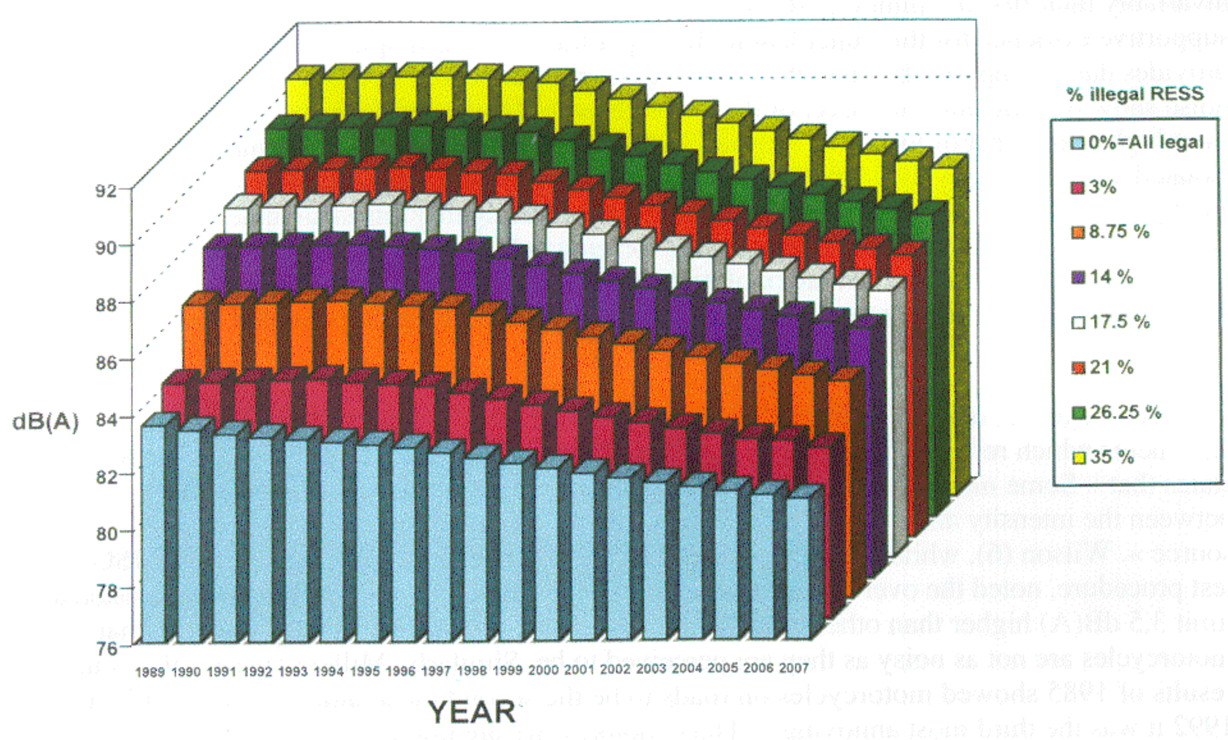
*RESS: Replacement Exhaust Silencing System

- a complete motorcycle must satisfy not only noise requirements but also safety, exhaust emissions, cost, productivity, durability, driveability and practicality considerations. A technology which only reduces noise and does not solve its own disadvantages is unacceptable.
- the analysis of the cost implications of meeting the limits agreed by the EU for 1998 showed that the cost to the user in terms of sales price would increase by about 9 %, resulting in a drop in sales in the order of 15 %. For the motorcycle to survive, a balance must be struck between performance and price, as well as product appeal.
- given conservative assumptions concerning future sales, scrapping rates for existing motorcycles and the illegality of illegal RESS, it is clear that tinkering with the limits for the original equipment fitted to new motorcycles will have a minimal effect when compared to, say, cutting the number of illegal exhausts currently in use by three-quarters: eg for mopeds, 0,32 dB(A) against 5,49 dB(A); for motorcycles 2,61 dB(A) against 3,73 dB(A). Even then, in both cases the remaining illegal exhausts would still double the average noise output.
- as summarised in the figure, the policy options are clear; the greatest and swiftest improvement in the environment would come from reducing the percentage of illegal exhausts in use, focussing on original equipment would bring small results over a very long period, whatever limit value was chosen.

Figure 5 : Summary of Noise Calculations



Therefore, in the industry's opinion, the most beneficial avenues for further investigation lie outside the scope of proposals for reducing noise from new vehicles and in the field of effective law enforcement.

1. Introduction

There is a conundrum at the centre of the motorcycle and moped noise issue: time and again independent researchers have shown that new motorcycles and mopeds are amongst the quietest vehicles on the road and yet they are perceived as a noisy nuisance.

In their original condition mopeds are already significantly quieter than future passenger cars and soon most motorcycles will reach the limits previously only attainable by four-wheelers. Like the conundrum, these facts are cloaked in a curious silence which muffles proper discussion and obscures the search for positive solutions.

The purpose of this report is to break out of this obscurity and, for the first time, present the results of several years' work by the industry into the curious silence surrounding motorcycle and moped noise.

2. Public attitudes

2.1. Researched opinions

Opinion research in the past has usually concluded that motorcycles are noisy, in an absolute sense, without considering the origin of the problem. For example Steven (1) states «Although quantitatively speaking motorcycles make up only a small proportion of total road traffic, they invariably rank first in opinion polls on noise nuisance, together with lorries ». There is no supportive evidence for this statement in the paper but it is a firm opinion. Stenschke (2) provides data to support the view that, « Surveys on the exposure of the population to traffic noise show that the nuisance level of the noise generated by motorcycles is considered to be even higher than that of lorries ». Nelson (3) makes the point that « in the home, the sudden, isolated and comparatively penetrating sound of a motorcycle, particularly if it is late at night can have a sharply disturbing quality heightened by a feeling that this is an unnecessary disturbance ». Such events are significant for forming public attitudes. An EU public attitude survey (4) concluded that « An index of noise exposure ... showed the highest EU exposure frequency indices to be : motorcycles, cars and lorries and barking dogs (in that order).».

The above extracts refer to motorcycle noise in absolute terms. However, there are other statements which refer to the qualitative aspects of noise. Armitage (5), while referring to noise states that « Some motorcycles can cause added irritation by virtue of the disproportion between the intensity and quality of their noise and the commercial unimportance of its source ». Wilson (6), while setting the values for the dB(A) figure associated with the ISO 362 test procedure, noted the over-reaction of people to the sound of a motorcycle and suggested a limit 3,5 dB(A) higher than other vehicles to compensate for this. He is thus implying that motorcycles are not as noisy as they are perceived to be. Similarly, Miller (7) states that « the results of 1985 showed motorcycles on roads to be the second most annoying source but in 1992 it was the third most annoying ». Thus, motorcycles are not invariably the greatest nuisance and they are becoming less important. Nelson highlights the importance of relative noise, « The greatest awareness of motorcycle noise occurs in situations where the overall noise levels are low and where people are otherwise generally reasonably content with the traffic noise to which they are subjected ». Any noise intrusion in these situations will raise awareness.

There are also references which state that motorcycles are not inherently noisy. Nelson (3) « It is perhaps surprising to find that the noise level/speed function for motorcycles operating in top gear is essentially identical to that obtained for passenger cars, implying that for free speed operation, motorcycles are among the quietest of all vehicles ». This question of speed and acceleration and the attendant noise increase is also noted by Steven.

Vanke (8) makes the best overall statement on the question of noisy motorcycles « motor-cycles are amongst the quietest vehicles on the roads. Yet public perception invariably labels them as the noisiest. This is because most people simply do not notice the quiet bikes but always notice the noisiest ones. This becomes equated with « all motorcycles are noisy ».

2.2. The link between noise and the state of the vehicle

However, Vanke's summary is self-contradicting and leads to the conclusion that the owners modify their vehicles such that they become noisy. A detailed German study (2) showed how easy such modifications are. In 1989 there were 1357 different types of silencer offered for sale which would have increased the vehicle's homologated value by up to 21 dB(A) (an increase of 128 times in sound pressure level).

Nelson's qualitative data suggests that young riders deliberately make their vehicles noisy, a point discussed in § 4 below. Romaine (9) identifies non-standard silencers as the source of additional noise and is supported by Dunmore (10) « this is hardly surprising since it is estimated that at least one third of Britain's 1,2 million motorcyclists have illegal (excessively noisy) silencers on their motorcycles ».

Thus, although the vast difference in noise output because of rider modification is widely recognised, it has not been officially researched or linked to complaints. Consequently, the significance of owner modification has not been fully realised at the policy level and the opinion is still that all motorcycles need to be made quieter.

3. Owner modification

3.1. Types of modification

There are essentially two types of owner modification which raise the noise output to illegal levels:

- physical alteration of the existing silencer (e.g. destroying the baffles, drilling holes)
- replacement of the exhaust system.

The first form of modification is difficult to survey but is thought to be a relatively small part of the parc (but not necessarily the nuisance) given the opportunities provided by the second option, replacement with illegal RESS.

3.2. The impact of the replacement market

3.2.1. The marketing and easy availability of illegal RESS

To assess the ease of access to illegal exhausts, a sample of 24 motorcycle magazines was collected from 7 European countries. There were 53 advertisements for illegal RESS in the 24 magazines.

The breakdown by country is indicated in the table below :

Country	Number of magazines examined	Number of adverts for illegal exhaust systems
Belgium	6	6
France	3	1
Germany	5	14
Italy	4	15
Netherlands	1	3
United Kingdom	5	14
Total	24	53

Except in Italy, where mopeds were also included, the advertisements were for motorcycles . In some cases the advertisements were for 'racing systems' and in others the compliance (if any) with the law was not clear. An additional analysis of a large mail-order catalogue showed 847 RESS on offer without any indication that the systems were legal.

In addition to advertisements there is frequent glamorised editorial coverage of new products and even articles based on comparative tests of noise and power in which information on illegal RESS is spread widely. Riders are attracted to such systems by :

- the racing image
- the claimed increases in power
- the lower retail price.

Illegal RESS are therefore freely advertised and available to the motorcyclist. The results of this availability and promotion are analysed in the next section. (Note: the only exception to this situation is France where new legislation has been introduced. At the time of writing it is too early to say how successful this new approach will be.)

3.2.2. The extent of illegal RESS in the EU parc

A survey was carried out by 12 independent observers in seven European countries to quantify the penetration of illegal RESS in the powered two-wheeler (PTW) parc. 6103 vehicles were inspected at a variety of locations e.g. city-centres, enthusiast events etc., between May and November 1993. In many cases it needed specialist knowledge to recognise the legal status of the vehicle (Annex 1).

The results can be summarised as follows :

Table 1 Exhaust systems in the EU (%)

	Moped	Motorcycle < 80 cc	Motorcycle 80-175 cc	Motorcycle > 175 cc	Total Motorcycles
Original equipment	33%	38%	47%	65%	58%
Homologated After Market	2%	2%	5%	8%	7%
Non-homolog. After Market	65%	60%	48%	27%	35%
Total	100 %	100 %	100 %	100 %	100 %

Table 2 Percentage of illegal RESS by Member State

Italy	59
Spain	55
Netherlands	34
France	31
UK	19
Belgium	17
Germany	11

It is well known that the noise output from non-homologated RESS is almost invariably illegal and this fact has been used in the following discussion. These figures imply that over 2 million motorcycles and 7,5 million mopeds have illegal RESS. Stenschke established that these systems could be up to 21 dB(A) over the legal limit though other tests put the majority from 10 - 15 dB(A) over the limit. At this level the increased noise is the equivalent of adding 25,6 million 'standard' motorcycles to the existing parc of 6.8 million motorcycles and 79,8 million 'standard' mopeds to a parc of 12.3 million: it is the direct result of law breaking on an enormous scale.

(Note: the concept of a 'standard' vehicle is explained at the start of section 8 below.)

3.2.3. The consequences of illegal RESS

By dividing the PTW parc into legal and illegal vehicles (65 % of mopeds and 35 % of motorcycles (Table 1)), assuming a scrapping rate of 10 % and adding a figure of 12 dB(A) (conservative average rounded figure for the 10 - 15 dB(A) range) to the limit value, the impact of the illegal RESS can be calculated by comparison with a hypothetical parc, all of which meet the legal limit exactly.

Table 3 Comparative noise levels dB(A) (per standardised average vehicle)

	Moped		Motorcycle	
	All legal dB(A)	With modified RESS dB(A)	All legal dB(A)	With modified RESS dB(A)
1989	75,30	85,57	83,56	93,42
1997	75,02	85,29	82,57	92,73
2007	74,98	82,71	80,95	88,98

It should be noted that 1989 was the last year before EU Member States started to introduce the first stage limits of Directive 87/56 for motorcycles and that the proposed limits for 1997 have been assumed. Similarly, the small effect of the new limits over the period of nearly two decades reflects the influence of a very large parc of vehicles on a small volume of sales.

Although all figures fall over the period and even converge slightly there is still at least a 7-fold increase in the noise output due to the illegal systems.

4. Rider attitude survey

To examine the reasons behind the desire of owners to modify their vehicles to such a degree a survey was carried out in six European countries, generating 1.034 completed interviews (91 % male respondents).

In summary the results were as follows :

- 90 % agreed that there was a difference between noise and sound
- 86 % agreed that a racing sound was attractive on a race track
- 34 % disagreed and 58 % agreed (26 % strongly) that a racing sound was not attractive on public roads
- 31 % agreed and 56 % disagreed that a noisy motorcycle was safer than a quiet one
- 65 % agreed and 25 % disagreed that the quality of a motorcycle's sound was important in making a choice
- 47 % agreed and 41 % disagreed that a motorcycle's noise output was important in making a choice
- 38 % disagreed and 50 % agreed that the legality of a replacement was as important as its sound
- 26 % disagreed and 59 % agreed that the legality of a replacement was as important as its noise
- 73 % agreed that motorcyclists had a responsibility not to annoy the general public (14 % disagreed, 5 % strongly).

The reasons for choosing the last aftermarket replacement were :

	%
• performance	28
• price	20
• sound	16
• styling	14
• noise	7
• other	15
	100

78 % thought that a RESS could change the performance of a vehicle, 83 % in a positive way (torque, power etc.) and 17 % negatively. Respondents thought that quiet exhausts would reduce performance (30 %), increase it (10 %), have no effect (60 %).

These results show that the difference between sound quality and noise output is understood and that a racing sound is attractive to almost all on the race track. However, opinion is divided sharply over what should be heard on the road, with only 34 % agreeing that a racing sound is attractive. A similar number (31 %) think that a noisy motorcycle is safer. Noise is considered more important than the legality of the RESS by 26 %, though only 14 % think motorcyclists have no responsibility for not annoying the general public.

The 34 % appreciation of a racing sound on the public road and the allied attitudes listed above match neatly with the 35 % market penetration of illegal RESS in the parc. However, noise is only the 5th ranked factor (7 %) when the reasons for choosing a RESS are analysed. The main reasons for choosing a particular RESS are the performance of the vehicle and the price, sound and styling of the RESS.

The change in vehicle characteristics as a result of fitting a RESS is recognised as being potentially positive or negative. These characteristics include factors other than power, for example, torque, which has a major effect on driveability. The reference to performance is therefore not a simple search for engine power but refers to an engine response and the maintenance of an average road speed which suit the rider's personal style. The susceptibility of riders to the press articles and advertisements (§ 3.2.1 above) is therefore understandable.

The price argument is a simple reflection of the relative level of research and investment to be amortised, in the case of the conscientious RESS manufacturers; and the absolute lack of any significant cost for the unscrupulous, when compared to the vehicle manufacturer. Cut-throat competition maintains low prices in the RESS market adding to the pressure to cut corners by inadequate investment. In such a market it is ironic that the honest suffer most.

The issues of sound and styling are combined in the question of image. Tonal quality is extremely important to the image of the product as a whole and some brands in particular. The quality of the exhaust sound therefore has a high potential for alteration which has nothing to do with a desire to break the law or necessarily achieve a more satisfactory performance.

It would appear, therefore, that the general comments on noise analysed earlier are secondary attitudes generated by the realities of the RESS market. The significance of the one-third of riders with illegal exhausts and the corresponding views is clear. Less obviously, the importance of performance and sound will ensure that riders will expect to ride motorcycles with appropriate driveability and image characteristics. These characteristics can only be maintained if the sound limits are realistic. If the limits are set at a lower level the likelihood of owner modification is correspondingly increased, a point discussed further in § 8.4 below.

5. Motorcycles in urban and suburban use

5.1. Introduction

As part of the industry's overall programme of research into rider attitude and behaviour, a study was carried out in the period July-October 1994 to document typical motorcycle usage in European cities. In addition, previous studies (IMMA 1984, JAMA 1985, Piaggio 1991, Harley-Davidson 1992) had shown that typical vehicle speed, engine revolutions and gear selection did not match those specified in the legislative test; so this issue was also examined.

A representative sample of 10 models was drawn from 10 manufacturers and these motorcycles, equipped with vehicle and engine speed sensors, were ridden in 5 different cities by a variety of riders.

5.2. Method

The motorcycles were divided into two groups: one to be tested in Frankfurt, Stuttgart and Amsterdam, the other in Paris and Pisa. The routes were two-thirds city centre and one-third suburban driving.

The first group carried out 3 trips/day/motorcycle at 08h00, 13h00 and 15h00. The second group achieved a minimum of 10 trips/day/motorcycle covering the period 07h00-19h00. On average the duration of the trips was 35 minutes, the distance 18 kilometres and the average speed 29 km/h.

The riders were industry personnel familiar with the routes and the vehicles. They were briefed to ride according to their natural style while remaining with the general flow of traffic. Thus, for example, filtering through stationary or slow-moving traffic was acceptable; street racing was not. (Analysis of the traces showed that riding patterns typical for the course were predominant, with the occasional high speed burst.)

5.3. Analysis

5.3.1. Rider and vehicle behaviour in urban/suburban driving

Table 4 summarizes the key data from the study. Idling time was excluded as part of the analysis because in this condition the noise generated is not significant; the study therefore represents the worst case condition. Similarly, analysis was confined to the median and 95th percentile values for the principal variables as these are standard statistical reference points.

The most commonly used gear was third, followed by fourth. A range of lower gears was used by the largest motorcycles. The smaller motorcycles tended to spend less time than the larger vehicles in the lower gears, reflecting the need to keep the vehicle speed up to that of the traffic flow; as can be seen in the similarities of vehicle speeds.

Table 4 : A summary of IMMA's 1994 urban driving cycle data

Motorcycle				Gear most used				Vehicle speed		Engine speed		Stnd dev'n	Engine speed as a % S		Rpm/S at line BB' (%)		
Model	cc	Number	S	1st		2nd		median	95 percentile	median	95 percentile	all gears	median	95 percentile	(European test)		(EPA test)
code		of gears	rpm	gear	% time	gear	% time	km/h	km/h	rpm	rpm	rpm	rpm/S	rpm/S	2nd gear	3rd gear	
A	73	Var	6500	-	-	-	-	21,12	63,99	3306	7103	.	50,86	109,28	-	-	95
B	124	6	7900	3	22,95	4	22,74	31,78	67,1	3895	6798	1132	49,30	86,05	-	91	95
C	124	7	11500	3	31,36	4	29,17	26,51	54,33	3514	6125	951	30,56	53,26	-	-	95
D	150	Var	7750	-	-	-	-	32,31	60,68	3211	5082	.	41,43	65,57	-	-	95
Cat 2 Av	133	5	9050	3	27,16	4	25,96	30,20	60,70	3540	6002	1042	40	68	-	-	95
E	349	6	7600	4	31,13	3	23,21	30,05	66,14	2811	5138	850	36,99	67,61	108	86	81
F	498	6	8500	3	24,4	4	23,86	33,45	69,56	2620	4810	895	30,82	56,59	80	61	70
G	583	5	8000	3	34,59	4	28,11	29,27	61,51	1925	3428	681	24,06	42,85	83	59	62
H	916	6	9000	2	36,47	3	23,83	35,07	66,01	2088	3404	510	23,20	37,82	73	48	55
I	1085	5	7250	2	31,98	3	30,25	29,06	64,16	1633	3014	561	22,52	41,57	68	44	55
J	1340	5	5000	3	33,65	2	29,99	29,35	59,8	1630	2876	413	32,60	57,52	73	48	55
Cat 3 Av	795	5	7558	3	32,04	4	26,54	31,04	64,53	2118	3778	652	28,37	50,66	81	58	63

Note: A further motorcycle in category 3 was tested but due to data aquisition problems the results were unreliable and so have been excluded.

The ability of the larger and more powerful motorcycles to remain with the traffic flow while using lower engine revolutions is also clearly shown; median and 95th percentile rpm figures are almost 50 % higher for the smaller capacity engines. Another measure of this tendency is the size of one standard deviation for rpm in all gears; which shows that there is a declining spread in the rpm used as the engine capacity increases.

In addition to the data presented in the table the following general observations were made:

- the average engine rpm varied little during the day, indicating that differences in driving habits and traffic flow did not influence the engine speed
- vehicle speed varied for all models throughout the day, as a function of traffic flow
- the average vehicle speed was influenced by the street configuration and the general traffic flow. (In 'speed order'; suburban Frankfurt, Stuttgart, Pisa, Paris, Amsterdam, Frankfurt centre.)
- the average engine rpm/motorcycle/city tended to remain consistent, regardless of gear selected
- no individual variable, including acceleration rates, was statistically significant
- for Frankfurt and Amsterdam comparisons with the 1984 study on the same routes showed that median values fell (reflecting denser traffic) but 95th percentile values remained constant (indicating that not every part of the route had changed.) Increases in average engine powers also reduced the median rpm/S values.

The conclusions are therefore that riders maintain their riding style in different situations, the gearbox is used to keep the motorcycle with the traffic flow and that the larger the engine capacity, the lower the engine speed used and the smaller the range of rpm needed.

5.3.2. <u>The relationship between real use and the current legislative tests</u>

To examine how well the current legislative tests reflect reality the engine revolutions at line BB' (the end of the acceleration test strip) and the 95th percentile figures for engine rpm in urban/ suburban driving were compared (Table 4).

From this comparison it can be seen that the 'closing' rpm, as a % of S, for the European test in second gear are consistently and considerably higher than the 95th percentile figure (e.g. by 59 % on average for category 3). However, the difference for third gear is much less (e.g. + 14 % on average in category 3), which reflects the fact that third gear is the most commonly used.

The comparison with the EPA test from the USA also shows a closer correlation, although there is a 23 % disparity for category 3. In part this closer relationship reflects the fact that the EPA test was designed after a field study of motorcycles in use but also, more narrowly, the test takes account of the fact that larger motorcycles use less engine revolutions, as discussed above.

These findings therefore suggest that further work should be carried out to up-date the full acceleration method so that it can be used to effect a real change in motorcycle noise levels in urban areas.

6. Legislation and enforcement

Focussing specifically on the example of the European Union (EU), Table 5 summarises the legislative situation in November 1995. The subdivisions are for legislation covering:

- new vehicles
- vehicles in use
- RESS (legal requirements)
- illegal and racing systems

The conclusions are as follows:

- Member States have legislation type-approving new models, conforming to either the existing Directives, the United Nations Regulations or other national requirements
- the « grey import » vehicles are not checked in several countries, even though it is a significant part of the market in some states
- very few countries have regular checks on vehicles in use though spot checks are possible in most countries, even if they are considered ineffective. (In this context the industry recently succeeded in introducing a manufacturer's plate, with the necessary information on it to enable road-side testing to take place, into international legislation. This plate eliminates many of the problems for mounting effective road-side enforcement campaigns)
- the requirements for RESS are technically the same as for the original equipment on the new vehicle, though the marking and paperwork requirements are still complicated by a lack of harmonisation
- although advertising codes for RESS exist in two countries the general situation is that « race only » systems and illegal, unhomologated systems can be sold without difficulty in all countries except France and Belgium

In France, for example, in order to buy a racing exhaust, the customer has to produce a competitor's licence, a photocopy of which is attached to the bill. When the dealer wants to renew his stock, he has to submit the bill with the photocopy of the licence to the authorities. In theory the controls are comprehensive but there are problems in practice, especially with the racing exhausts. For example the customer can either go to another dealer or buy a racing exhaust in another country. The central authorities have evidence that customers have bought racing exhaust from several dealers. Nevertheless, there is an improvement in the situation because the stock of racing systems is more limited.

In general the effectiveness of legislation depends on whether or not it covers all the problem areas and if it is adequately enforced. The industry's review of current enforcement activities has revealed the following problem areas:

Table 5a Enforcement of legislation on noise for mopeds and motorcycles in the EU (Situation Nov. 95)

		B	D	DK	ES	F	GR	IRL	I	NL	UK
1. New MP* / MC*	1.1 MP Type - approval	R.63 or National	National	R.63	R.9	R.63 or National (TPSI)	R.63	None	R.63 or National	National	R.63 or National self certif.
	1.2 MC Type - approval	National R.41 EC stage 0	R.41 EC stage 2	EC stage 1	R.41 EC stage 2	EC stage 2	R.41 EC stage 2	None	national R.41 EC stage 1	EC stage 2	self certif. EC stage 1
	1.3 C.O.P. for MP for MC	Y Y	Y Y	N N	N N	N N	N N	N N	N N	Y N	N / (1) N / (1)
	frequency	not defined	3-4/year							1st + every 2 year	
	1.4 Grey import for MP for MC	Y Y	Y Y	Y Y	N N	Y Y	N N	N N	N N	impossible Y	N N
	method		theor.Y, often No	as 1.1 / 1.2		Static				Motion R41	
2. In use MP / MC	2.1 Regular check for MP for MC	N N	N (2) N (2)	N Y	N Y	N N	N N	N N	N N	N N	N (2) N (2)
	frequency	-	every 2 yr.	when sold if > 5 year	every 4 yr.	-	_	-	-	-	if > 3 yr. every yr.
	2.2 Spot checks for MP for MC	Y Y	Y Y	N Y	Y Y	Y Y	Y Y	N N	Y Y	Y Y	Y Y
	If yes: method	static	by ear TÜV (3)	static	< Ref. +5	Static	Static	-	static <Ref+5dB	Static <Ref+5dB	only Police opinion; no test proc.
	penalty	Fine + rectification vehicle (5)	DM 110 + 3 points	Fine + rectification vehicle (5)	confiscated until new test	FFR 300 rectification vehicle (5)	GRD 50.000	-	fine + new test	NLG 150 + (confisc.) (8)	Fine + rectification vehicle (5)
	effective ? (why not)	Not freq. enough	Lack of equipment and staff	Y	Y	Not freq. enough	No (6)	_	Not strict enough	Y	Not freq. enough, no provis. (7)

(1) If homologated by UK (e13): Yes.
(2) Safety items only, noise only if too loud or no marking
(3) Police does not measure, but can send owner to test institute (TÜV).
(4) Measured level should be lower as Reference level, 5 dB tolerance.
(5) Vehicle rectification notice, vehicle has to be put in original state and tested within certain time.
(6) Owner can ask appeal and replace parts before 2nd test
(7) The police has no legal provisions to measure noise level.
(8) MP: NLG 150, confiscation depends noise level, MC: NLG 250, no rectification or confiscation

* MP = moped
* MC = motor cycle

Table 5b Enforcement of legislation on noise for mopeds and motorcycles in the EU (Situation Nov. 95)

		B	D	DK	ES	F	GR	IRL	I	NL	UK
3. RESS	3.1 Limit MP	as 1.1	as 1.1	not allowed	as 1.1	Y T.P.S.I	N	N	as 1.2	as 1.2	BS AU 193
	3.2 Limit MC	EEC R41	as 1.2	as 1.2	as 1.2	as 1.2	N	N	as 1.2	as 1.2	BS AU 193
	3.3 C.O.P for MP	N	Y	-	N	N	N	N	N	Y	N
	for MC	N	Y	-	N	N	N	N	N	Y	N
	if yes: frequency	-	unknown	-	-	-	–	–		random check	-
	3.4 Verification appr.marks		Y	-	N	Y	N	N	N	Y	Y Y
	by whom		KBA	-	-	Customs	-	-	-	ECD	(11)
	Effective?	N	No, nearly never done	-	-	No regular verifications	-	N	-	Y	No time + resources
4. Illegal silencers	4.1 No approval allowed ? for MP	N	N	N	N	N	N	Y	No control	N	N
	for MC	N	N	N	N	N	N	Y	No control	N	N
	penalty		DM 110 + 3 points	confiscation parts, new test, fine		as 2.2	as 2.2 (6)		-	fine + confiscation of parts	fine
	4.2 Allowed to sell, etc.	N	Y	Y	Y	Y (9)	Y	Y	Y	N	Y
	If yes, restricted?	-	racing only	N		only if license (9)			racing only	-	racing only
	If no respected?		-	-	-	-			(10)	N	
	4.3 Allowed to advertise	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
	If no respected ?	-	-	-	-	N	-	-	-	-	N

(6) Owner can ask appeal and replace parts before 2nd test
(9) Parts can not be displayed on dealer show-room and theoretically, can be sold only to holders of racing permit
(10) Everybody is using racing silencers
(11) From 96.06.01 either self certification to BS AU 193 or an EU approval

1. There is a large and growing problem with used imported vehicles from other markets with less severe noise legislation. For example, it is estimated that for large motorcycles these 'grey imports' amount to 25% of the European market. At an average of 3-4dB(A) above the limit these vehicles have an appreciable impact on noise levels and individual noise nuisance.
2. Despite legislation requiring RESS to meet the same standards as the original equipment, the products actually sold often remain illegal. This problem reflects insufficiently tight control of the conformity of production and the absence of appropriate and correctly applied markings (see Annex for a detailed discussion).
3. As explained in section 3.2 above, the promotion of RESS is a significant factor and this is unchecked by any effective control on the sale of illegal systems, particularly those which exploit the 'for racing use only' loophole. The new French legislation covering motorcycles and mopeds and the Belgian regulations for mopeds are positive steps in the right direction and should be developed further.
4. Controlling new products, grey imports and the sale of RESS will reduce the number of units reaching the street. However, direct owner modification and the continued marketing of illegal products can only be controlled at the roadside. It is not practical to envisage a systematic use of, say, police time for this item but the more effective possibility of blitz campaigns in areas of high complaint would be a great step forward. Here, the industry has identified the following problems:
    - there is a lack of detailed legislation allowing the police to test vehicles at the roadside and requiring them to be put in order if found to be illegal
    - there is a lack of suitable, easily-used equipment, procedures and trained manpower for effective testing in accordance with the existing international stationary test
    - the enforcement of noise legislation has a low priority in police work
    - where regular (eg annual) inspections are held they have been shown to be too easily circumvented to be a practical option
    - there is no central databank of markings against which the vehicle's equipment can be checked.

Overcoming these problems on an international basis would improve the enforcement of the legislation substantially and would bring a corresponding improvement in the environment. Having identified the very real possibilities for improvement from more rigorous enforcement, the next section considers the options available from new vehicle design.

7. Technical parameters

7.1. Generally applied technology

7.1.1. Identification of noise sources and existing solutions

Major noise sources of motorcycles include the intake system, exhaust system, engine, drive train, tyres, etc. The exhaust system used to be one of the noisiest parts, thus motorcycle noise could be reduced by tackling the exhaust system alone. However, as measures have advanced, the percentage contribution of each noise source has become almost equal, and noise cannot be reduced further for the more recent motorcycles unless measures are taken for all noise sources.

Therefore, there is no single solution since the contribution of each noise source differs depending on the type of motorcycle (Figure 1).

The generated noise used to be measured by the time-consuming "lead-masking" method. In recent years, noise sources have been measured rather more easily using acoustic intensity as shown in Figure 1. Thus, patterns of noise sources can be determined. Although the measuring and analysis methods have been improved significantly, there are no innovative technologies to reduce noise itself. The major trends in conventional technologies are explained below.

The present technologies used to counteract motorcycle noise are basically the same as for other motor vehicles. However, measures for motorcycles are more difficult to realise than for motor vehicles for the following reasons :

1. a restriction on the silencer capacity (because of the space available and driving stability)
2. an exposed engine (practical reasons, e.g. maintenance)
3. a relatively high engine revolution speed (to maintain necessary performance with a small engine displacement).

The characteristics of noise vary for different motorcycles and so a technology that is effective for one type of motorcycle may not be effective for other types. Thus, development through trial and error for each type of motorcycle is required. For example, the inner structure of the silencer is completely different for each motorcycle type. Alternatively, if there is any resonance, improving the rigidity of parts for particular types of motorcycle may result in the opposite effect if applied to other types, due to their different frequencies.

Figure 2 shows an example of typical measures currently used for each noise source on a motorcycle. Furthermore, Figure 3 shows examples of measures for the engine. These measures are applied according to the characteristics of each motorcycle and, having existed for a long time, are not recent innovations.

7.1.2. <u>Implementation of technologies and impact on real and perceived emission levels</u>

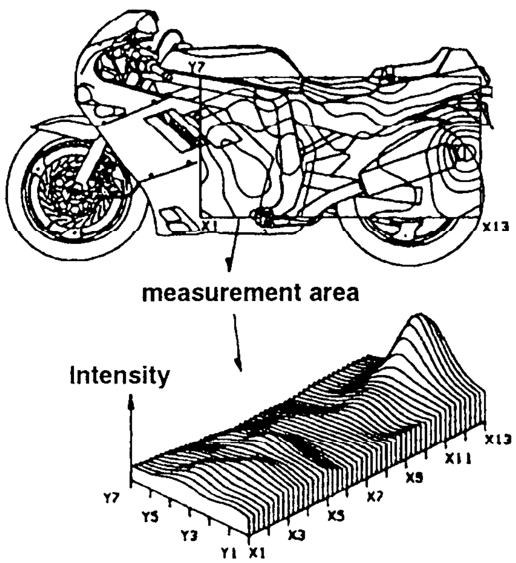
Over the past twenty years, the noise of motorcycles has been significantly reduced, as shown in Figure 4.

Table 6 shows an example of the effects of measures for each noise source implemented from 1987 to 1991 to reduce the noise energy by one half as shown in Figure 4. This shows that the effect of each measure is less than 0.2 dB(A). These repeated efforts have produced a total effect of several dB(A)s. However, these noise reduction techniques have reached a limit and further noise reduction can be achieved only if the basic functions of the motorcycle are sacrificed.

For example, assuming that the exhaust noise energy is reduced to half of the current level and that the noise from each source is equal (that is, the noise from the intake system, exhaust system, engine, drive train and others each contributes 20 %), then the vehicle noise reduction is only 10 % overall when none of the other sources are modified. As the following equation for the total noise shows, the reduction will be only about 0.4 dB(A).

Fig.1 Identification of Noise Sources

**Acoustic intensity method
(Detection of Noise Source)**



**Typical Example of Energy
Contribution of Noise Source**

MC (cc)	Contribution (%)					
	Exhaust	Intake	Engine	Drive	Tire	Other
1200	35	15	35	5	5	5
750	25	13	42	8	2	10
250	15	28	32	8	4	13
600	31	21	11	8	10	19
850	15	10	28	10	10	27
250	30	31	19	8	8	4
400	29	27	18	8	12	6
750	32	25	23	8	10	2
Average	26	21	26	8	8	11

Measured Intensity Patterns of Noise Source of 4 Motorcycles

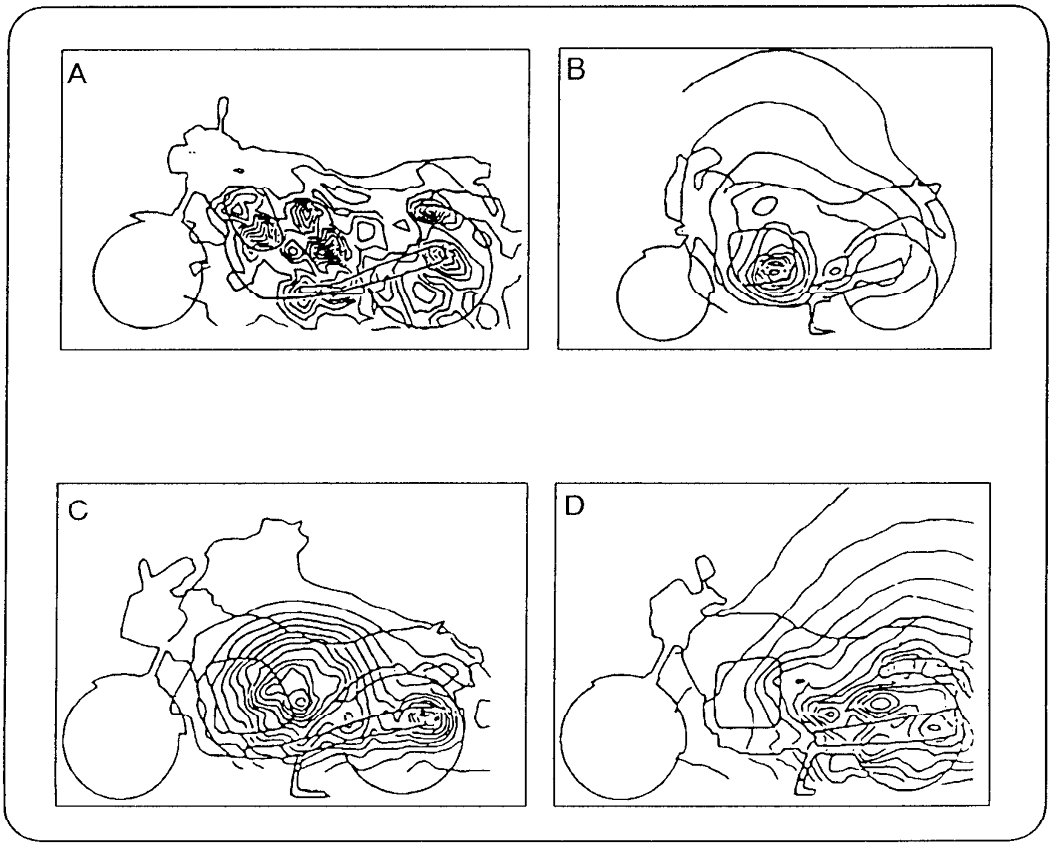


Fig. 2 Existing Solutions

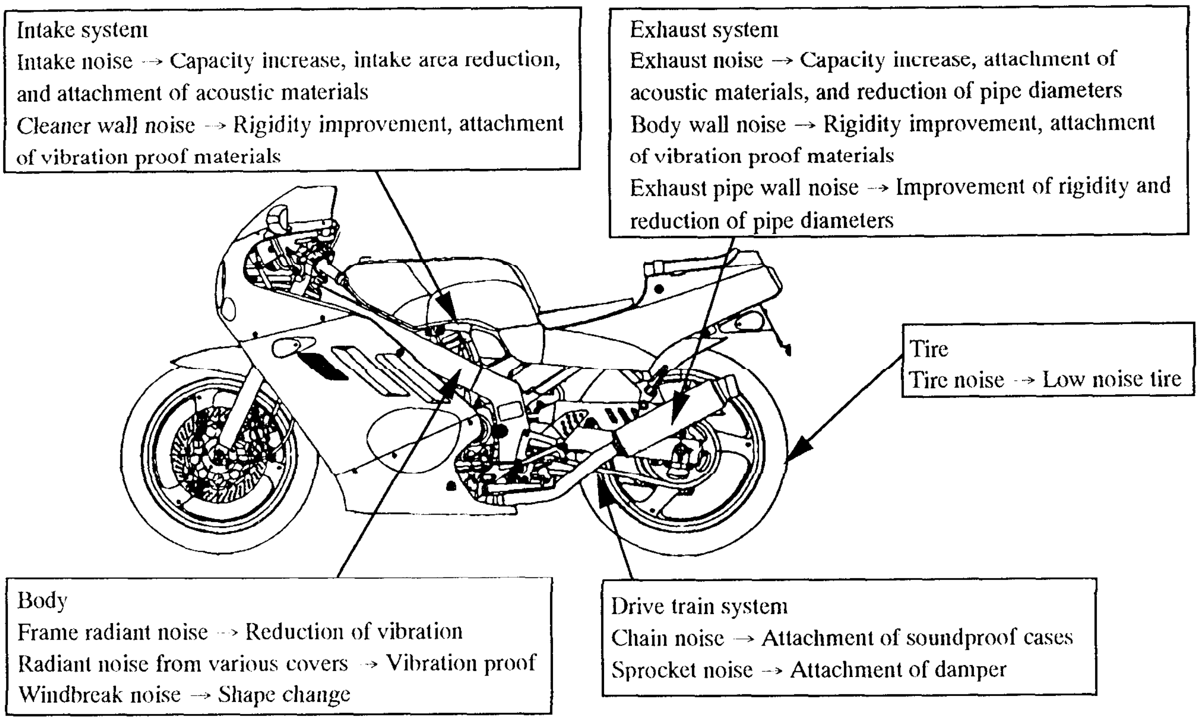


Fig. 3 Existing Solutions for Engine

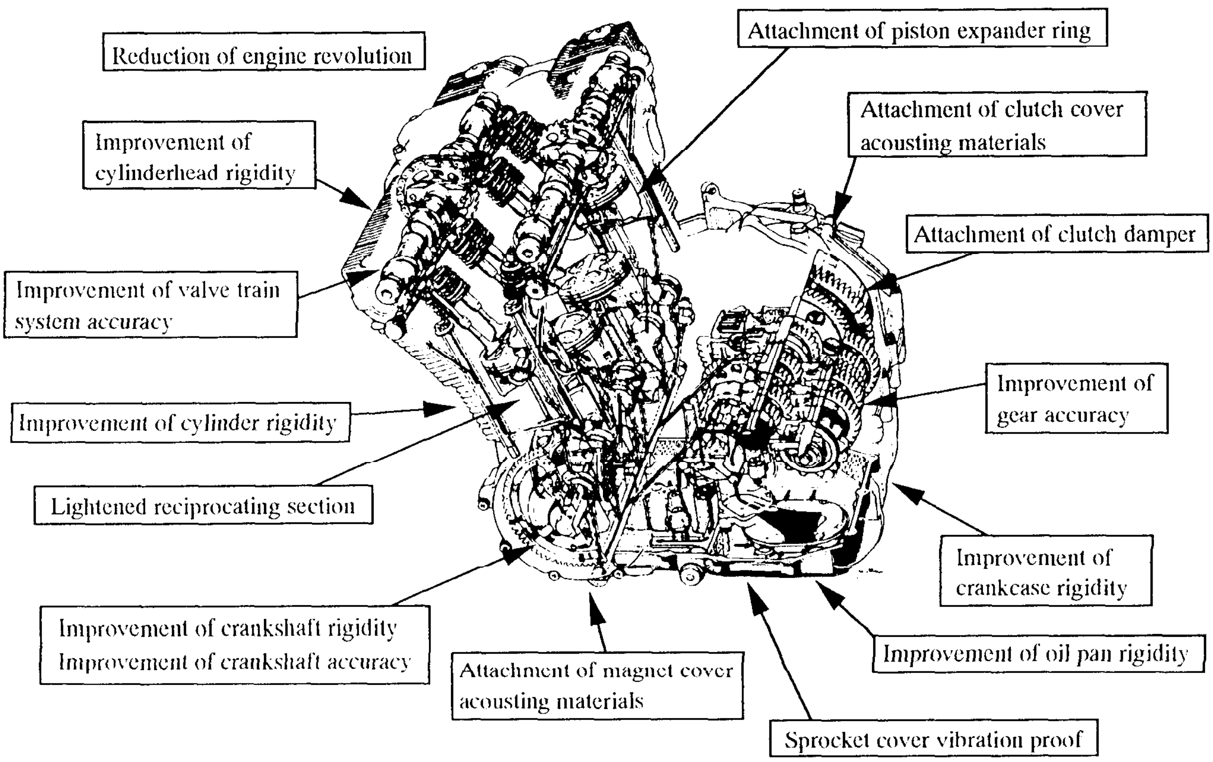


Figure 4 History of Motorcycle Noise

Table 6 : Impact of Noise Abatement Technologies

Actual example of air cooled four-stroke 400 cc motorcycle

Measured items	Measured section	Measured method	Noise reduction effect*
Engine	Cylinder	Attachment of cooling fin vibration proof rubber	0.1 dB
	Cylinder	Attachment of cooling fin vibration proof rubber	0.1 dB
	Valve train system	Attachment of automatic tensioner	0.1 dB
	Piston	Adoption of off-set	0.1 dB
	Crank shaft	Improvement of rigidity	0.1 dB
	Crankcase	Improvement of rigidity	0.2 dB
	Mission gear	Improvement of tooth shape accuracy	0.1 dB
	Oil pan	Increase in the number of attached points	0.1 dB
Intake system	Air cleaner	Capacity increase (5,000 → 7,600 cc)	0.2 dB
		Length increase and diameter reduction of suction pipe	0.1 dB
		Improvement of body rigidity	0.1 dB
Exhaust system	Muffler	Capacity increase (4,800 → 7,982 cc)	0.1 dB
		Body rigidity increase	0.1 dB
		Silencer structure change	0.1 dB
		Attachment of acoustic materials	0.1 dB
	Exhaust pipe	Strengthening of vibration proof	0.1 dB
Drive train system	Sprocket gear	Attachment of damper	0.1 dB
	Chain case	Material change	0.1 dB
Others	Cowling	Attachment of acoustic materials	0.2 dB
			Total 3.1 dB

* Noise reduction effects indicate the effects of each measure on the noise of a whole motorcycle.

10 log (1-0.1) = 0.458
Therefore, reducing the energy of any typical noise source of modern motorcycles that already incorporate the advanced measures shown in Figure 4, is very difficult.

Furthermore, a complete motorcycle must satisfy not only noise requirements but also safety, exhaust emissions, cost, productivity, durability, driveability and practicality considerations. A technology which only reduces noise and does not solve its own disadvantages is unacceptable.

For example, a typically effective measure for the exhaust system is to make the silencer capacity larger and the exhaust becomes quieter. However, problems of space and exterior design occur, and the handling and fuel consumption are adversely affected due to the increased weight. In addition, if the capacity is large, the silencer surface area increases, causing a larger transmitted noise to offset the reduced noise of the exhaust system.

Covering the engine causes problems of heat radiation and weight increase. In some cases, radiated noise occurs due to the vibration of the cover itself. Technologies are therefore only applicable to mass-produced motorcycles if these problems can be solved.

Table 7 shows how the effect of one noise measure differs for each motorcycle type. Such differences cannot be simply identified with engine types (classified by stroke and crank design), or by types such as on-road or off-road, but are caused by the details of each model of motorcycle. Therefore, the effects of a measure for a specific model may not be effective for other types; simply evaluating them in terms of numerical data is not accurate.
If the present technologies are developed and applied in the next stage of the Directive (82 → 80 dB(A) for 175 cc or more), the expected noise reduction effects are shown in Table 8. All of these measures incur greater costs. In order to reduce the noise of a motorcycle by 2 dB(A), price increases due to significant changes in specifications and a reduction in performance cannot be avoided.

7.1.3. <u>Cost benefit analysis of technologies needed to meet the EU limits proposed for 1997</u>

The production quantity is a major factor when studying cost, with the cost per unit rising for smaller production runs. Studies must therefore be made in advance to predict how sales volumes will be affected with the application of new and more expensive technologies. Part of this analysis has to consider the consumer perception of the benefit from the increased costs. The analysis of the cost implications of meeting the proposed 1997 limits showed that the cost to the user in terms of sales price would increase by about 9 %, resulting in a drop in sales in the order of 15 %. For the motorcycle to survive, a balance must be struck between performance and price, as well as product appeal.

7.2. <u>Advanced technologies</u>

The term 'advanced technologies' covers those technologies which have reached the production stage but are not yet widely used throughout the product range. A 'prototype technology' is one for which the scientific possibilities are established but not the means of practical application. For motorcycle noise 'prototype technologies' do not exist at present. The advanced technologies are therefore at the forefront of technical progress and are based on the same techniques as are applied in other vehicle industries.

Table 7 : Application of Noise Abatement Technologies

Noise source	Technologies	Model			
		A	B	C	D
Exhaust noise	1. Increased volume of silencer	Δ	X	Δ	Δ
	2. Modified internal structure of silencer	O	Δ	Δ	O
	3. Duplex structure	Δ	Δ	O	Δ
	4. Vibration proof outer shell & reinforcement	Δ	Δ	O	Δ
	5. Additional auxiliary silencer	Δ	O	X	Δ
Intake noise	1. Increased volume of silencer	Δ	X	Δ	Δ
	2. Modified shape of intake duct	O	O	Δ	O
	3. Vibration proof outer shell & reinforcement	Δ	Δ	X	X
	4. Installation of resonator	X	Δ	Δ	Δ
Engine noise	1. Improved accuracy of components	Δ	Δ	X	X
	2. Change of component material	O	Δ	O	X
	3. Adoption of silent chain	Δ	O	X	Δ
	4. Improved rigidity of shafts and cases	Δ	O	X	Δ
	5. Vibration proof covers	O	X	Δ	Δ
	6. Water cooling	Δ	Δ	X	X
	7. Trial of enclosure	Δ	X	Δ	X
Driving system noise	1. Soften collision between chain and sprocket	Δ	O	X	Δ
	2. Belt of shaft drive method	Δ	X	Δ	Δ
Frame vibration noise	1. Decreased engine vibration	Δ	Δ	Δ	Δ
	2. Vibration proof components	X	X	Δ	Δ
Tire noise	1. Improved tread pattern	O	X	Δ	O
	2. Change of material for tire	Δ	O	Δ	Δ

Model A : Sports model example
Model B : Trial model example
Model C : Scooter example
Model D : Business model example

O : effective
Δ : insignificant
X : not effective

Table 8 : Prediction of Effects of Measures (An example of a 4-stroke / water cooled 250 cc motorcycle)

Measured item	Technical factor	Noise reducing effect	Weight increase	Technical problem	Solution	Prospect of practical application
Engine	Reduction in revolutions	0.2 dB	-	Deterioration of acceleration and hill climbing ability	Engine torque increase	More new technologies are required
	Improvement of crank shaft rigidity	0.1 dB	0.7 kg	Weight increase	Reduced weight of other parts and shape optimization	New technologies are required for some parts
	Improvement of crankcase rigidity	0.1 dB	3 kg	Weight increase	Reduced weight of other parts and shape optimization	New technologies are required for some parts
	Cylinder shape change	0.1 dB	1 kg	Weight increase	Reduced weight of other parts and shape optimization	Problems are coped with by the extended application of the current technologies
	Improvement of cover rigidity	0.1 dB	1 kg	Weight increase	Reduced weight of other parts and shape optimization	Problems are coped with by the extended application of the current technologies
	Improvement of gear accuracy	0.1 dB	-	Machining equipment accuracy	Improvement of production facility ability	Problems are coped with by the extended application of the current technologies
Intake system	Silencer capacity increase	0.1 dB	0.5 kg	Attachment space	Body structure change	Problems are coped with by the extended application of the current technologies
	Vibration proof of silencer wall surface	0.1 dB	1 kg	Weight increase	Reduced weight of other parts	Problems are coped with by the extended application of the current technologies
Exhaust system	Improvement of muffler body rigidity	0.1 dB	1.5 kg	Weight increase and durability of supports	Improvement of part strength	Problems are coped with by the extended application of the current technologies
	Silencer capacity increase	0.2 dB	1 kg	Weight increase and attachment space	Changes in body structure	Problems are coped with by the extended application of the current technologies
Drive train system	Attachment of chain case	0.1 dB	1 kg	Weight increase	Reduced weight of other parts	Problems are coped with by the extended application of the current technologies
Tyre	Improvement of block pattern	0.1 dB	-	Safety when running on the road	Joint research with tyre makers is inevitable	
Others	Attachment of cowling	0.2 dB	5 kg	Weight increase and reduction in cooling ability	Improvement of cooling method	Development of new technologies is required partially

Noise reduction effects indicate the effects of each measure on the noise of a whole motorcycle.
When these noise energies are calculated, the reduction amount of a total motorcycle becomes 2 dB.

Table 9 : Advanced technologies for noise reduction of motorcycles

Measured item	Measured section	Measured method	Motorcycles
Engine	Cylinder block	Improvement of rigidity	●
	Crank case	Improvement of rigidity	●
	Mission gear	Improvement of tooth shape accuracy	●
	Gear train	Belt drive	▲
	Crank pulley	Adoption of twist vibrating damper	✖
	Cooling fan	Adoption of electric fan	●
		Adoption of fluid-coupler	✖
	Oil pan	Increase in the number of attached points	●
		Adoption of floating-construction	✖
	Gear case	Reinforcement of ribs	●
Intake system	Air cleaner	Capacity increase	▲
		Improvement of body rigidity	●
		Installation of resonator	●
Exhaust system	Muffler	Capacity increase	▲
		Modification of construction of inner section	●
		Double-walled outer shell	●
		Attachment of accoustic materials	●
		Adoption of auxiliary muffler	▲
	Exhaust pipe	Adoption of double-walled pipe	●
		Adoption of flexible joints	✖
		Adoption of expanded end	●
Drive train system	Tyre	Adoption of less-noisy tyres	●
Chassis	Engine hood Under cover	Adoption of sprayed-on sound-absorbing materials	✖ (※1)

● : possible, ▲ : difficult, ✖ : impossible

※1 : Sound-absorbing materials are adopted under the cowling for motorcycles

Table 9 shows the techniques considered under this heading . It should be noted that where the table shows 'possible' this is because the technique has already been partially introduced in order to meet existing legislation. Substantial reductions due to technological progress are therefore unlikely.

The ability to control exhaust noise through the use of electronic cancellation (anti-noise) has emerged as an intriguing research tool for passenger cars. This technology has not yet been proven feasible on other vehicles. Control system complexity and component durability continue to be major obstacles for automotive applications. These problems would have to be resolved before development of motorcycle applications could begin.

8. Likely patterns of development within the European PTW parc

8.1. General

Traditionally the PTW market has fluctuated with booms and recessions. Over the last five years, the European PTW market has fallen and assuming a future upturn it is reasonable to forecast, conservatively, that over the next 13 years sales will remain constant at around the 1993 level. Similarly, the scrapping rate for PTWs is approximately 10 % per year. Given the other parameters discussed in § 3.2.3 above, an overview of the likely future patterns within the PTW parc is possible, based on the standardised average moped or motorcycle, starting from 1989 parc of 5,9 million motorcycles and 12,3 million mopeds. Given these assumptions there is a steady increase in the motorcycle parc and a decrease in the moped parc. (Note: the sound output of a 'standard' vehicle is the total sound output of all vehicles, weighted by the limit value for each category, divided by the number of vehicles in the parc.)

8.2. Mopeds

Taking 1989 as the base year and varying the main parameters the results are as follows:

Table 10 - Predicted sound output levels for a standard moped

	Assuming all vehicles legal		With the 97 limits, + current % illegal RESS at + 12 dB(A)	With a 50 % reduction in the number of illegal RESS	75 % in reduction in the number of illegal RESS
	With no change in 1997 dB(A)	With the proposed 97 limits dB(A)	dB(A)	dB(A)	dB(A)
1989	75,30	75,30	85,57	82,90	80,58
1997	75,30	75,02	85,29	82,62	80,30
2007	75,30	74,98	82,71	80,03	77,22

It is the central column which represents the current situation. From the second column it can be seen that a decrease of 0,32 dB(A) could be achieved by 2007 with the unification of the many moped limits at a new lower level (assuming all vehicles were legal) and this would be a considerable feat bearing in mind the weighting effect of a very large parc of existing vehicles.

However, the more important difference is the 7,73 dB(A) which would remain between the legal possibilities and the reality of the modified parc. Here the improvements could be substantial: a halving of the illegal exhausts in use would reduce this difference to 5,05 dB(A) and a further halving would reduce it to 2,24 dB(A).

8.3. Motorcycles

Taking 1989, the year before several large markets introduced the first stage of EU Directive 87/56, as the baseline and the parameters given in § 8.1 and 8.2 the results are as follows:

Table 11 - Predicted sound output levels for a standard motorcycle

Assuming all vehicles legal	With no change in 1997 dB(A)	With the proposed 97 limits dB(A)	With the 97 limits, + current % illegal RESS at + 12 dB(A) dB(A)	With a 50 % reduction in the number of illegal RESS dB(A)	75 % in reduction in the number of illegal RESS dB(A)
1989	83,56	83,56	93,41	90,84	88,57
1997	82,67	82,57	92,11	87,86	85,94
2007	82,01	80,95	88,46	85,29	83,61

Again, it is the centre column which represents the current situation. From the second column, it can be seen that by 2007 a theoretical improvement of 2,61 dB(A) in the average motorcycle noise output could be achieved by the proposed 1997 limits, despite the very large parc, if all vehicles were legal.

However, just as with the mopeds the gap between the legal possibilities and the reality of the modified parc is large (7,51 dB(A)), more than a 4-fold increase in the average noise level. Cutting the illegal parc by half would reduce this to 4,34 dB(A) and a further halving would bring it down to 2,66 dB(A), a drop of 3,83 dB(A).

Could such a reduction of 3,83 dB(A) in average noise levels be achieved by reducing the limits for new motorcycles? Using the same calculation method (and assuming the current proportion of illegal exhausts in use remains unchanged), a hypothetical reduction of the noise limit for new motorcycles in 1997 by 79 dB(A) to an absolute value of 1 dB(A) would reduce the average noise output in 2007 by only 0,41 dB(A) more than the proposed limits. A limit value of 1 dB(A) is, of course, purely theoretical and only for the purposes of calculation. By way of comparison, other typical recorded values are as follows (11):

	dB(A)
• normal conversation at 1 metre	65
• a quiet office	40
• a quiet bedroom	35

So even in the most extreme of hypothetical cases, (a limit of 1 dB(A)), reducing limits for new motorcycles could not match the improvements to be gained from reducing the number of illegal RESS in use. In practical terms, therefore, the reduction of limits for new motorcycles will have very little effect, if any, on the noise output from the motorcycle parc as a whole.

8.4. Overview

In 1980 (12) the USA's Environmental Protection Agency (EPA) published findings on motorcycle noise as part of its rule-making activity. In those findings was a table (reproduced below as Table 12) which showed the relative benefits and costs associated with different policy options.

Table 12 - Benefits and costs
Reduction in impact (1)

EPA regulatory level	With current limits + 12 % modifications (2)	With current limits + 7 % modifications (3)	With current limits + 3 % modifications (4)	Motorcycle price increase	Total annualised cost (5)
83 dB(A)	4-9 %	17-36 %	24-62 %	6 (0.3 %)	$ 12 M
80 dB(A)	15-43 %	47-56 %	61-75 %	36 (2.0 %)	$ 94 M
78 dB(A)	22-57 %	53-67 %	78-83 %	120 (7.6 %)	$ 218 M

(1) Percentage reduction in noise impact shown here apply to interferences with human activities. The range of values is attributable to differences in the impact of the regulation on various types of human activities (e.g. sleep, speech). These measurements are used as an indicator of people's adverse reaction to noise intrusions.
(2) This is the effect of reducing noise level of new motorcycles only
(3) This is the combined expected effect of exhaust system regulations, tampering and labelling provisions and new motorcycle standards
(4) This is with effective enforcement programme at the state and local level
(5) 1978 dollars.

In short, the EPA concluded that average noise levels could be brought down by reducing either the original equipment (OE) limits or the degree of owner modification (then approximately 1/3 of the European level in 1994). Dramatically greater improvements were predicted for the second policy option. In addition, the EPA warned that the lower the OE limits were set the greater the likelihood of owner modification.

These findings are also reflected in the research reviewed above (the likelihood of modification is discussed in section 4) and the same policy options are clear.

9. Summary and conclusions

Motorcycle noise arouses strong feelings and presents many challenges. Past discussions have tended to result in a piecemeal approach to the issues. The purpose of this paper has been to present a complete picture of the issues involved in trying to find a satisfactory and lasting solution to the motorcycle noise question.

In summary the research reviewed in this paper leads to the following conclusions:

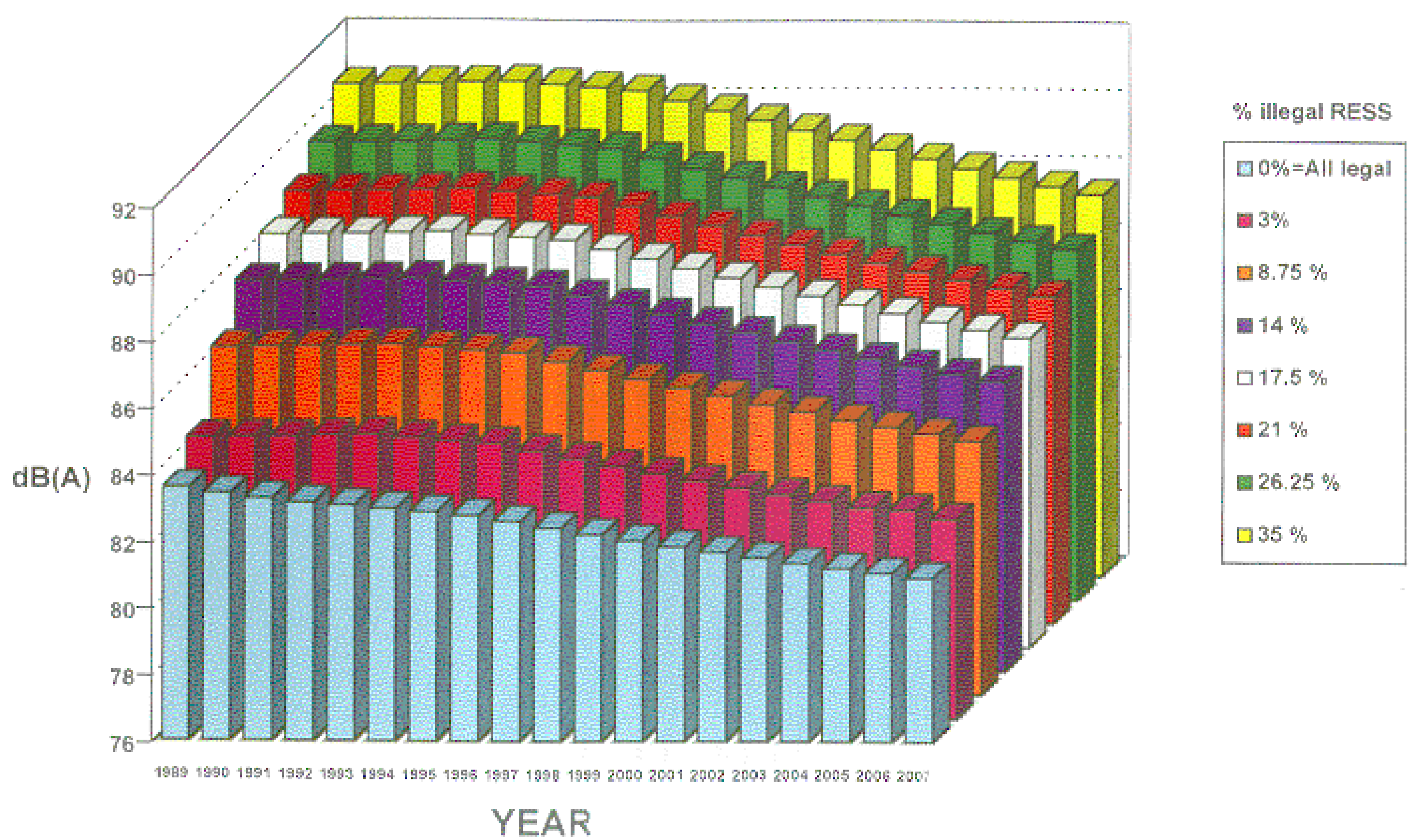
- new motorcycles are quiet
- 2/3rds of riders are against excessive noise on the public highway and 73 % believe riders have a responsibility towards the environment
- motorcycles are noisy because they are equipped with an illegal exhaust
- illegal replacement exhausts are promoted heavily
- in the present parc of vehicles, 35 % of motorcycles and 65 % of mopeds have illegal exhausts
- the presence of so many illegal systems raises the average noise output 7 times
- aftermarket replacement exhausts are mainly bought for their general performance (driveability, response etc.), price and image (sound quality etc.)
- the new vehicle is effectively controlled but the replacement exhausts, individual imported vehicles and vehicles in use are not.

As summarised in figure 5, the policy options are clear: the greatest and swiftest improvement in the environment would come from reducing the percentage of illegal exhausts in use. Focussing on original equipment would bring small results over a very long period, whatever limit value was chosen.

In the industry's opinion the most effective way forward is not in reducing the limits for new motorcycles and mopeds but in the field of effective law enforcement.

The conundrum is explained: new vehicles are quiet but modifications turn them into noisy nuisances. The curious silence has been broken and the direction for finding positive solutions established. The industry is ready to participate in all future discussions aimed at producing such solutions.

Figure 5 : Summary of Noise Calculations



Annex 1

Problems in the identification of illegal RESS

Problems arise for several reasons. The original markings, before Directive 89/235 entered into force, were to a large extent at the discretion of the manufacturer. The brand, OE part number and identification number could be anywhere.

The homologated aftermarket is even more difficult. The EU Member States, for example, have differing requirements and the observer needs to be fully aware of the local legal requirements. For example: in France the exhaust is legal on machines prior to October 1993 if it is marked with either a real « e » number, correct branding and part number, a UTAC approval noted by « TP SI » being stamped in the correct place or a German KBA approval which has an « ABE » approval stamping. Similarly, the Germans accept « e », « ABE » and « TP SI ».

However, the observer must also be aware that the « e » approval has to be followed by the country of approval code (1, 2, etc.) and the correct number of digits. This varies from 3 in GB to 5 in Germany. Many exhausts surveyed had the « e » stamped into them but nothing following. Thus it appears to a casual observer that the exhaust is approved but without the country code and the correct number it is not. There is nothing illegal in stamping an « e » in an exhaust so this would be difficult to control.

The UK does not recognise the « ABE » or « TP SI » approvals but it does accept the « e » and its own national law which is signified by the use of « BS AU/193 » which should be followed by T1, T2 or T3 to signify the test method. This is often left out making the product illegal.

Some manufacturers are stamping the approval number in the middle section of the exhaust thus permitting the fitment of a « racing can ». Thus to an inexperienced observer there is a number evident, it has all the right digits etc. but the output could be up to 20 dB(A) over the limit.

Examples were noted where a rival brand approval was etched into a « race can » and another where a plate declaring legality was riveted over the statement « FOR RACE USE ONLY ».

In broad terms a systematic use of identification by trained observers would result in a significant reduction in the use of illegal products. The minority left by devious means would stand out more and could be controlled by other « in use traffic offences ».

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*RESS: Replacement Exhaust Silencing System

LIST OF REFERENCES

1. Steven/FIGE, Germany: Noise investigations of motorized cycles - 1982

2. Stenschke, Umweltbundesamt, Berlin, Germany: Possibilities for reducing noise emissions from motorcycles - 1989

3. Nelson, FIOA: Controlling vehicle noise: A general review - 1992

4. EC and UK 16th European Omnibus Survey: Attitudes to noise - 1981

5. Sir A. Armitage: Report of the enquiry into lorries, people and the environment - 1980

6. Wilson report on noise (CMNO 2056) - July 1983

7. Miller, the Manchester Area Pollution Advisory Council: Environmental noise survey - 1992

8. Vanke: Lara symposium - April 1993

9. Romaine, Derby City Council, Housing and Environmental Services: Motorcycle noise - August 1987

10. Dunmore: National Society for Clean Air: Annex C to noise committee agenda (19/11/87) - August 1987

11. Taylor R: p56, Noise, Pelican, 1979

12. Federal Register Vol 45 N° 252, 31 December 1980