Stock Car Racing Noise—Conflicts and Feasible Controls

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The following is a brief history of a noise problem, attempts to rectify it, and an analysis of the situation as it exists today at the Beltsville Speedway, Maryland. The results of a series of tests conducted by the Department of Transportation and the National Bureau of Standards to identify the nature of stock car noise and the effectiveness of present efforts to reduce noise at Beltsville are reviewed. This report, while dealing, primarily with Beltsville, is applicable to the problem of auto racing noise wherever it is, or may become, a problem of conflict between the interests of auto racing and race track neighbors.

Ask an avid race fan about quieting the noise generated by a race car and you will be in for an argument which may equal the loudness of the cars in question. To this group of people, the noise adds to the excitement and, as in many other situations, sound is equated to power. Ask a non-race fan resident near a race track, however, and you will receive a quite different argument about that same noise, about the late hours of racing, about the traffic and about his rights as a citizen and property owner, etc.

This is but one of many cases where noise is the subject of a direct clash of citizen interests with which many state and local government bodies will have to wrestle. In many locales the debate on racing noise has just begun, while in others, solutions have been evolved. Beltsville, Maryland, is an example of a case where numerous approaches have been attempted and where an accommodation has been reached via the good offices of the Prince George County Council sitting in judgment of the claims and arguments of the differing interests.

Background

The Beltsville Speedway, a 0.537 mile, high banked, asphalt oval, was completed in 1965 at a cost of one million dollars. It is located on a 53 acre plot of land located within a triangle bounded on the east side by the Baltimore-Washington Parkway; on the west by the U.S. Department of Agriculture Research Center; and on the north side by the right-of-way for the proposed outer Beltway of Washington, D.C. Farther north there was undeveloped land, a power transmission line right-of-way and more undeveloped land. Since commencement of racing, the land to the north of the track has been developed with residential units which are now within 1250 feet of the center of the track.

Prince George County requires consideration of traffic, noise and other impacts upon nearby areas before issuing a permit for any public gathering. Auto racing is no exception.

Accordingly, when complaints were registered by residents to the north of the Beltsville Speedway, the County Commissioners required the Speedway to retain a firm to conduct a study of the problem. Community noise measurements were made with high quality equipment and were portrayed in a foresighted time statistical display of 1, 10, 50, 90 and 99 percentile sound levels, but the use of overall (unweighted) and B-weighted sound levels, instead of "A-weighted" sound levels makes the results of the study of limited value. Increases in community sound level attributable to auto racing were, however, shown to be quite sizable with occasional peak levels at several sites exceeding an estimated value of 85 dBA. Such noise peaks were sometimes experienced late at night, nearing midnight. It was clear from these data that by any description of time-varying noise in the community, the noise from the Speedway was imposing some disturbance and warranted more detailed study and corrective action.

On the premise that line-of-sight barriers could be used to reduce noise propagated into the community, a barrier made of straw, two bales deep, 20 feet high and 400 feet long was constructed during the course of the summer along the northern part of the track. A retest in the community, 3400 feet north of the track, was made in an attempt to ascertain the effectiveness of the temporary barrier, but yielded contradictory results. The re-test indicated a reduction in peak levels of about 1 dB for the small car races and about 5 dB for the large car races; however, the median levels (levels of noise exceeded 50 percent of the time) increased by 2 dB for both race car categories after installation of the straw barrier.

Notwithstanding the ambiguous results of the barrier test or the failure of the study to report the sound levels in a metric which could be readily compared to existing community noise criteria, plans for the 1971 race season moved forward with, for some unknown reason, plans to install a canvas barrier around the north end of the track which the track proprietor apparently believed would be adequate to abate the noise.

Any experienced acoustician, if consulted, would have apprised the proprietor that such a barrier would be ineffective, but the proprietor was not willing or able to enlist adequate expertise to develop a credible noise abatement plan. Residents of the community were not satisfied with the prospects for a quiet community deriving from the planned barrier. The residents banned together in an informal "committee" to discuss the problem and to evolve an action plan. Some of the committee sought consultation with the county government and sources of acoustical expertise, while others undertook independent study of noise and noise abatement techniques.

After several days of hearings and debate, the County Commissioners approved issuance of a permit which stipulated that racing would be permitted only after the Speedway erected a 20 foot high, 1100 feet long barrier, constructed of ⅝ inch plywood, as specified in the public hearings by the community committee to be necessary to provide adequate transmission loss through the barrier.

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Further, the permit stipulated that no racing would be permitted beyond the hour of 11:00 P.M. The permit issued by the County also stipulated that sound measurements would have to be continued at Speedway expense to provide a basis for considering the permit for the next year of operation.

Racing began in the spring, but noise monitoring apparently was not again undertaken until August of 1971. The Speedway officials retained the services of a man who had had some prior industrial noise monitoring experience. This consultant used a hand-held sound level meter to obtain data at several sites in the community; he reported maximum levels sometimes, average levels at other times, and frequently neglected to qualify his readings at all.

The surveys in 1971, nevertheless, showed that peak noise levels generated by the racing events were still of such a level as to be annoying and that further actions would be required to allay the concerns of the track neighbors.

Continuing complaints from the Speedway neighbors resulted in provisions in the permit for 1972 operation of the Speedway which prohibited racing by any vehicle on the track which was not equipped with an exhaust system muffler. The permit also required the Speedway to *limit* noise in the community to 60 dBA at locations selected or approved by the Director of the Deparment of Permits. The Speedway was still required to monitor the noise levels in the community but, in addition, now all reports were to be submitted to the Director, Department of Licenses and Permits and should any such report indicate community noise levels *in excess of 60 dBA*, an explanation was required.

These permit stipulations required such actions as would reduce the maximum race noise level at the nearest residential locations by as much as 21 dB and at other locations by perhaps 10 dB.

Little information existed on the noise reduction capability of mufflers which could be used by the race cars. Nor was much known about the impact upon engine power, cooling or speed of the cars equipped with mufflers. Spectator reaction was also an unknown quantity at this time.

A series of muffler tests were performed at the Speedway by the consultant to ascertain the effectiveness of commercially available and "home built" mufflers installed on the exhaust system of a large displacement Late Model Sportsman auto. These tests were performed on March 25, 1973, by running high speed circuits of the track as in-time trials. Measurements were made using a general purpose sound level meter set to A-weighting and *"slow response."* The sound level meter was located 50 feet to the side of the edge of the track at the start/finish line. In the high speed "groove," the cars pass very close to the outer wall at this point on the track, thus the sound level meter was actually some 90 feet from the centerline of travel of the car. A solid retaining wall, backfilled with earth, was on the far side of the car, providing a path for sound reinforcement. The following are the results obtained.[1]*

	dBA "slow" @90 feet
No mufflers	107, 107, 107
Thrush Muffler	87, 87, 87
Thrush Muffler	86, 89, 87
3 "Home Built"	105, 105, 106
Short Thrush	99, 98, 100
Long Thrush	96, 96, 95

*No model numbers or installation details provided.

Thrush mufflers became standard equipment in light of the achievement of the needed 20 dB noise reduction. Some difficulty was experienced during the season when a muffler occasionally fell off a car. Another problem was experienced on the occasions of big races which draw cars and drivers not experienced with muffler requirements. One big race program was cancelled because of this problem. In general, however, few mechanical difficulties were experienced and a new track record was set by a muffled car for single lap high speed.

Community noise monitoring clearly indicated a 10-15 dB reduction had been achieved at the more remote sites, but at the most proximate housing, sound levels were still in excess of the County-stipulated limit of 60 dBA during virtually all of the time that cars were racing. Wind and other meteorological conditions were found to be significant factors in the sound levels measured on any given night, accounting for a range of peak noise levels from 65 to 78 dBA at one site.

Negotiations with the County for the 1973 permit centered around the unrealistic 60 dB limit imposed for 1972 and the U. S. Department of Housing and Urban Development (DHUD) Policy Circular on Noise Standards[3] (on a 3-hour base, rather than 24 hours) as a more reasonable community limit. The permit issued on February 9, 1973, included the previous stipulations of the 11:00 P.M. curfew, proper maintenance of the sound wall, and equipping each car with mufflers now specified to be equivalent in performance to the Thrush T5163A mufflers used in 1972. The 1973 permit, however, codified the heretofor voluntary procedure of individual car noise monitoring as a mandatory condition and set a 92 dBA "trackside" limit, except for the first two races for which 94 dBA would be permitted. (The County failed to stipulate the meter response [fast or slow] or the measurement distance for these individual car tests). Also retained from prior years was the requirement for the Speedway officials to monitor and report on the community noise levels. The criteria for acceptance, however, was changed to the following:

dBA shall not exceed the levels tabulated below:	For a cumulative time span in excess of that shown below for any race day
70	30 sec.
68	12 min.
66	24 min.
64	40 min.
62	60 min.[2]

These criteria represent an adaption of the DHUD guidelines, applied on a 3-hour basis, and overtly, or by error, cutting down the permissible time above 68 dBA from the DHUD "normally acceptable" limit to intercept the "clearly acceptable" zone at a level of about 71 dBA.

Limited records of the monitoring which took place during 1973, indicated that the consultant was attempting to obtain the distribution of sound levels using only the general purpose hand-held sound level meter owned by the Speedway. The consultant was unaware of the DHUD findings as to the inaccuracy of this technique, but if he had been aware of them, it is doubtful that the Speedway budget would have supported rental of the equipment needed to accurately assess the noise climate in the neighborhood. Hand-held sound level meter results that the consultant acquired, for what they are worth, indicated that at the nearest site the levels were usually within the DHUD "normally acceptable" zone, but that the County-

specified cutoff of the higher sound level end of the "normally acceptable" zone was frequently exceeded.

In considering the 1974 permit, the County considered the following well-documented facts:

1. Noise levels in all but the nearest track neighborhoods had been lowered to completely acceptable values by any standard of judgment, including, and especially, the opinions of the residents;
2. Noise levels at the nearest residence to the Speedway were within the "normally acceptable" zone of the DHUD noise guidelines (as applied over a three-hour period, instead of the 8 times less stringent 24-hour base applied by DHUD);
3. Consistent, significantly lower, noise levels were being measured at trackside — which accounted for the acceptable levels in the community;
4. The sound wall was being well-maintained; and
5. The curfew was being observed.

Therefore, the 1974 permit was drawn up deleting the community noise limits and the requirements to monitor noise in the community. Inspectors from the County, however, were dispatched throughout the 1974 season to observe the trackside monitoring by Speedway officials, and reports of the trackside monitoring were required.

1975 Beltsville Tests

In May 1975, the promoter of the Beltsville Speedway suggested to the author that tests could be performed to answer some of the questions which were still being raised. Accordingly, a test program was designed to obtain data pertinent to the questions of:

1. Fast vs slow meter response sound levels;
2. 50 foot vs 100 foot sound levels;
3. Muffled vs unmuffled sound levels;
4. Sound levels on straight-away vs turns;
5. Coasting vs powered sound levels;
6. Spectral aspects of the sound; and
7. The contribution (if identifiable) of the exhaust, engine, tires, engine cooling fan and differential to total car noise.

On June 2, three regular Late Model Sportsman competitors at Beltsville were on hand for the tests. Two cars were Chevelles (#'s 11 and 55) and one car (#66) was a Cougar. All three cars had 355 cid engines. Cars 11 and 55 were equipped with four (4) Thrush T5163A mufflers (see Figure 1), while car number 66 utilized two Gebler mufflers. The following is a matrix of tests performed.

Test Location	Car Operation	Car Equipment	Test Cars
Start/Finish Line	Hi speed, Full Throttle, 7000 rpm	Muffled Fan On	11, 55, 66
Start/Finish Line	Hi speed, Coastby Engine Off	—	11, 55, 66
Start/Finish Line	Static, No Load Rev Up 7000 rpm	Muffled Fan On	11, 55,66
Start/Finish Line	High Speed Full Throttle 7000 rpm	Muffled No Fan	11, 55, 66
Start/Finish Line	Static, No Load Rev Up 7000 rpm	Muffled No Fan	11, 55, 66
Start/Finish Line	High Speed Full Throttle 7000 rpm	Unmuffled Fan On	55, 66
Start/Finish Line	Static, No Load Rev Up 7000 rpm	Unmuffled Fan On	55, 66
Turn 1-2	High Speed Power — 4500 rpm	Muffled Fan On	11, 55
Turn 1-2	Static, No Load — 4500 rpm	Muffled Fan On	11, 55
Turn 1-2	High Speed Coast By	—	

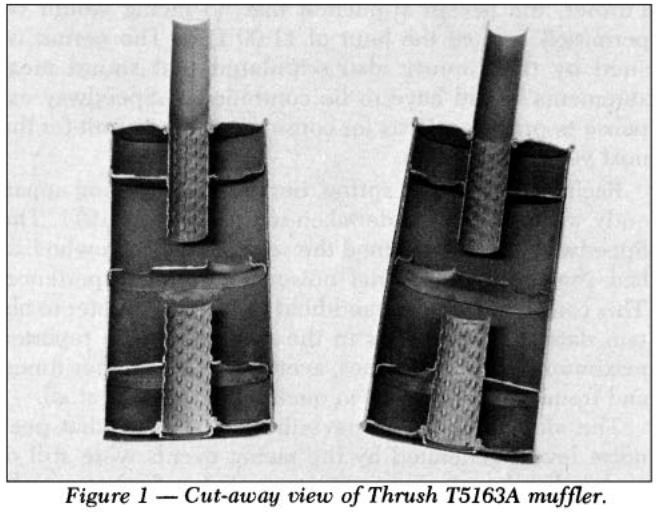

Figure 1 — Cut-away view of Thrush T5163A muffler.

Simultaneous measurements were made at 50 feet and 100 feet from the vehicle centerline by personnel from the Applied Acoustics Section of the National Bureau of Standards, Department of Commerce, using precision sound recording instrumentation (see Figure 2).

The following Table illustrates typical levels measured at the start/finish line and compares fast and slow responses.

Car No.	A-Weighted Sound Level, dBA High Speed Drive-By @50′ "FAST"	"SLOW"	Δ	Start/Finish Line @100′ "FAST"	"SLOW"	Δ
11 (Race Config)	98.6	96.8	1.8	90.8	89.2	1.6
"	98.8	97.0	1.8	91.4	89.6	1.8
"	99.2	97.2	2.0	92.0	90.0	2.0
"	99.4	97.4	2.0	91.8	90.0	1.8
"	98.8	96.8	2.0	91.2	89.8	1.4
Average			1.9			1.7
55 (Race Config)	97.0	94.8	2.2	88.2	87.2	1.0
"	97.4	95.2	2.2	87.4	86.2	1.2
"	96.6	94.8	1.8	87.8	86.6	1.2
"	97.2	94.8	2.4	87.4	86.2	1.2
"	96.8	94.4	2.4	87.4	96.0	1.4
Average			2.2			1.2
Average 33 Drive Bys (Cars 11, 55 & 66, All Configurations)			2.0			1.5
Average 8 Coast Bys (Cars 11, 55 & 66)			1.3			1.2

From this comparison it can be seen that the drivers were extremely consistent in their operation of the cars. A reliable value of 2 dB difference can be used to compare fast and slow levels at 50 feet and 1.5 dB difference can be used for 100 foot data comparisons on the start/finish line for drive bys. Coast bys, however, tend to have less peaked signatures (smoother time signatures) than the drive-bys, hence less of a difference is exhibited between fast and slow response.

Comparison of levels recorded at the 50 foot and 100 foot measurement locations, below, provides an insight into the propagation field in which the tests were performed.

33 Drive-bys (50′ level) – (100′ level): average 7.8 dB;
8 Coast-bys (50′ level) – (100′ level): average 8.1 dB.

The high values of attenuation (as compared to the theoretical 6 dB attenuation rate for each doubling of distance) appears to indicate that the guard rail between the 50-foot and 100-foot microphones enhances the levels recorded at 50 feet, attenuates the levels recorded at the 100-foot microphone, or both. (No location around the track appears to

afford relief from this characteristic. Locations along the back straight would be additionally influenced by the 20 foot high sound wall.) The start/finish line tests were run at that point in the track because the cars reach full engine speed there and because all of the past Speedway measurements had been made there. Tests were also made midway through the first and second turns. These results will be discussed in the final report.

Comparison of "mufflers on" and "no mufflers" tests are shown below.

Car No.	Test Operation	Meas. Dist.	A-Weighted Sound Level dBA*		
			Muffler On	No Muffler	Noise Reduction
55	High Speed	50 Ft.	97.0	112.8	15.8
"	" "	100 Ft.	86.4	102.7	16.3
66	" "	50 Ft.	102.2	116.1	13.9
"	" "	100 Ft.	91.6	105.7	14.1

From these data it would appear that the 20 dB noise reduction found in the 1972 tests at Beltsville was not achieved by car 55 which was equipped with four Thrush mufflers or by car 66 which was equipped with two Gebler mufflers. The apparent failure of car 55 to achieve the 20 dB reduction may be ascribed to the fact that "no muffler" testing was performed in 1975 simply with open headers (no tail pipe), while the 1972 tests used a car with a tail pipe whose outlet faced the measurement location. Note the 1972 slow meter response level, unmuffled was 107 dBA @90 feet.

The June 1975 test series was structured to attempt to provide some measure of the individual sources of noise which contribute to overall vehicle noise.

Tire noise can be directly measured by coasting the vehicle with engine off. Exhaust noise can be varied by removing the mufflers, but the residual exhaust cannot be assessed without more equipment. Fan noise can be varied by removing the fan, but if the fan is not a major source of noise, no difference will be observed in the "fan off" sound levels. Preliminary estimates were made of tire noise, fan noise and engine noise and the test program was structured to extract what could be ascertained about the other sources through simple test variations and frequency analysis.

From the measured data and unconfirmed estimates we can begin to piece together a source-by-source picture of the race car noise on the front straight-away as follows:

Source	A-Weighted Sound Level @50 Feet, dBA		
Muffled Race Cars	**Car 11**	**Car 55**	**Car 66**
Total (Measured)	99	97	102.2
Engine (Estimate)	92	92	92
Fan (Estimate)	85	85	85
Differential (Estimate)	88	88	88
Tires (Coast-by Level Measured)	80.5	81.5	82
Muffled Exhaust (Net)	97.2	93.7	101.4
Unmuffled Race Cars			
Total (Measured)	—	112.8	116.1
Unmuffled Exhaust (Net)	—	112.7	115.5

The insertion loss (actual reduction of **exhaust noise** by the mufflers) as compared to the net noise reduction is shown on the following Table:

Car Number	Insertion Loss, dB	Noise Reduction, dB
55	19	15.8
66	14.1	13.9

*50-foot data A "fast"; 100-foot data A "Slow"

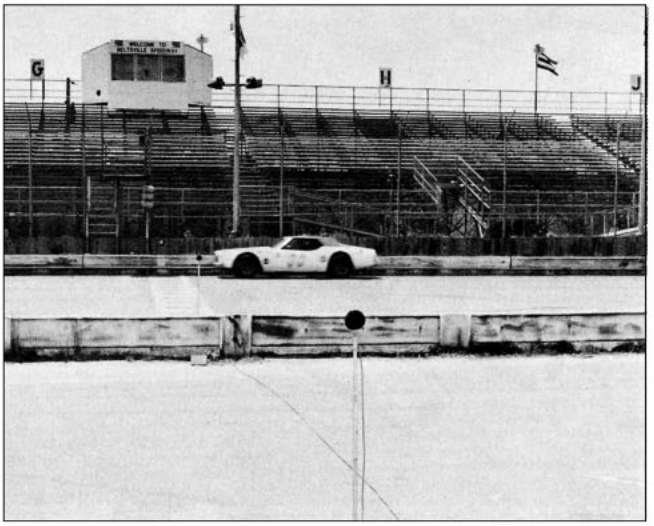

Figure 2 — Noise measurement setup at Beltsville Speedway.

This analysis indicates that as much as 3.2 dB of the insertion loss capability of the mufflers used on the cars at Beltsville is obviated by other sources of noise on the cars. To place this conclusion in clearer perspective, let us assume that by some unspecified means we could reduce the muffled exhaust sound levels of the cars by an additional 10 dB; the postulated source levels for these cars and the resultant total noise level would then be as shown below:

Source	A-Weighted Sound Level @50 Feet, dBA		
	Car 11	**Car 55**	**Car 66**
Engine (Estimate)	92	92	92
Fan (Estimate)	85	85	85
Differential (Estimate)	88	88	88
Tires (Coast-by Level Measured)	80.5	81.5	82
Exhaust (Postulated)	87.2	83.7	91.4
Total (Postulated)	95.0	94.6	96.1
Total Actual Muffled	99	97.0	102.2
Net Reduction by Postulated Additional Muffling	4.0	2.3	6.1

A 2 dB reduction in noise is not readily perceptible to the ear, but a 6 dB reduction would be appreciable. From this assessment it would appear that cars below 99 dBA at 50 feet cannot be significantly quieted by addition of more exhaust muffling, but that cars which presently generate levels in excess of 99 dBA at 50 feet can be further quieted by using more effective exhaust mufflers. These conclusions are, of course, based heavily on the estimated levels of the engine, fan, and differential. Should these estimates be substantially in error, the whole analysis would be incorrect. Accordingly, a simple supplemental series of tests were proposed whereby special auxiliary mufflers would be designed and tested in tandem with the normal race car exhaust system. The auxilliary mufflers would be designed for maximum insertion loss in the high frequency range (1 to 3 kHz) which contains the differential gear mesh frequency and which is the range of sound that controls the A-weighted sound level of the drive by. Such a test program would not verify the postulated engine, fan or transmission noise levels, but would directly address the question of further exhaust noise reduction potential.

Discussions as to the feasibility of designing and fabricating such an auxilliary muffler were held with personnel of the Donaldson Company, the nation's leading man-

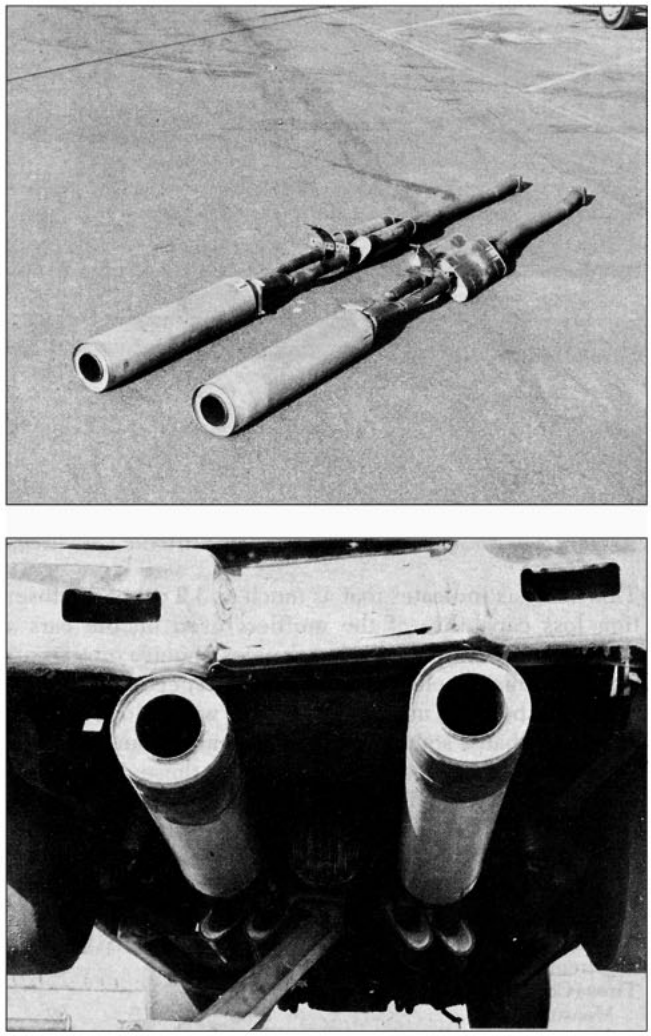

Figure 3 — Exhaust muffler system consisting of four Thrush units and two specially-made Donaldson units.

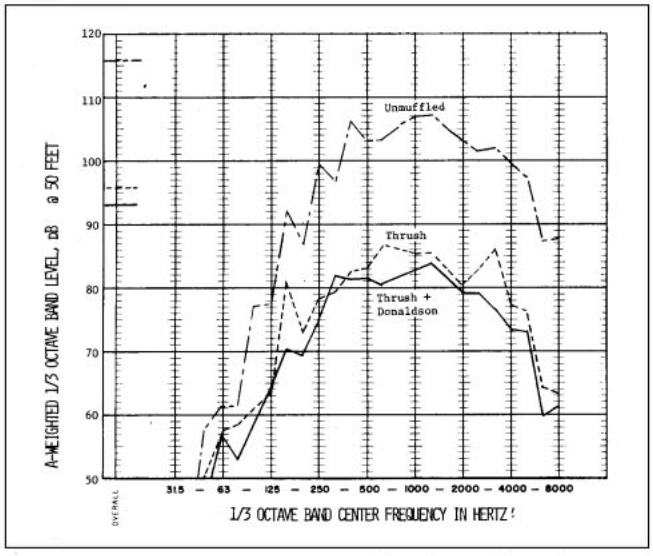

Figure 4 — A-weighted, ⅓ octave band analysis of drive-by noise.

ufacturer of truck mufflers and the supplier of all mufflers used in the DOT Quiet Truck Program. The Donaldson Company, in the interest of noise abatement, undertook the task without compensation and in September, the two Donaldson mufflers were received, along with the results of the development tests performed by Donaldson in their Minneapolis laboratories. The two special fiberglass-packed test mufflers, designated 5145H27 by Donaldson, were 32.1 inch long cylindricals, with an outside diameter of seven inches and a straight-through inside diameter of four inches (designed to handle the combined outflow from a pair of the Thrush mufflers with minimum back pressure).

Donaldson transmission loss tests, using a random noise input, yielded an effective A-weighted transmission loss of 22 dB for the test mufflers. Insertion loss tests, using the exhaust from one bank of a Detroit Diesel 8V-71N diesel engine @2100 rpm, yielded an effective 14 dBA insertion loss value with octave band values as indicated below:

Octave Band Center Frequency Hz	Band Insertion Loss dB
63	2
125	1.5
250	7
500	12
1000	14.5
2000	17
4000	16
8000	25

A series of tests were performed at Beltsville on November 14, 1975, (well after conclusion of the normal racing season) to evaluate the contention that further exhaust muffling would produce little noise reduction. Two of the three race cars tested in June had been wrecked and the third had been dismantled. Thus, a substitute car had to be used for these tests. The car volunteered for the November tests was Doug Hartley's Ginns Stationary Special, Number 38, a Limited Sportsman Chevelle with a 302 cid engine. A test sequence was performed similar to the earlier tests, plus runs with the Donaldson auxilliary mufflers installed. Photographs of the exhaust system, including the Donaldson test mufflers, are shown in Figure 3 installed in the car and laid out on the pit road.

Analysis of the A-weighted, one-third octave band spectrum of car 38 drive-bys indicates that the Donaldson mufflers should produce an insertion loss of 11 dB. Actual noise reduction realized by the addition of the Donaldson mufflers was less than 3 dB, as shown by Figure 4. Thus, it is evident that the Beltsville race cars, equipped with four Thrush T5163A mufflers, have been quieted by 20 dB or more and that additional muffling will produce little, if any, perceptible reduction in noise level beyond that already achieved.

Conclusions

The solution found at Beltsville is workable and cost-effective. The mufflers used provide essentially all the noise reduction possible without fundamentally changing the cars or the sport. The cost of the mufflers is reasonable (in the range of $15 to $20, each) and the residents in the neighborhood of the Speedway appear to be satisfied when all the cars are so muffled. Similar feasible controls can ameliorate community noise conflicts encountered elsewhere without restricting the sport of motor racing.

References

1. Private Communication, Herbert T. Wood to W. H. Close, June 1975.
2. Prince Georges County Department of Licenses and Permits, 1973 Operating Permit for Beltsville Speedway, February 9, 1973, Hyattsville, Md.
3. U. S. Department of Housing and Urban Development, Policy Circular 1390.2, Subject, "Noise Abatement and Control: Department Policy, Implementation Responsibilities and Standards," August 4, 1971, Washington, D.C.