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April 8, 1981

Director, Standards and Regulations Division
ANR-490
U.S. Environmental Protection Agency
Washington, D.C. 20460

Attention: ONAC Docket 81-02 (Medium and Heavy Trucks)

Dear Sir:

I am writing to go formally on record as being opposed to the possible recension of the 80 dB regulation for medium and heavy trucks. After having conducted several comprehensive studies concerning the urban noise environment, I am convinced more than ever that the truck is the principal problem.

We all realize and accept that this Administration has as a top priority the reduction of in-place regulations. We also realize that "supply side" economics calls for as many advantages as possible being provided to the private sector. However, it would be an excessive and unnecessary benefit to the trucking industry, should this noise standard be relaxed. We, as urban Americans, simply cannot withstand a change in direction in the area of noise levels.

A major study that I have recently completed for The National Academy of Science indicated that the Federal Government and the various state highway departments have already spent more than 100 million dollars on highway noise barriers. The study also indicated that to solve the remaining problems in highway noise, an additional 400 million to one billion dollars would be needed. These figures assume that trucks will be at least as quiet as they are now, and hopefully quieter.

Because medium and heavy trucks so dominate the urban noise environment, I fear that relaxation of the 80 dB regulation will have a devastating effect, when compared to the continued progress we have all assumed in the area of truck noise reduction. Please do not be deceived; the current noise level of 83 dB for medium and heavy trucks is simply too loud. Other studies that I have conducted indicate that there is potential to reduce heavy truck noise to 81 dB and below with an amortized capital cost, and yearly maintenance and operational costs of approximately 220 dollars per year in 1975 dollars. This cost per truck is totally insignificant when compared to overall cost of operations and maintenance for a typical heavy truck. I have enclosed a copy of this study.

As part of the recent study I completed for The National Academy of Science, an analysis was made of the urban dweller's perception of highway noise levels. The results of this analysis are very clear: Urban highway noise is perceived as a serious problem to those living in the vicinity of our freeways and expressways. Our data shows that more than 80% of the people queried have an interest in controlling highway noise. In several states the highway agencies receive so many requests for noise barriers on existing highways that quantitative prioritizing systems have been developed. Included are such urbanized states as California, Connecticut, and New York. These states and others report significant pressures from large segments of the urban population who are seeking relief from excessive highway noise.

In summary, let me state that my studies point to one inescapable conclusion: Recension of the 80 dB regulation for medium and heavy trucks currently scheduled for January 1, 1983, would not be in the public interest. I implore you to withstand the private sector pressure, to take the high road, and to maintain this regulation.

Sincerely,

Louis F. Cohn
Louis F. Cohn
Associate Professor
Civil Engineering

LFC:lh

Enclosure

From: Technical, Administrative, and Economic Impacts of Highway Transportation Noise Regulation, a report to the Rensselaer Polytechnic Institute, May 1978.

Louis F. Cohn, Ph.D., P.E.

THE COSTS OF ABATEMENT FOR HIGHWAY TRANSPORTATION NOISE

B.1 SOURCE - Previous discussions in this dissertation have indicated that the truck is the major source of highway transportation noise in most cases. Therefore, this analysis concerning costs of abatement for the source will emphasize the heavy truck, although medium trucks and automobiles will also be discussed.

The economic impact of heavy truck noise abatement is typically considered in three ways: Capital costs, operational costs, and maintenance costs. Each is reflected as an incremental difference from those respective costs for trucks that are not treated for noise abatement. For example, there is an initial (capital) cost associated with the addition or requirement of a flow-through enclosure for an engine. This cost would amount to approximately 450 dollars, and would result in a noise reduction for the engine of up to 11 dBA. However, this device would require an additional 6 hours of maintenance time per year and would add 250 pounds to the weight of the vehicle. In terms of costs, this would mean approximately 90 dollars per year additional for maintenance and 24 dollars additional for operation.[308]

There have been numerous federally funded and private studies aimed at determining the abatement potential for trucks and the associated costs.[309] Many of these studies are summarized in NCHRP Project 3-7/3, Volume 5, and NCHRP 173. In general, the indication is that a reduction of up to 14 dBA in overall truck noise is possible for the acceleration test case, up to 12 dBA reduction is possible under cruise conditions at 35 miles per hour, and up to 8 dBA is possible under cruise conditions at 60 miles per hour.[310] In tabular form, these reductions are:

Mode	Without Abatement	Reduction Potential	With Abatement
Acceleration	87 dBA	14 dBA	73 dBA
Cruise, 35 MPH	86 dBA	12 dBA	74 dBA
Cruise, 60 MPH	89 dBA	8 dBA	81 dBA

Sound Levels for a Typical
Heavy Truck
Table 18[311]

These overall reduction potential values have been determined experimentally under laboratory conditions by isolating the various noise generating components of the heavy truck, and seeking the reduction potential of each component. The components generally considered include the engine casing, the exhaust system, the cooling mechanism (fan), the air intake system, the tires, and the transmission.

As discussed in Chapter III of this dissertation, the engine and exhaust system noise from the heavy truck is independent of speed. Therefore, it would be expected that the noise reduction potential for the engine and exhaust would be constant over the range of operating modes. This turns out to be the case, for the data summarized in NCHRP Report 173. The 14 dBA reduction potential for the engine casing mentioned earlier may be achieved by attaching close fitting covers or shields made of laminated steel tightly over the valve covers, oil pan, blower covers, and cylinder block side panels. These shields will yield about 3 dBA reduction, and the additional 11 dBA reduction can be achieved by installing a vibration isolated enclosure completely around the engine. The enclosure should be completely sealed, and should be made of steel, aluminum or fiberglass with acoustical insulating material on the inside.[312]

The exhaust system of the heavy truck has the potential for a 19 dBA reduction for acceleration and cruise, despite the fact that it is not possible (because of heat) to completely enclose the system. Most of this reduction, 13 dBA, is achieved by increasing the insertion loss capabilities of the exhaust muffler. In order to minimize increased engine back pressure, it is necessary to increase muffler size to increase insertion loss.[313] Therefore, while it is conceivable to obtain as much as 30 dBA insertion loss in some cases, size and back pressure limitations dictate that about 13 dBA is the maximum practical.[314] An additional 6 dBA reduction may be obtained for the exhaust system with the inclusion of manifold mufflers and acoustically treated splitter "T" cans for dual exhaust systems.[315]

The cooling mechanism, or fan, offers the greatest potential for noise reduction of all the components for the heavy truck, particularly under cruise conditions where it is not necessary for the fan to be engaged for most of the time. Under cruise conditions, the potential is for at least 21 dBA reduction, and under acceleration conditions, when the fan is ordinarily engaged, the potential is for a 13 dBA reduction. The 21 dBA is simply the difference between the sound levels of a typically engaged fan, as compared to when it is barely engaged. The disengagement is achieved through the installation of a temperature controlled fan clutch. The clutch may be simply a viscous device which slows the fan speed as air temperature drops. For those cases where the fan must be fully engaged, the reduction of up to 13 dBA may be achieved by the installation of a high performance, low speed fan. However, there is currently no substantiating evidence to date that guarantees this reduction.[316]

Sound levels resulting from the air intake systems may show great variability depending on the truck and the engine.[317] This variability is usually related to the condition of the air cleaners, which, when good, should provide sufficient reduction based on commercially available cleaners. Inlet silencers and snorkels, when installed, can provide up to 12 dBA reduction.[318]

The next major noise component for the heavy truck is the tires, which offers relatively small potential for noise reduction. NCHRP 173 reports that from 4.5 to 6 dBA reduction may be gained by using rib tires in place of cross-bar tires.[319] It was discussed in Chapter III that tires contribute 77 dBA to the generalized truck noise emission level of 82 dBA. Therefore the limitation in noise reduction potential for the tires is a very significant constraint in truck noise abatement under medium and high speed conditions. However, the inclusion of the other abatement items would serve to lower the acoustic center of the truck to near pavement level, where tire noise originates. This then increases the abatement potential for roadside barriers, and berms.

The final component to be considered is noise from the transmission, where gear meshing can be a major source of noise.[320] This is particularly true for trucks with other noise abatement features which are operating at low speeds. The problem is relatively easy to correct, however, with the installation of transmission and differential enclosures, which have a noise reduction potential of 20 dBA for the acceleration and cruise conditions.[321]

As mentioned earlier, all of these abatement items together provide an abatement potential of 14 dBA for the acceleration case, 12 dBA for the cruise condition at 35 miles per hour, and 8 dBA for the cruise condition at 60 miles per hour. It is now prudent to consider the <u>cost</u> of these abatement items, so that the economic impact of source abatement for the heavy truck can be assessed. Table 19 shows the costs for parts and labor for the installation of the items of the abatement package discussed herein, taken from NCHRP 173. The costs are in terms of 1975 dollars.

Item	Cost	Item	Cost
Close Fitting Covers	143	Viscous Fan Clutch	100

Item	Cost	Item	Cost
Engine Enclosure	450	High Performance Fan	6
Exhaust Muffler (dual)	83	Snorkel and Air Cleaner	60
Manifold Muffler	121	Transmission Enclosure	120
Splitter "T" Can	19		

Table 19[322]

Thus, the total cost for this abatement package is 1,102 dollars, which represents an additional 2 to 3 percent capital investment on the purchase of a new heavy diesel truck.[323] Amortizing this capital cost in order to obtain a yearly cost factor will require the making of several assumptions. First, the useful life of each of these items is assumed to be 10 years, Second, there is no salvage value at the end of that time. And third, the investment potential for available money is 10 percent, compounded annually.

The factor [324] necessary to convert the present worth (1,102 dollars) of the money needed for the noise abatement items to an annual cost is 0.16275, assuming the 10 year useful life and 10 percent investment interest rate. The yearly cost, then, is equal[325] to 1,102 x 0.16275 = 179 dollars per year. Once the yearly maintenance and operational costs have been determined, it will be possible to add the 179 dollar yearly cost for the initial investment to determine an overall yearly cost for the noise abatement package in Table 19.

Maintenance costs will vary considerably, depending on the operational schedule of the truck. However, it is possible to estimate approximate yearly maintenance requirements in terms of time, based on experience gained in many of the recent studies, particularly the Quiet Truck Program sponsored by the U. S. Department of Transportation. These estimates show that the engine enclosure would add 6 hours of mainenance during a year, mostly because of the need to continuously remove and re-install it. The close fitting engine covers and the transmission shield would each add one hour of maintenance, and the splitter "T" can and exhaust muffler would together add one hour. Thus, the total additional maintenance time required for the noise abatement package is 9 hours. Assuming a prevailing labor charge of 15 dollars per hour for the maintenance work, the total cost would be 135 dollars per year.

The consideration of additional operational costs due to the noise abatement package is somewhat more complex, due to the added weight of the items, an increase in engine backpressure due to the splitter "T" can and muffler, and a power savings resulting from the viscous fan clutch. The following assumptions are necessary in order to quantify operational costs. First, the average heavy truck logs 125,000 miles per year, 80 percent of which are power limited and 20 percent of which are speed limited. Second, 5 percent of the truck operation is weight limited. Third, the cost of truck fuel is 50 cents per gallon. Fourth, the rate of return on cargo movement is 0.01 dollars per ton-mile. And fifth, there is a savings in fuel costs of 30 dollars per year for every unit of horsepower conserved. These assumptions are based on the studies summarized in NCHRP 173.[326]

The added weight of the noise abatement package, 567 pounds,[328] adversely affects operational costs in 2 ways. First, during the 95 percent of the time that the truck is not weight limited, the incremental increase in weight results in additional fuel consumption. The cost of this additional fuel is:

$$\Delta\$ = K_1 \times U \times FC \times W \qquad (31)^{327}$$

where $K_1 = 1.085 \times 10^{-6}$ gallons per mile-pound, which was determined during one study[329] in the Quiet Truck Program; U is the usage of the truck in miles per year, FC is the fuel cost per gallon, and W is the additional weight (of the noise abatement package) in pounds. Substituting the appropriate numbers into equation 31 yields:

$$\Delta\$ = (1.085 \times 10^{-6}) \times (1.1875 \times 10^{5}) \times (5 \times 10^{-1}) \times (5.67 \times 10^{2}) = 38.50 \text{ dollars}$$

Second, during the 5 percent of the time that the truck is weight limited, the lost revenue is:

$$\Delta\$ = K_2 \times W \qquad (32)^{327}$$

where $K_2 = 3.125 \times 10^{-2}$ dollars per year-pound, based on the 0.01 dollars per ton-mile rate of return for cargo movement and 6,250 miles of operation, and W is the additional weight. Substituting yields:

$$\Delta\$ = (3.125 \times 10^{-2}) \times (5.67 \times 10^{2}) = 17.70 \text{ dollars}$$

Because the splitter "T" can increases the engine backpressure by 21.5 inches (H_2O),[328] there will be corresponding degradation of engine performance, both for the power limited condition and the speed limited condition. The cost associated with the power limited case is, from NCHRP 173:

$$\Delta\$ = K_3 \times U_p \times FC \times \Delta_p \qquad (33)^{327}$$

where $K_3 = 1.08 \times 10^{-4}$ gallons per mile per inch (H_2O), which is also from a study[329] in the Quiet Truck Program; U_p is the usage in miles per year for the power limited case; FC is the fuel cost per gallon, and Δ_p is the increase in backpressure, in inches (H_2O). Substituting yields:

$$\Delta\$ = (1.08 \times 10^{-4}) \times (10^5) \times (5 \times 10^{-1}) \times (2.15 \times 10^1)$$
$$= 116.00 \text{ dollars}$$

The cost associated with the speed limited case is, again from NCHRP 173:

$$\Delta\$ = K_4 \times U_s \times FC \times \Delta_p \qquad (34)$$[328]

where $K_4 = 1.22 \times 10^{-4}$ gallons per mile per inch (H_2O), from the same study[329] in the Quiet Truck Program; U_s is the usage in miles per year for the speed limited case; and FC and Δ_p are the same as equation 33. Substituting yields:

$$\Delta\$ = (1.22 \times 10^{-4}) \times (2.5 \times 10^4) \times (5 \times 10^{-1}) \times (2.15 \times 10^1)$$
$$= 32.80 \text{ dollars}$$

The installation of the viscous fan clutch results in a considerable savings of power and resultant fuel because the fan no longer operates continuously. It is difficult to ascertain the exact number of horsepower to maintain a conventional fan at highway speeds, but it has been estimated to be in the 5 to 15 range. Therefore it may be assumed that 10 horsepower will be saved by adding the viscous fan clutch. Using the 30 dollars per year per horsepower unit yields:

$\Delta\$ = 10 \times 30 \quad = \quad 300$ dollars <u>savings</u>

Summing the yearly operational costs for the heavy truck with the noise abatement package given in Table 19 yields:

Weight, unlimited	+ 38.50 dollars
Weight, limited	+ 17.70 dollars
Power limited	+116.00 dollars
Speed limited	+ 32.80 dollars

Power, limited	-300.00 dollars (savings)
Total	- 95.00 dollars (savings)

Thus, it may be concluded that the installation of the noise abatement package will result in a significant benefit in terms of operation costs. The savings are 95 dollars per year, and owe themselves completely to the presence of the viscous fan clutch.

Consideration of the operation and maintenance costs together indicate that the cost of the package is 40 dollars per year (135 dollars minus 95 dollars savings). Consideration of all the costs involved yields:

Amortized Capital cost	179 dollars/year
Maintenance and operations costs	40 dollars/year
Total	219 dollars/year

It is also possible to estimate the noise abatement potential and the resulting capital, operating, and maintenance costs for automobiles and light trucks. Because both automobiles and light (medium) trucks are gasoline powered vehicles, it may be assumed that each have similar noise abatement potential. Therefore they will be considered as being in the same category.[330]

The abatement devices available for these vehicles are similar to those for the heavy truck, except that most automobiles already use rib type tires. Therefore, there is no significant abatement technique for tire noise, which is the predominant source at the higher speeds. Studies[331] performed by the General Motors Corporation indicate that the installation of close fitting covers on the valve covers will yield about 5 dBA reduction; installation of larger, dual mufflers with splitter "T" cans will yield up to 18 dBA reduction; installation of an auxilliary intake muffler will yield up to 6 dBA reduction; and the installation of a thermatic or viscous fan clutch and enlarged radiator will yield up to 13 dBA reduction in the acceleration mode and up to 21 dBA reduction in the cruise mode. It should be noted that, unlike the heavy truck case, the installation of a high insertion loss muffler does not necessarily mean an increase in engine backpressure.[332]

The overall noise abatement potential for automobiles and light trucks, based on the data in the preceding paragraph is 11 dBA for acceleration and 4 dBA at a cruise speed of 60 miles per hour, where tire noise plays a major role. The capital costs for the abatement package, which are developed in a manner similar to that for heavy trucks, are estimated to be 55 dollars for automobiles and 100 dollars for light trucks.[333] Amortizing these costs over a 10 year useful life yields annual costs of 9 dollars and 16 dollars, respectively. Additional operational costs resulting from the implementation of the noise abatement package would be almost negligible, averaging about one dollar per year.[334] The only increased maintenance costs involved would result from the installation of a more expensive muffler. NCHRP 173 estimates that this would be approximately 10 dollars per year.[334] (It should be noted that these costs were determined assuming incorporation into new automobiles, and not as a retrofit package.) Thus, it may be concluded that the overall annual increase in cost for this noise abatement package would be 20 dollars for an automobile and 27 dollars for a light, or medium truck.

Before discussing the economic impacts of path and receiver control of highway transportation noise, it would be useful to evaluate source control costs per vehicle versus the overall cost of the problem, in terms of cost per vehicle. There is no need to determine the national cost, because in dealing with per capita (vehicle) costs, only a significant sample is needed. Therefore, data obtained in a recent study[335] by the Rand Corporation for the City of Chicago and surrounding Cook County, Illinois will be utilized.

The approach used in the Rand study was to estimate existing (1975) noise levels from the major expressways in Chicago with the aid of NCHRP 117 as the prediction model. The estimates were checked with a small sample of measurements using a hand held sound level meter to validate accuracy. Applying econometric techniques and property value analysis methods very similar to those in the Tennessee, Penn State and McMaster studies discussed earlier in this chapter, the Rand study estimated that the cost of expressway noise in Chicago was 11.25 million dollars (1975).[336]

Assuming that all of this economic damage should be shared equally by all the vehicles registered in the City of Chicago yields a cost of 9 dollars per vehicle (total registration in 1973: 1,243,607). If it is assumed that the damage should be shared only by the 82,858 trucks and buses registered in the city, then the cost would be about 135 dollars per vehicle. If, on the other hand, it is assumed that the damage should be equally shared by all of the 2,638,204 vehicles in the entire county, then the cost would be about 4 dollars per vehicles.

Similarly, if only the 194,534 trucks and buses in the entire county should share the damages, then it would be about 58 dollars per vehicle.[337]

The value of the figures taken from the Rand study is not in the numbers themselves, because admittedly, many assumptions were made.[338] Rather, the value is in the observation of the order of magnitude considerations. That is, the cost of the noise abatement package for the heavy truck, 1,100 dollars, is nearly 10 times the estimated damages per vehicle in the City of Chicago. It is therefore unreasonable and economically unjustifiable to require that the problem be solved exclusively at the source. Instead, it should be shared by all 3 of the components (source, path and receiver). Also, it is not likely that the 1,100 dollar per truck expenditure by itself would reduce the damages to zero, because the Rand study assumed that 50 dBA for L_{10} is where zero damages would occur.[339] It is therefore proper and prudent to now examine the costs of highway transportation noise abatement from the perspectives of path and receiver.

B.2 PATH - The most widely utilized method for abating highway transportation noise along the path is the construction of barriers (vertical walls or earthen berms). As of 1976 there were 54 barrier systems constructed adjacent to highways in the United States, with at least 31 more proposed for construction. These may be categorized as follows: