EPA-AA-SDSB-80-13

Technical Report

The Aftermarket Costs of Heavy-Duty Diesel Mufflers

by

Daniel Heiser

July 1980

NOTICE

Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

Standards Development and Support Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air, Noise and Radiation
U.S. Environmental Protection Agency

Summary

Aftermarket muffler costs were determined for the various classes of heavy-duty diesel vehicles. These costs can be used with other data to predict maintenance cost savings of eliminating the need to replace the standard steel muffler on a heavy-duty diesel vehicle. These aftermarket muffler costs were based on a survey of muffler costs from a heavy-duty vehicle and engine parts dealership. The average muffler cost for each heavy-duty diesel vehicle class was estimated as follows (in 1980 dollars):

Class IIB-IV	$136
Class V and VI	$161
Class VII	$164
Class VIII	$181

Introduction

EPA is preparing to propose a heavy-duty diesel particulate emission standard. One possible control technique is the trap-oxidizer. The addition of a trap-oxidizer will require the use of an exhaust system that will last the lifetime of a vehicle (i.e., a stainless steel system). The trap-oxidizer has also been shown to reduce engine noise as well as current mufflers.1/2/ Thus, its use should eliminate the need for the muffler. This elimination would reduce maintenance costs, since the muffler would no longer need to be replaced. These savings would need to be taken into account when determining the net cost per vehicle of adding a trap-oxidizer. To estimate these savings, the aftermarket costs of mufflers must be known. Representative aftermarket muffler costs will thus be estimated in this report for the various heavy-duty vehicle classes.

The method used to estimate the muffler costs for heavy-duty diesel vehicles consists of three major steps. First, actual aftermarket muffler costs for various heavy-duty diesel engines will be obtained from a heavy-duty vehicle and engine parts dealership. Second, each engine (and its muffler) will be assigned to a particular vehicle class, based on a relationship between engine size and gross vehicle weight. Third, an average muffler cost will be estimated for each vehicle class from the range of costs available.

The average muffler costs will be determined by vehicle class because this will be the most convenient form for future use. The regulatory analysis for the heavy-duty diesel particulate regulations will likely break down the costs of control by vehicle class. This will be done because is it easier to predict future sales of heavy-duty diesels by vehicle class than it is to predict future sales of heavy-duty diesel engines by engine family. Thus, while muffler cost data is directly available for individual diesel engines, additional effort will be made to covert these costs into average muffler costs for each vehicle class. As it is likely that the regulatory analysis will group Classes IIB, III, and IV and Classes V and VI together, respectively, because of the relatively small sales in Classes III, IV, and V, that will be done here also.

All costs will be determined in 1980 dollars. The details of the analysis follow.

Muffler Prices

The first step in determining aftermarket muffler costs for whole classes of heavy-duty diesel vehicles is to obtain muffler costs for individual heavy-duty diesel engines. To do this, a survey of muffler costs from a heavy-duty vehicle and engine equipment supplier, A&L Parts, Inc. of Ann Arbor, Michigan, was conducted. Most of the heavy-duty diesel mufflers sold at this dealerships were produced by Riker Manufacturing. The description and cost of these mufflers can be found in a Riker Manufacturing heavy-duty engine muffler guide,4/ and a corresponding heavy-duty muffler resale price list.5/ The engine-muffler guide listed engine models from several diesel engine manufacturers with their corresponding number of cylinders, the engine displacement (in CID), the type of exhaust system (single vs. dual), and the cross reference muffler number. The price list listed the costs of these mufflers.

An examination of the price list showed that two different costs were given for each muffler. These costs are known as the "net price" and the "list price."4/ For example, the replacement mufflers for a Cummins model V6-155 dual exhaust engine are Riker Manufacturing mufflers, no. HD257 39 4/ (p. 5-3), with each of the two mufflers having a list price of $81.61, and a "net price" of $54.36.5/ (p. 5) For all the mufflers contained in the price list, the "list price" was 50 percent higher than the "net price." Discussion with the dealer revealed that these two costs are related to the types of services rendered by the dealer. A dealer selling truck parts and providing services such as installation often sells these mufflers at or near the "list price" while a dealer selling truck parts only would sell these mufflers closer to the "net price." Because no data is available on how often heavy-duty diesel owners pay each price, it will be assumed that the average muffler cost is halfway between the "net price" and "list price."

Further examination of the price list also revealed that a wide range of muffler costs exists, from a $47 muffler for an IHC-D354 diesel engine to a $306 muffler for a Cummins V903 diesel engine. This wide variance in costs appears primarily due to a wide range of engine sizes, the number of exhaust systems per engine (single vs. dual), and the number of mufflers per exhaust system.

Vehicle-Engine Relationship

To categorize the muffler costs found above, each muffler (via its engine) will be assigned to a vehicle class. A heavy-duty vehicle as defined by EPA is a vehicle whose gross vehicle weight rating (GVWR) exceeds 8500 pounds. The following standard truck classes then fall into the heavy-duty vehicle class:

Class	GVWR (Pounds)
IIB	8,500-10,000
III	10,001-14,000
IV	14,001-16,000
V	16,001-19,500
VI	19,501-26,000
VII	26,001-33,000
VIII	33,001 and over

Vehicle Class IIB in this report will always refer to vehicles in the traditional Class II category (6,000-10,000 pounds) with a weight above 8,500 pounds (i.e., those Class II vehicles which fall into EPA's heavy-duty vehicle category). For purposes of this analysis, these vehicle classes will be placed into four basic vehicle groups. These groups are:

Group	GVWR (Pounds)	Class
1	8,500-16,000	IIB,II,IV
2	16,001-26,000	V,VI
3	26,001-33,000	VIII
4	33,001 and over	VIII

The make-up of these groups is based on the projected future of each of the classes3/, which is shown in Table 1. From Table 1 it can be seen that the relative sales of Classes III, IV, and V are very small with respect to the other classes. Thus, it should be reasonable to group Classes III and IV with Class IIB and to group Class V with Class VI.

To facilitate the costing of mufflers for these vehicle groups, each group will be assigned a typical engine displacement. These engine displacements are 350 CID (Classes IIB, III, and IV), 500 CID (Class V and VI), 640 CID (Class VII) and 850 CID (Class VIII). These engine sizes were estimated from light-duty diesel truck and heavy-duty diesel vehicle and engine data.6/ The engine size estimated for a Class IIB-IV vehicle will be examined first.

No Class IIB-IV diesel vehicles are currently marketed. However, General Motors (GM) does market a light-duty diesel truck (GVWR = 6000-8500 pounds) with a 350 CID engine. As Class IIB-IV vehicles are generally commercially-owned and operated to maximize profit, they should not require the acceleration capabilities of a light-duty diesel truck, which is usually personally owned. Thus, an engine size capable of powering a 6,000-8,500 pound light-duty diesel truck should be sufficient for vehicles potentially twice that weight.

Table 1

Projected Heavy-Duty Diesel Sales by Class

	IIB	III	IV	V	VI	VII	VIII	Total
1984	14,335	2,685	456	1,114	56,338	31,678	159,555	266,161
1985	18,258	3,419	581	1,418	64,275	33,725	162,578	284,255
1986	22,316	4,179	710	1,735	72,490	35,824	165,600	302,854
1987	26,511	4,965	843	2,061	80,984	37,979	168,623	321,966
1988	30,841	5,776	981	2,398	89,755	40,187	171,645	341,583

To demonstrate that an engine size of 350 CID is at least conceivable for a Class IIB-IV vehicle, it can be shown that a few vehicles even heavier than 16,000 pounds are equipped with engines even smaller than 350 CID. For example, while most Class VIII vehicles are equipped with engines in the 600-900 CID range, a GMC JV-75 heavy-duty vehicle (40,000-50,0000 pounds) is usually equipped with a Detroit Diesel 6V-53N engine of 318 CID.6/ Thus, a 350 CID engine should at least be a reasonable engine size for Class IIB-IV heavy-duty diesel vehicles.

Looking next at the other extreme, Class VIII vehicles, the average size of 850 CID reflects 1) the popular use of Cummins engines, nearly all of which are 855 CID (rounded to 850 CID for this analysis) and 2) that about as many engines are larger than 850 CID as are smaller than 850 CID for Class VIII vehicles.6/

Concerning Class VII vehicles, a Caterpillar 3208 engine was known to be popular engine for many of these vehicles. The Ford 87000 is one vehicle with this engine.6/ The size of this engine is 636 CID, or rounded to 640 CID for this analysis. Again, this average engine size appears to be in the middle of a range of engine sizes that exist for Class VII vehicles.6/ Thus, an engine size of 640 CID was assigned to Class VII. For Class V and VI vehicles, insufficient data were available for estimating an average engine size. Thus, the average of the Class IIB-IV engine size (350 CID) and the Class VII engine size (640 CID) was assumed to be a reasonable engine size for a Class V and VI vehicle. This comes to an engine displacement of 500 CID.

An engine's horsepower rating would be another parameter for relating an engine to a particular heavy-duty vehicle class and initially, would appear to be a better one. However, even here no simple correlation exists between engine power and vehicle class. For example, the GM heavy-duty gasoline vehicles TP-31382, CE60, and C550 come equipped with engines having maximum brake horsepower ratings of 240, 159, and 120, and have GVWRs of 14,500, 13,600-18,500, and 13,800-18,000 pounds, respectively. In other words, the lightest vehicle is equipped with the most powerful engine. In addition, a GMC CE65 vehicle(GVWR = 19,000-32,000 pounds) comes equipped with a engine having a maximum horsepower rating of 198.6/ Thus, engine power does not appear to be that more suitable than engine displacement for determining a relationship between engines and vehicles. Also, future applications in the sizing and costing of other emission control hardware components will most likely be done by engine size rather than by power, since the size of cost of components are primarily related to engine size. For example, control hardware costs for the light-duty diesel particulate regulations were estimated according to engine size.7/ It is likely that a similar methodology will be used for the proposed heavy-duty diesel particulate regulation. Thus, it would be convenient and consistent to have a single engine/vehicle class relationship for use in the overall analysis.

Engines from the five largest diesel engine manufacturers, Caterpillar, Cummins, Detroit Diesel, International Harvester, and Mack, will be used in this analysis as these manufacturers comprise about 97 percent of the total heavy-duty diesel engine market.3/ In order to determine the vehicle group to which each engine is associated, the engine displacement of these engines (as found in the Riker Manufacturing engine-muffler guide)4/ will be matched to the closest engine size determined for the four vehicle groups. Thus, for purposes of this analysis only, a heavy-duty diesel engine size of 0-425 CID will be assigned to Classes IIB-IV, an engine size of 426-570 CID will be assigned to Classes V and VI, an engine size of 571-745 CID will be assigned to Class VII, and an engine size of 746 CID and larger will be assigned to Class VIII. While these engine size/vehicle class relationships are not exclusive in reality, they should serve the purposes of this analysis. As stated above, no Class IIB-IV diesel vehicles are currently marketed, so that none of the engine sizes between 0-425 CID used here currently belong to a Class IIB-IV vehicle. However, this analysis will assume that engines of 0-425 CID will have muffler costs that most closely represent the muffler costs of future Class IIB-IV diesel vehicles. For example, a Cummins diesel engine model V6-155 has an engine size of 378 CID and will be assigned to Class IIB-IV in this analysis,4/ (p. 5-3) while at present this engine is probably used to power Class VI, VII, or VIII vehicles.

Cost Per Vehicle Group

Now that the engine-vehicle relationship has been determined, the third step in this analysis is to estimate the average muffler costs for each of these four groups of vehicle classes. A sales-weighted average should provide a reasonable estimated muffler cost for each group. However, a sales-weighted average of all mufflers within each group can not be determined as sales data on mufflers are not available. Another method for estimating average costs would be to determine the relative sales of each engine sold within each vehicle group, and then examine which mufflers are associated with each engine, and thus indirectly develop a sales-weighted average of mufflers costs for each vehicle group. However, this approach also has several problems. First, some heavy-duty diesel engines have several applications other than powering heavy-duty vehicles. For example, a given engine may be used to power a tractor as well as an over-the-road heavy-duty vehicle. 6/ The breakdown of engines sold for each type of application is not available. Second, even if the above breakdown were known, the number of engines sold to power each associated heavy-duty vehicle is not available. It is known, for example, that a Caterpillar 3208 or a Ford V363 engine can be used in a Ford 87000 vehicle,6/ but it is not known how many engines of each model are sold to power this vehicle. Thus, no simple sales relationship exists between engines and vehicles. Third, each engine used to power heavy-duty vehicles may have many in-use applications that affect the noise output and thus may require several different types of mufflers. For example, five different types of mufflers can be used on a Cummins V555 engine.4/ Estimated sales for each type of muffler for each engine would be difficult to predict. Thus, a single sales-weighted muffler cost for each vehicle group can not be determined due to the lack of sales data of either mufflers or engines.

Another possible method for determining average muffler costs would be to analyze the muffler costs associated with single exhaust and dual exhaust systems within each vehicle group separately. This further breakdown should be helpful because muffler costs appear to be much less for single exhaust systems than for dual exhaust systems. Also, a projection of relative sales of vehicles with single and dual exhaust systems can be made by assuming that turbocharged engines have single exhaust systems and that naturally-aspirated engines have dual exhaust systems.3/ Using this assumption, approximately 3/4 of all heavy-duty diesel vehicles will utilize a single exhaust system. This corresponds to the fraction of turbocharged diesel engines sold by the five largest manufacturers.3/ The remaining 1/4 of the engines (those being naturally-aspirated) are assumed to have dual exhaust systems. While a cross-over pipe could be used instead of a dual exhaust system on these naturally-aspirated engines, this is highly unlikely due to their large engine size. Thus, these naturally-aspirated engines are assumed to require two exhaust pipes and two mufflers. This breakdown of single and dual exhaust is assumed to apply to each vehicle class.

Because of the lack of additional sales data within each exhaust system type, a single muffler cost for each single exhaust and dual exhaust group of mufflers cannot be determined by a true sales-weighing. Instead the midpoint of the range of muffler costs within these groups will be used as the single representative cost. In other words, the estimated value for the single exhaust muffler and for the dual exhaust muffler for each vehicle group will be computed by taking the midpoint of the minimum and maximum costs listed for the two types of mufflers. If a single exhaust system consists of two mufflers in series, then the sum of these two mufflers will be considered as the cost of the muffler for this exhaust system. The final average cost for each particular vehicle group would be estimated from the predicted sales fraction of single exhaust and dual exhaust systems determined above.

Looking first at single exhaust mufflers for a Class IIB-IV vehicle, the least expensive muffler can be found on an IHC-D354 engine (engine size = 354 CID). This muffler's minimum cost is $58 (halfway between net price = $47 and list price = $70). Likewise, the most expensive Class IIB-IV single exhaust muffler can be found on a Detroit Diesel 6V-53N engine (engine size = 318 CID), which costs $182. The midpoint of the minimum and maximum cost is $120, and will be assumed to be the sales-weighted average cost of a Class IIB-IV single exhaust muffler.

Estimating the cost of a dual exhaust muffler on a Class IIB-IV vehicle is done similarly as above. The least expensive muffler can be found on a Cummins V6-155 engine (engine size = 378 CID), which has a minimum cost of $136. The most expensive Class IIB-IV dual exhaust muffler costs $235, and can also be found on a Detroit Diesel 6V-53N. The midpoint of the minimum and maximum cost is $185, which is the cost of Class IIB-IV dual exhaust mufflers. The costs of the single and dual exhaust mufflers for the remaining vehicle groups were determined using the same method as that for Class IIB-IV mufflers and can be found in Table 2.

The final average costs of a Class IIB-IV muffler is the estimated sales-weighted average of the single exhaust and the dual exhaust mufflers, or $136 ((3/4 x $120) + (1/4 x $185)). Using the same method for the remaining groups of vehicle classes, the costs of mufflers on Class V and VI, Class VII, and Class VIII vehicles are $161, $164, and $181, respectively. Table 3 displays a summary of costs for each group of vehicle classes. These estimated aftermarket costs can now be used to estimate the effect of modifying or eliminating the muffler replacement schedule for heavy-duty diesels.

Table 2

Costs of Mufflers on Single and Dual Exhaust Systems

Vehicle Class	Single Exhaust (S) or Dual Exhaust (D)	Engine Equipped with Least Expensive Muffler, with Engine Size (CID)	Minimum Cost 1/	Engine Equipped with Most Expensive Muffler, with Engine Size (CID)	Maximum Cost 1/	Midpoint of Minimum and Maximum Cost
IIB-IV	S	IHC-D354 (354 CID)	$ 58	Detroit Diesel 6V-53N (318 CID)	$182	$120
	D	Cummins V6-155 (318 CID)	$136	Detroit Diesel 6V-53N (318 CID)	$235	$185
V, VI	S	Mack END-510 (510 CID)	$ 82	Cummins V8-185, V8-215 (504 CID)	$213	$148
	D	Cummins V8-185 (504 CID)	$146	Detroit Diesel 8V-71N (568 CID)	$255	$200
VII	S	Caterpillar 1673T, 1674TA (638 CID)	$ 95	Caterpillar 1150 (573 CID)	$218	$156
	D	Caterpillar 1160 (636 CID)	$146	Caterpillar 1160 (636 CID)	$235	$190
VIII	S	Cummins NH230, NH250, Super 250 (855 CID)	$119	Cummins V903 (903 CID)	$202	$160
	D	Cummins V903 (903 CID)	$235	Cummins V903 (903 CID)	$255	$245

1/ Halfway between "net cost" and "list cost" for each engine.

Table 3

Costs of Mufflers, According to Groups of Vehicle Classes

Group of Vehicle Classes	Average Single Exhaust Cost	Average Dual Exhaust Cost	Overall Average Cost per Group of Vehicle Classes
IIB-IV	$120	$185	$136
V, VI	$148	$200	$161
VII	$156	$190	$164
VIII	$160	$245	$181

References

1/ Penninga, J., TAEB, EPA, "Second Interim Report on Status of Particulate Trap Study," Memorandum to R. Stahman, Chief, TAEB, EPA, August 28, 1979.

2/ Alson, Jeffrey, SDSB, EPA, "Meeting Between Texaco and EPA to Discuss Particulate Trap Work," Memorandum to the Record, October, 1979.

3/ "Regulatory Analysis and Environmental Impact of Final Emission Regulations for 1984 and Later Model Year Heavy-Duty Engine," SDSB, EPA, December, 1979.

4/ "Heavy-Duty Muffler Applications," Riker Manufacturing, Inc., No. 176A, 1976.

5/ "Heavy-Duty Mufflers and Exhaust System Part, Suggested List and Resale Price," Riker Manufacturing Inc., No. 190-4, July 1, 1979.

6/ "Chiton's Automotive Industry," April, 1978, pp. 79-85, 94-95, 104-107.

7/ "Regulatory Analysis of the Light-Duty Diesel Particulate Regulations for 1982 and Later Model Year Light-Duty Diesel Vehicles," SDSB, EPA, February 20, 1980.