REPORT NO. DOT-TSC-OST-76-14, II

TRUCK NOISE X
NOISE REDUCTION OPTIONS FOR DIESEL POWERED INTERNATIONAL HARVESTER TRUCKS
Volume II - Cost-Noise Analysis and Field Installation

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APRIL 1977

FINAL REPORT

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
OFFICE OF THE SECRETARY
Office of the Assistant Secretary for Systems Development and Technology
Office of Noise Abatement
Washington DC 20590

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT-TSC-OST-76-14, II		

4. Title and Subtitle	5. Report Date
TRUCK NOISE X NOISE REDUCTION OPTIONS FOR DIESEL POWERED INTERNATIONAL HARVESTER TRUCKS Volume II - Cost-Noise Analysis and Field Installation	April 1977
	6. Performing Organization Code
	8. Performing Organization Report No. DOT-TSC-OST-76-14, II
7. Author(s) S. T. Razzacki	
9. Performing Organization Name and Address International Harvester Company* Truck Engineering Center P.O. Box 1109 Fort Wayne IN 46801	10. Work Unit No. (TRAIS) OS607/R7805
	11. Contract or Grant No. DOT-TSC-721-2
	13. Type of Report and Period Covered Final Report Jan 73-May 75
12. Sponsoring Agency Name and Address U.S. Department of Transportation Office of the Secretary Office of the Asst. Sec. for Sys. Dev. & Tech. Office of Noise Abatement Washington DC 20590	14. Sponsoring Agency Code

15. Supplementary Notes

*Under contract to: U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge MA 02142

16. Abstract

Noise reduction option development work was carried out on two in-service diesel powered IH trucks, consisting of a Cab-over model and a Conventional model with a baseline exterior noise level of 87 dB(A) each. Since no specific noise goals were set, International Harvester established an exterior noise reduction goal of 83 dB(A). Then, for each vehicle, proper noise source identification techniques were applied and major contributors were established. The commercially available source noise reducing components were tested singly, and were selected based upon an optimum evaluation. The selected components were collectively installed on the trucks and cumulative performance in the total truck environment was found to be adequate to meet the established noise level goals.

17. Key Words	18. Distribution Statement
Retrofit, in-use, Diesel Trucks, noise source-identification noise level, exhaust, muffler, pre-muffler, fan, cooling, shroud, engine, structural noise, block panels, bellypan.	DOCUMENT IS AVAILABLE TO THE U.S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	122	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

As part of its noise abatement effort, the Transportation Systems Center, on behalf of the Office of Noise Abatement, Office of the Secretary, U.S. Department of Transportation, initiated a project to develop noise reduction options for in-use diesel powered trucks and buses. The project was carried out in a number of parallel contracts awarded to (1) PacCar; (2) GM Truck & Coach; (3) Rohr Industries; (4) McDonnel-Douglas in conjunction with White Motor Company; and (5) International Harvester Company (IH). The objective of these contracts was to evaluate commercially available noise reduction modifications and finally to select retrofit kits suitable to reduce exterior noise of in-use vehicles.

This report is a comprehensive assimilation of the data, results and conclusions covering the development phase of the IHC contract along with detailed discussions of the efforts expended in conducting the work. It portrays the present state of art and technology available to reduce the noise of a selected number of IH in-use diesel vehicles. It is hoped that the information contained herein will be helpful to the legislators and owner-operators alike in their respective tasks of legislating and reducing truck noise levels.

International Harvester, in its endeavor to conduct the contract tasks, had to depend upon the voluntary cooperation of many manufacturers of truck components for pertinent information. It is our privileged duty to acknowledge the following manufacturers for their fine cooperation:

1. Donaldson Company, Inc., A Subsidiary of Garlack

2. Riker Manufacturing, Inc.

3. Stemco Manufacturing Co., Inc.

4. Cummins Engine Company, Inc.

5. Detroit Diesel Allison, Division of General Motors Corp.

6. Flex-a-lite Corporation

7. Schwitzer Company, Division of Wallace-Murray Corp.

8. Rockford Clutch, Division of Borg Warner Corp.

9. Horton Manufacturing Company, Inc.

10. Cowl Industries, Division of James B. Carter Limited

11. W. R. Grace and Company

12. Brookside Corporation

13. Northern Tube, Division of Quester Automotive Products.

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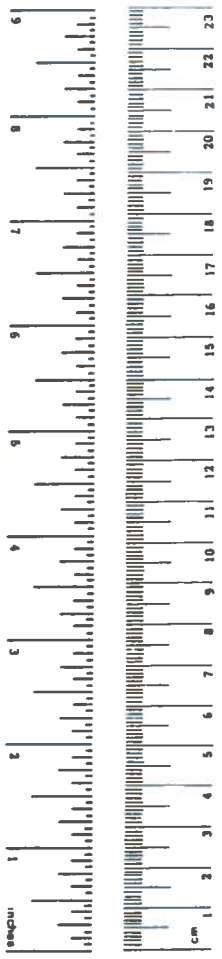
METRIC CONVERSION FACTORS

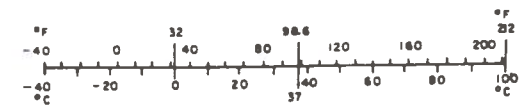
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



1. BACKGROUND

1.1 INTRODUCTION

The Department of Transportation awarded to International Harvester one of several parallel Noise Retrofit Contracts to develop kits of commercially available components to reduce the exterior noise of the existing trucks. The development work was carried out on two representative IH make model/engine combinations designated as primary series trucks. The selection of primary trucks involved population study, noise characteristic and extrapolation possibilities to other similar trucks, designated as secondary series trucks. A cab over engine 6x4 truck with a Cummins engine (COF4070A/NHC250), and a conventional 6x4 truck with a Detroit Diesel Allison (DDA) engine (2000D/6-71N65) were selected using this procedure.

Since no specific noise level figures were stated in the contract, the owner-operator law of 86 dB(A) was established as a meaningful goal. However because of the noise variations that occur between identical model-engine combinations built on the same assembly line due to manufacturing tolerances, and varying maintenance practices, a target figure of 83 dB(A) was established in order to satisfy the compliance concept.

The data, results and conclusions of the entire program covering the development work has been reported in Part One of the Final Report by the author and a summary is given in Section 1.2. This report (Part Two) describes the Cost-Noise Study and Field Installations carried out under this program. A Service Bulletin covering complete

installation and servicing of each noise reduction system developed under the contract was prepared and disseminated to the owner operators upon DOT approval. A copy of the Service Bulletin is also included in Appendix A.

1.2 SUMMARY OF DEVELOPMENT WORK

International Harvester's Used Truck Sales organization procured representative in-service samples of the selected model-engine combinations for development work under the contract.

Following a complete inspection and repair to "well-maintained" truck condition, overall exterior noise levels were measured and recorded for these unmodified vehicles. Additional exterior measurements were made including constant speed drive-by and Idle-Max Speed-Idle (IMI) noise levels at 80, 90 and 100 percent of maximum rated governed speed. Secondarily in-vehicle noise levels were measured per Bureau of Motor Carrier Safety (BMCS)stationary regulation and SAE J336 acceleration test. The baseline exterior noise levels of both the COF4070A/NHC250 and 2000D/6-71N65 were 87 dB(A), and the interior noise levels were 87 and 94 dB(A) respectively.

Source identification was then carried out by artifically silencing all major noise sources except the engine. Engine source noise reduction was obtained by applying a bellypan or commercially available panels to avoid the time consuming wrapping process. After making the trucks reasonably quiet, evaluation of commercially available noise reduction components was started.

In the case of COF4070A/NHC250 engine, various components to reduce the major truck noise sources such as exhaust fan and engine were tested. Based upon the evaluation results, the following commercially available components

were selected to achieve the target figure of 83 dB(A) for total truck exterior noise level:

1. Exhaust (improved) muffler 549483 C1.
2. Additional Fan Spacer 391987 C1 to optimize fan location.
3. Engine oil pan enclosure and block sound panels for Cummins engine.

In the case of 2000D, 6-71N65 exhaust source noise reduction mufflers were evaluated and selected. No commercially available metal or plastic fans were found which would reduce fan noise and retain required engine cooling. Originally the fan was not fully covered by the shroud, and fan-to-core spacing was at its optimum limit. In this case the fan could not be moved closer to radiator core for full immersion in the shroud and still retain optimum fan to core distance. A contoured shroud extension was thus developed to improve fan coverage that subsequently reduced fan noise. No engine noise reduction treatment was commercially available. Therefore research work was directed towards developing a feasible and effective engine noise reducing subsystem. Extensive design and test work resulted in the development of a sheet metal bellypan that reduced engine noise as well as fan source noise.

The effect of the bellypan on cooling and interior noise was also evaluated. The investigations revealed that the bellypan is feasible but produces a slight reduction in cooling capacity; whereas, the interior cab noise increased requiring cab treatment to meet the BMCS regulation.

Intake and "Others" noise levels were originally low so that their contribution to the overall truck noise

was insignificant in both the development vehicles.

Finally the selected kits consisting of the exhaust, fan and engine treatments were collectively installed on the respective trucks and all the baseline noise tests were rerun to measure the overall improvements in exterior and interior noise levels. The exterior noise level for COF4070A/NHC250 was recorded to be 83 dB(A) whereas for 2000D it was 83.5 dB(A). The interior noise level of COF4070A was noted to be 85 dB(A), 2 dB(A) reduction from baseline level as a result of exterior noise treatment. However, the interior noise level of 2000D was measured to be 96 dB(A), a 2 dB(A) increase in the baseline figure because of bellypan. Systematic sealing of the cab, and interior treatment with absorption and barrier material successfully reduced the in-vehicle noise below the levels specified in (BMCS) regulation (90 dB(A)).

1.3 COST BENEFIT AND FIELD INSTALLATION SUMMARY

The cost-benefit study discussed in Section 2 of this report was made with the assistance of a computer program that yielded all possible noise reduction combinations. Also, corresponding cost factors were established on the basis of most current rates. These figures were then fed to the computer that plotted truck noise level vs. added cost. The increased maintenance costs due to engine covers, panels and bellypan were also investigated.

To evaluate the selected retrofit kits, these kits were installed on various customer vehicles including primary and secondary series trucks as described in Sections 3, 4 and 5 of this report. Applicability was determined by taking noise measurements to assess their noise reduction potential. These field installations clearly pointed out that each truck is an individual in itself and applicability

varies from truck to truck. Also the noise reduction potential of the selected truck modifications may be consistent, but the truck environment in which they perform have tremendous bearing on their effective performance. In this context, proper maintenance of the truck cannot be over emphasized.

To inform in-field vehicle service organizations and vehicle owners, a Service Bulletin was compiled incorporating the vehicle modification instructions with appropriate details and diagrams for parts and installation thereof. Also included was the information regarding the side effects of such modifications and cost/noise reduction analysis. A copy of this bulletin for each primary vehicle and its related secondary vehicles is given in Appendix A.

2. COST-BENEFIT STUDY

2.1 INTRODUCTION

The accelerated mobility of goods and services today is vital in maintaining a healthy economy and diesel powered highway trucks play a major role in this regard. However, the diesel powered highway trucks also generate sound energy which is identified as a major factor in the overall noise picture of our countryside and urban areas. As a result of public awareness, many states and cities have established regulations for allowable noise produced by the new vehicles as well as those in-use. With the implementation of the noise technology in the current production, the new trucks produce less noise whereas the trucks built prior to these regulations (older, in-use vehicles) will require retrofittable components to effectuate reduction in the noise produced by them.

The Department of Transportation (DOT) recognized the need to conduct an organized study of the applicability of the present noise reducing art to retrofit the in-use vehicles for exterior noise reduction. This study specifically included a cost-benefit analysis in order to estimate the economic ramifications of regulating noise standards for in-use vehicles.

The modification costs for both the development trucks (primary), COF4070A/NHC250 and 2000D/6-71N65, were studied as a function of noise reduction based upon the evaluation results. The material and installation costs to the customer of various noise reduction modifications were included

in a computer analysis of the cost-noise tradeoffs. The computer compiled through a summation process, the cost factors consisting of the material cost plus installation cost for all possible noise reduction combinations. The maintenance cost was not accounted for in the computer model since no field information is available for engine treatments such as engine oilpan enclosures, block sound panels and bellypans. The maintenance effects of engine treatments were estimated later on as a separate step in the cost analysis.

2.2 ACOUSTICAL COMBINATIONS

By using the source identification technique, the development (primary) vehicles were sufficiently silenced for evaluation of source modification. The major noise sources were identified to be exhaust, fan and engine, and modifications for these sources were considered. The contribution of each modification in reducing the pertinent source noise was printed out in the form of a 3 dimensional plot of sound level vs truck position vs frequency. This data was used as an input to the computer model program to obtain maximum number of combinations of the source noise reducing modifications. Essentially it was a summing process where contribution of each source for each modification was acoustically added by computer that furnished total vehicle noise for that combination without regard to economics.

2.3 COST FACTOR

The computer model program discussed in the above section was also set up for cost summation along with the noise level summation. Therefore, a total cost for each source modification was established that included

material and installation cost.

Customer costs of the commercially available components were obtained and costs for the hardware to be built locally were generated by using quantity purchase prices for materials and volume estimates of labor requirements. The installation cost for each source modification was first obtained by a theoretical time-study estimation. This cost estimate was later adjusted according to the actual time requirements during the field installations. All costs were treated as added cost to the truck at the time of modification for exterior noise treatment only regardless of whether the parts were in lieu of standard or in addition to standard.

These cost factors were fed to the computer and corresponding costs for all modification combinations along with overall truck noise levels were obtained. The computer then plotted all the combinations with noise levels as abscissa and cost as ordinate for graphic illustrations of cost-benefit tradeoffs as shown in Figures 2.1 and 2.2.

2.4 DATA ANALYSIS

The evaluation of noise reduction components during the development work included noise tests with radiator shutters open and closed. Since these tests were used for cost-benefit analysis, the data points in Figures 2.1 and 2.2 represent the noise reducing combinations, shutters closed.

The data points plotted by the computer appear in a cluster with open spaces. Scarcity of commercially available noise reducing components did not allow to obtain sufficient data points to fill in these spaces. Hence these plots portray the present state of the noise reducing

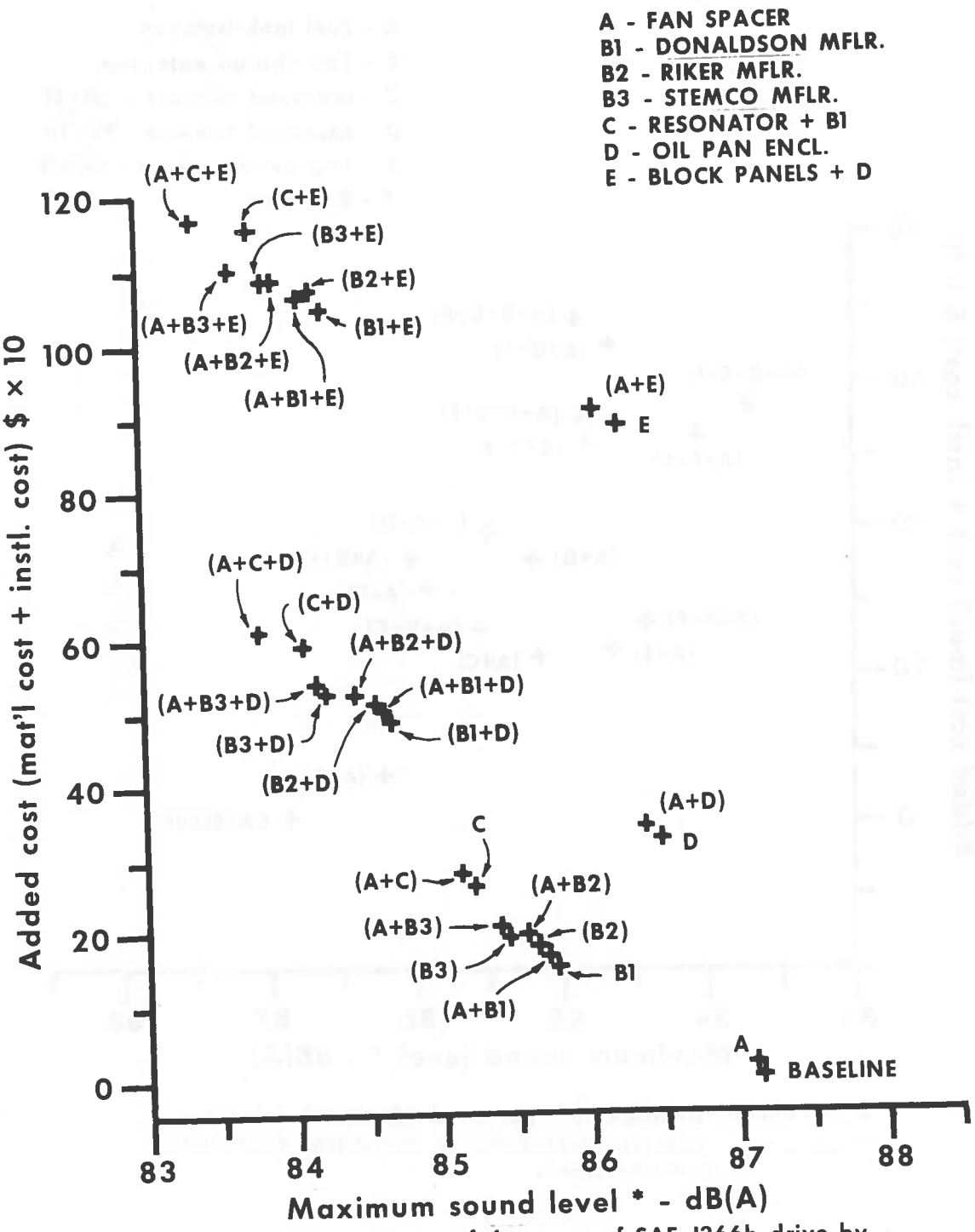
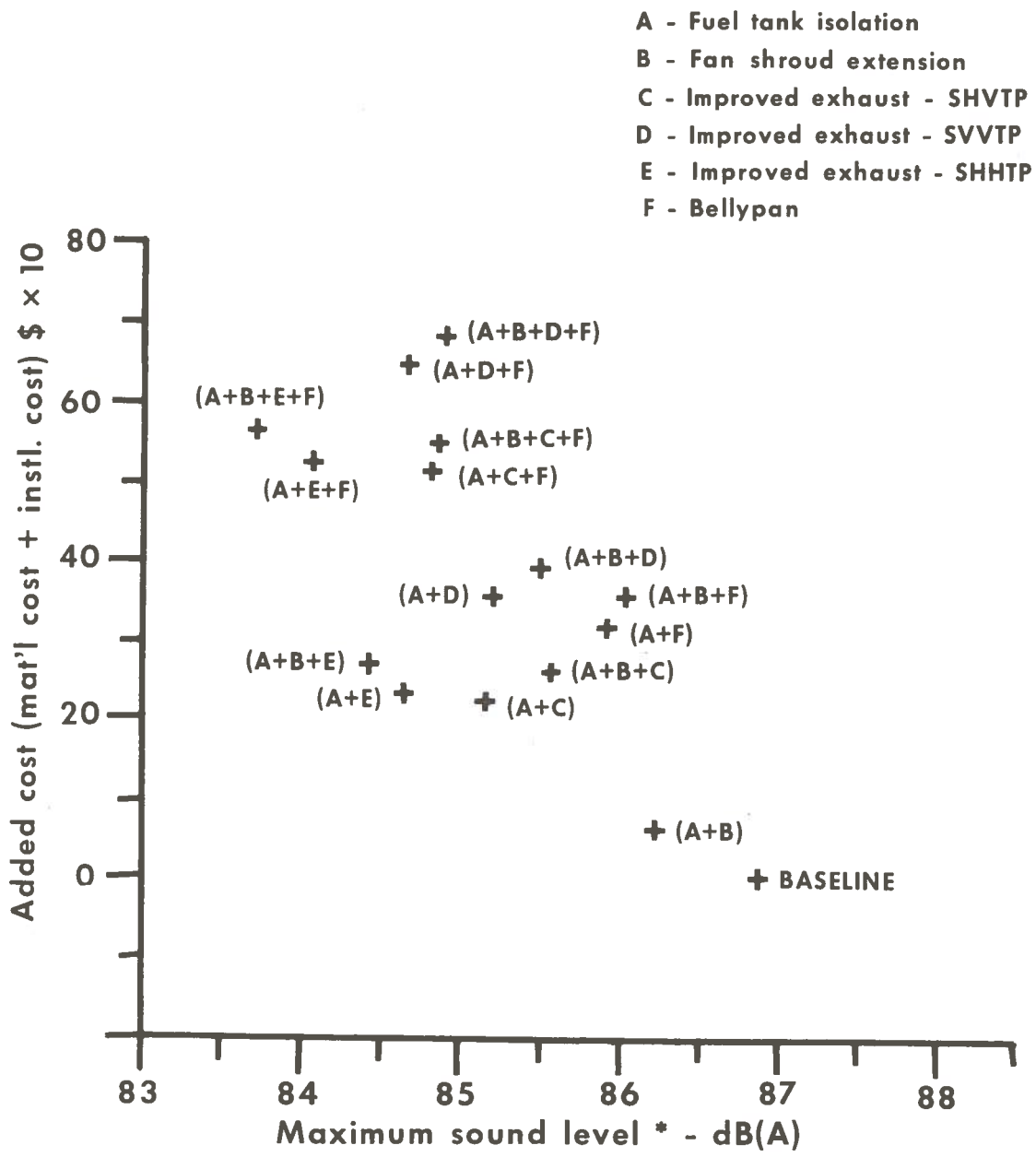


FIGURE 2.1 COMPUTER PREDICTIONS OF COST-NOISE TRADE OFFS COF-4070A/NHC-250 & SVVTP.



* Arithmatic average of 4 passes of SAE J366b drive-by.

FIGURE 2.2 COMPUTER PREDICTIONS OF COST-NOISE TRADE OFFS 2000D/6-71N-65.

art to retrofit the in-use vehicles for exterior noise.

The data points in Figures 2.1 and 2.2 show that the cost of modification increases sharply with the demands for higher gains in the truck exterior noise reduction. To better comprehend, all the data points in Figures 2.1 and 2.2 have been fully identified. It is obvious from Figure 2.1 that the installation of oil pan enclosure and engine block sound panels in COF4070A/NHC250 results in high added cost for moderate noise benefit. Again, in Figure 2.2 for 2000D/6-71N65, high added cost is predicted by the computer as a result of the bellypan installation for engine noise modification. It is evident from these graphic illustrations that the theoretical optimum cost-noise benefit points occur on the extreme left.

2.5 MAINTENANCE COST

The maintenance cost of the parts in lieu of standard such as mufflers, mountings, etc., would be no different than that of the standard parts as they replaced similar components of the baseline truck. Whereas the direct maintenance cost of the parts in addition to standard such as engine block sound panels for Cummins N-series engine, oil pan enclosure and bellypan for DDA 6-71N engine could not be firmly established as these are new parts and field information on their maintenance is not available. However, their impact on truck maintenance cost is recognized, discussed and estimated in the sections below.

It might be recalled that the engine covers and panels were used in COF4070A primary truck for NHC250 engine noise treatment, and bellypan was used in 2000D primary truck for 6-71N65 engine noise treatment. Furthermore, bellypan treatment is offered for 6-71N Detroit Diesel engine in chassis-model 2000D only. The Cummins engine

covers and panels are selected for all Cummins N-series engines regardless of chassis model. Hence added truck maintenance cost due to each engine treatment will be dealt with separately.

2.5.1 Covers and Panels Related Maintenance

The engine block sound panels and oil pan enclosure was developed and is marketed by Cummins for their N-series engines for engine structure noise suppression. These are basic sets of covers and panels and require cutting and fitting to accommodate each truck manufacturer's engine accessories. The installation of these covers and panels in the development phase as well as during the field installation was found to offer hindrances for normal truck maintenance resulting in increased maintenance cost. Some of the major hindrances are discussed below.

Normal oil seepage due to removal of valve cover to check injectors, and similar oil seepage due to removal and reinstallation of compressor, plus other engine leaks can cause oil to be trapped in the fiberglass lining. It will eventually result in the reduction of its acoustical property of sound energy absorption.

The injector inspection and compressor rebuild is normally carried out every 100,000 miles (160934KM). It is, therefore, assumed that the oil and water leakages would destroy the sound absorption properties of the fiberglass after 2-3 such inspections. The customer, therefore, is expected to either change the covers and panels altogether every engine overhaul (250,000 miles (402336KM)) or replace the fiberglass lining and rubber mounts. The latter alternative seems to be more appropriate from a cost standpoint, although the panels have to be removed in both cases.

Oil pan removal and reinstallation to check engine for water leaks and clean the oil pan, or to check the crankshaft bearings, etc., would also require removal and reinstallation of oil pan enclosure. An additional four hours time is estimated for oil pan enclosure removal, handling, and reinstallation over and above the normal time for oil pan removal. Similar increases in maintenance costs due to block panels are anticipated for removing and reinstalling the compressor, fuel injection pump, and starter assembly.

Apparent hazards due to engine panels are also noted that would possibly add to the maintenance cost as follows:

1. The Cummins Engine Company manufactures the basic set of panels that require extensive modifications of cutting and fitting to accommodate individual vehicle manufacturers' fittings and accessories. This cut-and-fit operation leaves the panels with sharp edges that are hazardous for regular maintenance work on the engine or accessories. Also, fuel lines and water hoses might rub against jagged edges and rupture.

2. Longer oil fittings are required to accommodate the panel thickness. These longer fittings pose the danger of breaking due to engine structure vibrations.

3. Close fitting engine panels and oil pan enclosure are suspected as heat and fire hazards.

2.5.2 Bellypan Related Maintenance

There was nothing commercially available for engine noise treatment for the DDA 6-71N series engines. A bellypan

was, therefore, developed by IH during the contract work on the 2000D primary truck with this engine. Hence the bellypan maintenance information is not available in the field to substantiate the maintenance requirements. Further, the estimates of increase in the truck maintenance due to bellypan could not be firmly established. However, the installation at the time of development and during the field installation provided insight in this matter and some concrete points are discussed here.

First of all the direct maintenance cost of bellypan is considered negligible since it will not deteriorate enough to incur maintenance costs during first 5 years of its life barring any physical damage. But the major costs related to the bellypan are the increases in the truck maintenance requirements since it closes the service access to the engine. Clearly, oil pan removal and reinstallation would require complete tear down of the bellypan. Filter replacement would have added maintenance time for removal and reinstallation of an inspection cover in the bellypan. It also conceals oil leakages in some cases and in others it hinders access to oil leak sources. Starter maintenance would also require bellypan removal.

2.6 TRUCK DOWN TIME

Noise treatment of in-use vehicles would involve descheduling of the trucks from their operation and pulling them in the service shop. For the time the truck stays in the shop for noise modifications, it could be on the road earning revenue for the owner. Hence, when there is a truck down time involved, the dollar value of the down time should be accounted. Approximations of the down time is based upon the information obtained from field installations. It is observed that the first instal-

lation was always time consuming, and, having learned from it, the second installation was less time consuming.

The down time is assumed to be, essentially, the time required to complete the noise modifications. It varies with the extent of modification required to meet the current noise regulations. It is, therefore, recommended to make the modifications in stages to minimize the material and labor costs as well as the truck down time. The exhaust and fan modifications should be carried out first, and installation or truck down time is approximated to range between 3 - 5 hours depending upon the exhaust system configuration. The oil pan enclosure should be installed next on the Cummins engines (NHC250, NH230, NTC-290, 335 and 350) which takes about 6 - 8 hours of installation time. Finally, installation of block sound panels is approximated as high as 25 - 28 hours since it requires removing all the accessories, cutting and fitting the basic panels, and reinstalling the accessories.

2.7. UNIFORM ANNUAL COST AND PRESENT WORTH

The computer analysis of the cost-noise benefit in Section 2.3 did not cover the maintenance cost. It is, therefore, intended to account for these approximations in this section. This study deals with engine treatments, specifically oil pan enclosure and block sound panels for Cummins engines (NHC250, NH-230, NTC-290, 335 and 350), and bellypan for Detroit Diesel 6-71N engine in Fleetstar D only. It is based upon the assumption of a 5-year component life that would incur in uniform annual increased maintenance cost. The present worth of the increased maintenance cost per truck per year is added to the modification cost to obtain the total expense figures for quieting and maintaining a truck. The present worth

of total maintenance cost incurred for 5 years is computed with present worth factor $F_{rp} = \frac{(1+i)^n-1}{i\ (1+i)^n}$ at an annual rate i of 10% including interest and inflation, for n equals 5 years.

2.7.1 Cummins Engine Treatment

The oil pan enclosure and engine block sound panels were selected for Cummins NHC250, NH230, NTC290, 335 and 350 engines. The related increases in the truck maintenance time is discussed in Section 2.5.1. It is assumed that the engine overhaul will be warranted every other year at 250,000 service miles (402336KM). It is further assumed that the oil pan removal and service on compressor, fuel injection pump, and starter etc., will be needed once every year. Approximate increases in maintenance cost are determined in terms of man hours and converted in dollars by multiplying with the most current national average labor rate of $15.10 per hour for the month of November '74. This rate was obtained from IH Service Branch monthly operating statement. This gives uniform end-of-year annual amount to be incurred every year for five years. The present worth is then determined according to time period involved at a rate of 10% compounded annually. Following costs are considered to estimate the increased uniform annual maintenance cost:

1. Direct maintenance of oil pan enclosure and block sound panels once every two years -
   20 sq. ft. of fiberglass @ $1.05/sq. ft. = $ 21.00
   Remove old lining, cut and fit new lining,) attach the new lining to sheet metal with) adhesive: approximate time 7.2 manhours.) = $108.72
   Total increased uniform maintenance cost per truck every two years = $129.72

2. Four (4) hours increase in maintenance time for removing oil pan requiring removal of oil pan enclosure = $ 60.40

3. Four (4) hours increase in miantenance work on compressor, injection pump, etc., due to block panels, once a year = $ 60.40

4. One (1) hour increase in starter maintenance time due to block panel, once a year = $ 15.10

Total increased uniform annual maintenance cost per truck = $135.90

The present worth factor (Frp) discussed in Section 2.7 is then utilized to compute the total increased miantenance cost at 10% annual rate over a period of 5 years as assumed. Hence, the present worth of the increased maintenance cost, is estimated to be $710.98 per truck. Now:

The present worth of Total Cost = Initial engine modification (oilpan encl. + block panels) cost + maintenance cost

= 891.76 + 710.98

= 1602.74

2.7.2 Bellypan Installation

Detroit Diesel 6-71N engine in chassis model 2000D had to be treated with a chassis underpan, called the bellypan. As mentioned in Section 2.5.2, the oil pan removal, oil filter replacement, and starter maintenance would require bellypan tear down. Here again, it is assumed that the engine maintenance work would warrant oil pan removal once a year which would mean disassembling bellypan as such. The bellypan removal is also assumed to be necessitated for the maintenance work on starter once a year.

An additional 6 - 8 hours for bellypan removal and reinstallation is required when the engine oil sump must be removed or starter requires maintenance. However, filter replacement is usually carried out once every two months, which would require removing the inspection cover resulting in 1/2 hour added maintenance time per filter replacement. The total added maintenance time per year then amounts to about 3 hours. Therefore,

Annual increased maintenance time due to bellypan = Added filter service time + bellypan removal time = (3 + 8) = 11 hrs.

Therefore, increased uniform annual maintenance cost per truck = $ (11 x 15.10) = $166.10.

The present worth of increased maintenance cost per truck for 5 years at the rate of 10% = $629.65. Now,

The present worth of total cost = Initial engine modification cost (bellypan) + present worth of increased maintenance cost = 200.48 + 629.65 = $830.13.

2.8. TOTAL MODIFICATION COST

The noise reducing modifications developed on primary trucks COF4070A /NHC-250 and 2000D /6-71N65 are: the improved exhaust muffler, fan noise treatment, and engine noise treatment. The present worth of total cost due to engine treatment that included initial engine modification cost and present worth of increased truck maintenance cost has been estimated in the preceding sections. The total modification cost can then be determined by adding exhaust and fan modification costs (material cost + installation cost) to the present worth of total cost due to engine treatment. Hence, for COF4070A/ NHC-250:

Exhaust and fan modification cost per truck	=	$ 210.35
Present worth of total cost due to engine treatment (Cummins covers and panels)	=	$1602.74

Therefore, the present worth of total modification

cost per COF4070A NHC-250 engine	=	$1813.00
Similarly, for 2000D 6-71N65:		
Exhaust and fan modification cost per truck	=	$ 234.17
Present worth of total cost due to engine treatment (bellypan)	=	$ 830.13
Therefore, the present worth of total modification cost per 2000D 6-71N65 engine	=	$1064.00

The present worth of total truck modification costs are estimated specifically for the two primary trucks that may require total treatment.

3. FIELD INSTALLATION

3.1 INTRODUCTION

To verify the adaptability and noise performance of the retrofit kits, field tests on arbitrarily chosen in-use vehicles were conducted. These vehicles comprised both the primary and secondary series.

3.2 INSTALLATION PROCEDURE

The field installation on primary series trucks was carried out by utilizing all noise reduction techniques developed in the lab, in order to realize the maximum gain in total truck exterior noise reduction. In a similar manner, the maximum number of applicable noise reduction components were installed on secondary series trucks. Primary series truck installations were made in steps and noise measurements were taken after every modification. Whereas the secondary series truck installations were made with all applicable modifications installed at the same time. The customers were advised that the noise reducing kits installed under the DOT contract were free for them to keep, and might at their discretion, remain on their trucks. The replaced material was also returned for disposition as they deem fit. A statement to this effect was transcribed (see Appendix B) and the customer affixed his signature on it with full comprehension. The customer was requested to furnish an inspection report (the format is shown in Appendix C) for the components installed every 10,000 miles (16093.4KM) or 3 months, whichever occurred first.

3.3 NOISE MEASUREMENTS

Preliminary inspection of the trucks was conducted

to check for exhaust leaks, malfunctioning mechanical parts, etc. Engine speed governor was checked with a master tach for engine manufacturer's specified maximum speed. The above inspection prepared the truck for baseline noise measurements where baseline condition is defined as a properly maintained, unmodified truck. Baseline exterior truck noise level was then established by making the SAE drive-by tests, per J366b Standard Practice. The baseline cab interior noise level was also measured according to the procedure covered in BMCS stationary regulation. SAE J366b Standard Practice and BMCS Regulations are presented in Appendices D and E respectively. All measurements were taken with the same Bruel & Kjaer Precision Sound Level Meter. A Statement of Calibration issued by B & K Instruments, Inc. for this particular instrument is given in Appendix F.

3.4 MEASUREMENT SITE LOCATION

Site requirements for SAE drive-by noise measurements are described in SAE J366b Standard Practice in Appendix D. These requirements were keenly observed in locating adequate site wherever the installation was scheduled. May it be a big city or small, finding a site was equally difficult because of traffic situation. Open area with paved surface with no reflecting surfaces within 100 foot (30.48M) radius of measurement zone as required could not be found. Parking lots were specifically checked, and those that met the requirements were extremely busy. As a substitute, T-intersection roadway segments were found that were not heavily travelled, and met other critical requirements. A typical site is shown in Figure 3.1. The sound level meter was located on a tripod in the middle of the road teeing in the straight road at 50 feet (15.24M) from the centerline of the left lane of the straight road. Another mark was located at 50 feet (15.24M) from the centerline of the right lane.

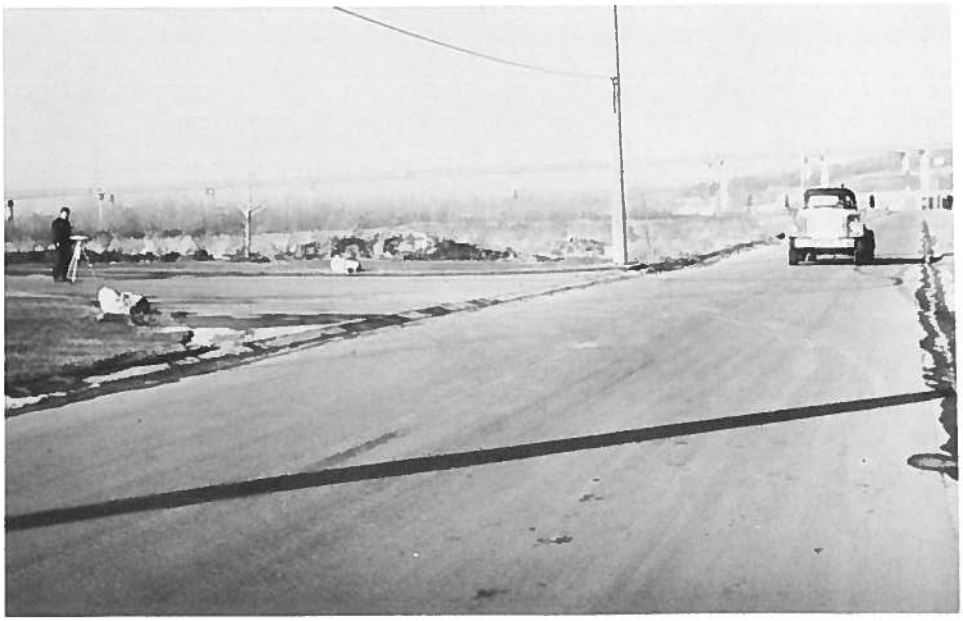


FIGURE 3.1 TYPICAL SITE FOR SAE J336B DRIVE BY TEST

Measurements for left and right side of the truck were taken by moving the sound level meter accordingly.

3.5 FIELD TRUCK LOCATION

A preliminary list of model-engine combinations for CO4070A and 2000D that included primary and secondary series for field installation was drawn in consultation with IH Service Organization personnel as shown in Table 3.1.

TABLE 3.1 LIST OF FIELD INSTALLATION TRUCKS

Combination Series	Engine	No. of Trucks	Customer/Location
CO4070A (P)	NHC-250	2	Alpha Chem., Tampa, Fla.
CO4070A (S)	NH-230	1	*
"	NTC-290	1	(Crouch Bros.
"	NTC-335	1	(St. Joe, Mo.
"	NTC-350	1	**
"	6-71N65	1	(Mr. Eugene Stone (Cleveland, Ohio
2000D (P)w/SHVTP	6-71N65	1	Grane Trucking Chicago, Illinois
2000D (S)w/SVVTP	"	1	Grane Trucking Chicago, Illinois
" w/SHHTP	"	2	(Ruan Trade-In (Des Moines, Iowa
" w/SHVTP	NHC-250	1	(Gardner Cartage, (Cleveland, Ohio
" "	"	1	Caroline Freight Carrier
" "	NH-230	2	(Cleveland Cartage, (Cleveland, Ohio

(P) = Primary

(S) = Secondary

* This secondary combination could not be located as it is a low power engine and is scarce in the field.

** This secondary combination was difficult to locate, and since vehicles with NTC-290 and 335 engines had already been found, they were considered as sufficient representative samples.

Based upon this list, the IH Service Organization conducted field survey by utilizing the sales record. Upon receiving the customer response, contacts were made to explain the scope of the contract and customer consent for cooperation was obtained.

Single vertical muffler, vertical tailpipe (SVVTP) was the only exhaust system offered on CO4070A chassis model. Therefore, fewer trucks were selected for field installation to cover only the engine effects. Whereas in the chassis model 2000D additional field installations were scheduled to cover the effects of all three exhaust system configurations offered, namely, single vertical muffler, vertical tailpipe (SVVTP), single horizontal muffler, vertical tailpipe (SHVTP) and single horizontal muffler, horizontal tailpipe (SHHTP).

4. FIELD INSTALLATION OF CO4070A SERIES

As listed in Table 3.1, five installations were scheduled for CO4070A primary and secondary series model engine combinations. The primary series truck installation was carried out in steps, and noise measurements were taken following the installation of every modification. The secondary series installation was made with all applicable modifications installed at one time.

4.1 PRIMARY SERIES INSTALLATION

Field installation of two customer vehicles consisting of primary combination of CO4070A with NHC250 Cummins engine, were performed during the week of January 27, 1975, at the IHC Service Branch in Tampa, Florida. The modifications included:

Improved exhaust muffler IH #549483-C1
Added fan spacer IH #391987-C1
Engine block sound panels - Cummins Kit #AR-11353
Oil pan enclosure - Cummins Kit #AR-11351

Following the preliminary inspection the overall exterior noise levels of unmodified trucks were measured by running four passes each left and right side, shutters open and closed. The first primary series CO4070A was owned by Alpha Chemical Co. of Florida and had baseline noise level of 86 dB(A) shutters open and closed. The secondary primary series CO4070A was a trade-in unit, traded by the customer as part of the deal for purchase of a new truck. The baseline noise level of this truck was 88 dB(A) shutters open and 87 dB(A) shutters closed. The summary of installations is given in Table 4.1, items 1 and 2. The installation of optimized noise reducing components was carried out

TABLE 4.1 FIELD INSTALLATION SUMMARY OF CO4070A SERIES/SVVTP EXHAUST SYSTEM

Item	Owner Customer	Chassis Number	Engine	Baseline Noise Level dB(A) Exterior *S.C.	Exterior S.O.	Interior S.C.	Interior S.O.	Final Noise Levels*** dB(A) Exterior S.C.	Exterior S.O.	Mileage at Installation
1	Alpha Chem. Tampa, Fla.	G.520129	NHC-250	86.5**	86	86	84.5	84	85	228,204
2	IH Used Truck Tampa, Fla.	G.457351	"	87	88	86	88	86.5	84	127,404
3	Mr. Eugene Stone, Clev. Ohio	G.303957	6-71N65	88	87	87	87	85	84.5	167,699
4	Crouch Bros. St. Joe, Mo.	G.477702	NTC-290	95	92	87	88	90	87	208,765
5	"	G.449822	NTC-335	93	91	85	84	89.5	88	556,019

* SC - Shutters Closed

SO - Shutters Open

** Highest figures underlined

*** Final interiors were not taken since the original interiors were well below BMCS regulated level.

in two parts by treating the exhaust and fan first and engine later.

4.1.1 Exhaust and Fan Modification

The outlet of the improved muffler is offset and required positioning for clearance between muffler body and air intake pipe. Longer bolts for the added fan spacer presented problems as the bolts got too close to the radiator core at fan installation. After installing the improved exhaust muffler and added fan spacer, SAE drive-by test was made which recorded .5 -1 dB(A) reduction in the total truck noise level compared to the baseline figures. The attenuation was not very significant, but the baseline noise level was only 86 dB(A). Although the fan noise could generally be considered as not excessive, the IH Trade-In vehicle (see Table 4.1, Item 2) cab was detected to be about 6.00 inches (152.4mm) higher than standard over the chassis, allowing the fan noise from the engine cutout in the rear, especially when the shutters were closed. Consequently, the peaks during drive-by test were recorded at the end of the measurement zone.

4.1.2 Cummins Engine Modification

Cummins oil pan enclosure and engine block panels were installed next to suppress the engine radiated noise. These close fitting covers and panels were developed by the Cummins Engine Company for their N-series engines. These are basic panels, made of 0.30 inch (7.62mm) thick sheet steel lined with 1.00 inch (25.4mm) thick fiberglass batting, provided with openings for standard accessories. Consequently, extensive modifications of cutting and fitting the basic panels are required to accommodate individual manufacturers' fittings and accessories. These basic panels are commercially

available in the form of kits marketed by Cummins through their dealerships. These covers and panels consist of:

Right side engine block panel
Upper left side engine block panel
Lower left side engine block panel
Oil pan front cover)
Oil pan sump cover) oil pan enclosure
Oil suction flange

The installation of right side block sound panel required removing the starter. The panel had to be cut to provide relief for starter. The installation otherwise was relatively simple. The lower left side panel installation was extremely time consuming and required disassembling the following engine accessories:

1. Water filter and bracket assembly
2. Air compressor and mounting bracket
3. Injection pump
4. Dip stick mounting bracket
5. Injection pump solenoid
6. Oil temperature sending unit
7. All fuel and water lines, fittings and other accessories
8. Transmission shift console assembly and linkage

The openings needed for these attachments were laid out and air chisels or sheers were used to cut and fit the panel. The panel was mounted by using the existing tapped holes in the engine block. However, these were in-use vehicles with several hundred thousand service miles, and mounting holes were found to be badly clogged shut. Therefore, these holes had to be retapped. Following the panel installation, all the engine attachments and accessories were mounted back on. Figure 4.1 shows the left side panels installed and attachments reinstalled.

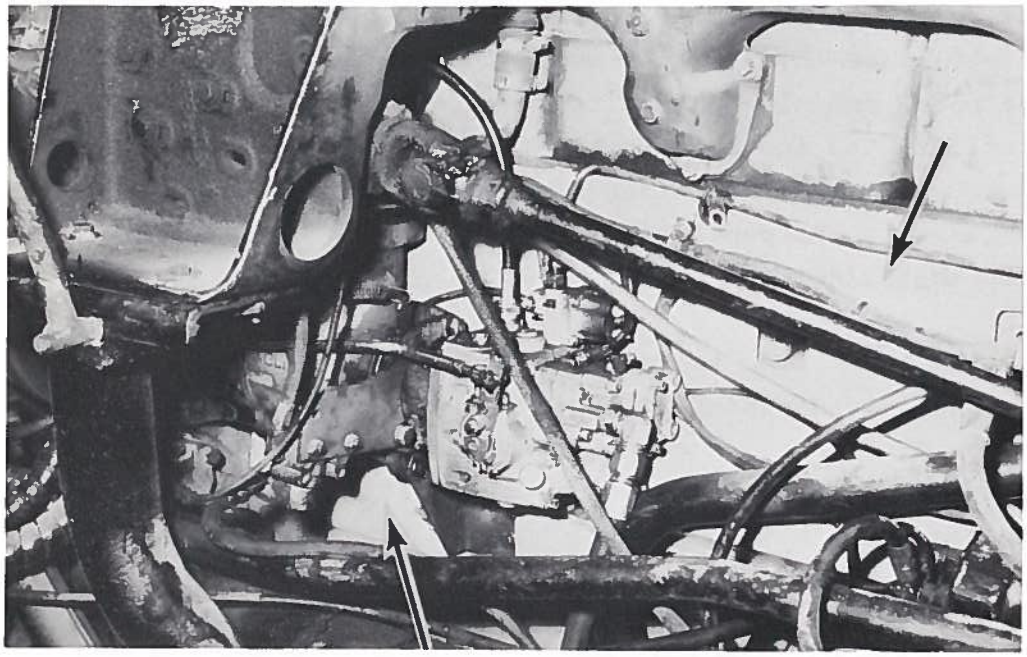


FIGURE 4.1 LEFT SIDE ENGINE PANELS INSTALLED

The oil pan enclosure consisted of front pan cover and rear sump cover. Installation of oil pan enclosure required spacing the oil return fitting out to fit the enclosure properly. This spacer arrangement is also marketed by Cummins as Oil Suction Flange Kit #AR-11352 that included 1.00 inch (25.4mm) longer hose and clamps to replace the original hose. The enclosure was mounted to the oil pan mounting bolts and a jack and a wooden block had to be used to force the enclosure to align the mounting holes. The lower left side panel and oil pan enclosure were connected with brackets to utilize the installation as shown in Figure 4.2. These brackets and other mounting hardwares were provided by Cummins with the panel kits. Figure 4.3 shows the sump cover installed with suction flange.

The total time to complete the installation of covers and panels is measured to be 33 manhours with greater portion of time being expended for the installation of left side engine block panels. This estimation included disassembling the engine attachments, cutting and fitting the panels, and reassembling the attachments.

4.1.3 Final Noise Measurements

The final truck exterior noise levels showed about 1 dB(A) reduction in the baseline noise levels that sufficiently substantiated the results obtained on the development truck. The baseline and final noise levels are shown in Table 4.1, Items 1 and 2. It is interesting to note that the baseline exterior noise levels with shutters open and closed had very little difference. But the added fan spacer, that moved the fan 3/4 inch (19.05mm) closer to the radiator core apparently increased the difference with greater reduction in shutters open noise level.

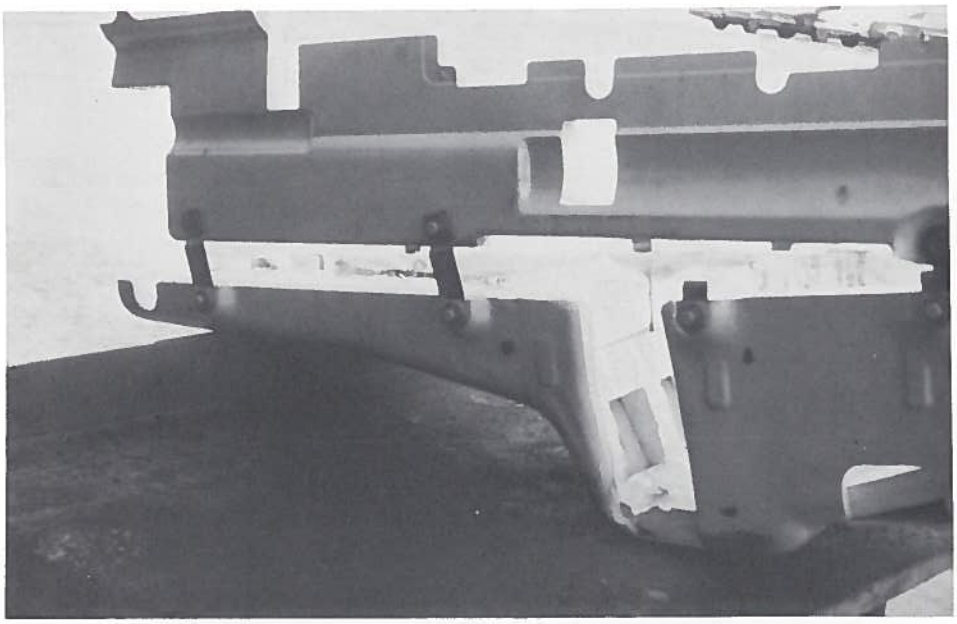


FIGURE 4.2 PREASSEMBLED OIL PAN ENCLOSURE UTILIZED WITH LOWER LEFT PANEL.

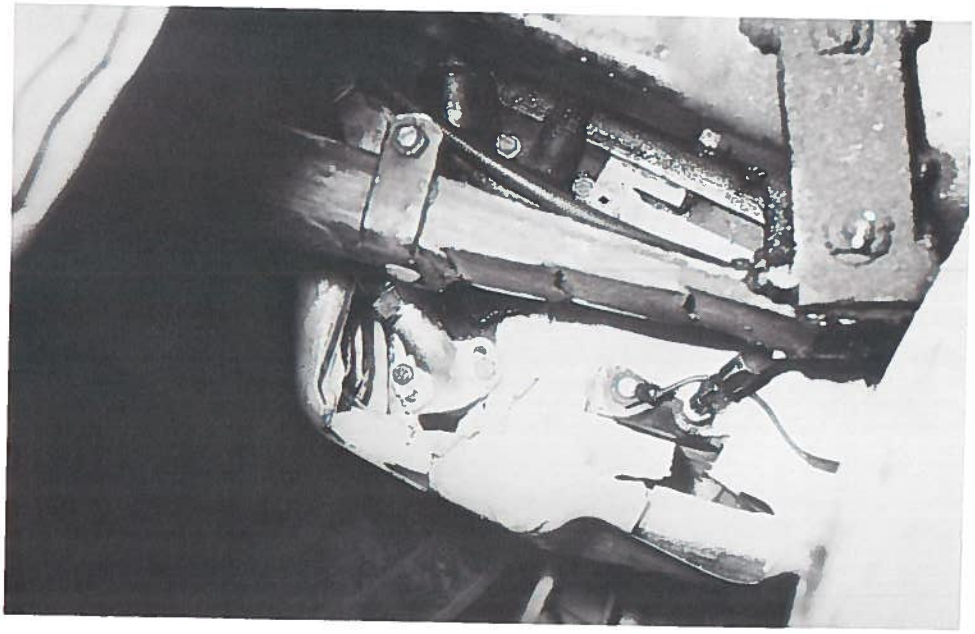


FIGURE 4.3 OIL PAN ENCLOSURE AND SUCTION FLANGE INSTALLED.

4.2 SECONDARY SERIES INSTALLATIONS

The secondary series model-engine combinations were as follows:

CO4070A with 6-71N Detroit Diesel Engine
CO4070A with Cummins NTC290 turbocharged engine
CO4070A with Cummins NTC335 turbocharged engine

Field installation was carried out for one each of the model-engine combinations listed above.

4.2.1 CO4070A W/6-71N Detroit Diesel Allison Engine

Applicability of the noise reducing components, developed on the primary test trucks in the lab, from the standpoint of attenuation and ease of installation on the secondary trucks is defined as spreadability. Hence, from the spreadability aspect, only exhaust and fan treatments were applicable to CO4070A with 6-71N engine. The treatments consisted of an improved muffler to reduce exhaust source noise and a thicker spacer to optimize the fan location.

This model-engine combination was provided by Mr. Eugene Stone of Cleveland, Ohio. It was discovered upon inspection that it was really a CO4000, an earlier model, that was reworked with CO4070A front end. Since major components are same for both models, the installation was completed on CO4000. Preliminary inspection revealed that the governor was advanced from 2250 rpm high idle no load to 2600 rpm. The owner was informed and with his consent the governor was adjusted to the specification. Few exhaust leaks were also discovered at the flex pipe connections and were repaired. Baseline exterior noise of unmodified vehicle per SAE drive-by test was measured to be 87 dB(A) shutters open, and 88 dB(A) closed, whereas

cab interior noise level per BMCS regulation was measured to be 86 dB(A) shutters open, and 87 dB(A) shutters closed.

The original exhaust muffler was removed and an improved muffler, IH No. 549483-C1 (Donaldson #WTM10-0066) was installed with larger clamps and new brackets required due to larger body diameter. Figure 4.4 shows the muffler installed on the truck.

The Detroit Diesel Allison 6-71N65 engine in this vehicle had a pre-1970 front end design with a 1.59 in. (40.4mm) diameter fan pilot. Fan spacers for 1.59 in. (40.4mm) diameter pilot and the pilot both have been discontinued as a result of the engine front end redesign. Currently in production is a 2.05 in. (52mm) diameter fan pilot, DDA #5144789 and the corresponding spacer, IH No. 411451-C1. Therefore the obsolete fan pilot and the spacer were replaced with the current production parts which provided 100% fan coverage as shown in Figure 4.5.

Overall exterior noise level of modified truck was measured to be 84.5 dB(A) with shutters open and 85.5 dB(A) with shutters closed as listed in Table 4.1, Item 3.

4.2.2 CO4070A W/NTC-290 and 335 Cummins Engines

Field installations of two Cab over-Transtars powered with NTC-290 and NTC-335 Cummins turbocharged engines respectively, were made at IHC Branch in St. Joe, Missouri. On these trucks the owner had replaced the standard cooling fans with plastic fans. Preliminary inspection was made to check exhaust system for leaks, and engine governed speed for specified high idle no load setting. The plastic fans were also replaced with the standard steel fan, IH part #410992-C2. The trucks at this point were ready

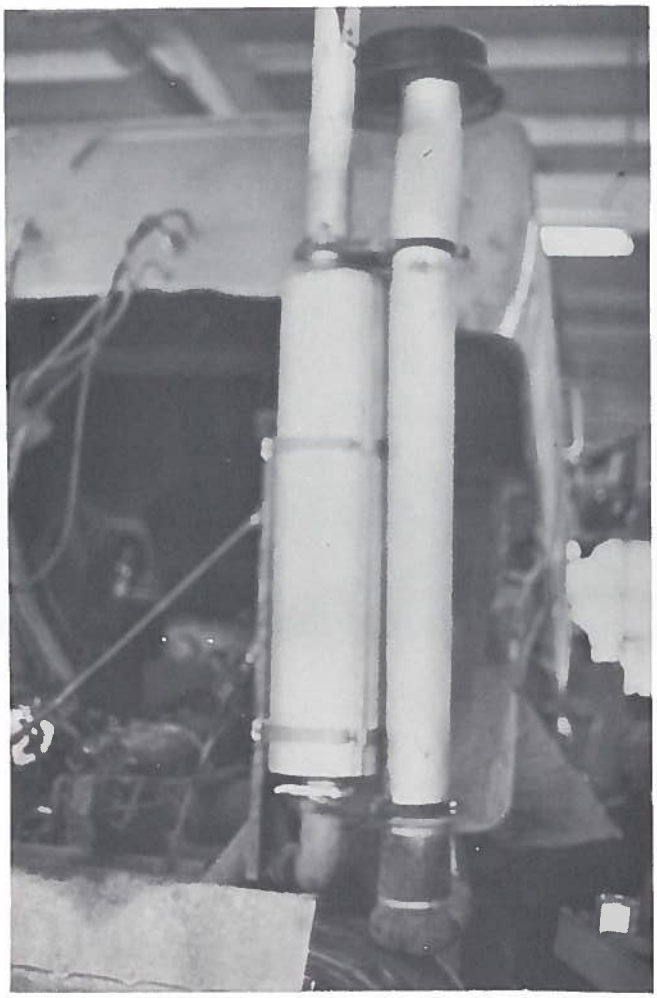


FIGURE 4.4 WTM10-0066 MUFFLER INSTALLED

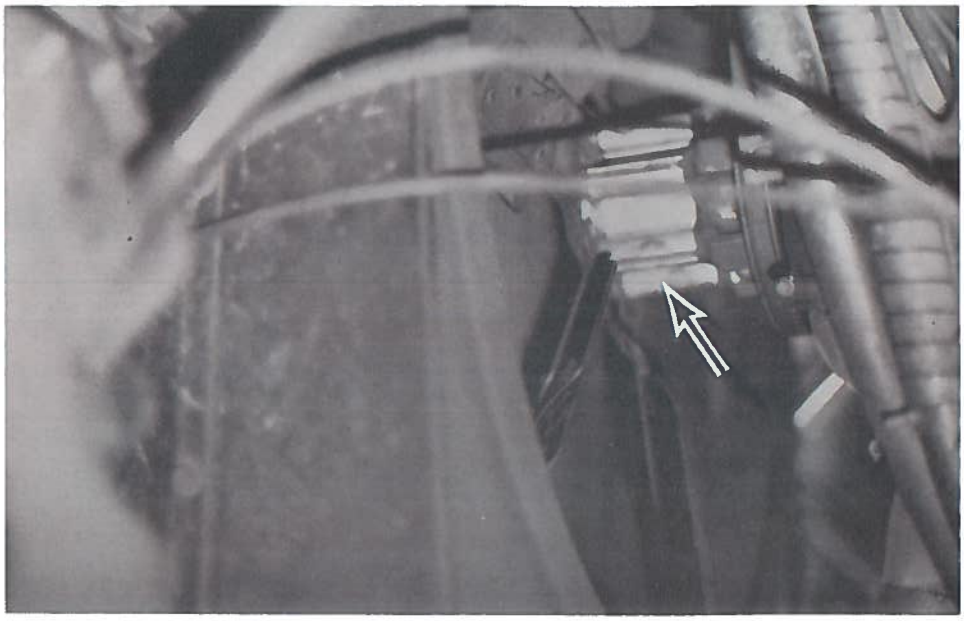


FIGURE 4.5 FAN SPACER INSTALLED.

for baseline noise measurements where baseline condition is defined as a well-maintained vehicle with original production hardware. SAE drive-by tests were run that provided the overall noise levels of the unmodified trucks ranging between 93 and 94 dB(A).

4.2.2.1 Fan Noise Isolation

During the baseline drive-by tests the peak noise levels were detected to occur close to or at the end zone which suggested that the fan was predominant. Fan was subsequently removed and SAE drive-by runs were made which resulted in formidable drop of 9 - 10 dB(A) in the overall truck noise levels with fan. In both these trucks the cooling fan was mounted to the water pump shaft that made fan ratio change unfeasible since pump speed cannot be reduced. The old version of the engine front end has this arrangement, whereas the new version (post 1971) has the bracket mounted fan, a revision incorporated to combat fan noise problems. Further investigation into the matter disclosed that earlier engineering efforts with the application of source identification technique to this model-engine combination had isolated the fan source noise level to be about 89 dB(A) shutters closed, and 83 dB(A) shutters open. Engineering study to attenuate the fan source noise in this combination of fan and engine version had resulted in the development of fan noise suppressing packages as follows:

CAB SIZE	PACKAGE DESCRIPTION
83 inch (2108mm)	A rubber shield mounted under the cab on the left side wheel well, and an aluminum cover over rear cab cut out.

50 inch (1270mm)	A four sided dog house type cover starting at the top of the cab rear cut out and covering the exposed portion of the engine down to the frame rails.

These are essentially line-of-sight sound barriers that change the directivity of the sound energy emitted by the fan and effect reduction in fan noise level.

4.2.2.2 Retrofit Installation

The retrofit installation was carried out without the fan noise treatment listed above since these modifications were not part of the primary vehicle development program. Noise treatment under retrofit contract included installation of improved muffler IH part no. 467355-C1 (Donaldson #MFM09-0249), Cummins oil pan enclosure and engine block sound panels.

The exhaust muffler #467355-C1 was installed using same mounting hardware as that of the original muffler since body diameter was same. However, the upper integral mount for muffler and intake stack was revised from outlet mount to body mount since the improved muffler was 10.0 in. (254mm) longer than the original muffler. An additional muffler clamp was used to accomplish this, and muffler installed is shown in Figure 4.6.

Installation of oil pan enclosure and block sound panels was difficult as described in earlier installation cases. In addition to the attachments to be removed in Section 4.1.2 for left side panel installation, the automatic lubrication system and quick oil drain connections that were furnished on the chassis had to be removed also. Figure 4.7 shows the accessories attached to the left side of engine block that must be removed prior to the

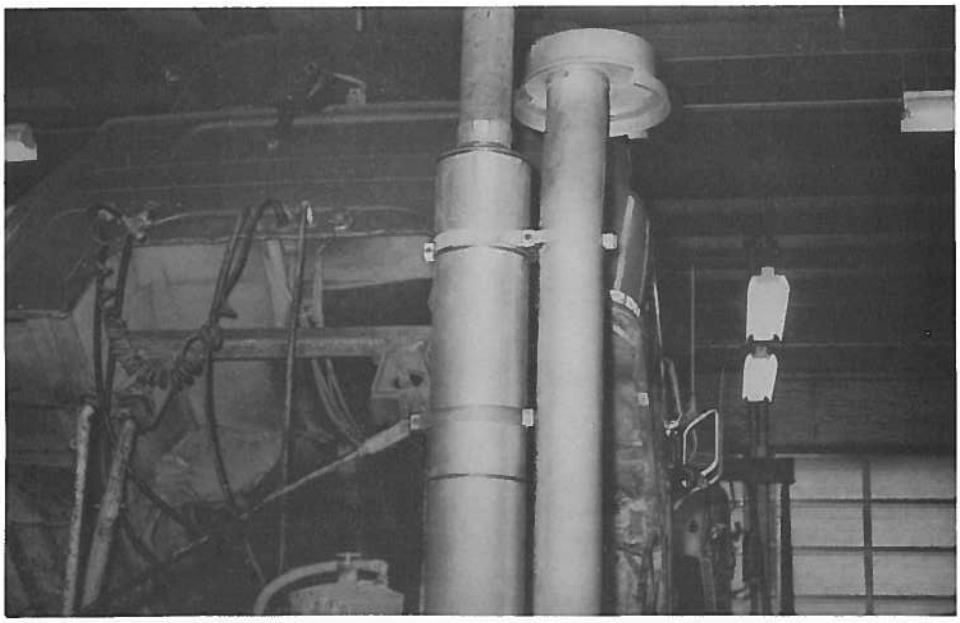


FIGURE 4.6 MFM09-0249 MUFFLER INSTALLED.

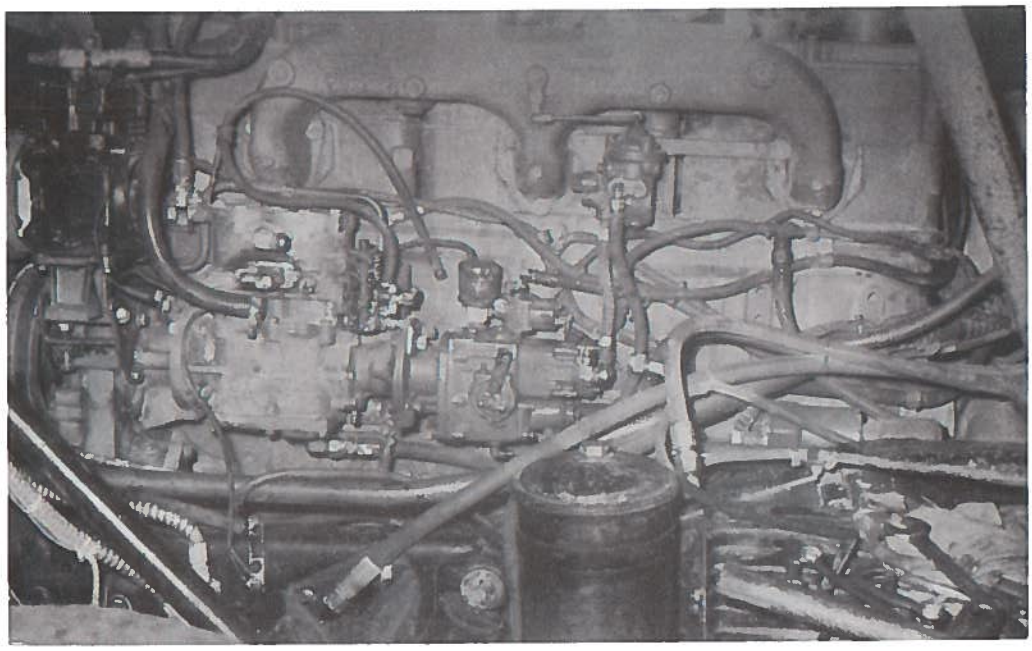


FIGURE 4.7 LEFT SIDE ENGINE BEFORE PANEL INSTALLATION

left side panel installation.

Following the exhaust and engine treatment, final noise measurements were taken with standard steel fan per SAE J366b Standard Procedure. As presented in Table 4.1, items 4 and 5, the total truck noise, shutters closed, is predominantly fan noise as exhaust and engine noise was substantially reduced. At this point, the benefit from exhaust and engine treatment was nullified due to the dominant fan source noise. Hence, the treatment for this model-engine version-fan combination to meet 86 dB(A) level may require installation of the retrofit exhaust muffler and engine covers and panels in conjunction with the fan noise reducing packages listed in Section 4.2.2.1. It may be reemphasized that this alternative is applicable only to the vehicles with cooling fan mounted on the water pump shaft, whereas the vehicles having later version of the turbocharged engines with bracket mounted fan do not have any problem. Also, the earlier version engines with water pump shaft mounted fan can be updated to a later version front end on an optional basis during an out-of-chassis overhaul.

4.2.2.3 Final Disposition

The director of Maintenance, Crouch Brothers, visited the branch after the installation was completed. He was apprised of the DOT contract and field installation in compliance thereof. In his analysis, the disadvantages due to engine covers and panels out weighed the advantages and he decided against leaving them on. Following the successful evaluation, the covers and panels were removed but the exhaust mufflers were left on at the discretion of the customer. The plastic fans were also reinstalled at the request of the customer.

5. FIELD INSTALLATION OF 2000D SERIES

Table 3.1 in Section 3 gives the primary and secondary series 2000D trucks selected for field installation. Again, the primary series installations were performed in steps and noise measurements were taken after each modification. Whereas for the secondary series only final noise measurements were taken following the installation of all applicable modifications.

5.1 PRIMARY SERIES INSTALLATION

The primary combination consisted of 2000D with 6-71N65 Detroit Diesel engine and single horizontal muffler, vertical tailpipe (SHVTP). Only one primary series truck was scheduled for field installation. There were two more installations with primary model engine combination but different exhaust system configurations and are treated in the next section as secondary series trucks. Modifications included:

1. Improved primary exhaust muffler IH part #439797-C1 in conjunction with a stack muffler IH part no. 871136-C1.

2. Bellypan

3. Fuel tanks isolation

4. Fan shroud extension

The modifications were installed in the order listed above and exterior and interior noise measurements were taken at each step.

Preliminary inspection indicated that the governor was properly set at the specified speed, and all components were operating normally. The vehicle was in a good state of condition as evident from the low baseline exterior noise levels of 86.5 dB(A) shutters closed, and 86 dB(A) shutters open. Cab interior noise levels per BMCS regulation were measured to be 92 dB(A) shutters open and closed. A summary of the truck and noise levels before and after modifications is presented in Table 5.1, Item 1.

5.1.1 Exhaust Modification

The original muffler was removed and improved muffler (Figure 5.1) with a stack muffler (resonator was installed. The retrofit muffler is smaller in length compared to the original muffler but has the same body diameter. Therefore, a new mounting hole was drilled in the frame 4.5 inches (114.3mm) forward of the existing hole for rear clamp mounting. Since the body diameter was same, the original muffler clamps and brackets were reused. It also required a longer flex pipe to accommodate for shorter muffler length. The stack muffler was installed but cutting the tailpipe equivalent to the length of stack muffler to maintain the same overall exhaust system length. This is important since the length is designed in accordance with the exhaust valve opening frequency. The noise measurements per SAE drive-by test with exhaust modification indicated 1-2 dB(A) reduction in the baseline exterior noise levels.

5.1.2 Bellypan Installation

The bellypan was developed at IH Truck Division Engineering under the contract for 6-71N Detroit Diesel engine noise treatment, since no engine noise reducing subsystems were commercially available. It was constructed by the Experimental Shop at IH Engineering for field installation purpose. It is a frame mounted bellypan consisting of right and left

TABLE 5.1 SUMMARY OF 2000D SERIES FIELD INSTALLATION

Item	Customer	Chassis Number	Engine	Exhaust	Baseline Noise Levels dB(A) Exterior *S.C.	Baseline Noise Levels dB(A) Exterior S.O.	Baseline Noise Levels dB(A) Interior S.C.	Baseline Noise Levels dB(A) Interior S.O.	Final Noise Levels dB(A) Exterior S.C.	Final Noise Levels dB(A) Exterior S.O.	Final Noise Levels dB(A) Interior S.C.	Final Noise Levels dB(A) Interior S.O.	Mileage at Installation
1	Grane Trucking Co. Chicago, Ill.	G.474446	6-71N65	SHVTP	86.5***	86	92	92	84	84	86.5	86.5	205,625
2	"	G.269447	"	SVVTP	87.5	87	95.5	96.5	84	83.5	86.5	85	---
3	Ruan Trade-In Des Moines, Iowa	G.363657	"	SHHTP	94	92	95	95	84.5	84	**---	---	276,709
4	"	G.345434	6-71N60	SHHTP	91	92	90	89	84	84	**---	---	275,000
5	Clev. Cartage Cleveland, Ohio	G.415515	NH-230	SHVTP	89.5	88.5	95	92	87	86	88	86	103,740
6	"	G.414735	"	"	90	88	97.5	92	86	85	88	86	336,149
7	Gardner Cartage, Clev. Ohio	G.453942	NHC-250	"	89.5	88	95	93	87	85.5	88.5	86.5	96,607
8	Carolina Frt. Carrier Cleveland, Ohio	G.385294	"	"	87	86.5	94	92	85	86	88	86	307,164

* SC - Shutters Closed

SO - Shutters Open

** Interiors Not Treated

*** Highest figures underlined

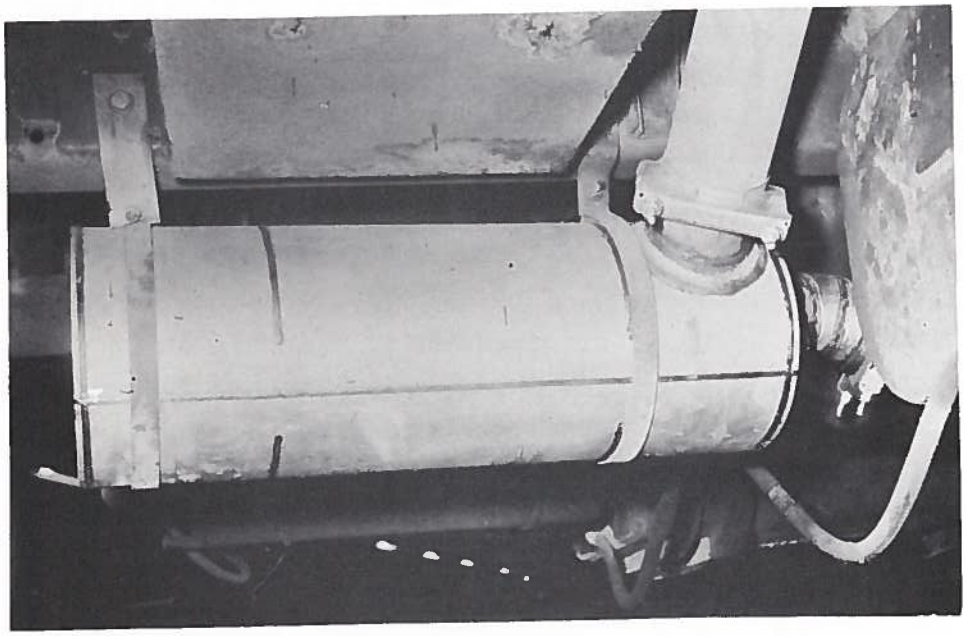


FIGURE 5.1 MAM10-0052 MUFFLER INSTALLED.

panels bolted to the center section. The right side panel was provided with an inspection cover for servicing the oil filter. All mounts were adequately vibration isolated, and the center section was provided with cross-ridges to break standing waves. The bellypan was first preassembled loosely as shown in Figure 5.2. The vehicle was then raised on a hoist, and preassembled bellypan was held in position by two persons to align with the existing holes in the frame to mount a L-shape bracket. Front side mounts consisted of a bracket tack welded to the side panels, bolted to the L-shape bracket with rubber isolators. The rear side mount was accomplished by using the existing holes in the flange on frame rails, both sides. The bellypan was mounted to an existing saddle shape crossmember in the rear at the bell housing using two U-clamps with isolators as shown in Figure 5.3. The bellypan was clamped to the radiator mounting saddle shape crossmember in the front as shown in Figure 5.4. After completing the six point mount of bellypan to the frame rails and crossmembers, all the nuts and bolts were tightened. Whenever the fiber mounts were used for vibration isolation, the impact wrench was not used for bolt tightening. Also, in the case of attaching the side panels to the center section, the bolts were hand tightened lest the tab weld nuts might shear off.

While tightening the bolts and nuts, it was noted that the starter solenoid was mounted below the starter motor causing metal-to-metal contact with the bellypan. Normally the starter solenoid is mounted above the starter motor, and therefore during bellypan development no other positions were considered. Apparently, this was a rebuilt starter. To accommodate the solenoid, the bellypan was shaped on the job to provide sufficient clearance. It was further noted that the bellypan, as designed and built, did not contain access for adjusting the clutch which requires reaching

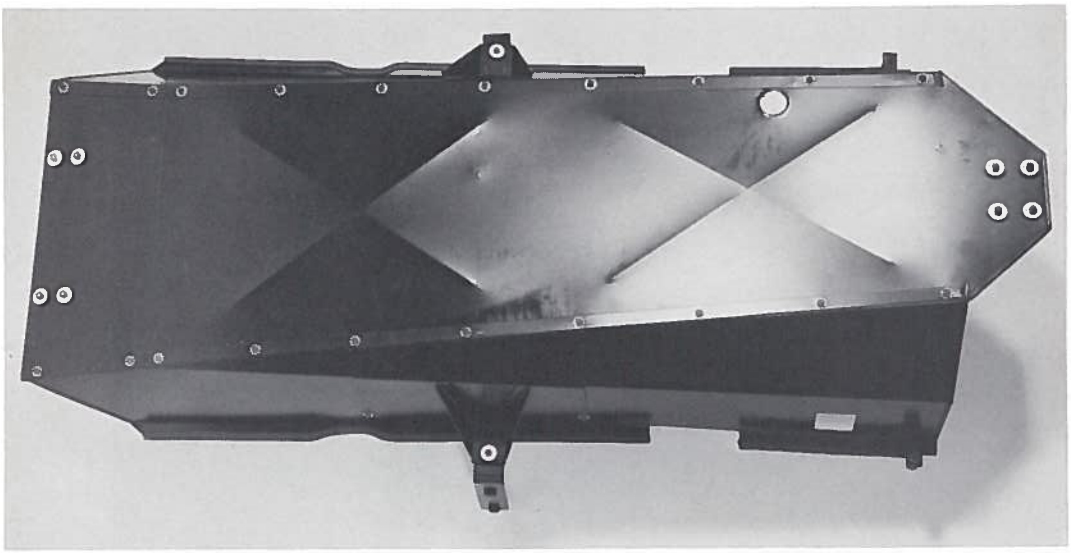


FIGURE 5.2 'ASSEMBLED BELLYPAN.

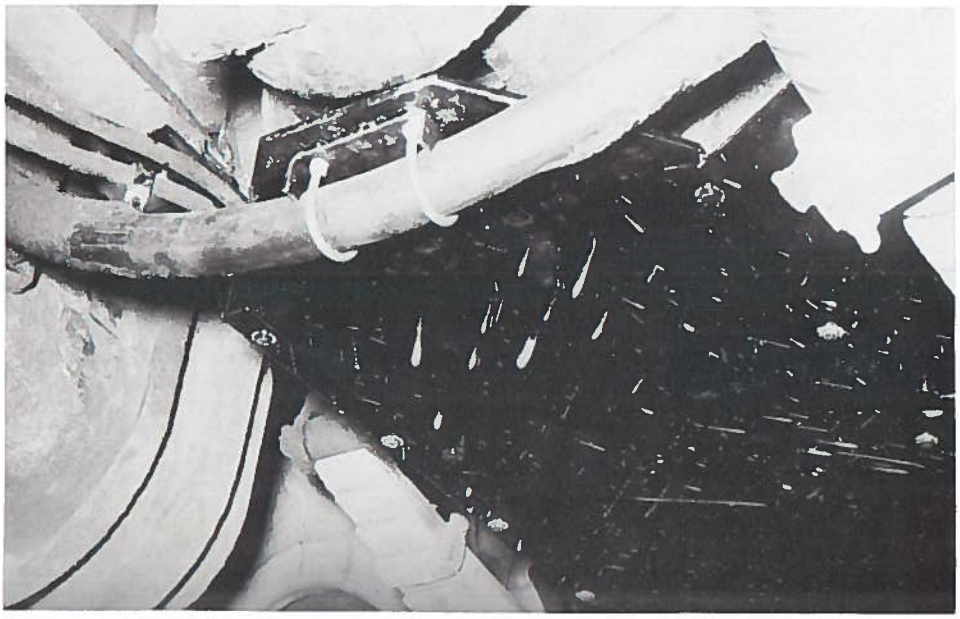


FIGURE 5.3 BELLYPAN REAR MOUNT.

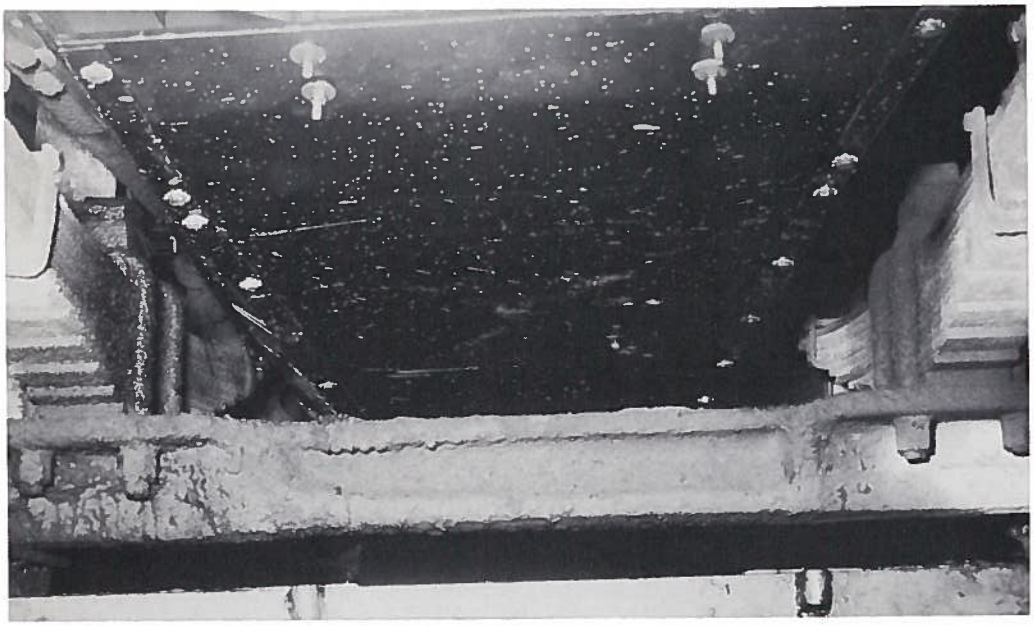


FIGURE 5.4 BELLYPAN FRONT MOUNT.

through the opening in the clutch housing.

Noise measurements were taken with exhaust modified and bellypan installed. The truck exterior noise level per SAE drive-by test was reduced more than 1 dB(A) in addition to the reduction due to modified exhaust. However, the cab interior noise level increased by 1.5 dB(A) with bellypan installed compared to baseline interior noise level.

5.1.3 Fuel Tank Isolation

The engine mounts in the 2000D model were isolated with high stiffness material. Consequently the structure-borne vibrations of the engine are transmitted to the frame, cab, etc. The fuel tanks are strap-mounted to the frame rails on both sides without isolation. Frame rail vibration is sufficient to excite the fuel tanks making them significant contributors to the overall truck exterior noise. Therefore, the mounting straps were isolated with rubber straps as shown in Figure 5.5 and noise measurements were taken with exhaust modified, bellypan installed, and fuel tanks isolated. Since exhaust modifications and bellypan installation had quieted the truck exterior noise to fairly low level of 84.5 dB(A), only .5 dB(A) reduction was realized with fuel tank isolation in the total truck environment.

5.1.4 Fan Modification

In the effort to optimize fan location with production hardware and to achieve 100% fan coverage in the shroud, a contoured shroud extension was developed in the lab that provided 2-3 dB(A) reduction in the fan source noise level. However, the development chassis had about 58% projected width of the fan covered in the shroud and an extension was effective in regard to noise reduction by providing

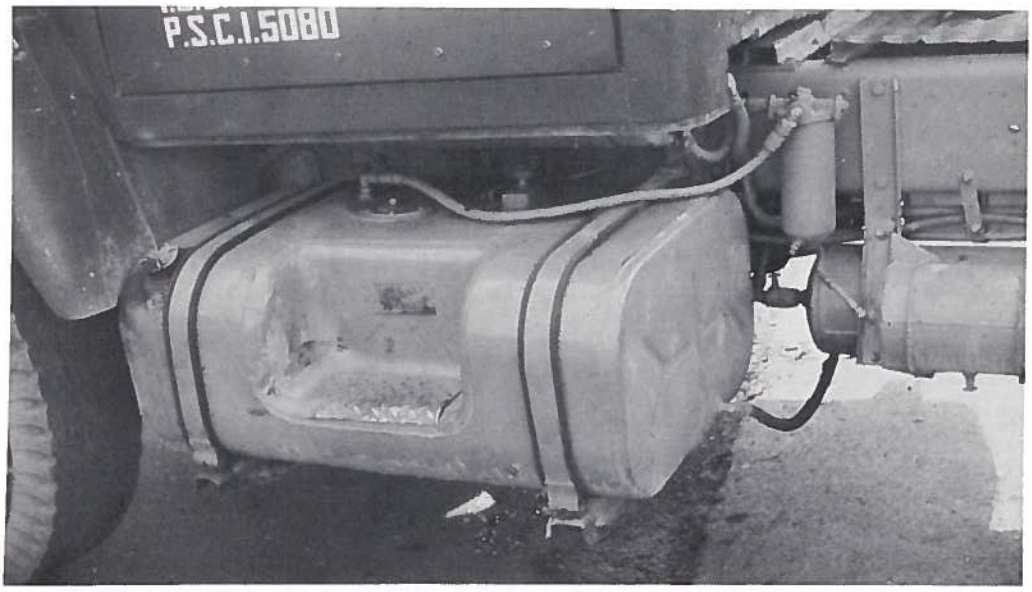


FIGURE 5.5 FUEL TANK ISOLATED.

100% fan coverage. The field installation chassis was noted to have 100% fan coverage initially. Furthermore, the fan-to-core and fan-to-rear spacings were measured to be well within the limits of optimized fan location. Also, substantial reduction in fan noise had been realized with the bellypan as an added benefit. Therefore, contoured shroud extension was not installed.

5.1.5 Interior Treatment

The bellypan which serves as a line-of-sight sound barrier in reducing the truck exterior noise also causes increase in the interior noise level by intensifying the sound energy in the driver compartment. Therefore, a truck that originally marginally complies with the BMCS regulation of 90 dB(A), may require interior treatment with bellypan installed. The baseline interior noise level of this primary series truck was measured to be 92 dB(A), but it went up to 93.5 dB(A) with the bellypan installation.

The Fleet Service Letter No. SLF 74-21 dated April 15, 1974 (See Appendix G) was issued with instructions for cab interior treatment to comply with the BMCS regulation. The interior of this field installation truck was hence treated in accordance with the Fleet Letter cited. It included an enclosure over the engine access cover, sealing the cab with caulking compound, and cab insulation with absorbing material sandwiched between layers of barrier material. An additional seal was cemented around the floor opening for engine cover besides the seal attached to the cover itself. The two seals compressed against each other and very effectively reduced the sound energy entering the cab. Final cab interior noise level was measured to be 86.5 dB(A) shutters closed and open.

5.2 SECONDARY SERIES INSTALLATION

The secondary series field installation trucks are

listed in Table 5-1, items 2 thru 8. The summary of this table gives the truck exterior and interior noise levels before and after modifications. Chassis model across the board is same 2000D as primary series, but engines and exhaust systems are different.

5.2.1 2000D W/6-71N Engine & SVVTP

Since this vehicle was same as the primary series model engine combination except the exhaust system, single vertical muffler, vertical tailpipe, (SVVTP), the modifications were installed in steps. The modifications included:

1. Improved exhaust muffler 549483-C1 (Donaldson No. WTM10-0066)

2. Bellypan

3. Fuel tanks isolation

4. Shroud extension

Installation of these subsystems were made in the order listed above.

Following the preliminary inspection, baseline truck exterior noise measurements were taken per SAE J366b Standard procedure to be 87.5 dB(A) shutters closed and 87 dB(A) shutters open. The baseline cab interior noise per BMCS regulation was measured to be 95.5 dB(A) shutters closed, and 96.5 dB(A) shutters closed.

5.2.1.1 Exhaust Modification

The SVVTP exhaust system brackets offered with 2000D had two versions of muffler mounting mechanism: the pre-

1970 version was a bolted-bracket support assembly and the post-1970 version was a pedestal type welded assembly. Installation of improved muffler with bolted-bracket muffler mount assembly was found to extend the overall truck width beyond the federally regulated limits of 96.0 inches (2.438M). Whereas muffler location and installation with pedestal type welded assembly was easier to maintain the overall width of the truck. Hence pedestal type muffler mount assembly was standardized for exhaust modification with 549483-C1 muffler.

The field installation truck had the bolted-bracket muffler mount and was replaced with the pedestal type bracket for installation of improved muffler as shown in Figure 5.6. The exterior truck noise level per SAE J366b with improved muffler showed more than 1 dB(A) reduction in the baseline truck exterior noise level.

5.2.1.2 Final Modified Truck

The bellypan installation followed next and was performed in exactly the same manner as described in Section 5.1.2. The starter solenoid was no problem in this truck. However, the filter drain plug was protruding type that was interfering with the bellypan. It was changed to Allen type drain plug that cured the problem. SAE drive-by test was run with modified exhaust and bellypan installed that showed additional 2 dB(A) reduction in the truck exterior noise over the modified exhaust only. Fuel tank straps were then isolated with rubber lining and SAE drive-by tests were made showing additional .5 dB(A) reduction.

The cooling fan in this truck was about 79% covered in the shroud, and therefore, installation of shroud extension was considered beneficial. However, the original shroud on the truck was cut off on the left side beyond the lip to which the extension has to be riveted. Therefore, the

FIGURE 5.6 WTM10-0066 MUFFLER INSTALLED WITH WELDED MOUNT.

shroud extension was not installed.

Thus in the final condition, the truck had exhaust modification, bellypan, and isolated fuel tanks, and overall noise levels of modified truck per SAE J366b was 84 dB(A) shutters closed, and 83.5 dB(A) shutters open. The interior treatment was also carried out in accordance with the IH Fleet Letter SLF 74-21 as cited in Section 5.1.5, and final interior noise levels per BMCS regulation were found to be 86.5 dB(A) shutters closed, 85 dB(A) shutters open.

5.2.2 2000D W/6-71N65 Engine & SHHTP

Again, this model-engine combination was the same as that of the primary series except the exhaust system with single horizontal muffler, horizontal tailpipe. Two identical trucks were scheduled for field installation shown in Table 5.1, items 3 and 4. Preliminary inspection of the trucks revealed the governor was advanced from 2250 rpm to 2450 rpm high idle no load, and was set back to engine manufacturers' specifications. The exhaust and flex pipes in one of these trucks required repair for leaks. It was also noted that the exhaust discharge pipe was set to discharge outboard, facing the noise measuring instrument. The baseline exterior noise levels per SAE drive-by test were measured to range between 92-94 dB(A). The baseline interior noise level per BMCS regulation of one truck was measured to be about 95 dB(A) whereas the other truck was measured to be 90 dB(A). Modifications were then installed in steps that included:

1. Improved muffler, Donaldson No. WOM12-0197

2. Bellypan

3. Shroud extension

5.2.2.1 Exhaust Modification

The selected Donaldson muffler (WOM12-0197) for the treatment of SHHTP exhaust system was oval shaped, large volume, wrapped muffler. The improved muffling technique utilized in the construction of this muffler attenuated the exhaust noise while the integral wrap with absorbing material curtailed the muffler shell noise. It was longer and heavier than the standard muffler and required new mounting holes in the frame rail, and new bracketry. Primarily, the muffler was rigidly clamped at inlet and outlet with the brackets mounted to the frame rail. Additional body support was accomplished with a strap and existing bracket modified. An existing stub pipe with 45^{o} bend was used as exhaust discharge pipe turned toward centerline of the vehicle. Complete installation is shown in Figure 5.7. SAE drive-by noise was measured with exhaust modification only that produced about a 6 dB(A) reduction in the baseline truck exterior noise levels. These results indicated that the overall truck noise was dominated by exhaust noise.

5.2.2.2 Final Modified Truck

The bellypan was installed next for engine treatment as described in Section 5.1.2. This particular IHC Branch was not equipped with hoist, so, the truck was raised on Jacks and the bellypan was assembled on the truck instead of positioning the preassembled bellypan for installation. SAE drive-by tests with exhaust modified and bellypan installed showed an additional 2 dB(A) reduction in the total truck noise.

Fan noise treatment was the final step in retrofitting the truck for noise reduction. However, fan in both the trucks was originally 100% immersed in the shroud which is in variance with the production setup, and should be

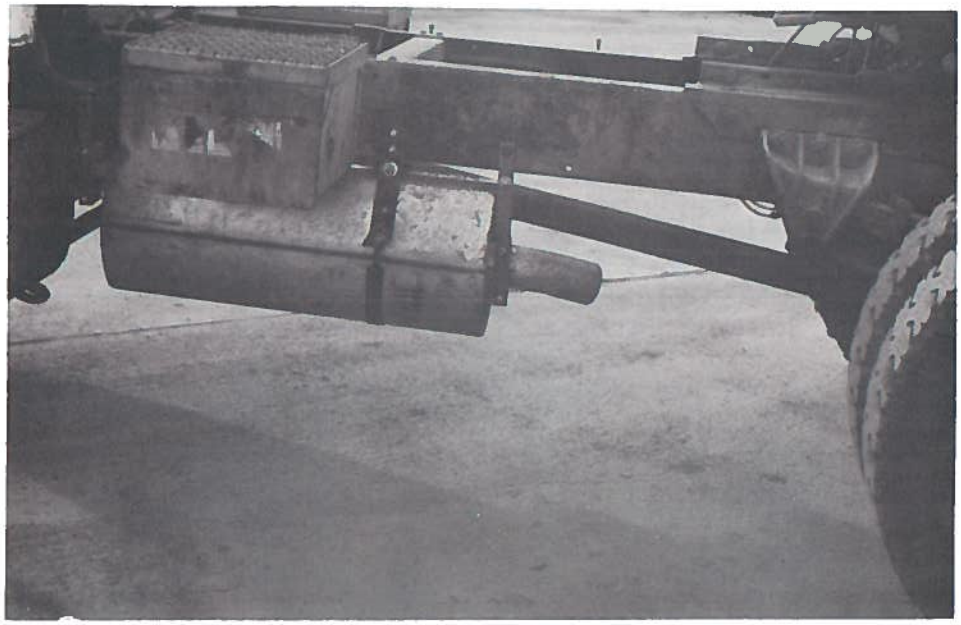


FIGURE 5.7 WOM12-0197 MUFFLER INSTALLED

optional or special equipment arrangement. Part of the fan noise had already been reduced due to bellypan as a side benefit, plus the fan was already covered 100%, hence the shroud extension originally planned for this vehicle was not required.

The final exterior noise levels per SAE drive-by test of the overall modified trucks were found to be 84 dB(A).

5.2.3 2000D W/NHC250 & NH230 Engines

Four 2000D Fleetstars, two each with NHC250 and NH230 Cummins engines were selected for field installation of retrofit packages. As shown in Table 5.1, items 5 through 8, all four vehicles were equipped with single horizontal muffler, vertical tailpipe (SHVTP). These secondary series combinations of the same model, but with different engines were treated with identical exhaust modifications and Cummins engine covers and panels. The fan treatment was not applicable as standard shroud opening had very small lip blended with large radius that did not permit installation of shroud extension to accomplish 100% fan coverage.

Following the preliminary inspection, a baseline exterior noise measurement was taken and first three trucks recorded 90 dB(A) shutters closed, whereas the last truck in item 8 of Table 5.1 was quietest of all with about 87 dB(A). This particular truck had taller exhaust stack pipe of 122" (3.1M) long, measured from muffler to the discharge end above, and was sawed off to production length of 99.6" (2.52M). The cooling fan was not a production item. The blades had wedge type construction with tips curved toward the radiator as shown in Figure 5.8. The pitch width of this fan was measured to be 1-7/8" (47.6mm), and as a result of this, the truck exterior noise was lower than the other 2000D's. Reflecting back on the development work under this contract, where a fan with twisted blades and a smaller pitch width

FIGURE 5.8 TWISTED BLADE FAN

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FIGURE 5.8 TWISTED BLADE FAN

(1.5" (38mm)), was evaluated, the results indicated a lower fan noise level but considerable reduction in the cooling ability. This may be true in the case of this particular fan.

5.2.3.1 Exhaust Modification

The exhaust modification consisted of an improved primary muffler No. 439797-C1 installed in conjunction with a stack muffler No. 871136-C1 as described in Section 5.1.1 for primary series truck. A rain cap was required by the customer, and it was tack welded to the stack muffler in such a manner that it opened away from the sound level meter during measurement.

5.2.3.2 Engine Treatment

The Cummins oil pan enclosure and engine block panels were selected for engine noise treatment of all N-series engines. From spreadability aspect, this modification is applicable to same engine, different model. Therefore, engine treatment was carried out by installing these covers and panels in all four vehicles for field installation in the same fashion as detailed in Section 4.1.2. Again, the installation of covers and panels required disassembling the engine attachments, cutting and fitting the panels and reassembling the attachments. It consumed 35 hours to complete the installation with more than 33 manhours devoted to covers and panels only.

5.2.3.3 Final Exterior Noise

The results of retrofitting the exhaust and engine described in the preceding sections was generally good with 3-4 dB(A) reduction in the baseline exterior noise levels per SAE drive-by test, except the one truck with low baseline noise level. The final exterior noise level of this truck showed 2 dB(A) reduction in the baseline noise level with

shutters closed but no measurable change in the noise level with shutters open as shown in Table 5.1, item 8.

5.2.3.4 Cab Interior Treatment

The baseline interior noise levels per BMCS regulation as listed in Table 5.1, items 5 thru 8, were measured to be 95 dB(A) and higher, shutters closed. The primary objective under the contract was to install retrofit packages for truck exterior noise, and the modifications discussed in the preceding sections did not adversely effect the cab interior noise. The cab interior noise was treated as a secondary objective whenever possible in order to acquire useful information for compliance with the BMCS regulation. The results of cab interior treatment are tabulated in Table 5.1 and in all cases it was effective in reducing interior noise below BMCS regulation level.

Hence, treatment of the driver compartments of all four field installation vehicles was carried out in accordance with IH Fleet Service Letter No. SLF 74-21 (Appendix G). It included sealing the cab with caulking compound, treating the cab floor with absorbing and barrier material, installing dog house cover constructed with barrier material, and lining the cab rear panel with absorption material.

Final cab interior noise levels showed substantial reduction of 6-9 dB(A) in the baseline interior noise levels, which was well below the BMCS regulated levels.

6. SUMMARY

Installation procedure presented in the Service Bulletin in Appendix A suggests that the source noise modifications be performed in the following steps: exhaust, fan and engine. The noise measurements should be taken after each modification to determine the need of the next step, which obviously depends upon the regulated noise compliance. Based upon the results of the field installations of representative in-use vehicles discussed in Sections 4 and 5, it appears that some of the IH vehicle models including cab-over Transtar-A and Conventional Fleetstar-D with Cummins NH-series and Detroit Diesel 6-71N engines can be treated for exhaust and fan source noise to conform to 86 dB(A) level. However, compliance to limits lower than 86 dB(A) will warrant engine treatment.

The cost vs. noise level for field-evaluated trucks is superimposed on the computer plot of the theoretical data points for COF4070A in Figure 6.1 which shows baseline as well as modified truck noise levels recorded. The points pertaining to the primary model trucks are identified as P1 and P2, and the points for secondary model trucks are identified as S1, S2 and S3. The selected kit for noise reduction installed on the two primary model trucks for field evaluation produced 1 dB(A) reduction in the baseline noise levels for both the trucks for practically the same added cost as theoretically established for a 4 dB(A). The gain in noise reduction was not comparable to the theoretical prediction. Further, the selected noise modification kit collectively installed on the development (primary) truck provided 3 - 4 dB(A) reduction in the baseline truck exterior noise level of 87 dB(A). However, the field evaluation of the same kit did not effectively produce the same results.

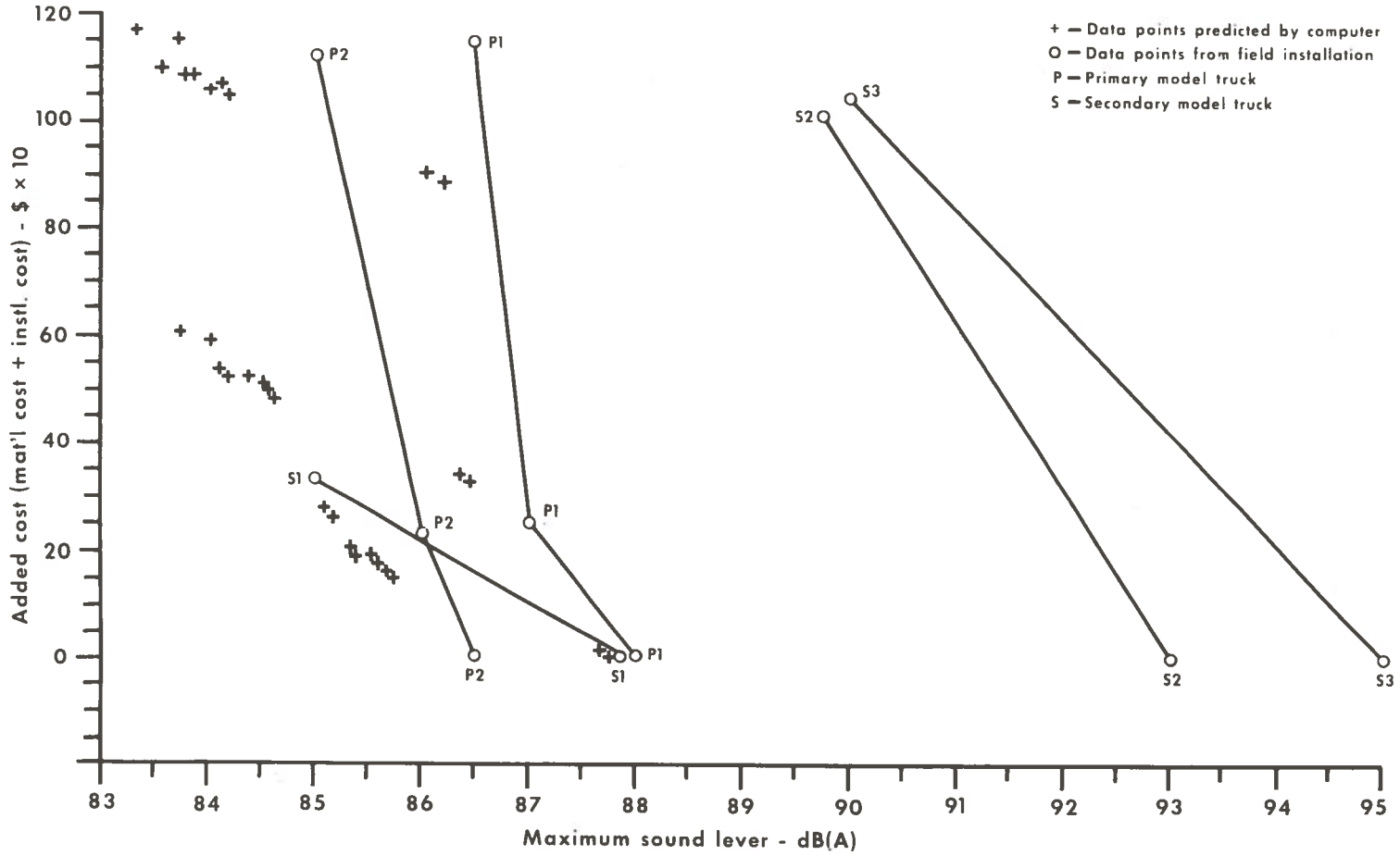


FIGURE 6.1 COST-NOISE TRADE OFFS FROM FIELD INSTALLATION MODEL COF4070 TRUCKS

Using the spreadability criteria for secondary model trucks, the applicable noise source modifications were evaluated on the representative vehicles. A secondary combination of COF4070A with 6-71N engine was treated with exhaust and fan modifications which provided 3 dB(A) reduction in the baseline truck noise level of 88 dB(A). The other two secondary model trucks of COF4070A W/NTC-290 and 335 engine were fitted with only applicable modifications of exhaust and engine. These modifications effectively attenuated the exhaust and engine source noises and the remaining truck noise was dominated by the fan source noise (refer Section 4.2.2.1).

Figure 6.2 shows the field installation results of 2000D primary and secondary model trucks superimposed on the computer plot of the theoretical cost-noise analysis. The field evaluation of the selected noise reduction kit for 2000D with 6-71N engine and different exhaust system configurations effectively produced equivalent noise reduction as theoretically predicted. But in some cases, the added cost for noise modification in the field was higher compared to the theoretically computed cost. The secondary model treated with applicable exhaust and engine modifications along with fuel tank isolation. These modifications provided 1.5 dB(A) reduction in the baseline exterior noise levels of two trucks. However, installation result of the third truck whose baseline noise level was relatively low showed only about .5 dB(A) reduction for the same added cost.

These installations have provided additional insight into the matter that each truck is individually different and should be treated per se. Also, variations in manufacturing tolerances effect the overall truck noise levels accordingly. Therefore, the same modifications applied normally to identical trucks, will provide varying degrees of noise reduction. The importance of proper maintenance of the truck and its

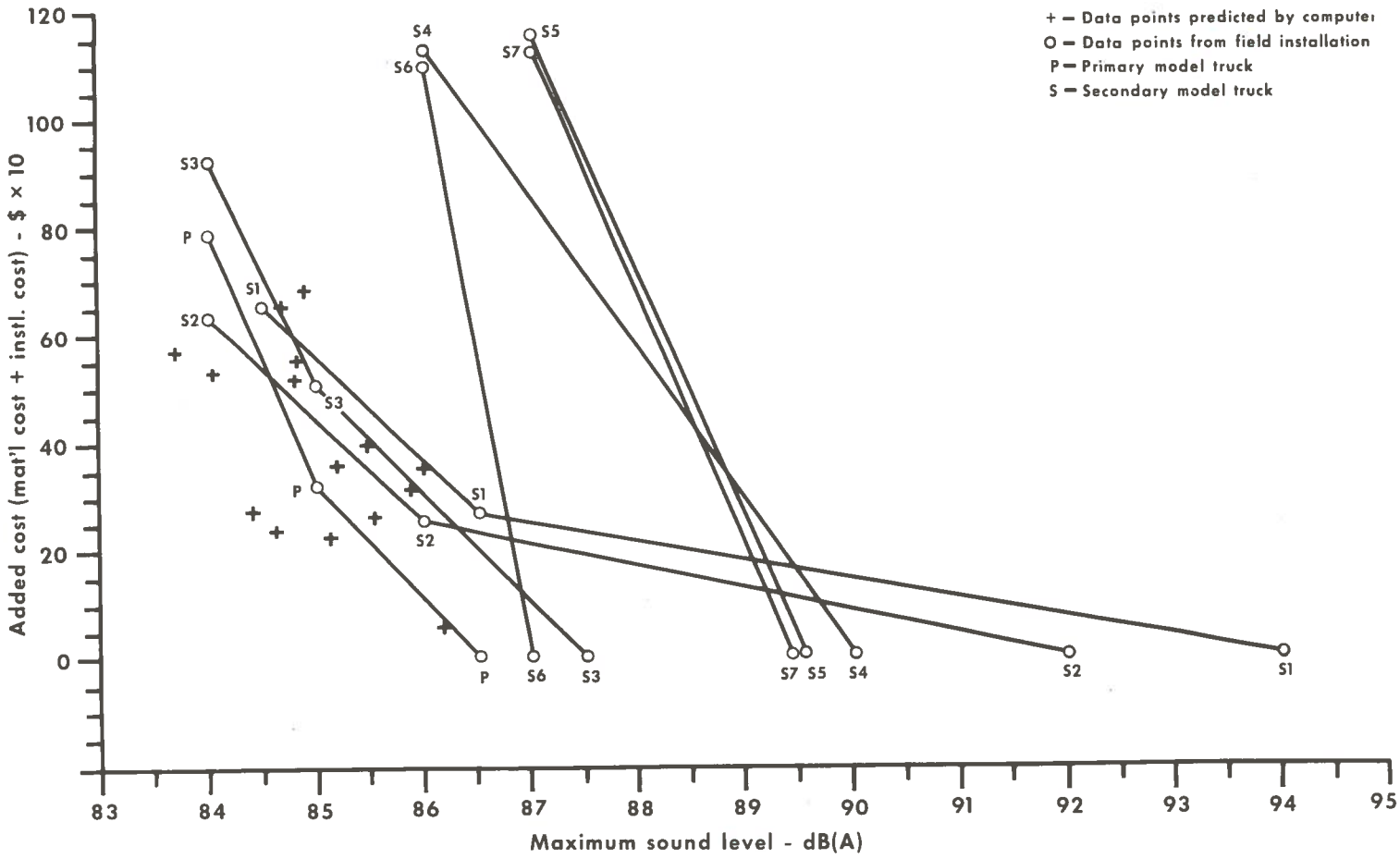


FIGURE 6.2 COST-NOISE TRADE OFFS FROM FIELD INSTALLATION OF MODEL 2000D TRUCKS.

components may also be reiterated as the contribution of poorly maintained parts to the total truck noise increases tremendously.

7. CONCLUSIONS

1. The cost of retrofitting an in-use vehicle increases sharply with the increasing demand in truck exterior noise reduction.

2. Practical noise retrofit technology is limited and its application is difficult.

3. Some trucks now in service could not be retrofitted to exterior noise levels below 86 dB(A).

4. Retrofitting costs increase sharply after the simple treatments to the exhaust and cooling systems have been made.

5. Based upon development data and field installation results for representative vehicles, most diesel trucks can not be retrofitted practically for noise levels of and below 83 dB(A).

6. Proper vehicle maintenance is essential to noise control.

7. The noise reduction which can be attained through retrofitting an in-use truck is quite unpredictable since each truck is an individual, and results of noise modifications vary accordingly.

8. The truck owners and operators are concerned about the heat and fire hazard of engine covers and panels for Cummins N-series engines.

9. Based upon major difference in installation time as well as consistent noise reduction as seen during field installation, the frame mounted bellypan was more effective than close fitted engine covers and panels.

APPENDIX A

EXTERIOR NOISE REDUCTION PACKAGES

FLEET SERVICE NEWS LETTER

Service

INTERNATIONAL TRUCKS

SLF 76-5

Latest Improvement and Techniques For ALL Servicemen

Date: January 22, 1976

Subject File: GENERAL

TO ALL FLEET OPERATORS:

Exterior Noise Reduction Packages (*)
To Bring Older Trucks into Compliance
With Noise Regulations.

Noise Abatement

As outlined and illustrated herein, the International Harvester Company has developed specific guidelines along with installation instructions for reducing exterior noise levels on existing CO-4070A and 2000D in-use vehicles.

If reducing cab interior noise is the major objective, other techniques should be used (see CTS-1037).

The development work was carried out on vehicles manufactured from 1969 to 1973. In this context, reference is made to the following two service letters previously issued.

Letter Number	Date	Subject File	Subject
SLF 74-21	4/15/74	GENERAL	1. Familiarization of Decibel. 2. Cab Interior Noise Regulations. 3. Suggested Methods to Reduce Interior Noise Levels.
SLF 74-98	9/20/74	GENERAL (Noise Abatement)	1. Familiarization of Noise Abatement Regulations & Methods of Measuring Exterior Noise. 2. Suggested Modifications to Lower Noise.

Vehicle Models

This Fleet News Letter outlines specific retrofit noise reduction hardware and techniques to reduce vehicle exterior noise levels on the following model-engine combinations.

CO-4070A with Cummins NHC-250 Engine
CO-4070A with Cummins NH-230, NTC-290, NTC-335 & NTC-350 Engines
CO-4070A with Detroit Diesel 6-71N Engine
2000D with Detroit Diesel 6-71N Engine
2000D with Cummins NHC-250 & NH-230 Engines.

(*) Developed under Department of Transportation Contract No. DOT-TSC-721.

II. Cab Interior Noise Regulations.

The Bureau of Motor Carrier Safety (BMCS) has published the regulations pertaining to truck cab interior allowable noise levels under Docket No. MC-22, Notice No. 73-27.

The regulation is listed in the Federal Register, Volume 38, No. 215 dated November 8, 1973 and is as follows:

Section #393.94 Vehicle interior noise levels.

(a) Application of the rules in this section. This section applies to all motor vehicles manufactured on and after October 1, 1974. On and after April 1, 1975, this section applies to all motor vehicles manufactured before October 1, 1974.

(b) General rule. The interior sound level at the driver's seating position of a motor vehicle must not exceed 90 dB(A) when measured in accordance with paragraph (c) of this section.

(c) Test procedure.

(1) Park the vehicle at a location so that no large reflecting surfaces, such as other vehicles, signboards, buildings, or hills, are within 50 feet of the driver's seating position.

(2) Close all vehicle doors, windows, and vents. Turn off all power-operated accessories.

(3) Place the driver in his normal seated position at the vehicle's controls. Evacuate all occupants except the driver and the person conducting the test.

(4) Use a sound level meter which meets the requirements of the American National Standards Institute Standard ANSI S1.4-1971 Specification for Sound Level Meters, for Type 2 Meters (accurate within 2 decibles). Set the meter to the A-weighting network, "fast" meter response.

(5) Locate the microphone, oriented vertically upward, 6 inches to the right of, in the same plane as, and directly in line with, the driver's right ear.

(6) With the vehicle's transmission in neutral gear, accelerate its engine to either its maximum governed engine speed, if it is equipped with an engine governor, or its speed at its maximum rated horsepower, if it is not equipped with an engine governor. Stabilize the engine at that speed.

(7) Observe the A-weighted sound level reading on the meter for the stabilized engine speed condition. Record that reading, if the reading has not been influenced by extraneous noise sources such as motor vehicles operating on adjacent roadways.

(8) Return the vehicle's engine speed to idle and repeat the procedures specified in paragraphs (c) (6) and (c) (7) of this section until two maximum sound levels within 2 dB of each other are recorded. Numerically average those two maximum sound level readings.

(9) The average obtained in accordance with paragraph (c) (8) of this section is the vehicle's interior sound level at the driver's seating position for the purpose of determining whether the vehicle conforms to the rule in paragraph (b) of this section. However, a 2 dB tolerance over the sound level limitation specified in that paragraph is permitted to allow for variations in the capabilities of meters.

It is highly important to understand the position of International Harvester to noise level laws. In general, trucks are built to meet operator noise level regulations in effect at the time the particular chassis was manufactured. Where subsequent noise levels for operator are lowered, the burden of meeting the new regulations is with the owner/operator.

Since there are owner/operator regulations which apply to all chassis and as more stringent maximum noise regulations are enforced, the owner/operator is responsible for rectrofitting the chassis to meet the new lowered limits.

III. Suggested Methods to Reduce Cab Interior Noise.

Due to increasing requests to seal cabs from exterior noise the following text has been prepared.

Before attempting to reduce noise level inside the cab, it is important that major sources of exterior noise be corrected prior to reduce noise entering the cab.

The three most common items which may require attention are:

A. Exhaust system changed from standard. Make sure correct applications of muffler are installed on the chassis involved.

B. Flexible exhaust tubing is leaking. A small hole will greatly increase noise level.

C. Install low opening shutterstat, 140 degree replacing 180 degree shutterstat. Chassis with thermatic-operated shutters must be changed to air-operated (shutterstat controlled). Thermatic operated shutters cannot be adjusted to 140 degrees opening temperature.

International will offer technical assistance for the particular vehicle combination in question.

Service personnel should not make any recommendations which might affect noise before getting prior regional approval.

The consequences of altering a vehicle or system to reduce a noise level could have other adverse effects and void the engine manufactured warranty.

As an example, altering the exhaust system to reduce noise could increase back pressure beyond prescribed limits.

ITEM NO	DESCRIPTION	QTY REQD (NH-230, NHC-250, 6-71N)	QTY REQD (NTC-290, NTC-335, NTC-350)	PART NO
1	MFLR (DONALDSON WTM10-0066)	1 *		549483C1
2	MFLR (DONALDSON MFM09-0249)		1	467355C1
3	ANGLE, MFLR SUPT	1		FIG. 2
4	CLAMP, MFLR FRONT	2		FIG. 3
5	SHIELD, MFLR	2		FIG. 4
6	PIPE, TAIL	1 **		758971-C1
7	PIPE, TAIL		1 **	360493C1

* USE THIS STRAIGHT TAIL PIPE ONLY IF EXISTING TAIL PIPE HAS CURVED OUTLET.

** IF PRODUCTION TAIL PIPE IS REUSABLE (45.0 LONG), CUT 9.0 OFF TOP, IF SERVICE TAIL PIPE IS REUSABLE (48.0 LONG), CUT 12.0 OFF TOP; IF TAIL PIPE CANNOT BE REWORKED, USE ITEM 7.

* POSITION MFLR SO THAT OFFSET OUTLET IS TOWARDS REAR OF CHASSIS.

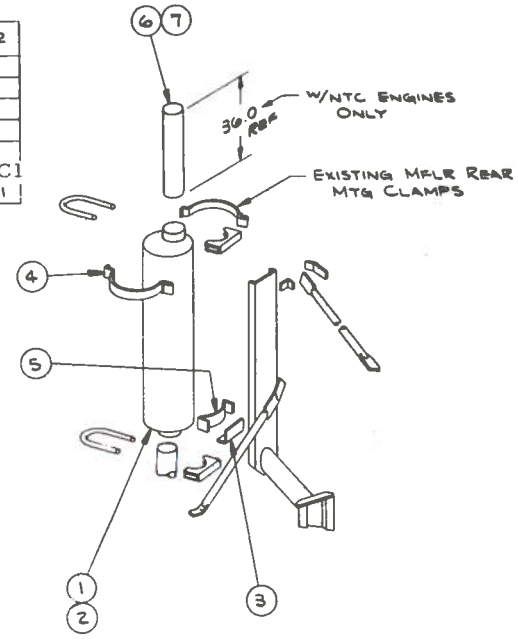


FIG. 1 FOR CO-4070A SERIES W/NH-230, NHC-250, NTC-290, 335, 350 & 6-71N

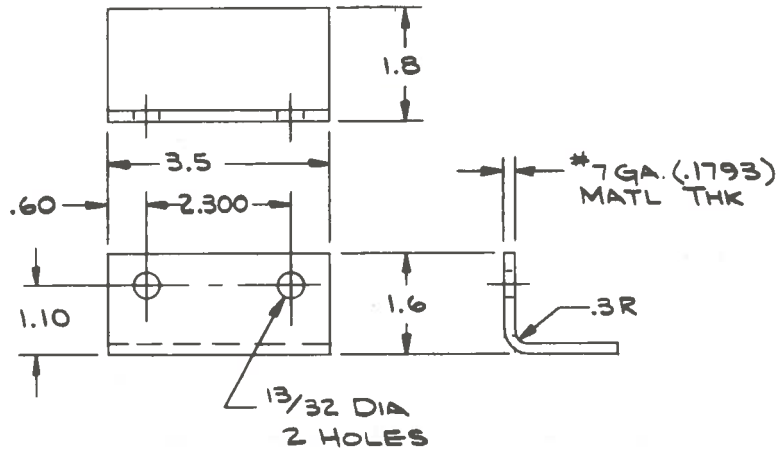


FIG. 2 MUFFLER SUPPORT ANGLE

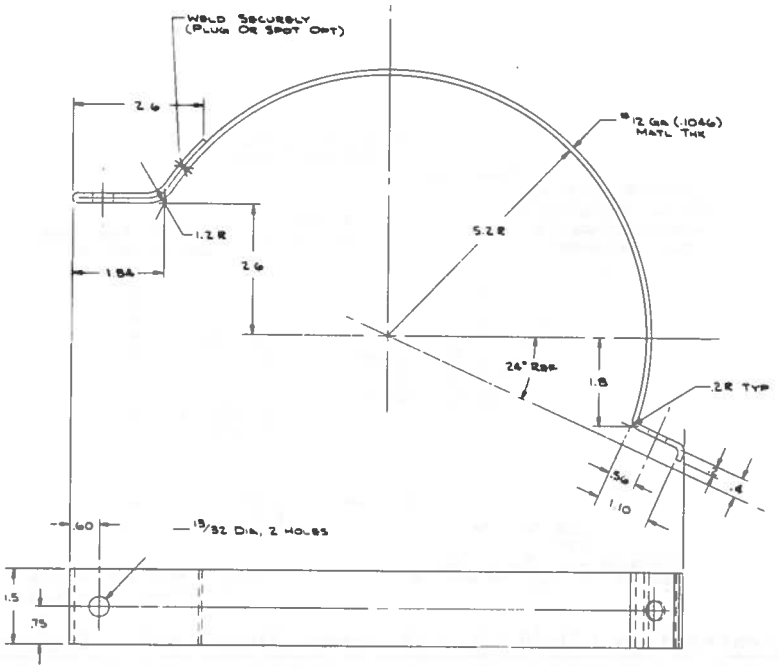


FIG. 3 VERTICAL MUFFLER MOUNTING CLAMP

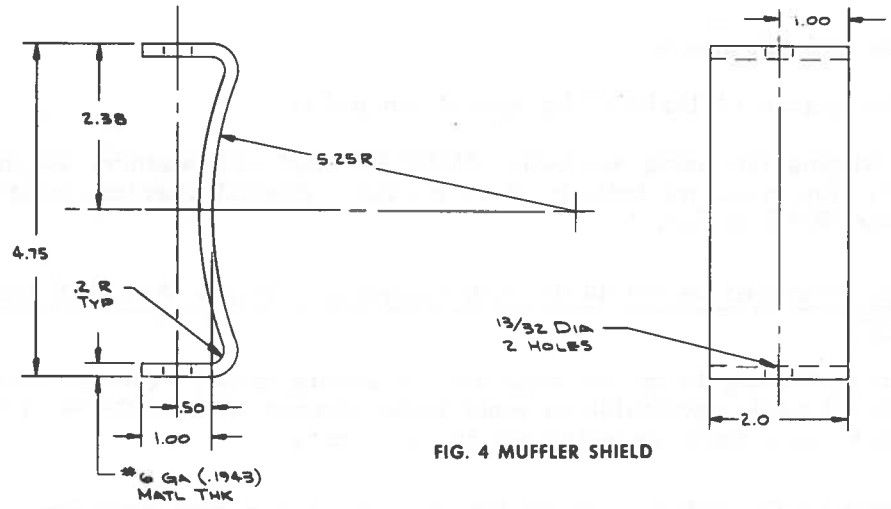


FIG. 4 MUFFLER SHIELD

Cooling System Treatment on CO-4070A with Cummins NHC-250 and NH-230 Engines

1. Obtain fan spacer (391987-C1) and six bolts (24846-R1) for cooling noise level treatment.
2. Remove fan.
3. Position fan spacer (391987-C1) on end of existing spacer.
4. Reinstall existing fan using six 3/8 - 16 x 4 1/2" bolts as shown in Fig. 5.
5. Torque fan mounting bolts to 30-38 ft. lbs.

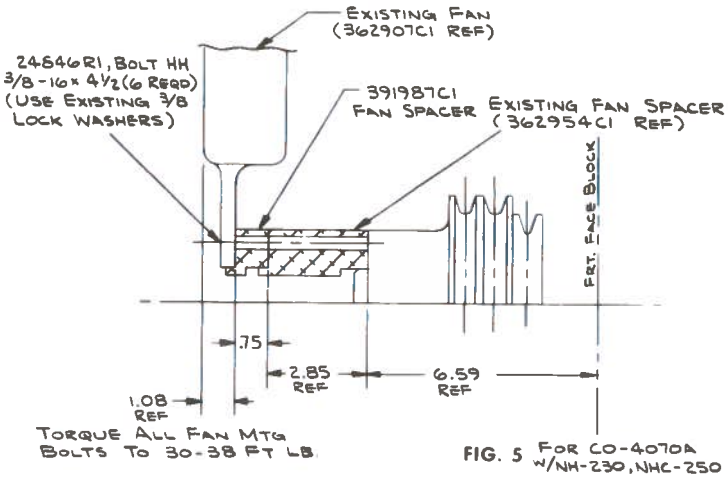


FIG. 5 FOR CO-4070A W/NH-230, NHC-250

Cooling System Treatment on CO-4070A with Detroit Diesel 6-71N Engine

1. Obtain fan spacer (411451-C2) and six bolts (26057-R1) for cooling noise level treatment.

2. Remove fan and fan spacer.

3. Position fan spacer (411451-C2) on end of fan pulley.

4. Reinstall existing fan using six bolts (26057-R1) and lock washers as shown in Fig. 6. Torque mounting bolts to 18-23 ft. lbs. Special attention must be adhered to the NOTE in Fig. 6.

Cooling System Treatment on CO-4070A with Cummins NTC-290, NTC-335 and NTC-350 Engines

Information pertaining to the development for cooling noise treatment under subject contract was not directly applicable to some model chassis with NTC-290, NTC-335 and NTC-350 engines, as a major redesign would be required.

Engine Treatment on CO-4070A -- Block Panels and Oil Pan Enclosure for Cummins NH-230, NHC-250, NTC-290, NTC-335 and NTC-350 Engines

Engine side panels and oil pan enclosures are made of sheet metal lined with fiberglass insulation. The fiberglass is sandwiched between metal panels and engine. The sheet metal panels are isolated with the use of rubber grommets.

Instructions for installing engine enclosures are supplied with the packages. These packages are available through any Cummins authorized dealer by ordering:

AR-11353 - Kit, Engine Side Panel

AR-11351 - Oil Pan, Enclosure

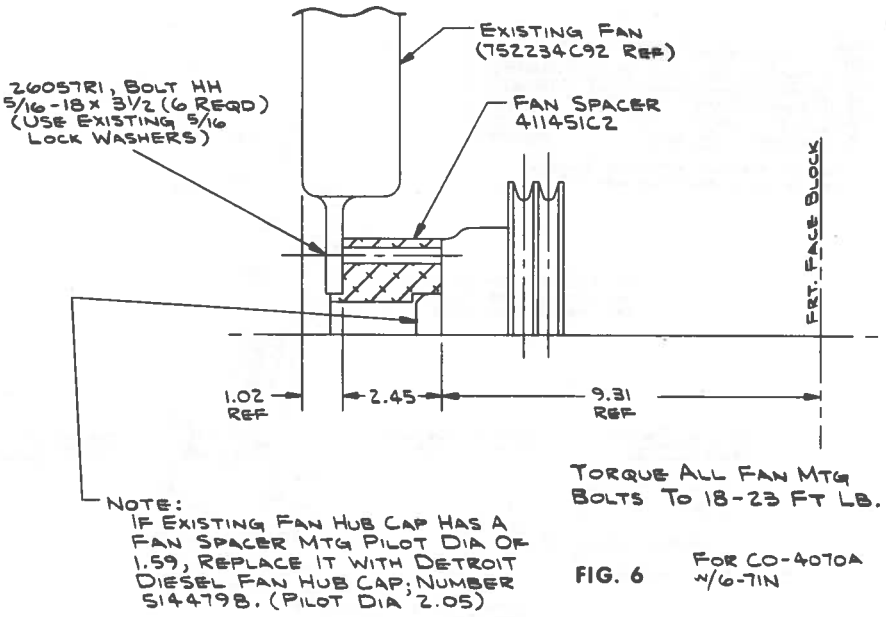


FIG. 6 FOR CO-4070A W/6-71N

Exhaust Modification on 2000D with Detroit Diesel 6-71N Engine, Cummins NH-230 and NHC-250 Engines, Horizontal and Vertical Tail Pipe (SHVTP)

1. Remove the following components: muffler, flex tube and exhaust pipe at muffler inlet.

2. New parts required for this modification are:

439797-C1	Muffler assembly (Donaldson # MAM10-0052)
320235-C1	Flex tube
464962-C1	Pipe exhaust (muffler inlet)
873840-C1	Extension stack exhaust (Donaldson # AEM00-1193)
459067-C91	Bolt, U (stack bottom)

3. Muffler rear mounting bracket will be relocated on the frame by drilling a 17/32" diameter hole, 4-1/2" forward of present location (see Fig. 7).

4. Cut 32 inches from top end of original tail pipe.

5. Position flex tube and exhaust pipe (items 3 & 4 - Fig. 7) on chassis.

6. Install muffler rear support in new location (Fig. 7).

7. Position muffler support straps on muffler and assemble muffler on end of exhaust pipe (item 3, Fig. 7).

8. Install original tail pipe; since tail pipe lower end remained the same, the tail pipe will automatically locate new muffler when installed. All support straps and U-bolts for flex tube, rear exhaust pipe, muffler and tail pipe must be tightened.

9. Install stack extension and tighten U-bolt securely.

ITEM NO	DESCRIPTION	QTY REQD	PART NO
1	MFLR (DONALDSON MAM10-0052)	1	423791C1
2	STACK EXT (DONALDSON AEM00-1193)	1	871136C1
3	EXHAUST PIPE	1	466962C1
4	FLEX TUBE	1	320235C1
5	EXHAUST CLAMP ASSEM	1	450067C91

FOR COMPLETION OF EXHAUST SYSTEM, SEE IH TRUCK PARTS CATALOG MT-120.

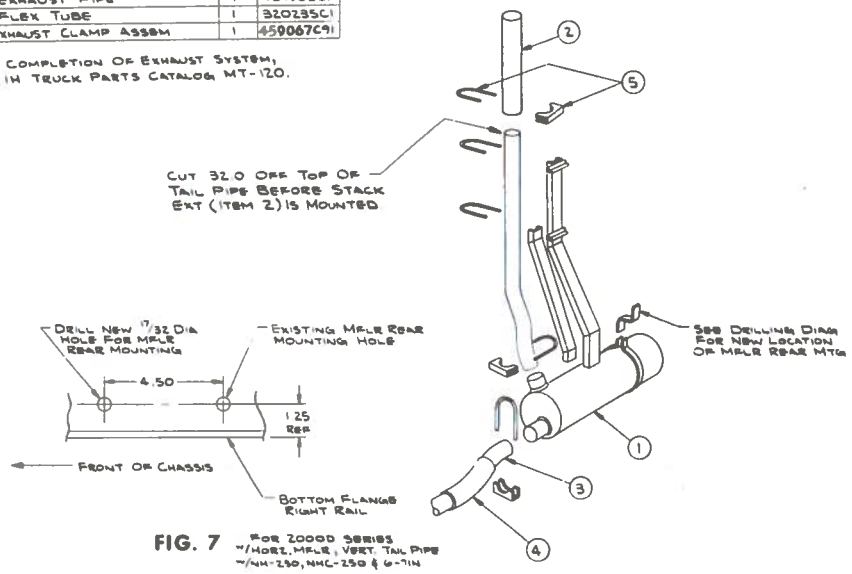


FIG. 7 FOR 2000D SERIES W/HORZ. MFLR, VERT. TAIL PIPE W/NH-230, NHC-250 & 6-71N

Exhaust Modification on 2000D with Detroit Diesel 6-71N Engine, Cummins NH-230 and NHC-250 Engines with Vertical Muffler and Tail Pipe (Welded Muffler Mounting Support) (SVVTP)

1. Remove the following components: muffler exhaust pipe (from flex tube to muffler) flex tube, and all straps and brackets.

2. Muffler rear straps (see Fig. 8), flexible tube and exhaust pipe (423791-C1) may be used in modification if serviceable.

3. The following components are to be made locally using illustrations provided.

   (Fig. 2) Muffler Support Angle
   (Fig. 3) Muffler Front Mounting Clamp - 2 Required
   (Fig. 4) Muffler Shield - 2 Required
   (Fig. 13) Muffler Guard Assembly

   NOTE: Components required to make guard assembly are:
   (Fig. 9) Muffler Guard Angle - 2 Required
   (Fig. 10) Muffler Guard Reinforcement Straps - 3 Required
   (Fig. 11) Muffler Guard Clamp - 2 Required
   Flattened Carbon Steel Industrial Mesh 3/4" #16 Gauge (.0598) 15.5" x 44.5" to be formed around guard.

   (Fig. 12) Muffler Guard Clamp - 2 Required

4. Assemble muffler guard components as shown in Fig. 13.

5. Original exhaust pipe (423791-C1) must be reworked to obtain 19.6" dimension shown in Fig. 14 using a piece of 4" O.D. tube .8" long.

6. New parts required are:

   549483-C1 Muffler (Donaldson # WTM10-0066)

7. Install all components as shown in Fig. 8.

ITEM NO	DESCRIPTION	QTY REQD	PART NO
1	MFLR (DONALDSON WTM10-0066)	1 *	549483C1
2	SHIELD, MFLR	2	FIG. 4
3	CLAMP, MFLR FRONT	2	FIG. 3
4	ANGLE, MFLR SUPT	1	FIG. 2
5	PIPE, EXHAUST REAR	1	FIG. 14
6	GUARD ASSY, MFLR	1	FIG. 13
7	CLAMP, MFLR GUARD	2	FIG. 12

FOR COMPLETION OF EXHAUST SYSTEM, SEE IH TRUCK PARTS CATALOG MT-120 CHASSIS NO "G" AND UP.

* POSITION MFLR SO THAT OFFSET OUTLET IS TOWARDS REAR OF CHASSIS.

REF. NOTE:
NO CHANGE REQD TO EXISTING VERTICAL MFLR SUPPORT AND BRACE.

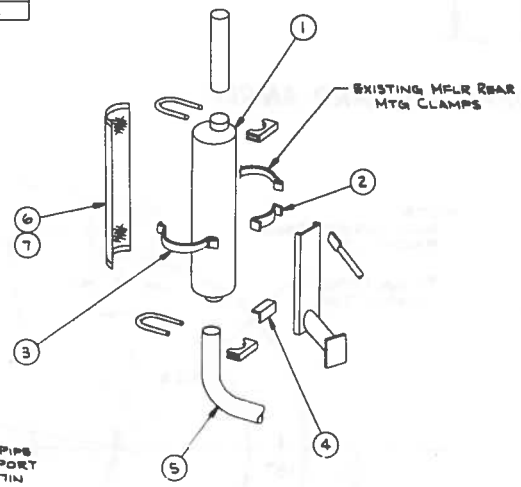


FIG. 8 FOR 2000D SERIES W/VERT. MFLR & TAIL PIPE W/WELDED MFLR SUPPORT W/NH-230, NHC-250 & 6-71N

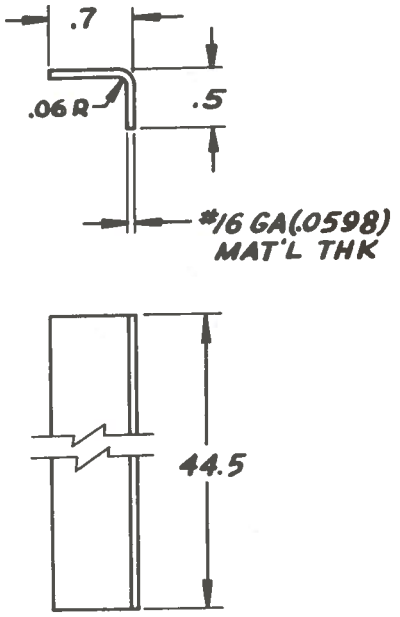


FIG. 9 *MUFFLER GUARD ANGLE*

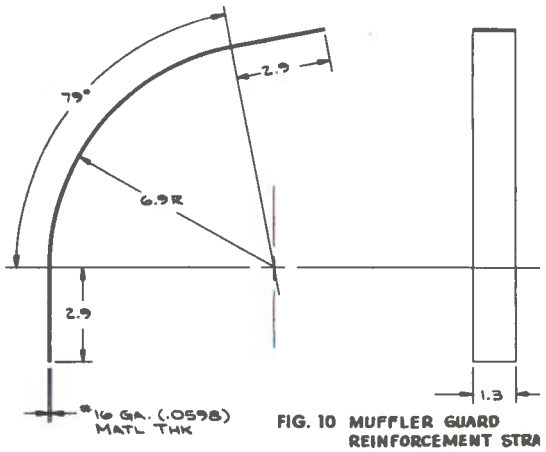


FIG. 10 MUFFLER GUARD REINFORCEMENT STRA

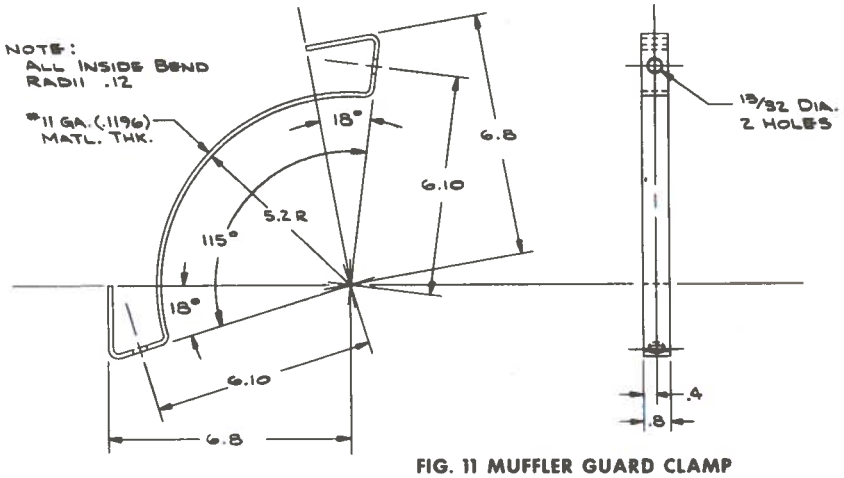


FIG. 11 MUFFLER GUARD CLAMP

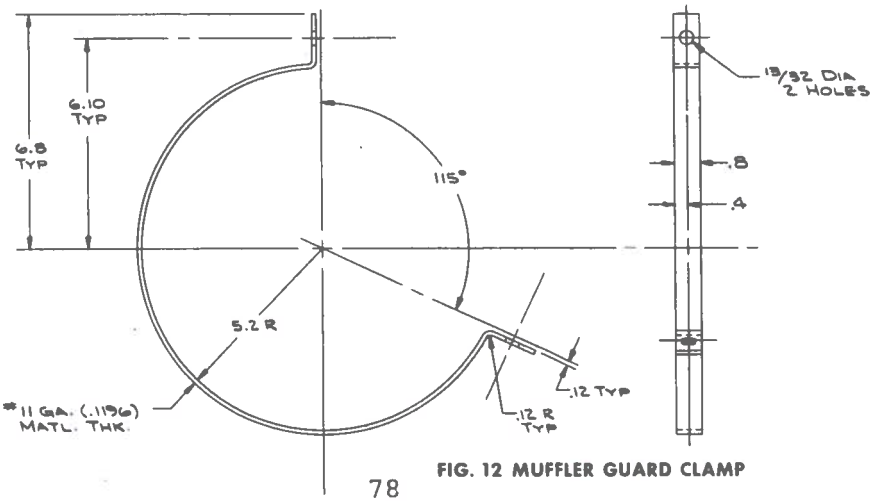


FIG. 12 MUFFLER GUARD CLAMP

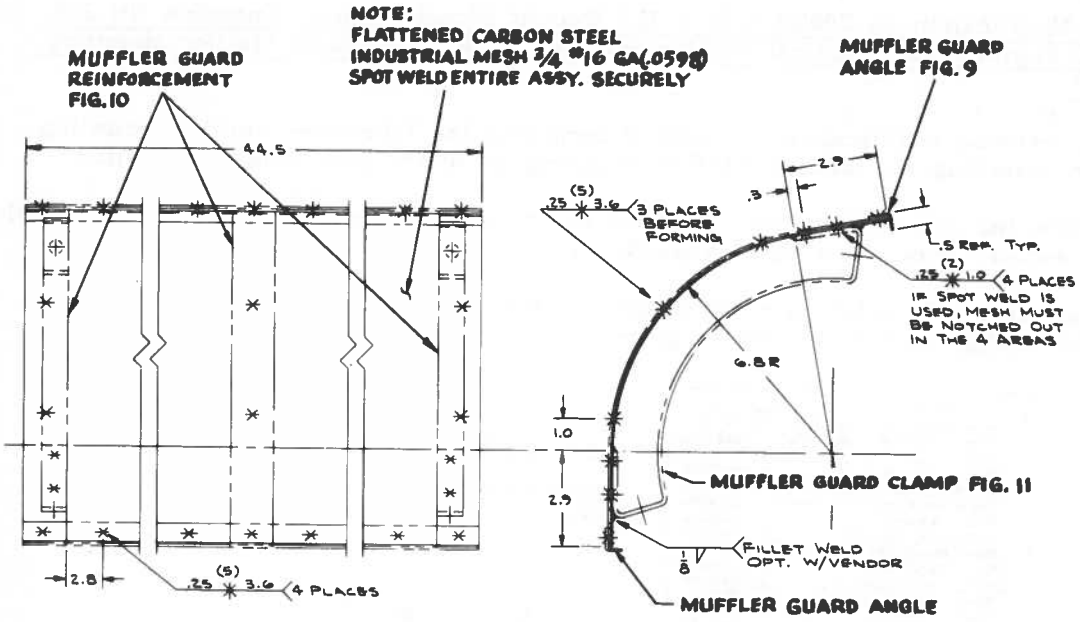


FIG. 13 MUFFLER GUARD ASSEMBLY

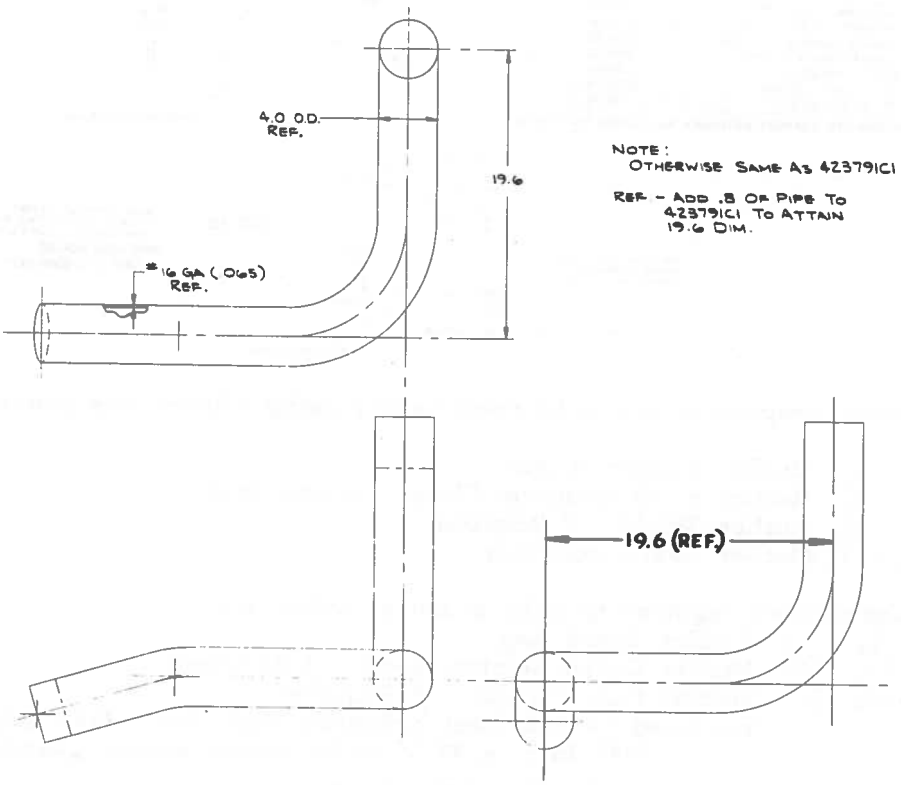


FIG. 14 REWORK EXHAUST PIPE

Exhaust Modification on 2000D with 6-71N Detroit Diesel Engine, Cummins NH-230, NHC-250 Engines with Vertical Muffler and Tail Pipe (Fabricated Muffler Mounting) (SVVTP)

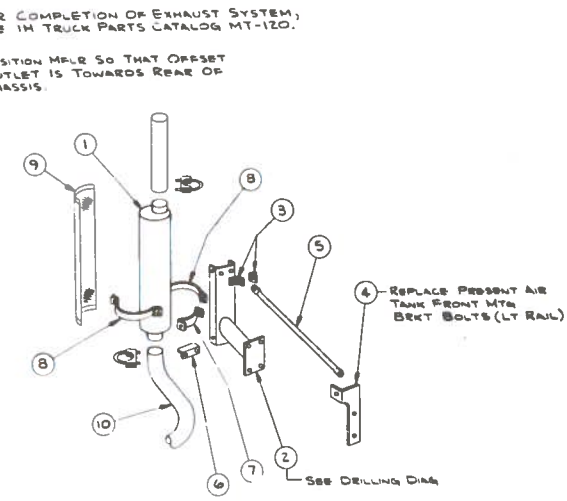
This exhaust modification consists of removing the fabricated muffler mounting and then installing the welded muffler mounting as in the preceding installation.

1. Remove the following parts: muffler, entire muffler mounting system (brackets) and exhaust pipe (flex pipe to muffler).

2. Locate and drill holes in right frame rail for vertical muffler support assembly. Refer to Fig. 15 for drilling diagram.

ITEM NO	DESCRIPTION	QTY REQD	PART NO
1	MFLR (DONALDSON WTM10-2266)	1 #	5494333C1
2	SUPPORT ASSEMBLY SEE NOTE #1	1	423793C1
	BOLT, 1/2 NC x 1 1/2	4	24862R1
	NUT, LOCK 1/2 NC	4	94122230
3	BRACE, MFLR SPT BRKT REAR	1	3716546C1
	BRACE, MFLR SPT BRKT FRONT	1	3716555C1
	BOLT, 1/2 NC x 1 1/4	2	24861R1
	NUT, LOCK 1/2 NC	2	94122230
4	BRKT, BRACE SPT	1	423795C1
	BOLT, 1/2 NC x 1 3/4	2	24863R1
	NUT, LOCK 1/2 NC	2	94122230
5	BRACE, VERTICAL MFLR	1	423790C1
	BOLT, 1/2 NC x 1 1/2	2	24862R1
	NUT, LOCK 1/2 NC	2	94122230
6	ANGLE, MFLR SPT	1	FIG. 2
	BOLT, 3/8 NC x 1	2	24840R1
	NUT, LOCK 3/8 NC	2	94139179
7	SHIELD, MFLR	2	FIG. 4
	BOLT, 3/8 NC x 1 1/4	6	140483H
	NUT, LOCK 3/8 NC	6	94139179
8	CLAMP, MFLR FRONT	2	FIG. 3
	CLAMP, MFLR REAR	2	362929-1
	BOLT, 3/8 NC x 1 1/2	2	24841R1
	NUT, HEX 3/8 NC	2	255262R1
	WASHER, LOCK 3/8	2	3/8 R
	WASHER, PLAIN 3/8	4	257099R1
9	GUARD ASSEMBLY, MFLR	1	FIG. 13
	CLAMP, MFLR GUARD	2	FIG. 12
	BOLT, 3/8 NC x 1	4	24840R1
	NUT, LOCK 3/8 NC	4	94139179
10	PIPE, EXHAUST	1	FIG. 14

NOTE #1 REWORK SUPPORT ASSEMBLY AS SHOWN ON FIG. 16



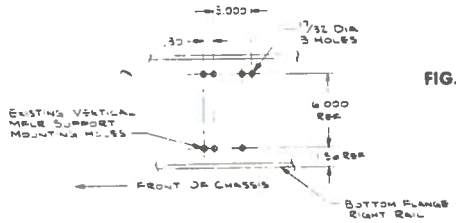


FIG. 15

FOR 2000D SERIES W/VERT MFLR & TAIL PIPE W/NH-230, NHC-250 & 6-71N
REPLACES BOLTED FABRICATED SUPPORT

3. The following components are to be made locally using illustrations provided.

   (Fig. 2) Muffler Support Angle
   (Fig. 3) Muffler Front Mounting Clamp - 2 Required
   (Fig. 4) Muffler Shield - 2 Required
   (Fig. 13) Muffler Guard Assembly

   NOTE: Components required to make guard assembly are:
   (Fig. 9) Muffler Guard Angle
   (Fig. 10) Muffler Guard Reinforcement - 3 Required
   (Fig. 11) Muffler Guard Clamp - 2 Required
   Flattened Carbon Steel Industrial Mesh 3/4", #16 Gauge (.0598) 15.5" x 44.5" to be formed around guard.

   (Fig. 12) Muffler Guard Clamp - 2 Required

4. Assemble muffler guard components as shown in Fig. 13.

5. Exhaust pipe (423791-C1) must be reworked to obtain the 19.6" dimension shown in Fig. 14 using a piece of 4" O.D. tube .8" long.

6. New parts required to complete this exhaust modification are listed on Fig. 15. Support assembly (423793-C1) mounting flange must be reworked as shown in Fig. 16.

7. Install exhaust system as shown in Fig. 15.

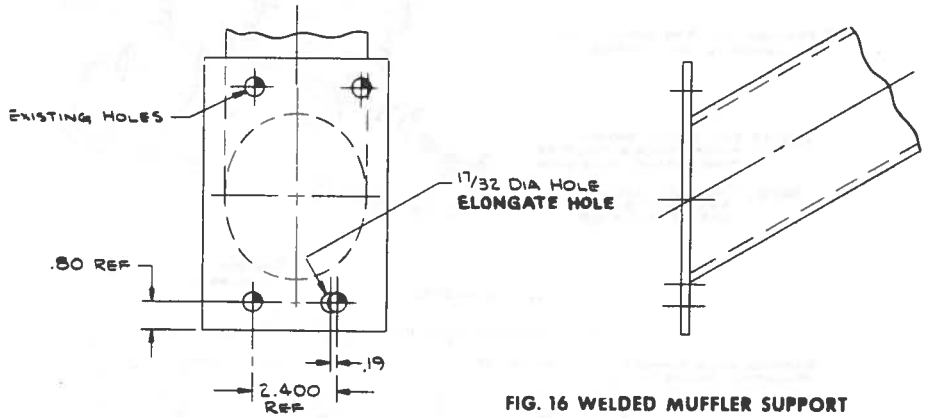


FIG. 16 WELDED MUFFLER SUPPORT

Exhaust Modification on 2000D with Detroit Diesel 6-71N Engine, Cummins NH-230, NHC-250 Engines with Horizontal Muffler and Tail Pipe (SHHTP)

NOTE: This modification is not available on 2000D 4x2 chassis with 132" W.B. or 6x4 chassis with 144" or 150" W.B.

1. Remove entire exhaust system including flex tube to tail pipe.

2. Locate and drill holes in right frame rail for muffler supports as shown in Fig. 17.

3. The following components are to be made locally using illustrations provided:

   (Fig. 18) Muffler Clamp Bar - 2 Required
   (Fig. 19) Muffler Clamp Line - 1 Required

4. Original muffler rear support bracket must be reworked as shown in Fig. 20 and reinstalled in same location.

5. Part numbers of additional components required for completion of exhaust modification are located in Fig. 17.

6. Form strap assembly (item 12 - Fig. 17) to fit contour of muffler. Do not use muffler as form.

7. Install exhaust system as shown in Fig. 17.

ITEM NO	DESCRIPTION	QTY REQD	PART NO
1	BAR, MFLR CLAMP	2	FIG. 18
2	BOLT, 1/2 NC x 1 1/2	2	24862R1
	NUT, LOCK 1/2 NC	2	9412230
3	BOLT, 3/8 NC x 2	2	24849R1
	WASHER, 3/8 HARDENED	4	25709R1
	NUT, LOCK 3/8 NC	2	9413979
4	LINK, EXHAUST PIPE	1	FIG. 19
5	LINK, EXHAUST PIPE	1	FIG. 19
6	PIPE, TAIL	1 *	198383R1
7	CLAMP ASSY, EXHAUST	4	459067C91
8	MFLR (DONALDSON WOM12-0197)	1	
9	PIPE, EXHAUST	1	466496ZC1
10	FLEX PIPE	1	320236C1
11	BRACKET	1	FIG. 20
12	STRAP ASSY.	1	226478R91

* POSITION TAIL PIPE APPROX 45° TOWARDS ℄ OF CHASSIS

FOR COMPLETION OF EXHAUST SYSTEM, SEE IH TRUCK PARTS CATALOG MT-120.

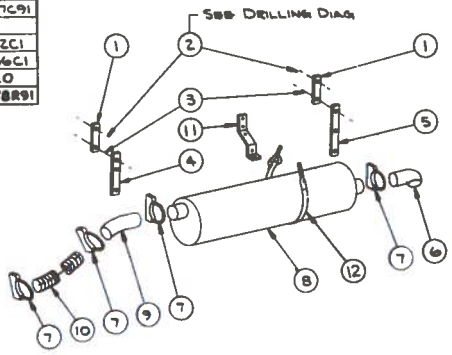
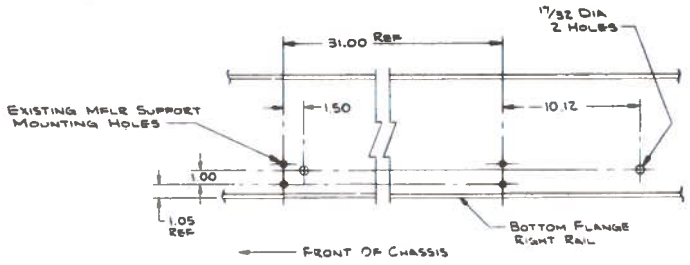


FIG. 17 FOR 2000D SERIES W/HORZ MFLR & TAIL PIPE W/NH-230, NHC-250 & 6-71N

NOTE: THIS INSTL N/A WITH: (4x2) 132 W.B. (6x4) 144 & 150 W.B.



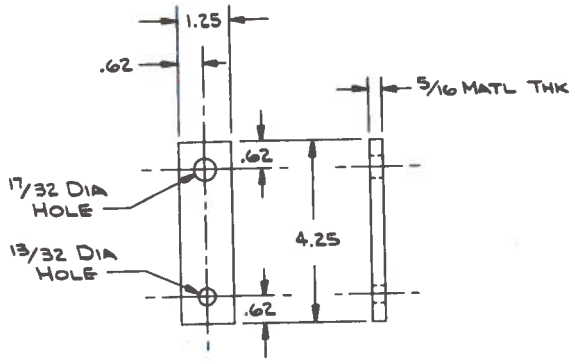


FIG. 18 FOR 2000D SERIES W/HORZ MFLR & TAIL PIPE, W/NH & 6-71N ENG.

PART NO	A	B
FIG. 17 ITEM 4	1.62	7.5
FIG. 17 ITEM 5	6.38	12.3

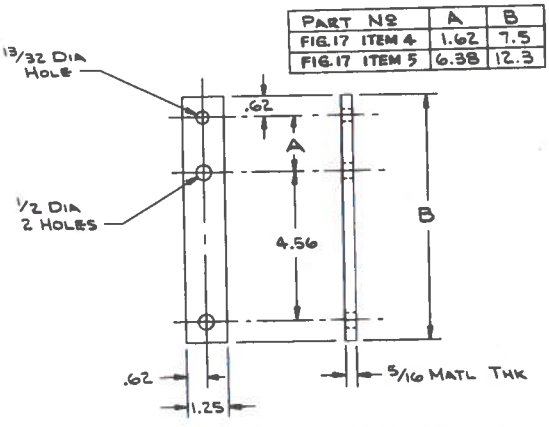


FIG. 19 FOR 2000D SERIES W/HORZ. MFLR & TAIL PIPE

Cooling System Treatment for 2000D with Detroit Diesel 6-71N Engine

Contoured extension for radiator shroud must be made locally as shown in Fig. 21

Install contoured extension on radiator shroud as shown in Fig. 22.

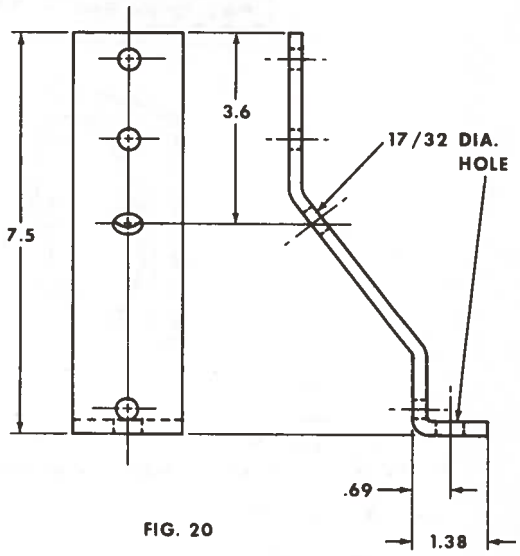


FIG. 20

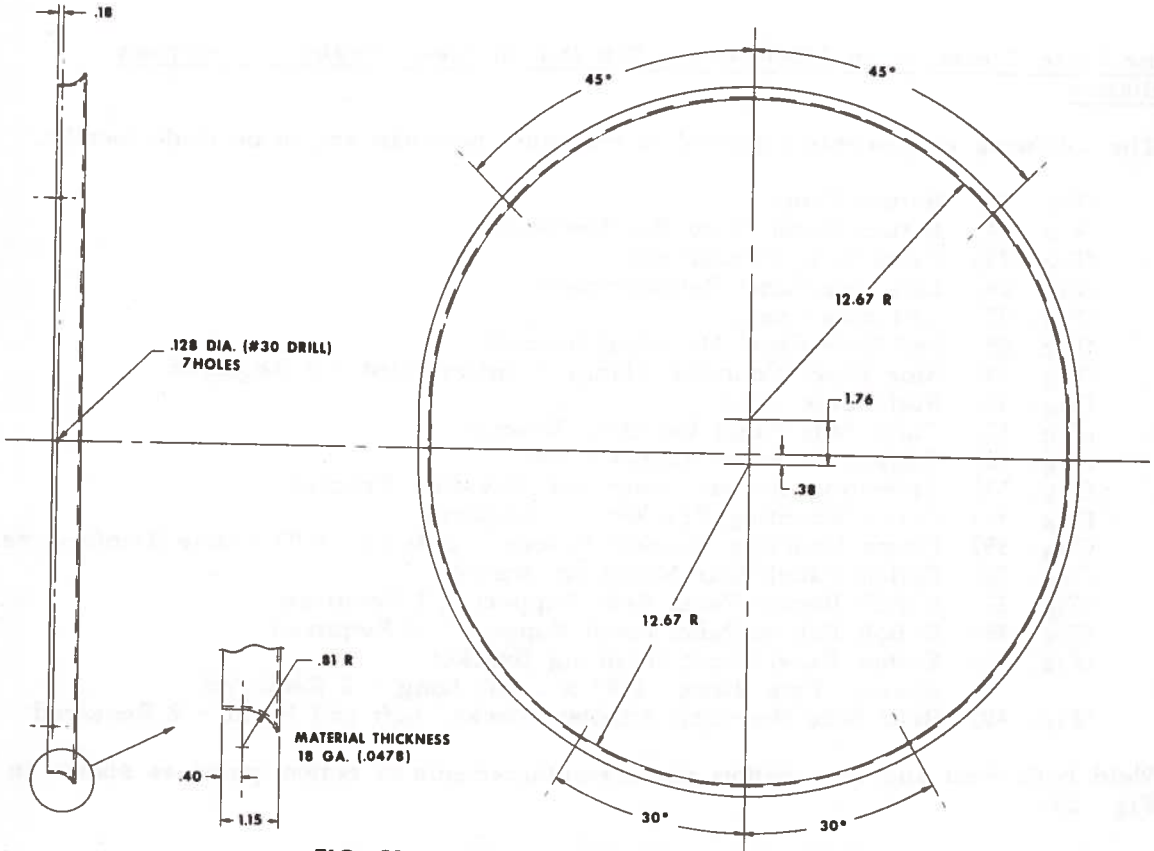


FIG. 21 SHROUD EXTENSION FOR 2000D W/6–71N ENG.

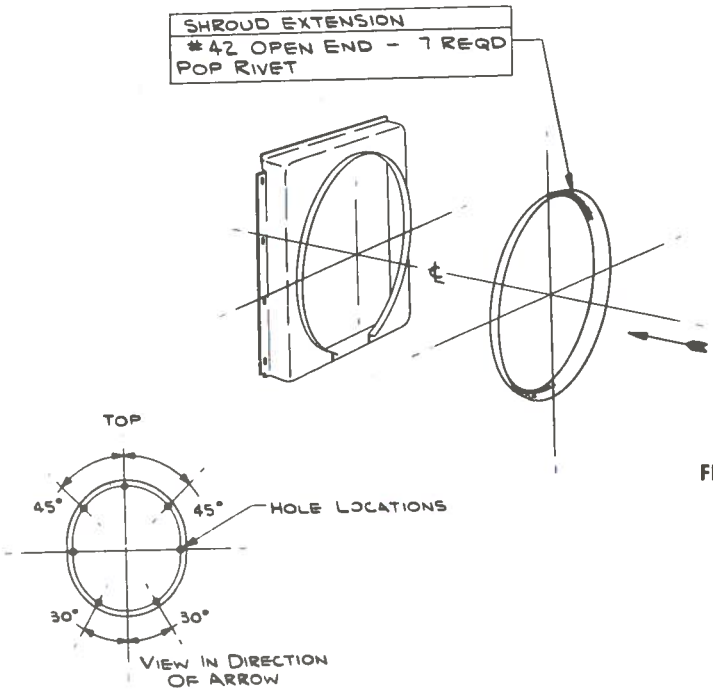


FIG. 22 FOR 2000D SERIES W/6-71N ENGINE

Engine Noise Treatment on 2000D with 6-71N Detroit Diesel Engine -- Bellypan Installation

1. The following components required to construct bellypan are to be made locally.

(Fig. 23) Bottom Panel
(Fig. 24) Bottom Panel Front Reinforcement
(Fig. 25) Panel Rear Reinforcement
(Fig. 26) Left Side Panel Reinforcement
(Fig. 27) Left Side Panel
(Fig. 28) Left Side Panel Mounting Bracket
(Fig. 29) Side Panel Mounting Flange Reinforcement - 2 Required
(Fig. 30) Right Side Panel
(Fig. 31) Right Side Panel Mounting Bracket
(Fig. 32) Right Side Panel Access Cover
(Fig. 33) Assembly, Access Cover and Mounting Bracket
(Fig. 34) Frame Mounting Bracket - 2 Required
(Fig. 35) Frame Mounting Bracket Spacer - 2 Req'd. W/O Frame Reinforcement
(Fig. 36) Bottom Panel Rear Mounting Bracket
(Fig. 37) U-Bolt Bottom Panel Rear Support - 2 Required
(Fig. 38) U-Bolt Bottom Panel Front Support - 2 Required
(Fig. 39) Bottom Panel Front Mounting Bracket Spacer, Pipe Block, 3/8" x 1.06" Long - 2 Required
(Fig. 40) Rear Side Mounting Adapter Blocks, Left and Right - 2 Required

2. Weld both front and rear bottom panel reinforcements to bottom panel as shown in Fig. 23.

Weld left side panel reinforcement mounting bracket and flange reinforcement to left side panel as shown in Fig. 26. Weld mounting flange reinforcement to right side panel as shown in Fig. 30.

Weld right side panel mounting bracket to right side panel access cover as shown in Fig. 33.

3. Additional parts required to complete engine noise treatment are:

252552-C1	- Nut Tab Weld, Gripco (22 Required -- used on bottom panel and right side panel)
108686	- Elbow, 1/2", 90 Deg. Street
	Huntington Fibromounts M87 (10 Required)
25752-R1	- Bolt, Hex Hd. 1/4-20x1/2" (22 Required)
174916	- Washer, Lock, Internal-External (22 Required)
	Washer, Flat, 1/4-10x1-1/8 O.D. (12 Required)
22200-R1	- Nut, 1/4-20 (12 Required)
1/4x2L	- Bolt, Hex Hd. 1/4-20x2 (4 Required)
1/2x1-1/2L	- Bolt, 1/2-13x1-1/2
1/2 V	- Nut, 1/2-13
416980-C1	- Seal (Scout Door)
9413979	- Nut 3/8-16 (2 Required)
21318-R1	- Bolt, 3/8-16x2-1/2 (2 Required)

4. Position vehicle on a hoist and raise vehicle. A hoist will aid in the installation as the bellypan can be assembled and installed as a complete assembly. If a hoist is not available and the vehicle cannot be raised high enough to position complete belleypan assembly under the chassis, the bellypan must be assembled on the vehicle to complete installation.

5. Install 1/2", 90 degree street elbow in engine oil drain. The elbow permits draining of crankcase oil after the bellypan assembly is installed.

6. Assemble right and left side panels on bottom panel using 1/4-20x1/2" bolts. Do not tighten bolts at this time.

7. Cut and fit seal (door seal) to length and install on edge of right and left side panels as shown in Fig. 41.

8. Cut and fit seal for access cover assembly (Fig. 33). Position seal on cover (Fig. 41).

9. Assemble access cover assembly on left side panel. Do not tighten bolts at this time.

10. Assemble frame mounting brackets (Fig. 34) on left and right side panel mounting brackets as shown in Fig. 41 (insert).

11. Position bellypan assembly under chassis, then lift complete assembly in position on lower edge of frame flange and align frame mounting bracket with existing holes in frame. Install 1/2"-13x1-1/2 bolts and 1/2 nuts. Do not tighten bolts and nuts at this time.

NOTE: In some instances the rear of the bellypan assembly may require positioning on top or upper side of rear crossmember (Fig. 42). Additional

1/4" flat washers may be required and inserted between Fibromounts and brackets to adjust bellypan assembly so that the seal is in contact with lower flange of frame rail.

12. Assemble rear side panel mounting as shown in Fig. 41 (insert). Do not tighten mounting.

13. Insert bottom rear mounting bracket and install bottom panel rear support U-bolts (Fig. 37) as shown in Fig. 42.

14. Insert front bottom panel mounting bracket and install bottom panel from support U-bolts as shown in Fig. 43.

15. Tighten all mounting bolts and pan bolts.

Additional instructions for engine noise level treatment!

a. Protruding oil filter drain plug is to be replaced by an Allen head type drain plug.

b. If starting motor solenoid is mounted in the 6 or 7 o'clock position, interference with bellypan can be overcome by prying the bellypan assembly out before tightening bolts.

c. Bellypan must be removed to adjust clutch.

Engine Treatment on 2000D with NHC-250 and NH-230 Engines

Engine oil pan enclosure and block sound panels marketed by Cummins Engine Company for their N-series engines should be installed in accordance with the instructions supplied by Cummins. These kits are listed on page 6.

Fuel Tank Isolation on 2000D with 6-71N, NHC-250 & NH-230 Engines

Engine noise treatment will be completed by installing fuel tank strap lining 471444-C1 under each tank strap. This is accomplished by loosening tank straps, inserting the lining, then retighten tank straps.

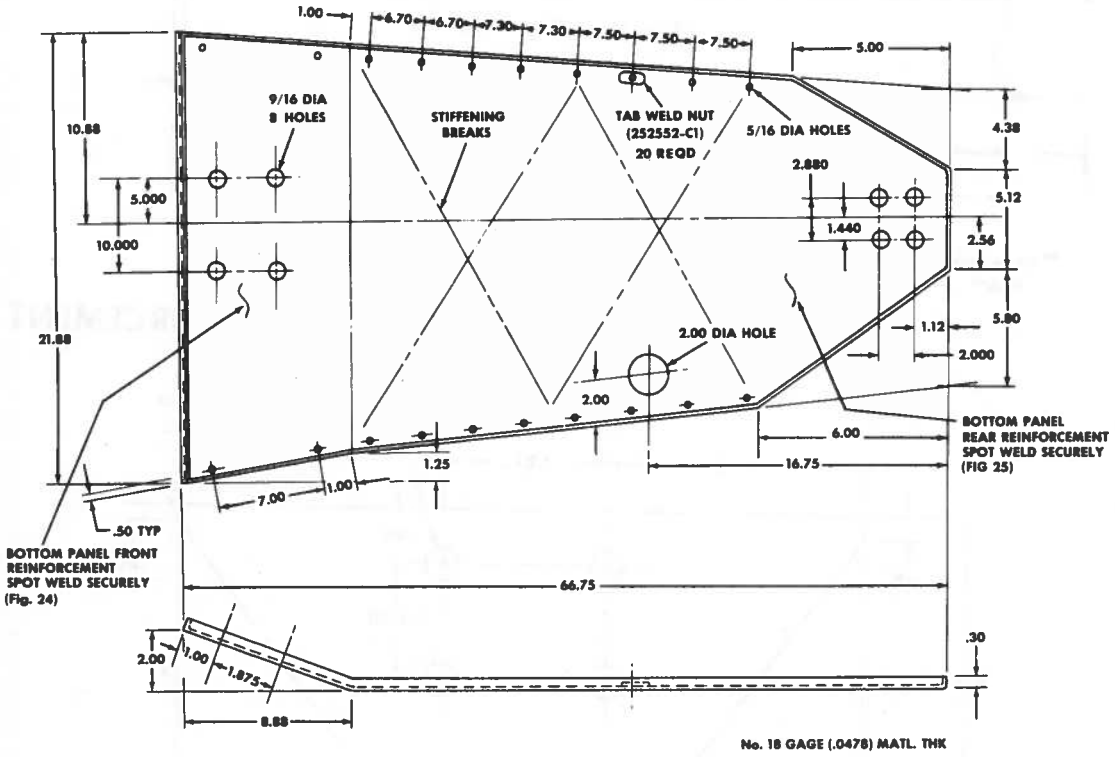


Fig 23 BOTTOM PANEL

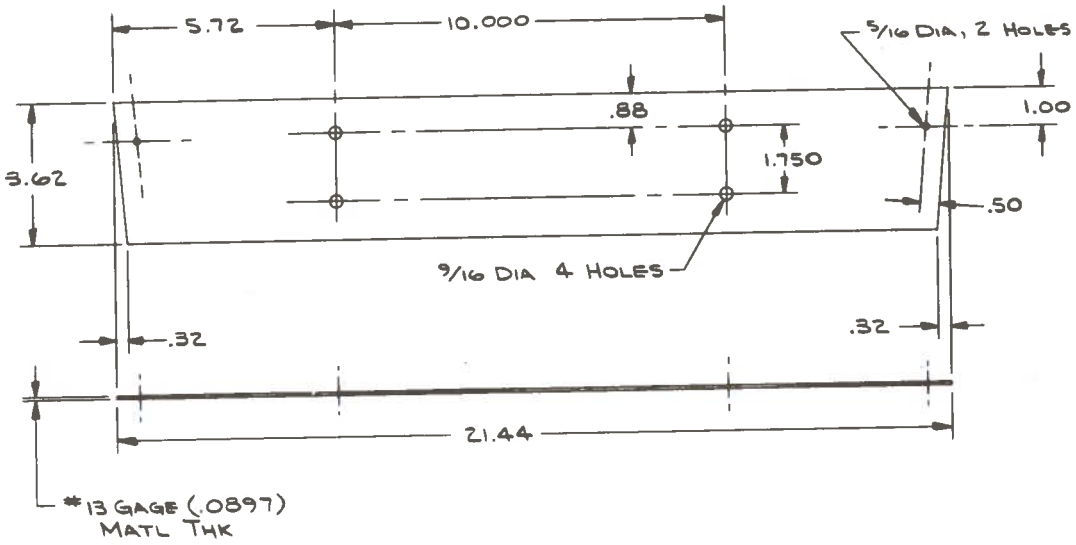
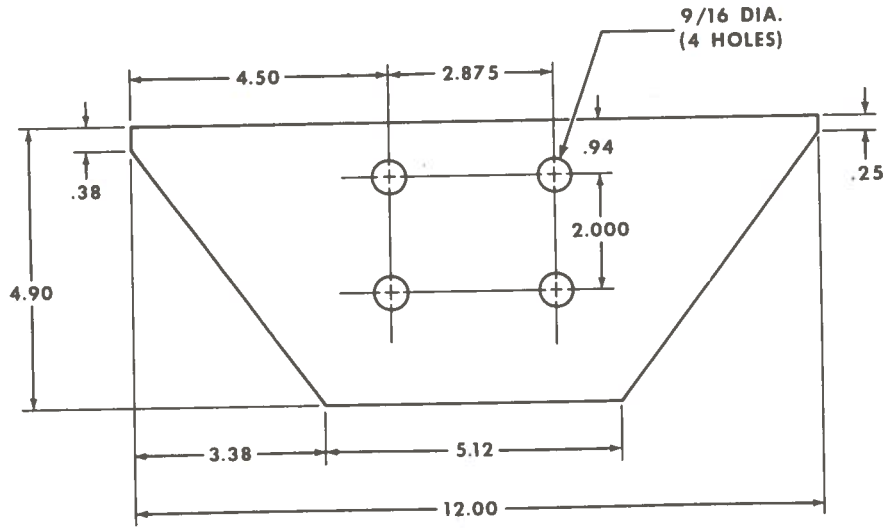


FIG. 24 BOTTOM PANEL FRONT REINFORCEMENT



#13 GAUGE (.0897) MATL. THK.

FIG. 25 BOTTOM PANEL REAR REINFORCEMENT

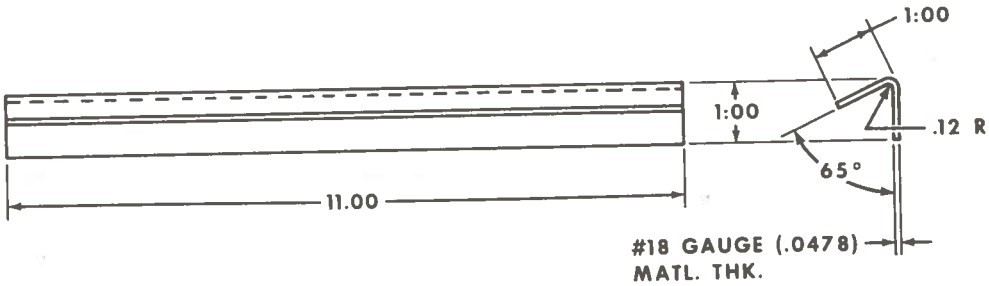
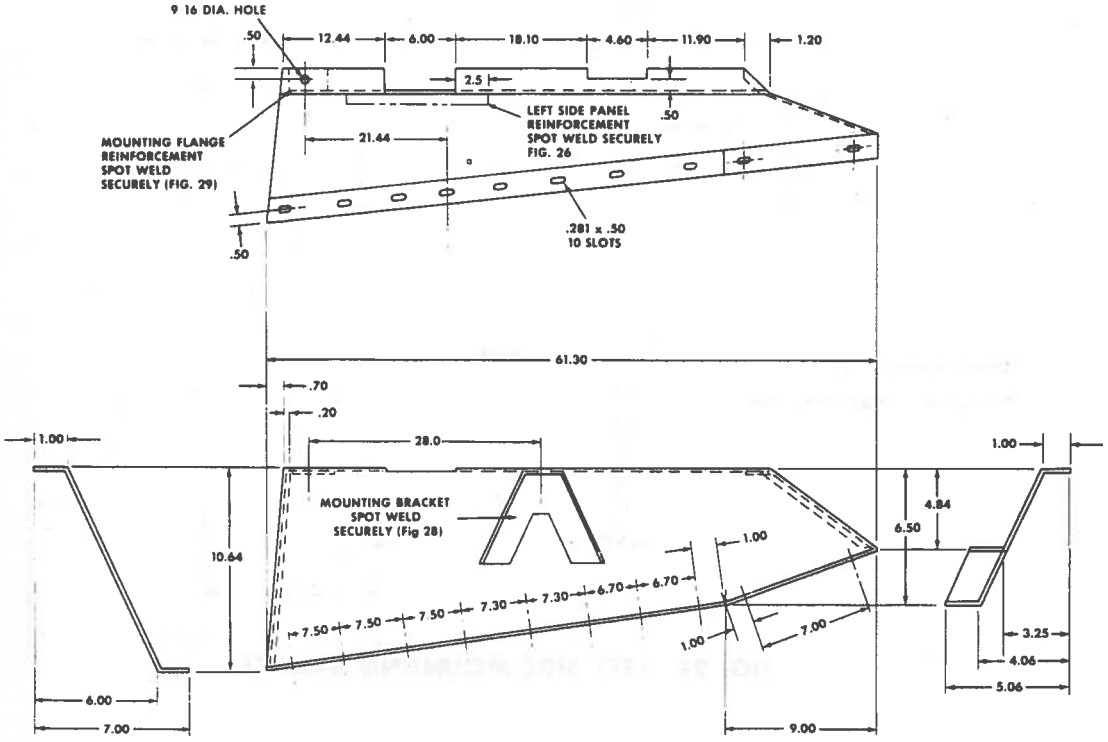


FIG. 26 LEFT SIDE PANEL REINFORCEMENT



18 GAGE (.0478) MATL THK
Bend Radius .06

Fig 27 LEFT SIDE PANEL

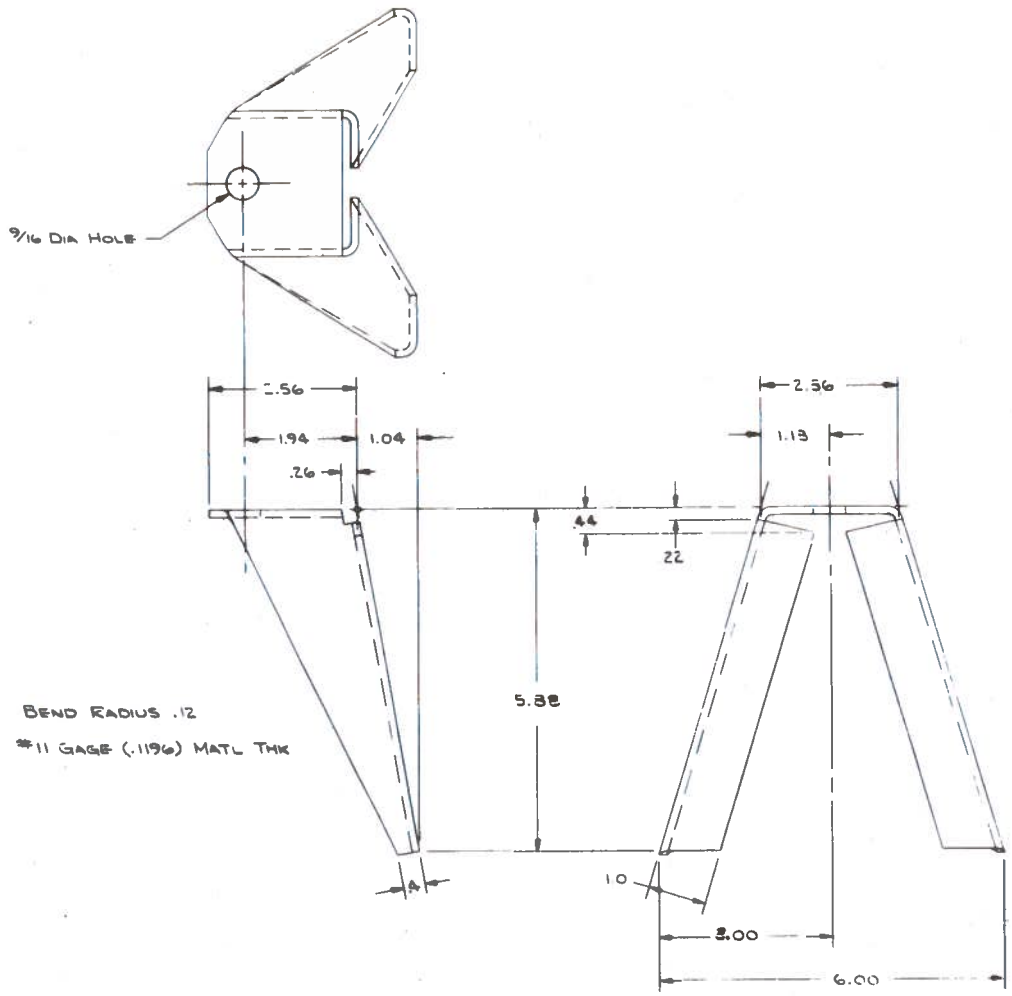


FIG. 28 LEFT SIDE MOUNTING BRACKET

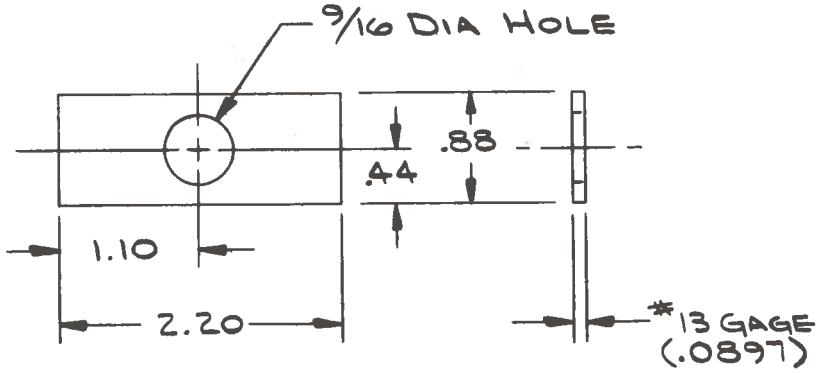


FIG. 29 SIDE PANEL MOUNTING FLANGE REINFORCEMENT

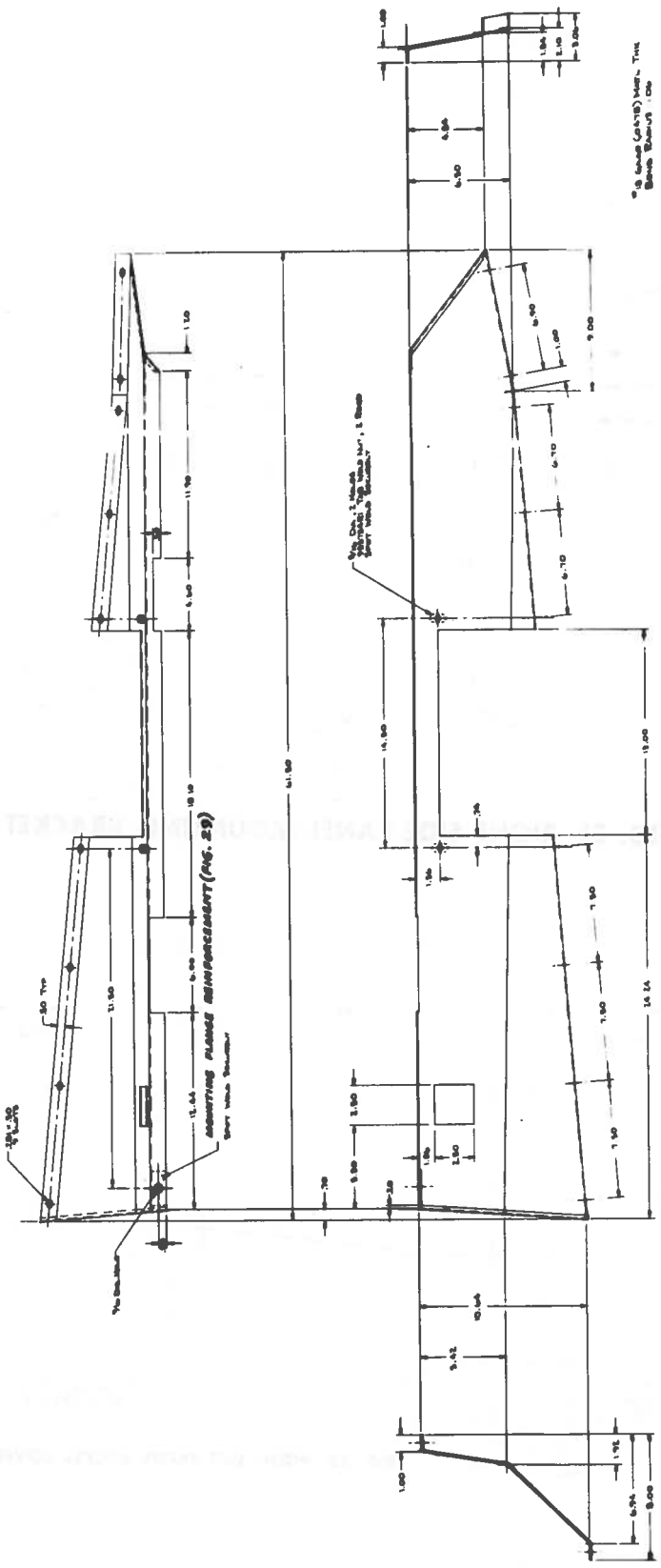


FIG. 30 RIGHT SIDE PANEL

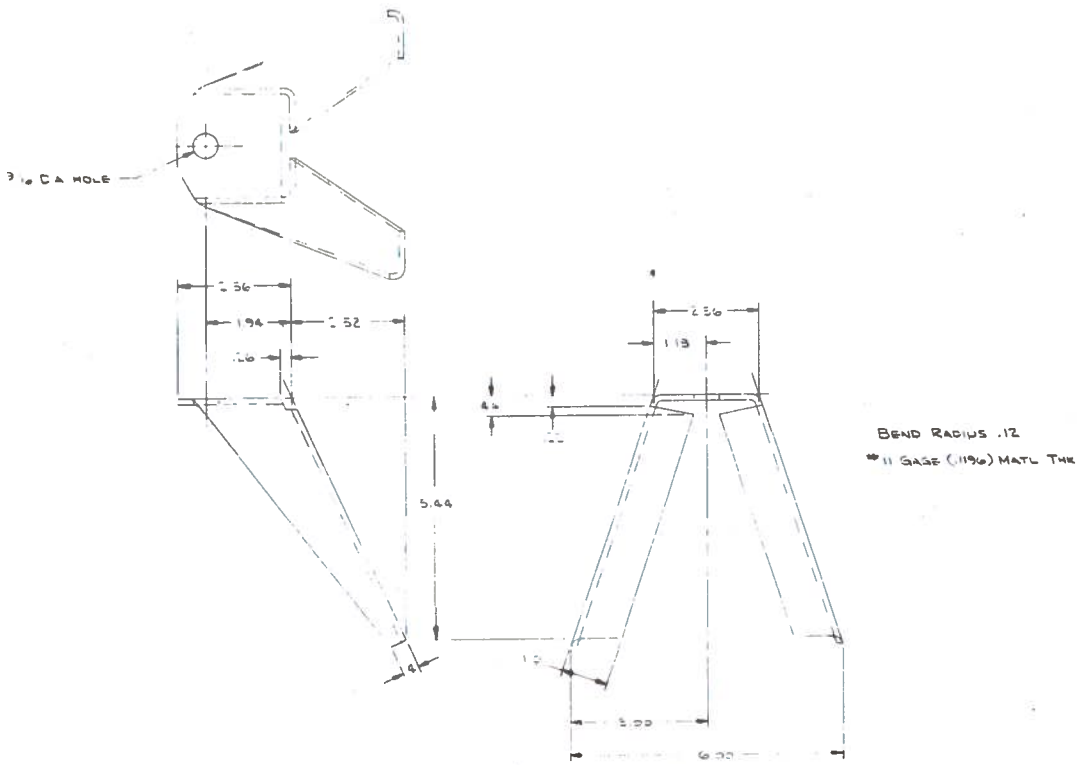


FIG. 31 RIGHT SIDE PANEL MOUNTING BRACKET

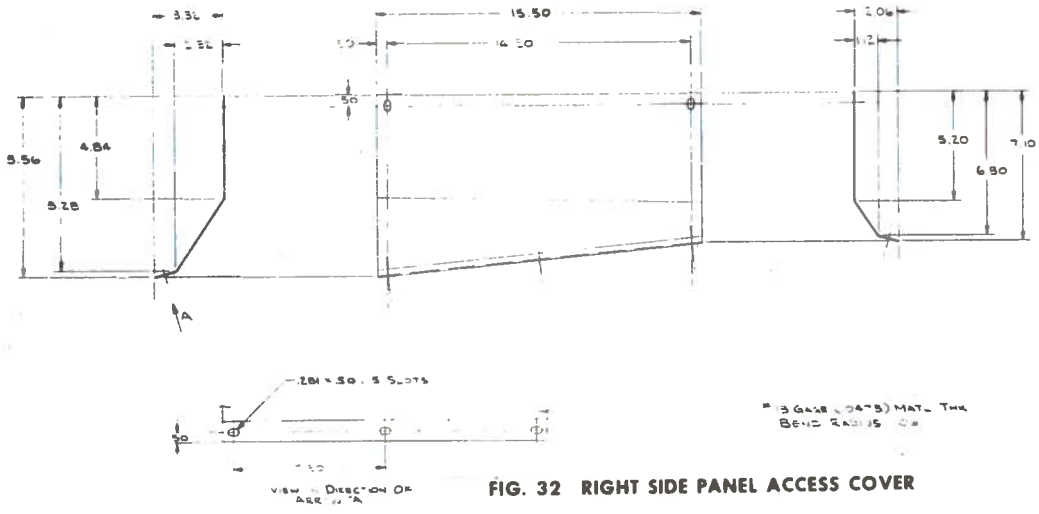


FIG. 32 RIGHT SIDE PANEL ACCESS COVER

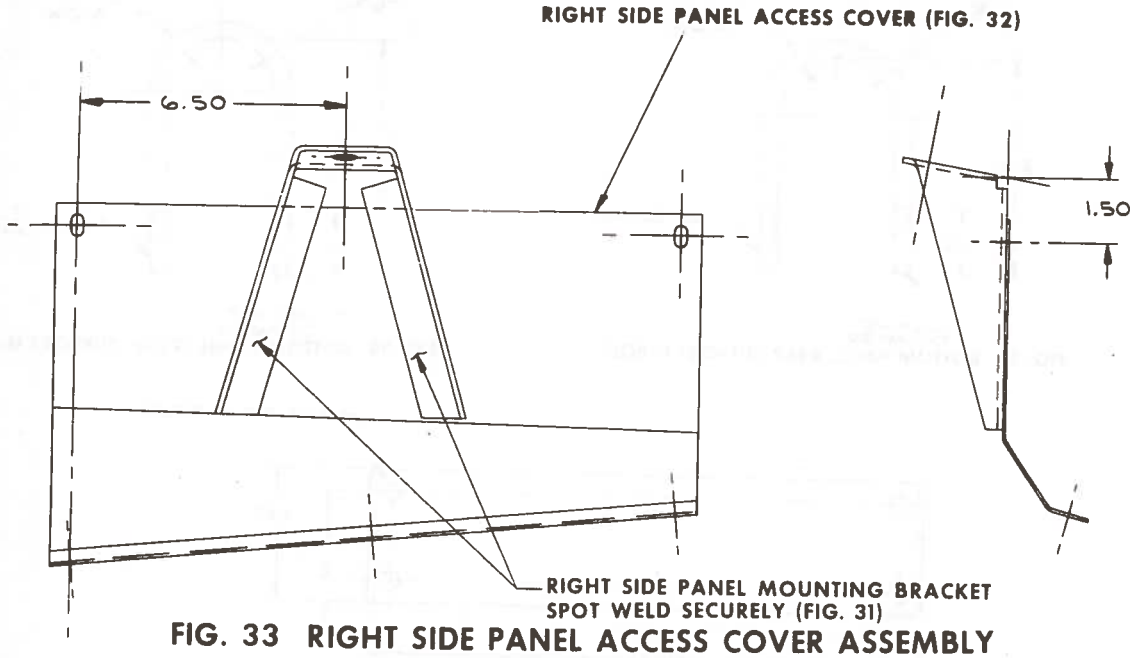


FIG. 33 RIGHT SIDE PANEL ACCESS COVER ASSEMBLY

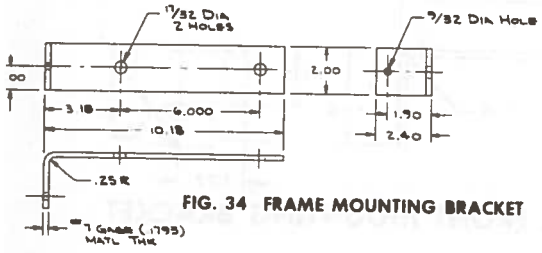


FIG. 34 FRAME MOUNTING BRACKET

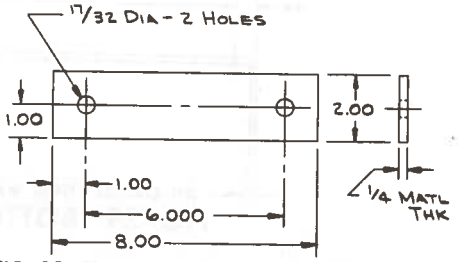


FIG. 35 FRAME MOUNTING BRACKET SPACER
(USED ON CHASSIS W/O FRAME REINFORCEMENT)

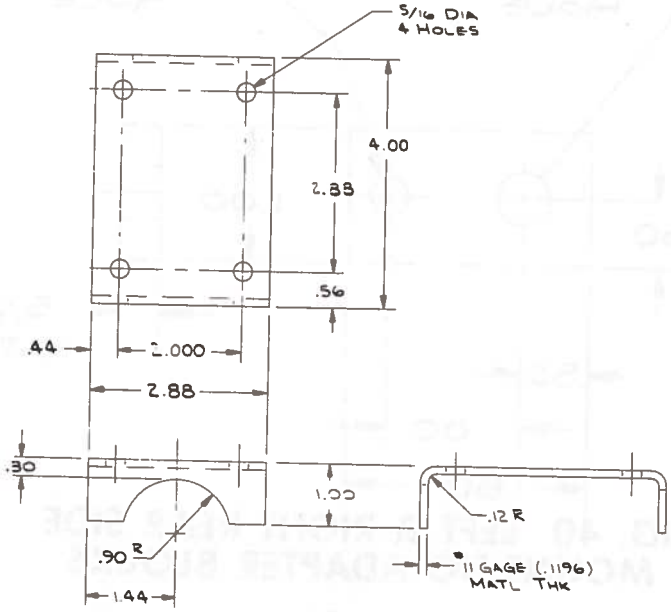


FIG. 36 BOTTOM PANEL REAR MOUNTING BRACKET

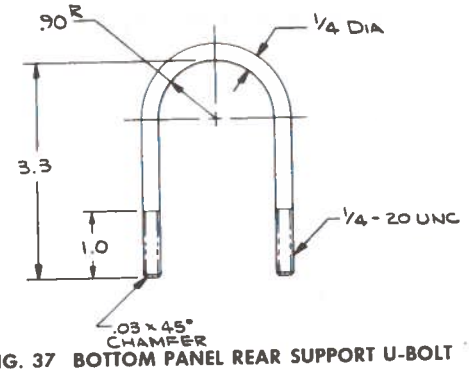


FIG. 37 BOTTOM PANEL REAR SUPPORT U-BOLT

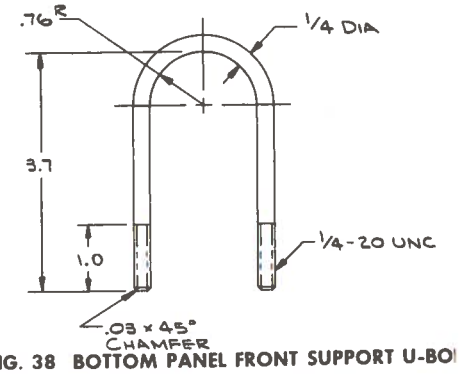


FIG. 38 BOTTOM PANEL FRONT SUPPORT U-BO

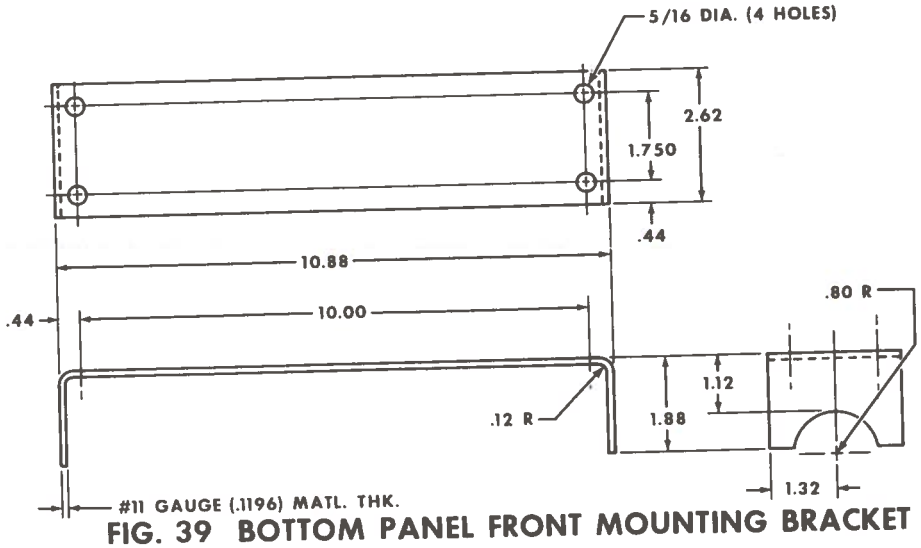


FIG. 39 BOTTOM PANEL FRONT MOUNTING BRACKET

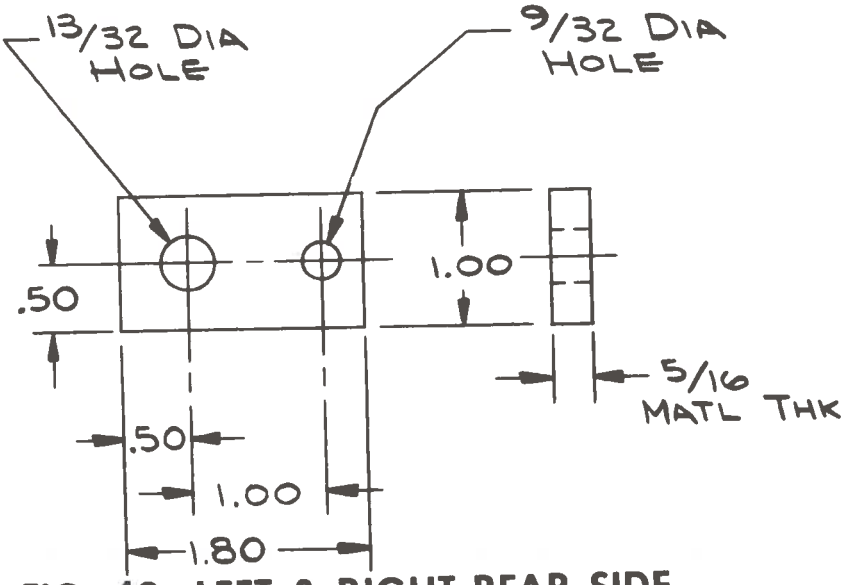


FIG. 40 LEFT & RIGHT REAR SIDE MOUNTING ADAPTER BLOCKS

Side Effects of Modifications

The exhaust back pressure with the selected exhaust mufflers has been found to be well below the engine manufacturer's specifications. Hence, exhaust modifications do not measurably affect the engine power or fuel economy. Added fan spacer on CO-4070A for optimization of fan location and shroud extension on 2000D for 100 percent fan coverage do not affect the cooling.

Installation of Cummins oil pan enclosure and block sound panels for Cummins N-series engines in CO-4070A or 2000D chassis models present problems such as:

1. Maintenance work on engine accessories.

2. Locating oil leaks.

3. Removal and installation of oil pan.

4. Oil soaked fiberglass lining, thus deteriorating its acoustical characteristics.

The bellypan installation on 2000D with 6-71N engine presents similar problems as those listed above for Cummins covers and panels, plus replacing the filter and servicing the starter, etc. The bellypan also decreases engine cooling slightly and therefore should not be installed on units operating in extremely high temperatures. The cab interior noise also increases due to bellypan.

Exhaust Modification on CO-4070A with Cummins NHC-250, NH-230 and Detroit Diesel 6-71N Engines

1. Remove the following components:

   Muffler,
   Front vertical mounting clamps,
   Tail pipe, only if equipped with curved outlet.

2. The following components are to be made locally using the illustrations provided:

   Muffler support angle (Fig. 2).
   Vertical muffler mounting, front clamps--2 required (Fig. 3).
   Muffler shield--2 required (Fig. 4).

3. Additional parts required are:

   IH No. 549483-C1 muffler assembly (Donaldson No. WTM10-0066).
   IH No. 758971-C1 pipe, tail (required on chassis when original tail pipe was equipped with curved outlet).

4. Install all parts as shown in Fig. 1.

Exhaust Modification on CO-4070A with Cummins NTC-290, NTC-335 and NTC-350 Engines

1. Remove muffler.

2. Install new muffler 467355-C1 (Donaldson No. MFM09-0249) as shown in Fig. 1.

3. If tail pipe is serviceable, cut pipe to provide a 36" length and install pipe. If tail pipe is to be replaced, install new 36" length pipe 360493-C1.

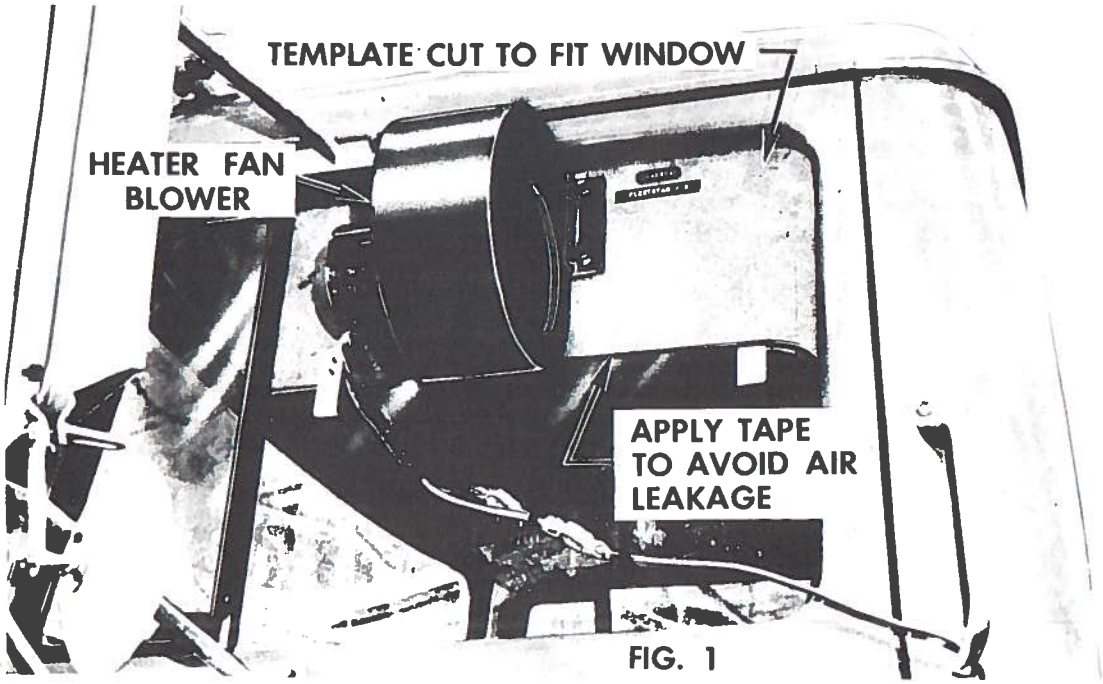
Altering cooling system components, such as a fan, fan speed ratio, radiator, shroud or shutters could have similar unfavorable effects on the cooling system or engine.

Checking all of the variables involved can become quite time consuming and costly therefore, it is recommended that regional guidance be obtained before making any such recommendations.

After eliminating excessive exterior noise, the following methods of sealing cabs from exterior noise may be performed on chassis in question. The following test and illustrations have been prepared using a 2000D chassis equipped with a 671N Detroit diesel engine as an example.

It has been found that where air can leak out of the cab, noise can enter the cab through the same openings. To locate air leaks, the cab must be pressurized by one two methods as outlined.

The best method to pressurize the cab is to use a heater-blower motor mounted in a window template such as the one shown in Fig. 1. A battery can be used to operate the blower at high speed.



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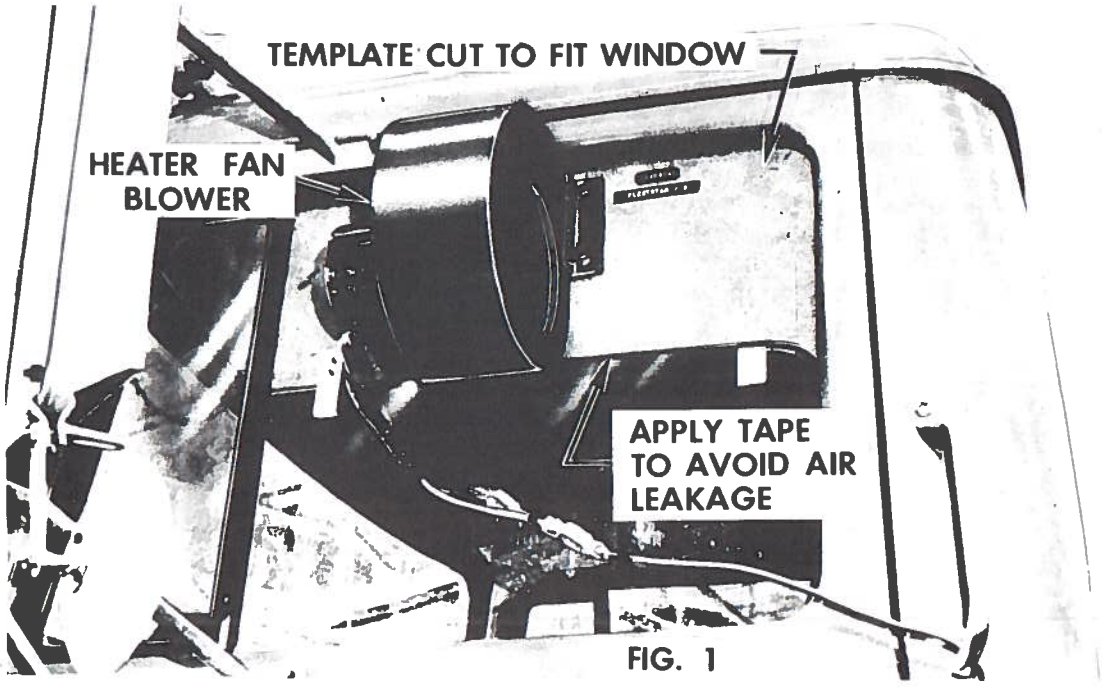

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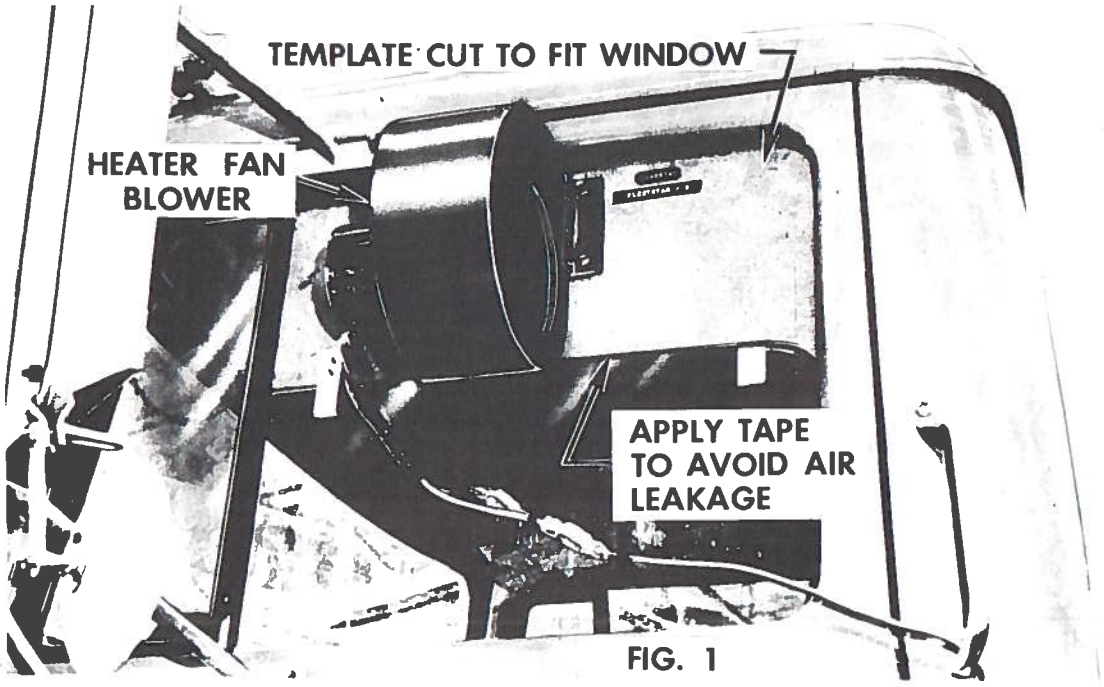


FIG. 1

The second method of pressurizing the cab--although not quite as effective as the first method--is to use the heater-blower in the cab. With the ignition switch on "ACC" position, turn heater fan "ON" and pull heater vent out.

All windows, air vents and heater vents must be closed (except heater vent in second method) and engine cover must be in place when blower is operated. Air leaks can be physically felt at different locations around and under the cab.

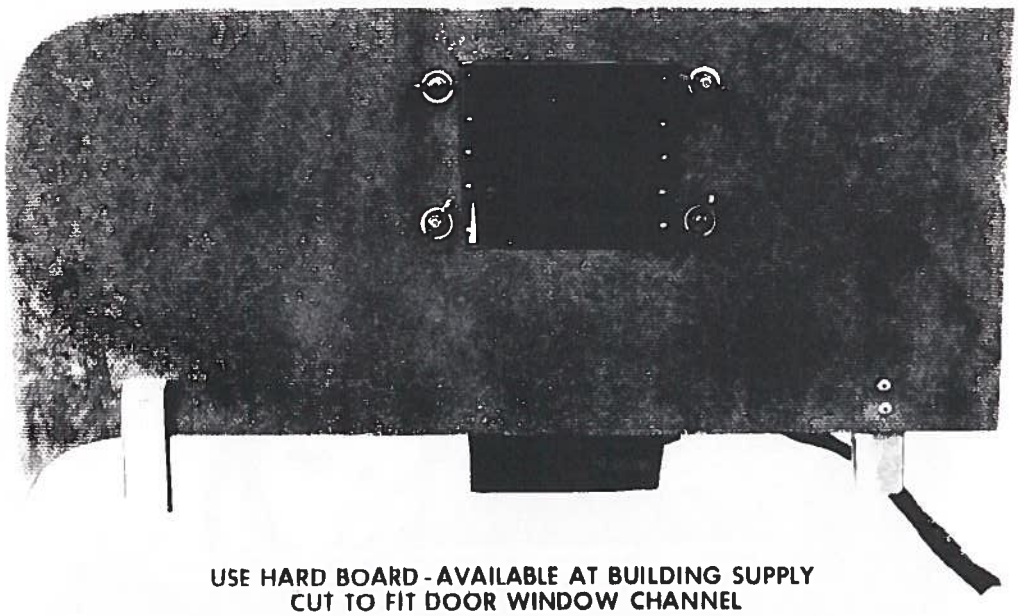
When the cab is sealed, you will note a definite change in the fan RPM when a window is opened slightly. However, if there is very little or no change in the blower RPM, the cab is not sealed tightly enough to prevent engine noise entering the cab.

If it is desired to pressurize the cab using a blower mounted in the window, it will be necessary to make a template using hardboard and cut to size. The hardboard can be obtained from any building supplier. The length of the template should be approximately twenty (20) inches to allow it to fit into the window glass channels. Use the door glass to make a pattern needed to obtain the top and bottom edge of the template configuration.

Although Fig. 1 does not illustrate tape being used on the blower assembly, masking tape should be applied--especially at the glass edge for a good, tight seal.

Fig. 2 illustrates two (2) aluminum angles riveted to the edge of the template. These angles are not mandatory since the template will be taped into place.

Before actually testing the cab, inspect the cab for all obvious openings, such as grommets that are not in place and installed where electrical wiring and air lines pass through the dash panel. Inspect door seals, clutch control shaft and steering column seals. Make sure they are in good condition. Replace any grommets or seals which are not in good condition.



USE HARD BOARD - AVAILABLE AT BUILDING SUPPLY
CUT TO FIT DOOR WINDOW CHANNEL

FIG. 2

In addition to sealing the cab, special accoustical materials were added to the test vehicle which also help in suppressing the engine noise.

It is recommended that the cab and engine compartment be cleaned thoroughly prior to performing any sealing or additions of special materials, since dirt and grease will hinder the adhering qualities of the sealing compound.

The following list has been prepared to assist in locating items which may need attention.

NOTE: When reference to "seal" is made in the instructions, use the nonhardening sealing compound.

A. Remove floor mat, both seats (complete) and engine cover.

B. Apply the fiberglass insulation material to the engine side of the engine cover using the spray adhesive, Fig. 3. Reinstall the engine cover.

C. Seal all grommets at electrical connections where air lines and control cables ent the cab, Fig. 3. Be sure to seal the electrical connectors where wires enter connectors.

D. Make sure button plugs are in place in floor. Seal any openings in dash panel and toe board--including weld nuts that are not used. Especially note the area at accelerator pedal mounting. Make certain transmission cover and engine riser sc are all in place.

E. Seal any openings at cowl outer extension panel, Fig. 3.

FIG. 3

F. Working under the cab, seal any openings at cab front mounting member at lower end of hinge pillar. Seal hinge pillars and bottom corners of cab if required.

G. Seal all openings at lower rear corner on outside of cab. Be sure to inspect seams at lower corner of cab. Seal all openings in rocker panel.

NOTE: Do not seal any drain holes (louver type openings in rocker panel). While at rear of cab check trailer plug connector adapter mounting.

H. Inspect the engine cover to riser and make sure it is sealed. Short pieces of rubber seal material can be added at corners (riser to dash panel) if needed.

I. Inspect transmission shift lever seal. Tape the seal to shift lever for a tight seal on lever.

J. After completing the foregoing sealing operations, pressurize the cab as previously instructed and inspect the entire cab by physically feeling around any openings where air can escape. If any leakage is noted, use the nonhardening sealing compound to seal leakage.

K. If the headliner is not of the perforated type with fiberglass insulation, a specially fabricated accoustical absorption type headliner along with fiberglass insulation can be installed. The fiberglass material should be of the long type to overcome possible sifting effect of material through the perforated holes in the headliner.

1. Position the fiberglass insulation in place pushing it between the roof and inner header panels. Use the spray adhesive to held the center portion while the headliner is being cut and installed.

2. Make up the new headliner using the perforated type material. Use the replaced headliner as a pattern to assist in cutting out the new headliner.

3. Cut the left and right headliner trim sections as required. Some additional trimming may be required at the points where the two radii are cut due to thickness of material.

4. Install new headliner in the same manner as the replaced headliner was retained. The 2000D headliner is installed as follows:

First position the rear portion over the edge of the rear header panel. Then bow the center portion of the headliner down so that the forward edge can be positioned over the windshield header. Release the center portion of the headliner allowing it to snap upward.

Position the right and left header trim sections in place by starting from the center of the cab and working outward toward the door forcing these sections over the door header panels. These trim sections will retain the outer edges of the center section.

L. The right and left rear pillars of cab with metal inner panels should be filled with a loose attic-type insulation to overcome noise amplification between the outer and inner panels of the cab.

A syphon type system (Fig. 4) should be used to be sure the pillars are filled.

NOTE: The headliner must be in place before blowing the loose insulation in the cab pillars.

1. Remove button plugs covering the grab handle reinforcements or drill holes in inner panels to enable insulation to be forced between the panels.

2. Fabricate the syphon using three (3) foot length of 1-1/4" I.D. rubber hose; drill a 3/16" diameter hole in the side of the hose about 14" from one end.

3. Put a slight bend about 2" from the end of a 1/4" copper tubing about 12" long Intert the bent end into the hole in the 1-1/4" I.D. hose.

4. Place one end of the hose over the insulating material in the sack and the other to the access openings.

5. Position air chuck to copper tubing and apply air to tubing. The insulation material will be drawn out of the sack and forced into the cab pillar assembly.

M. The new floor mat is to be a one-piece assembly except at the area at transmission shift lever opening cover. The cutout in the floor mat will permit transmission service without removing the entire floor mat.

1. Using all the pieces of the replaced floor mat, lay them out on the new floor mat material allowing enough material to cover the floor reinforcement channel. The new mat is to cover the entire floor with the seat risers positioned on top of the floor mat. To accomplish this, removal of complete seat assembly may be required.

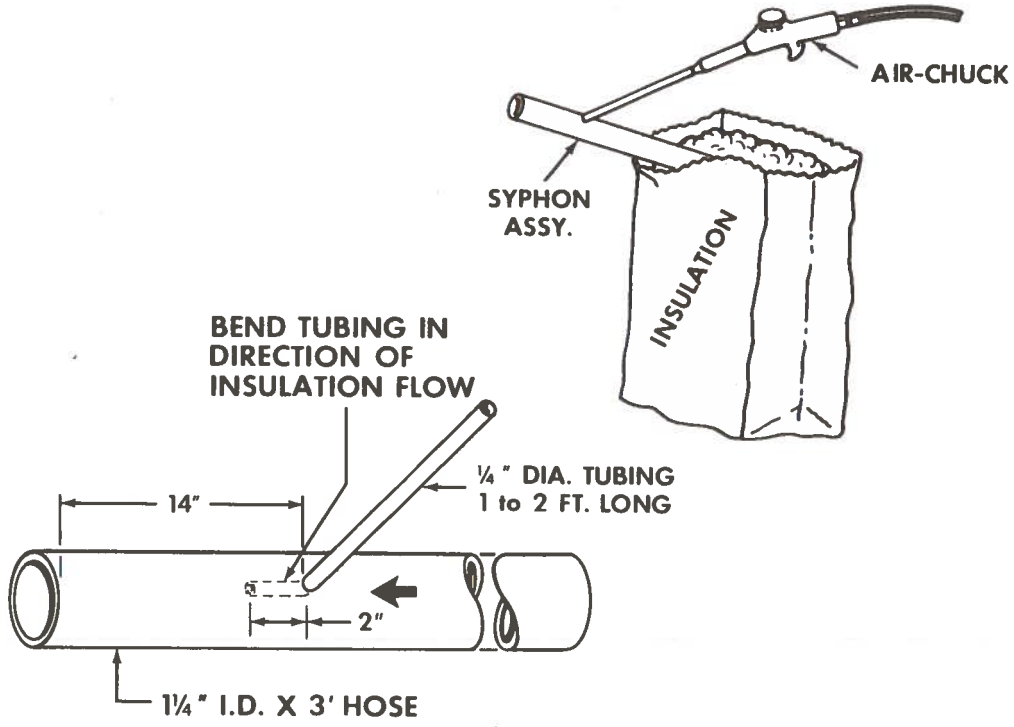


FIG. 4

2. Cut out the new mat as required.

3. Cut out that portion of the mat needed to obtain access to transmission shift lever cover.

4. Position entire floor mat in cab; also position the portion cut out for transmisstion access cover.

5. Cut pieces of floor mat retainer material to fit the access cover mat and install mat retainer with sheet metal screws.

Optional alteration to floor mat can be performed as follows:

Obtain 36 square feet of rolled roofing (not felt paper) from any buildin supplier and a piece of 36 square feet of 3/4" thick jute material. Jute material can be purchased from Ohio Rubber Company, Willoughby, Ohio 44094.

With the floor mat removed and using it as a pattern, cut both jute and rolled roofing to fit floor. Be sure to allow enough material to cover floor reinforcement channel. Make transmission shift cover access cutout.

Use the spray glue to assemble the different materials together. Small strips of rubber floor mat material will be required to cover the reinforcement channel.

N. Cowl inner panels will be covered with Blachford type "C" material cut to dimensions shown in Fig. 5 (right and left required). Slight variations to the dimensions may be required where installation is being performed on other chassis. Use the spray adhesive and install material to right and left cowl inner panels.

This concludes the complete suppression operation.

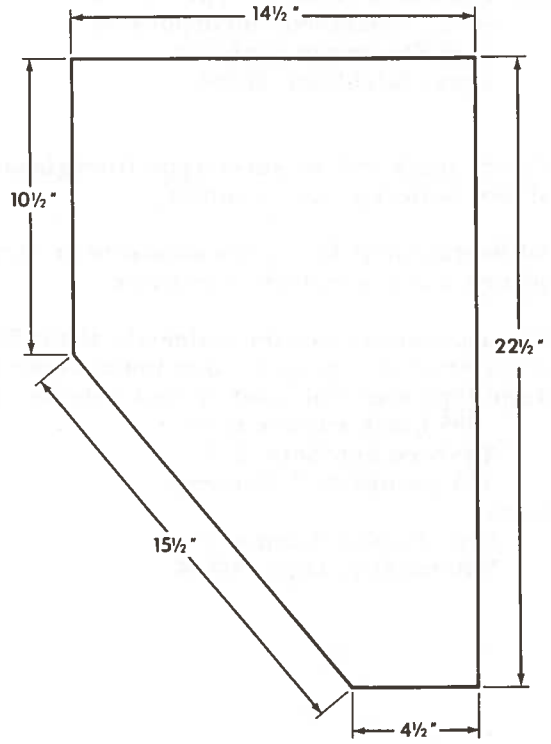


FIG. 5 COWL INNER PANEL INSULATOR
MAKE A RIGHT & LEFT (RIGHT SHOWN)

The special accoustical absorption or barrier types of materials needed to complete the engine noise suppression are:

Cab Sealing:	Use nonhardening sealing compound (dum dum) such as Mortex Sound Deadening Tape (1-1/4" x 1/8" x 30'--one roll) from: J. W. Mortell Company 550 North Hobbie Avenue Kankakee, Illinois 60901
Cab Corners (Rear):	Use attic-type loose insulation available from any building supply outlet (1/2 of a three cubic foot size bag).
Headliner Material:	Perforated hardboard per IH specifications TMS 7044 - 3837 - R - white, 3-1/2' x 6', from: Woodall Industries 7565 East McNichols Road Detroit, Michigan 48234 2" thick roll or sheet type fiberglass insulation (long type fiber--not super fine) 3-1/2' x 6', Fiberglass insulation used on test vehicle was PPG Texturfine with phenolic resin binder.
Cowl Inner Panel:	Use Blachford material type "C" (30" x 24") from: H. L. Blachford, Incorporated 1855 Stevenson Highway Troy, Michigan 48084
Engine Cover Insulation:	Use 2" thick roll or sheet-type fiberglass insulation available at any building supply outlet.
Spray Adhesive:	3M Scotch Grip #77 spray adhesive or similar type. Used to secure various materials in place.
Floor Mat:	Use accoustical barrier material; about 36 square feet (6' x 6') of material is required. See instructions for optional material. Same type material used on test vehicle--order: .095 black rubber B-40 Texture Synthetic E-8 3/4 pound/ft. 2 Deadener from: Ohio Rubber Company Willoughby, Ohio 44094

APPENDIX H

REPORT OF INVENTION

This document was prepared by International Harvester Company, Truck Division Engineering, Fort Wayne, Indiana, under contract DOT-TSC-721. International Harvester Company does not claim any patentable innovations, discoveries, improvements, or inventions as a result of the work performed under this contract.

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