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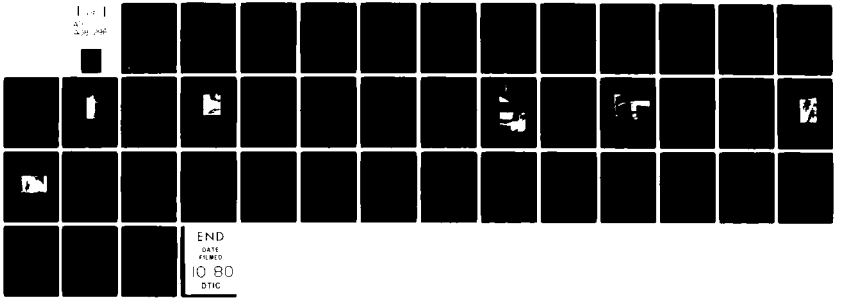

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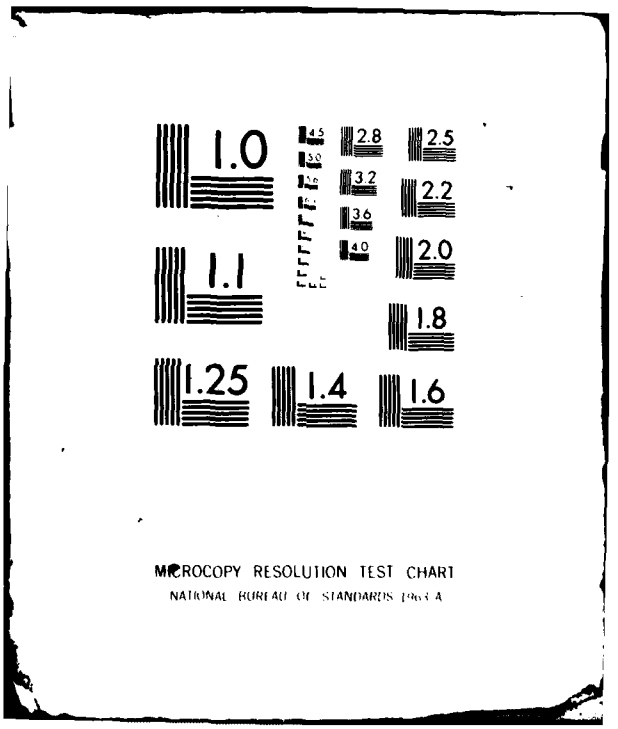
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Report TD 75297

GENERATOR EXHAUST SIGNATURE SUPPRESSION (GESS) SYSTEM MOUNTING ADAPTERS FOR THE 15 KW AND 30 KW DOD DIESEL ENGINE GENERATORS

Robert E. Wallace
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Texas Division
2201 Walnut Street
Garland, Texas 75040

June, 1980

Final Report

Distribution of this document is unlimited

Prepared for:

U.S.A. MERADCOM, ATTN: DRDME-RT (T. Steck)
Camouflage and Topographic Laboratory
Fort Belvoir, Virginia 22060

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This development was for 2 adapters to allow mounting of the Generator Exhaust Signature Suppression System (GESS) duct to 15 kw and 30 kw diesel driven generators. Adapters are mountable on these generators without any modification to the generators except removal of 13 bolts and the weather cap. Use of both adapters mounts the GESS duct in a horizontal attitude so that no hot parts of the duct are seen above a horizontal plane through the duct.

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This report describes the design of these adapters. The smaller adapter ("A" adapter) was patterned after one supplied by MERADCOM with two essential features: mounting to the generator without generator modification except the removal of small parts (bolts and the weather cap on the exhaust pipe), and provision of a lip on which to rest the GESS duct while it is being mounted. Adapter weight was to be less than 12kg.

The second ("B") adapter was experimental in nature, but was to mount the GESS duct in a down-tilted attitude so that no hot interior parts of the duct can be seen above a horizontal plane through the tip of the GESS duct.

Both adapters were to be insulated for thermal and acoustic effect.

This design effort produced two adapters satisfying the above requirements. The 8.6 kg weight of the A adapter was 28% less than the 12kg goal. Acoustic testing demonstrated that use of the adapters is acoustically compatible with the GESS System. Noise levels were measured at 25 feet from the generator exhaust end at 76.7 dBA - well below the 80 dBA limit presented in the Purchase Description for these adapters.

No thermal suppression tests were performed to assess the adapters effect thermally.

SUMMARY

The purpose of the work described in this report was to develop two adapters which make it possible to use the Generator Exhaust Suppression System (GESS) on 15kw and 30kw generators which have the same external configuration. One adapter (called the "A" adapter) was to be a refinement of a pattern adapter supplied by MERADCOM retaining two of its essential features: mounting to the generator without generator modification except the removal of small parts (bolts and the weather cap on the exhaust pipe), and provision of a lip for resting the GESS duct on to assist in GESS duct mounting. Adapter weight was to be less than 12kg.

The second adapter was experimental in nature, but was to mount the GESS duct in a down-tilted attitude so that no hot interior parts of the duct can be seen above a horizontal plane through the tip of the GESS duct. It was known as the "B" adapter.

Both adapters were to be insulated for thermal and acoustic effect.

This design effort produced two adapters satisfying the above requirements. The 8.6 kg weight of the A adapter was 28% less than the 12kg goal. Acoustic testing demonstrated that use of the adapters is acoustically compatible with the GESS System. Noise levels were measured at 25 feet from the generator exhaust end at 76.7 dBA - well below the 80 dBA limit presented in the Purchase Description for these adapters.

No thermal suppression tests were performed to assess the adapters effect thermally.

PREFACE

The work described here for adapters design and construction was authorized under Contract DAAK70-79-C-0207 from the Mobility Equipment Research and Development Command (MERADCOM). This adapters design work is associated with the continuing efforts which Varo has been involved with in design of generator thermal suppression devices and equipment. Preliminary work in duct design related to the Generator Exhaust Signature Suppressor (GESS) duct occurred in 1976 during development of equipment for the MALOR Mortar Locating Radar (now FIREFINDER) system und r contract DAAG53-76-C-0099 in 1976. Work on a small adapter to make the GESS duct fit 15 and 30 kw generators took place under contract DAAK70-77-M-3727, but its use did not remove the requirement to modify the generator for GESS attachment.

In 1978, two GESS ducts were made after minor design changes enhance producibility, under contract DAAK70-77-M-4895. It was this form of GESS duct upon which adapters design was based for the work being reported on here.

Apart from contracts with Varo, Inc., Texas Division as above, work related to this effort took place in 1978 for noise suppression of diesel generators under MERADCOM contract DAAG53-76-C-0169 to Industrial Acoustics Co., Inc. The noise control kit for 15kw and 30kw diesel generators which resulted from that work incorporated the GESS system. The pattern adapter upon which the A adapter refinement here was based was also generated under that contract and the test generator supplied to Varo for adapters development was one modified with the noise control treatment from Industrial Acoustics.

Varo wishes to acknowledge the overall guidance for these adapters development which was provided by Mr. Thomas T. Steck of MERADCOM. Mr. R. H. Laughlin of Varo monitored the development and Mr. Harry Loveless performed the detail design of the adapters under the guidance of the author and Mr. Laughlin.

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1.0 INTRODUCTION

This effort was directed at the goal of providing adapters for the 60kw Generator Exhaust Suppression System (GESS) to make it suitable for use with 15/30kw generators of the PATRIOT Air Defense Missile System. Two forms of adapters were developed - one for the main objective of coupling the GESS duct onto 15/30kw generators and the second to tip the duct down until the exposure of hot areas through the louvered opening is reduced to 0° above the horizontal.

A pattern model for the first adapter was supplied by MERADCOM which had two features which were specifically called out for inclusion in the new adapter patterned after it. They were (1) that the adapter require no drilling of holes in the generator or removal of anything but bolts in order to install the adapter, and (2) the inclusion of a lip at the bottom of the adapter upon which to rest the GESS while attaching it to the adapter after the adapter had been bolted onto the generator.

An adapter which simply permitted the GESS duct to be mounted on 15 or 30kw generators without leakage of hot air had been designed and built in 1978, but despite the small size and weight (about 35 inches x 8 inches and about 2 kg), it was judged to be unsatisfactory because it did not alleviate the requirement that generators on which the GESS would be used have holes drilled in them and the grill removed. That was deemed unacceptable due to the great reluctance of users to make any permanent modifications such as hole drilling.

In addition loss of the grill once removed was felt to be probable so that if the user wanted to restore the generator to the original condition, not wanting to use the GESS, he might find himself lacking a grill.

The Pattern adapter from MERADCOM overcame those objections and also provided a convenient lip upon which to rest the GESS duct (weighing 36 kg) while attaching it to the adapter. It, however, lacked mechanical strength in some places, was wider than necessary, and did not have any insulation inside the frame. Hot air leakage was also noted from several places as will be discussed in Section 2.0. This design effort was therefore authorized to improve the design of this adapter while retaining the two features mentioned above.

The resulting adapter is referred to hereafter in this report as the "A" adapter. The second adapter has the purpose of tipping the GESS duct down so that the opening for exhausts exit cannot be seen above a horizontal plane through the tip of the GESS. This adapter is hereafter referred to as the "B" adapter. It was to mount to the "A" adapter and permit GESS mounting in the desired orientation to reduce angular exposure of the inside of the GESS duct to horizontal viewing or below.

The two adapters are schematically represented in side view in Figure 1.

The adapters project effort can be broken down into four basic parts: hardware design, hardware fabrication, adapters testing (fit, attachment, acoustic), and report writing.

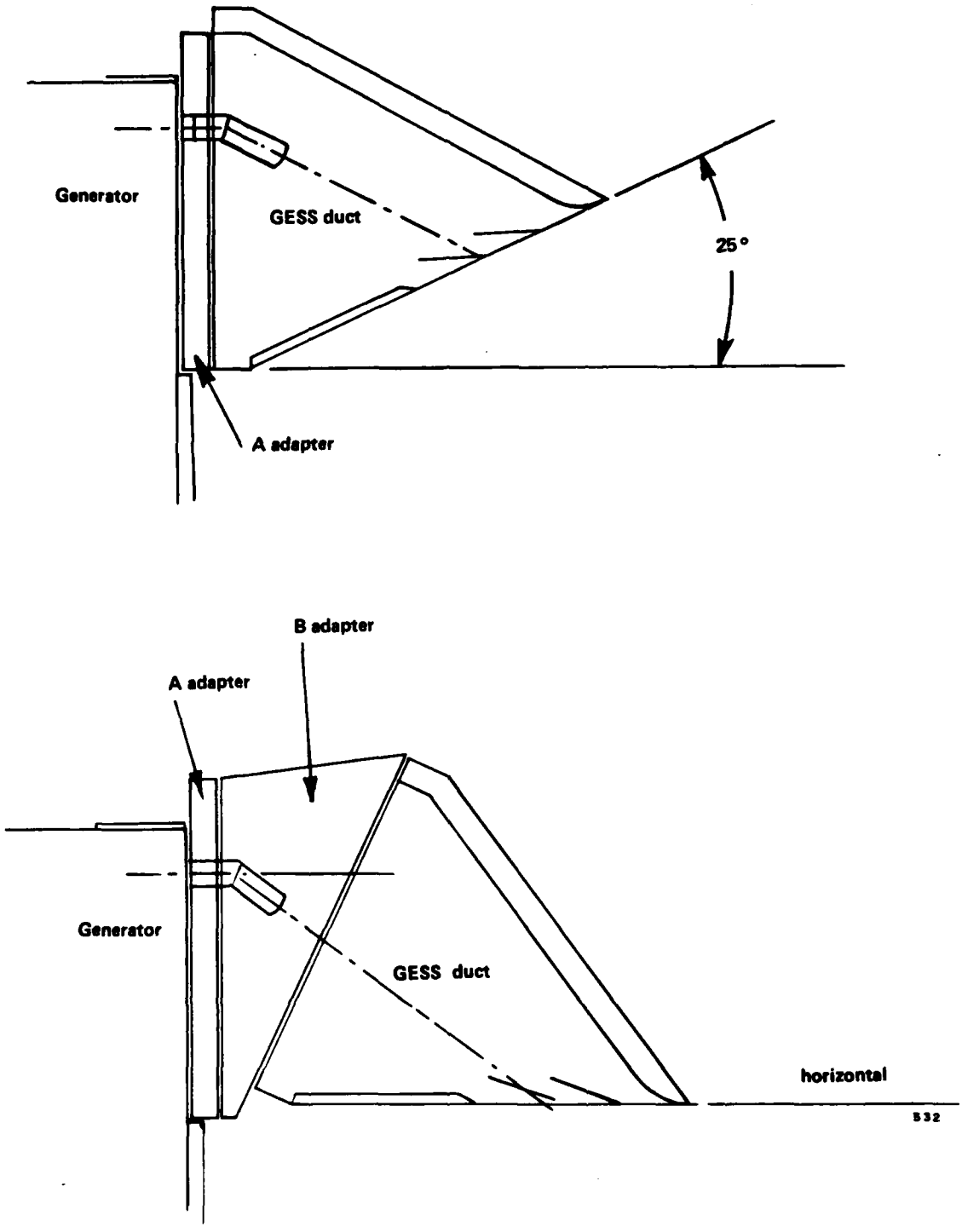

Figure 1. GESS Attachment to 15KW or 30KW Generators with Adapters A and B.

2.0 INVESTIGATION

2.1 Adapter A Design

2.1.1 Goals for Adapter A

The basic assumptions under which Adapter A was designed were mechanical and functional. As already mentioned it was to be mountable without modification to the generator (i.e. - no holes could be drilled in the generator nor could the grill be removed). The lip at the bottom of the pattern adapter was a requirement to assist during attachment of the GESS duct. A goal was set that Adapter A weigh less than 12 kg and that it be stronger than the pattern adapter. Insulation was also to be added for thermal and acoustic effect. Although thermal testing of the adapters was not in the scope of the contract, design attention was given to incorporating thermal insulation features of the GESS system into the adapters so that the adapter mounted GESS duct would function acceptably from a thermal standpoint.

2.1.2 Adapter A Description

The adapter which resulted from design to the above goals is shown in Figure 2 bolted onto the 15kw generator supplied to Varo for research. The grill does not have to be removed nor anything but bolts and the exhaust pipe weather cap removed for its installation. The resting lip is seen at the bottom and the latching system (the catch halves) at the side. The adapter was insulated around the sides and at the back of the top and across the top.

Figure 2. Completed A Adapter Mounted on a 15KW Generator

The frame of the adapter is 2.75 inches wide and the total weight (excluding the exhaust extension) is 8.6 kg, 28% lighter than the limit weight of 12 kg set as a goal.

Figure 3 shows the GESS duct mounted on the 15kw generator with the Adapter. Blanket insulation which would normally cover the adapter and generator is left off to show the adapter-GESS duct relationship.

Paragraphs to follow describe design aspects of the Adapter.

2.1.3 Strengthening and Lightening

Since the pattern adapter was made from steel, it was felt that strengthening and lightening could be accomplished by making the material choice of aluminum for the construction with thicker sections and gusseting. The deflection of beams is inversely proportional to the product of modulus of elasticity and the moment of inertia for the beam. But the moment of inertia is proportional to the height of the beam cubed. Therefore by making a beam thicker, the bending resistance rapidly becomes greater (with the cube of thickness). Aluminum is not as strong as steel (its modulus is just about 1/3 the value for steel), but the bend resistance loss incurred by going to aluminum can be readily compensated for by increasing thickness. Aluminum members made $\sqrt[3]{3} = 1.44$ thicker than steel counterparts (so that $(\text{thickness alum}/\text{thickness steel})^3 = 3$) should resist bending equally as well. Therefore by making the parts roughly half again as thick, but of aluminum rather than steel, the resulting part has about the same strength. Aluminum being only 1/3 the weight of steel thus yields equivalence in strength at roughly half the weight provided the thickness of sections is increased by about 1.5.

Figure 3. GESS Duct Latched to Adapter A on 15KW Generator

It had been noted when bolting the pattern adapter onto the generator that deflection of the mounting flange occurred. It was bent toward the front of the generator by the pull of the mounting bolt with the sealing gasket being by necessity several inches away. Therefore it was elected to place flange gussets near the upper and lower mount holes to help strengthen the mount flange. In addition and to help prevent overcompression of the sponge rubber gasket, spacers were placed on the mounting flange to limit the closure of the gap between the mount flange and the face of the generator. The spacers are designed to permit a maximum of 0.090 inch gasket compression. The use of these spacers had an unanticipated benefit it seemed in mounting the adapter. Without the spacers it was noted that the fasteners were very hard to turn for attaching the GESS to the adapter. Once the spacers were installed the force for fastening the GESS duct was greatly reduced to the planned level. That is attributed to the removal of adapter distortion induced by uneven tightening of the mount bolts without the spacers on the adapter.

2.1.4 Fastening

The fastener which was selected for the A adapter and B adapters was the same one formerly used with the GESS. No dissatisfaction with its performance had been noted earlier and tne quick release feature it lends was still thought to be desirable. This is the Simmon's "Link Lock" fastener with a spring force take-up to limit the clinch force to 80 lbs (unless bottomed out).

Gasket material was 3/8 thick x 1 inch wide silicone rubber sponge strips. They were attached to the adapters with Dow Corning RTV 732 adhesive/sealant. The surface of the

aluminum to which the gasket was to be applied was kept free of paint and cleaned with acetone as was the mating surface of the sponge gasket material.

2.1.5 Size Reduction

The pattern adapter was 3.88 inches thick with a 2 inch lip at the bottom. Conceptual attempts were made to compress the thickness of the adapter to less than an inch, but to do so would have required significant changes to the GESS duct. The internal bracing (channel braces just inside the back frame of the GESS duct) would have to have been curved so that they would not contact the radiator grill of the generator and the GESS duct itself would require slotting at the bottom to clear the grill side members. In particular, the latter modification was undesirable due to the potential for malfunction of the GESS duct due to leaking hot gases from the slot. To avoid this difficulty, it was necessary to make adapter A 2.75 inches wide, but that is still a 30% reduction in width of the adapter. Some minor changes to the outside of the GESS are still required due to the fastening catch location on the adapter being closer to the duct than formerly the case. They were deemed acceptable to keep the adapter as thin as possible since the GESS duct is not in production.

2.1.6 Thermal Effects and Considerations

The primary function of the GESS system is that it provide exposed surface temperatures which are near ambient levels. Preliminary investigative testing revealed that the pattern adapter had temperatures 10° to 25°C greater than on parallel GESS metal surfaces. Insulating the adapters was a

requirement of the contract at the beginning and this result supported the requirement. Because the GESS duct is already insulated and the thermal load from exhaust gases was anticipated to be similar, the same insulation thickness and type was selected for the adapters. That insulation was a silica/alumina ceramic fiber batt with good insulating performance and good acoustic absorption. It was retained in the adapter with 20 gage perforated aluminum sheet (50% open) riveted onto one inch thick spacers, the same type retaining as for the GESS.

These spacers which hold the perforated inner skin in place over the insulation were made of fiber glass reinforced plastic (FRP) chosen over aluminum because of the difference in thermal conductivity. Aluminum has a conductivity about 60 times higher than the value given for the FRP spacers.

Another thermal factor which was examined was the sealing of the adapter to the generator and to the GESS duct. Since a preliminary adapter was supplied by MERADCOM as a pattern, it was available for leak testing. It was mounted to the generator and the GESS duct attached and the generator started and run in different conditions of louver opening. These louvers control the cooling air flow depending on coolant temperature. They are opened automatically during normal operation of the generator as it warms to operating temperature, by means of a linkage.

Leakage was noted from slots at the bottom of the adapter (which are necessary to clear the side members of the radiator grill) once the louvers had opened roughly one-third or more. From the closed position to about 1/3 open, outside air was drawn in through the slot openings due

to the creation of a region of negative pressure inside the adapter/duct system at the slots. Since hot air ejection from the slots was pronounced with the louvers open full (condition of hottest exhausts through the GESS duct), it was regarded as important that this leak be treated in the new adapter design. It was determined that elimination of the slots was not possible in the new adapter as a solution to this leakage. A workable solution was to attach a rubberized fiberglass fabric patch across slots also provided in the new adapter. Figure 4 is a photograph of the bottom of the new adapter with the slot on the left side extending through the frame up to the lip angle at the back. Figure 5 shows the rubberized fiber glass fabric patch in place of over one slot with the adapter mounted on the generator. Because the fabric is both thin and flexible to some extent, it permits the adapter to be slid in with the slots around the side members of the grill and the patch passing under the grill side members back to the gasket.

Leak testing after completion of the adapter demonstrated successful prevention of leakage from the slots by this method.

Another leak source was discovered at the same time at the upper row of mounting holes in the adapter. The gasket line between the pattern adapter and the generator was just below that row of mount holes. Oversize holes in the adapter (to accomodate differences in hole patterns between different generators probably) were not filled by the bolt neads used to mount the adapter and hot air escaped out these holes. It would contribute unnecessarily to heat load on the bottom of the blanket just above that position when the blanket is attached in place to the top of the GESS duct.

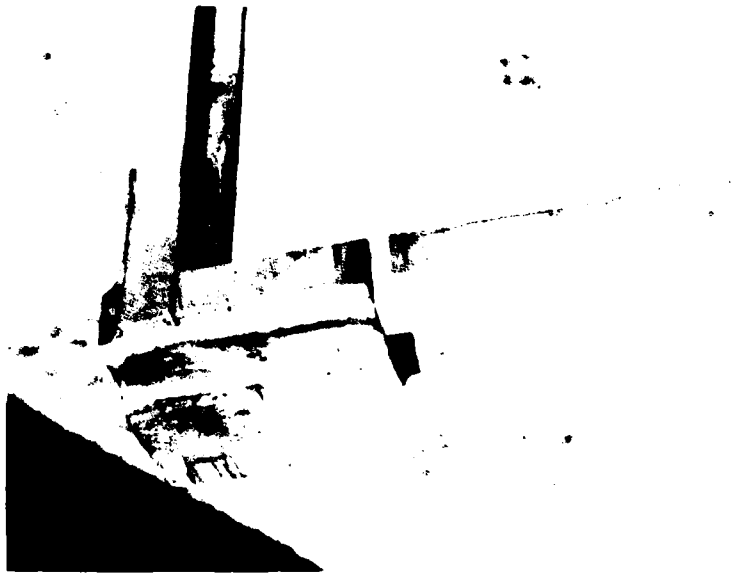

Figure 4. Radiator Grill Clearance Slot in Adapter A at the Bottom–One Side

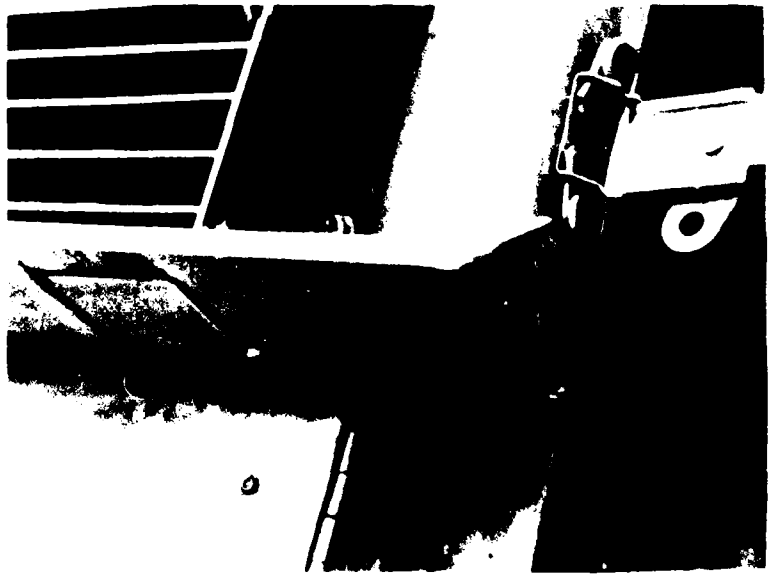

Figure 5. Rubbersized Fiberglass Fabric Patch over Radiator Grill Clearance Slot in Adapter A for Sealing

This matter was addressed in the new adapter design by moving the gasket upward placing it right across the mounting holes. That necessitates punching holes in the gasket but it was found that a one inch wide gasket is adequate to provide proper sealing around the holes.

As with the side mounting flanges of the adapter, spacers were placed at the top row of mount holes to avoid over-compression of the gasket and get even spacing of the adapter from the generator at the top. Without the spacers it was found that the torque necessary for proper gasket compression is much less than one normally tightens bolts so that gasket overcompression is likely. Furthermore, engine vibration may cause backing out of the bolts if they are only tightened sufficiently to compress the gasket the proper amount without spacers anyway. The spacers used along the top row of mount holes were thinner than the side spacers because there is already a sheet metal overlap at the top. Greater compression of the gasket was designed in there so the plane of the mounting surface of the adapter was maintained parallel to the main surface of the generator below the top inch where the overlap occurs.

Figure 6 shows a close-up of the side of the A adapter where the exhaust extension passes. A cut-out was required for clearance there since the exhaust is so close to the side of the generator. The figure shows the cut-out. To insure that the hot exhaust pipe will not contact the aluminum frame at the side of the adapter, a fiberglass reinforced standoff was positioned in the cut-out region to act as a bumper. It protrudes above the depth of cut-out about 1/16th inch so that it will contact the exhaust extension before the aluminum frame will. Having a thermal conduc-

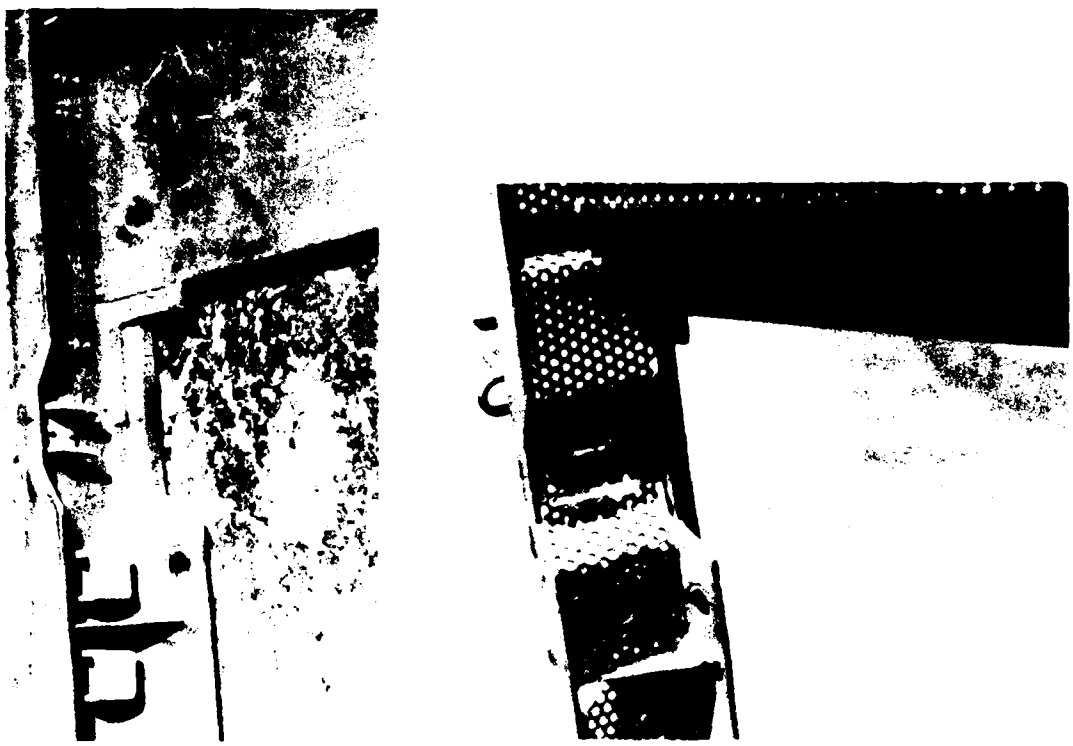

Figure 6. Cut-out in A Adapter Side Frame for Exhaust Extension Clearance

tivity about 1/60th that of aluminum it will avoid the heat flow to the side of the adapter which would take place if the exhaust extension were permitted to contact the adapter side. That contact is potentially a problem because the position of the exhaust pipe is not closely located with respect to the clearance hole for the exhaust pipe in the radiator section skin. The mechanical link follows the chain: exhaust pipe to muffler to engine to engine mounts to generator base frame to radiator frame to the radiator section where the clearance hole for the exhaust pipe is located. That long series of mechanical connections is likely to produce enough uncertainty in exhaust pipe location to cause the exhaust extension to touch the side of the A adapter in some cases, and so the insulating bumper was provided.

2.2 Adapter B Design

2.2.1 Goals for Adapter B

Adapter B is experimental in nature with the basic goal of mounting the GESS in a down tilted attitude so that none of the hot interior parts of the GESS can be seen above a horizontal plane through the tip of the GESS. There might be, however, secondary heating of the ground due to the ejection of hot gases downward as a result of this tipping down of the GESS. The degree of severity of ground heating or other secondary heating which may result is not known, and that is why the B adapter is experimental.

This adapter, like adapter A, was to be insulated for thermal control of surface temperatures. No weight limita-

tion was imposed, but similar construction techniques to those used in making the A adapter were followed so that the B adapter would be relatively lightweight also.

2.2.2 Description of Adapter B

Figure 7 is a photograph of adapter B latched in place on adapter A. The B adapter is a sheet aluminum weldment with insulation on the inside very similar to adapter A insulation. The complete B adapter with insulation and fastening latches weighs 19.7 kg.

Figure 8 shows the GESS attached to the B adapter. No opening is exposed above the horizontal. As for the A adapter a lip or shelf was provided to rest the GESS duct on during attachment. It should be mentioned that this photograph does not show any blanket or jacketing on the adaptes although they would be an indispensible part of the suppression system with the GESS duct. Both adapters must be covered in the same way as the GESS with blanket or jacket insulation in addition to that provided inside the metal skin of the adapters in order to get proper nighttime thermal suppression.

Insulation inside the B adapter is identical to that in adapter A except in the top section where an additional layer of fiberglass insulation is added to build up the insulation to the same level as for the GESS. The insulation is in fact of identical type and thickness to that in the top of the GESS - one layer one inch thick of

Figure 7. Adapter B Latched to Adapter A on 15KW Generator

Figure 8. GESS Duct Latched to Adapter B

silica/alumina fiber batt (8 lb/ft^3) just under the perforated metal sheet to the inside, and another inch thick layer of fiberglass batt (3 lb/ft^3) next to the outside skin of the adapter. The reason for use of the silica/alumina fiber batt to the inside of the adapters is primarily prevent any possible burning or "punking" of the insulation in the forced draft environment. There have been observations of occasional ejection of incandescent particles from diesel engine exhaust which could ignite fiberglass insulation if they were to lodge on it.

Since the B adapter mounts directly on the A adapter, where the GESS duct would mount if the B adapter were not in use, the same fastening system as for the A adapter and GESS must be used. Similarly the GESS must mount on the tilted face of the B adapter so that the fastening system there must mirror that on the A adapter. Thus the Simmons "link lock" catch and striker were used again.

2.3 Exhaust Extensions for Use with Adapters A and B

It was found in earlier design work with the GESS system that an important part of the flow control was redirection of engine exhaust gases toward the opening of the GESS duct by means of an exhaust extension. Experience showed that exhaust impingement on interior surfaces of the GESS duct caused excessive thermal loading there if allowed.

For the present adapters work analysis indicated that two exhaust extensions would be needed - one for each GESS duct configuration (normal and tilted down). Figures 9 and 10 show the two exhaust extensions with the angles of bend and twist which aim the exhaust at the center of the duct opening.

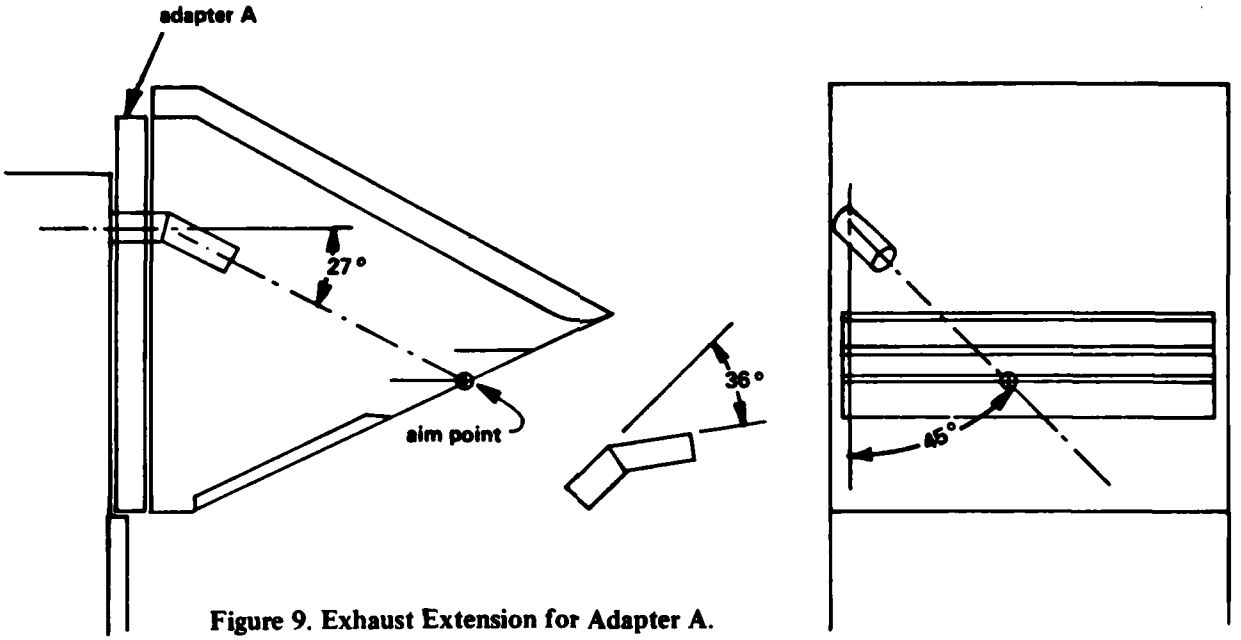

Figure 9. Exhaust Extension for Adapter A.

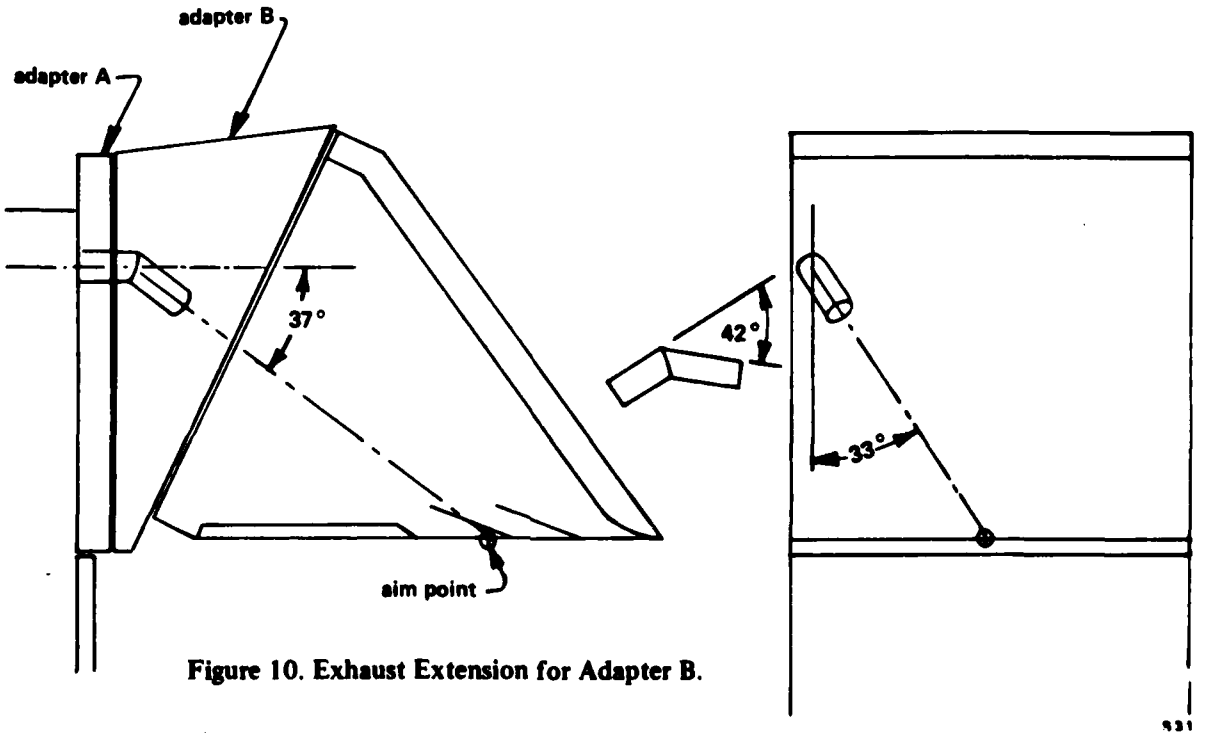

Figure 10. Exhaust Extension for Adapter B.

To force the installer to properly align the exhaust extensions, a mounting flange at the base of the extensions was designed with vertical slots which align with two existing holes in the sheet metal around the exhaust. It may be necessary to loosen the two mounting bolts holding the muffler assembly to the engine exhaust manifold so that the exhaust pipe will move to the proper position for mounting the exhaust extensions (aligning the two slots with two holes in the sheet metal face of the generator). With the exhaust extension in place the two muffler assembly mounting bolts should then be retightened.

The A adapter exhaust extension which was built from the first set of drawings was found to be too short for simple installation of the GESS duct. Although there is no interference between the extension and the internal duct bracing once the duct is in place on the adapter, difficulty was experienced while maneuvering the duct into place due to interference with the extension. The drawings were changed to lengthen the extension one inch before the bend. It is believed that this change will alleviate the installation problem.

2.4 GESS Duct Design Modifications for Compatibility with Adapters

The GESS duct itself was also modified in the drawings for compatibility with the A and B adapters. As a consequence of making the A adapter thin, the fastening catch, which was centered on the thinner adapter, was moved 0.40 inch closer to the GESS duct than was the case before. So the mating part (striker) on the GESS duct had to be moved back. That required relocation of the holes for mounting the striker

and increase in the size of the clearance cut-out in the side skin of the GESS duct at the bottom. At the top of the GESS duct no direct changes in the basic form were needed but the striker plate (plate on which the strikers for vertical and down pull are placed) was changed to accomodate the move back. Therefore, this different striker plate assembly must be used at the duct top to make the GESS fasteners compatible with the new adapters. That plate is also moved upward by one set of the holes in the side of the GESS duct frame to the top set of holes (4.5 inch apart). Those holes already exist so no new holes are needed at the top to mount the modified striker plate assembly on the GESS duct.

A little strengthening of the striker plate was built in after observation of bending during attachment of the GESS when the down pull latch was secured. The plate was widened slightly and a radius added at the plate corner at the bend.

2.5 GESS Blanket Design

2.5.1 GESS Blanket and Duct Jacket Changes

Several factors were involved in the need for blanket design changes. One was that the use of adapter A pulls the blanket which covers the generator forward by the thickness of the adapter. In addition, it had been found in past testing that the large generator blanket was not long enough to cover the rear most portions of the generator which are warm. Tests had also shown that the side cover jacket sections for the GESS duct were not sufficiently insulative. They needed to be made thicker to increase the resistance to heat transfer.

Finally, there were two difficulties with the area below the duct. The large generator blanket up to now has had two ear flaps sewn on which fold around the generator once the blanket is draped over the generator and link together in front of the battery compartment door to cover them. Sewing effects however were found to cause position errors in the ear locations which made the fit to the generator poor. There had also been a problem with clearance for the battery compartment doors to open past the bottom panel of the GESS duct jacket. Both these difficulties it was felt could be addressed by eliminating the ears on the large blanket and lengthening the bottom duct jacket so that it bent around to cover the battery compartment doors in place of the blanket ears. The bottom duct jacket panel would then be simply removed to access the batteries.

Then there was the new jacketing system which was required for the B adapter so that it may be used as an independent section with the GESS blanket and duct jacket system. Changes to the large generator blanket were the elimination of the ears, increasing the length from 56 to 63 inches, and the placement of a two inch wide loop tape attaching flap along the entire front (toward the GESS duct) edge of the blanket. This flap with loop tape on the forward edge serves to attach the blanket to hook tape on the duct (or B adapter) jacket and to hook tape on the bottom panel of the GESS duct jacket where it bends down to cover the battery compartment doors. The large blanket thus becomes simpler. It is just a rectangle with an attaching flap all along one edge.

Use of the GESS duct bottom jacket panel to cover the battery compartment doors required that it be readily removable to provide access to the batteries. In prior use, it had been attached with hook and loop tape directly to the

metal skin of the GESS duct and then the side jacket panels for the duct attached over the top of the bottom jacket panel. The necessary changes in attachment were made so that the side jacket panels attach directly to the metal GESS duct and the bottom jacket panel attaches outside of the side jacket panels and is therefore, easily removable when the batteries must be serviced. It was also extended in length so that it will cover the battery compartment doors as discussed before.

Modifications to the duct side jacket panels were made to make the attachment shift from over to under the bottom jacket panel and to enclose one added layer of 1/4 inch thick insulation foam. Hook tape for attaching the large generator blanket was also lengthened for more secure fastening of the blanket, to the GESS duct jacket.

2.5.2 B Adapter Jacket Design

Three jacket pieces were also designed for use with the triangular B adapter. They are made in much the same construction as the GESS jacket pieces with size and shape changes to fit the B adapter. The same number of insulation layers was used as for corresponding pieces of the duct jacket. Hook tape was provided where needed so that the blanket will attach to the B adapter jacket in much the same way it attaches to the GESS jacket pieces. The B adapter jacket was made in sections because the thickness required for proper insulation is not compatible with the tight bends needed to fit the adapter if the jacket were made in a single piece. That is basically the same reason the GESS duct jacket was made in four sections.

2.6 Acoustic Tests on the Adapters with the GESS Duct and Blanket

The generator which was supplied to Varo for use with the GESS and adapters was a 15 kw diesel driven set which had been modified by Industrial Acoustics Corp. for noise control features. Side doors for access to the generator and engine sections were replaced with thicker insulated doors faced with perforated metal inside. Short panels below the doors were also treated the same way. The air intake grill was also replaced with a silencing louver.

The generator was fitted with adapters, GESS duct and blanket for acoustic testing and the generator situated in the door of the storage building in which it was housed. Electrical load was maintained at 70% or 100% while sound pressure levels were measured at 25 feet from the generator. The measuring instrument was a GenRad model 1982 Precision Sound Level Meter and Analyzer. Figures 11 and 13 depict the site and give results in dBA.

It may be noted that the measurement situation was not optimum from several aspects. First, the siting of the generator partially inside a building could have affected the reading. It was not trailer mounted and therefore, was just about four inches off the floor. The asphalt road in front of the generator may also have increased readings somewhat, asphalt being a more acoustically live surface than grass. However, all measurements were well below the 80 dBA limit stated in the contract with either the A adapter and GESS duct or with both adapters and the GESS duct for both tests.

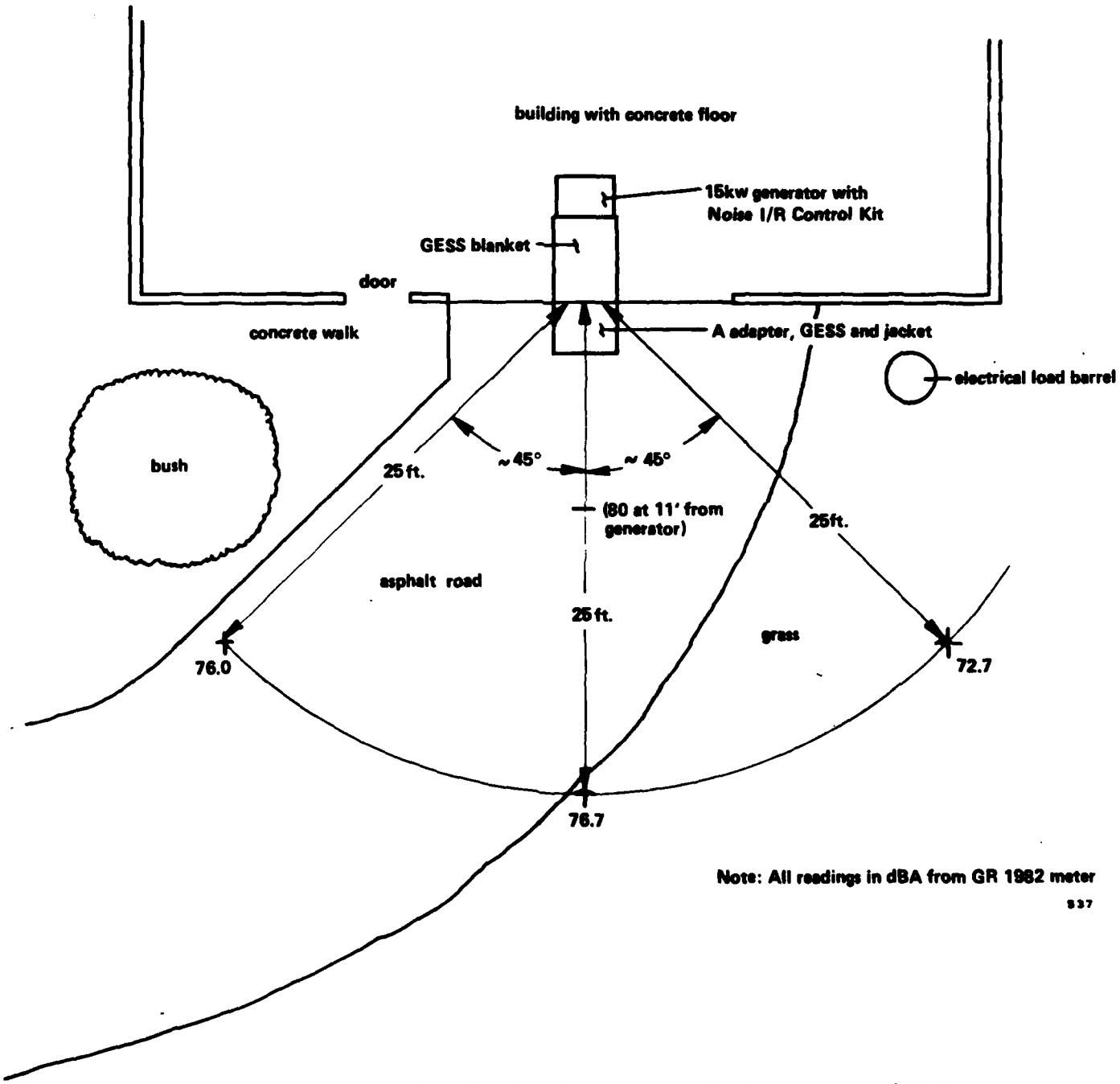

Figure 11. Sound Pressure Level Readings for Generator with A adapter and GESS Generator at 70% Load. Test Run on 4/18/80.

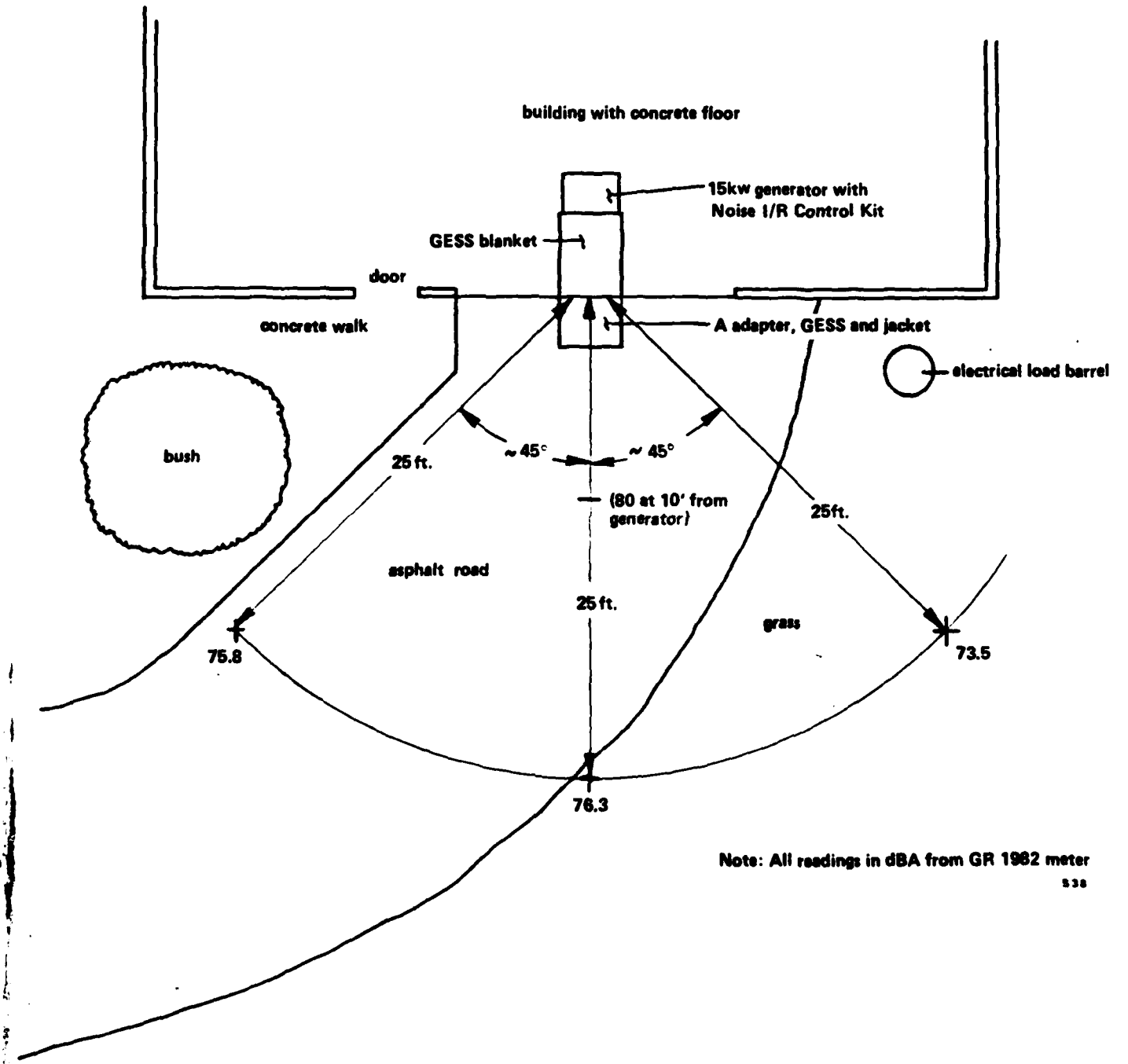

Figure 12. Sound Pressure Level Readings for Generator with A Adapter and GESS. Generator Load 100%. Test Run 4/18/80.

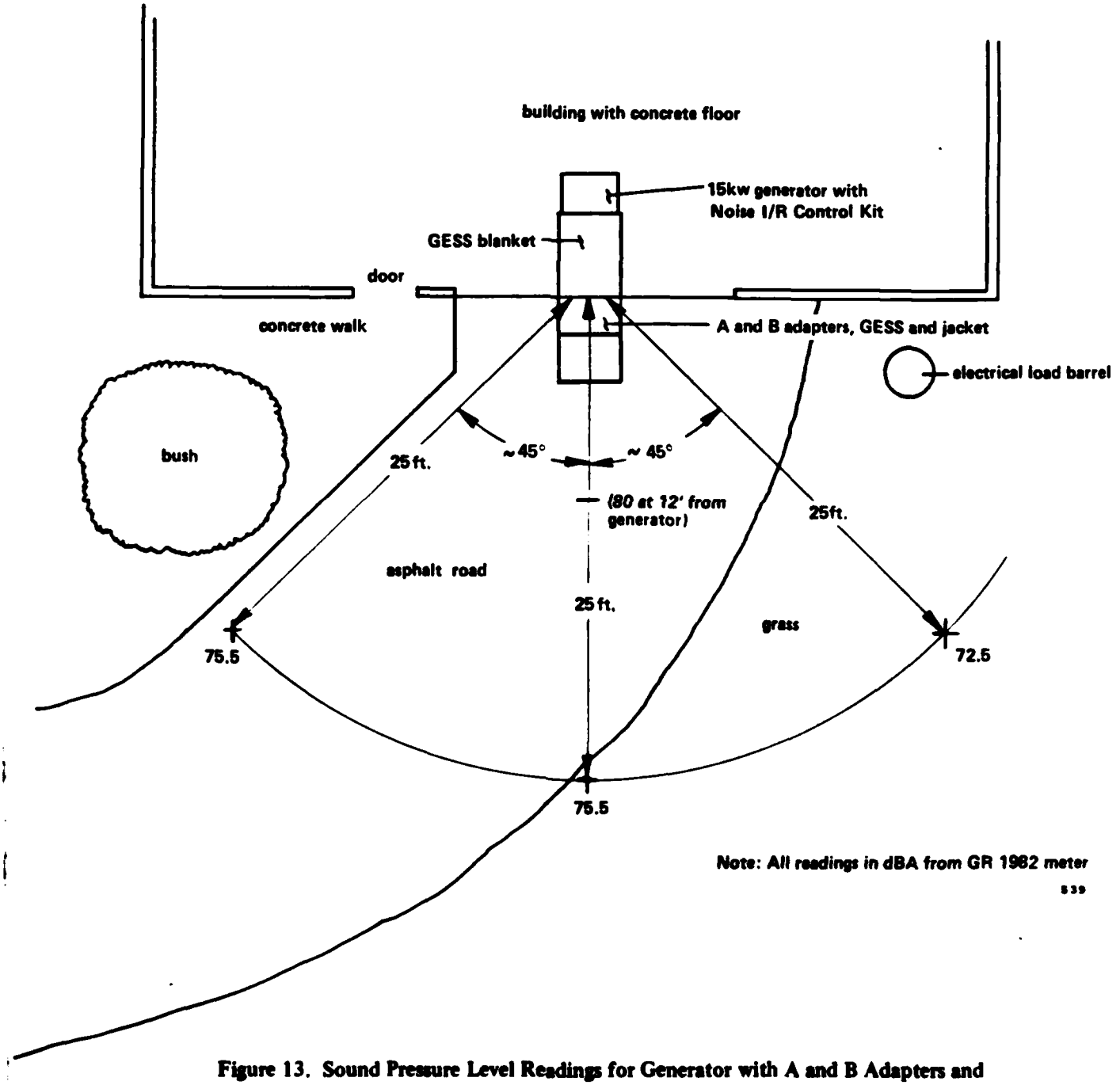

Figure 13. Sound Pressure Level Readings for Generator with A and B Adapters and GESS. Generator at 100% Load. Test Run on 4/18/80.

On the basis of this testing, it is projected that the adapters perform satisfactorily in regard to acoustic suppression with the GESS kit on the 15 kw generator as modified with the acoustic suppression doors, side panels and louver air intake.

3.0 DISCUSSION

Dimensional difficulties were experienced when the first parts were received from the vendor. Then it was ascertained that the pattern adapter drawing from which mounting hole locations were taken for design of the new adapter was in error although the adapter supplied to Varo had a correct hole pattern for mounting. The pattern adapter however, was prepared with gasketing on both sides and the supplied GESS duct had no gasket at all. That affected the sealing relationship between the A adapter and the GESS duct since the gasket must be applied to the duct (as required for compatibility with 60 kw diesel generators). Different areas were used for sealing when the pattern adapter was joined to the duct compared to the case in which the gasket is attached to the GESS duct and then mated to the new adapter. That resulted in the A adapter being slightly too short for optimum sealing to the GESS duct although the seal is adequate. Therefore, no change was made in the adapter furnished at the end of the contract, but modification to the drawings for the A adapter were made to increase the height for optimum seal.

Another difficulty was noted with the A adapter in frame squareness and twist. Notes were added to the drawings to control those factors. It is probable that some of this problem developed when four gussets were welded into the A adapter frame after having been accidentally omitted by the vendor for the first delivery.

Since there has been more than one GESS duct design during dvelopment of the GESS, is should be kept clear that the present adapters are designed to be compatible with the

latest GESS duct design resulting from contract DAAK70-77-M-4985 in 1978 (after the modifications indicated in section 2.4 of this report have been made). The duct supplied to Varo was not one of those although the differences are not great. The area of difference which causes some problem is the location of bolts on the bottom of the duct frame. Bolt heads of the duct were supposed to drop into holes provided in the B adapter lip put there to assist the duct installer. The lip is designed into the B adapter as in the A adapter to help support the weight of the GESS duct while it is being latched. Because of the slant at which the duct is mounted there was some concern that the duct bottom might slip forward off the lip and that is the reason why holes were placed in the lip. They were to allow the bolt heads protruding from the bottom of the duct to drop into the lip and prevent the duct from slipping off the lip. That objective could not be properly evaluated since the GESS duct provided has the holes in a different location from those in the lip (designed for the newer duct). There did not seem to be any special difficulty in holding the duct in place, however, without the assistance of the holes over the bolt heads, so that feature may possibly be omitted.

One fact it is felt must be emphasized is that the blanket and jacket sections are not optional parts of the GESS system. Insulation provided inside the metal skin of the GESS duct and the adapters is not sufficient to present surface temperatures near enough to ambient levels for adequate thermal suppression. The blanket and jacket sections must be in place on the exterior for proper nighttime thermal control.

4.0 CONCLUSIONS

The two adapters which were designed and built under this contract meet the original goals for performance mechanically and acoustically. The A adapter weighs about 30% less than the weight limit set at the beginning of the effort. Both adapters are readily installable by one man. The A adapter mounts to 15 kw or 30 kw diesel generators which have the same radiator/exhaust configuration as the MEP 113A (NSN 6115-00-118-1244) 15 kw generator by removing 13 bolts. It is not necessary to drill any holes or remove the radiator grill for this installation. Only the exhaust weather cap must be removed to install an exhaust extension.

The B adapter mounts to the A adapter in quick release fashion just as the GESS duct attaches. Both adapters provide a resting lip upon which to set the base of the GESS duct to facilitate attachment. Sealing around the interfaces between adapter A and the generator, between A and B adapters, and between the B adapter and the GESS duct is good allowing no significant hot air leakage so that all exhaust flows are ejected out the designed opening in the GESS duct.

5.0 RECOMMENDATIONS

Thermal testing is needed to invesigate whether the resistance to heat transfer afforded by the insulated adapters is adequate for thermal suppression effect. It must be noted that this testing must include blanket and jacket sections for all items in the test - i.e. blanket and GESS jacket with the A adapter and GESS duct, and blanket, B adapter jacket, and GESS jacket with the A and B adapters and GESS duct.

Secondary heating effects from the exhaust stream should be investigated with the generator in its normal position for various wind conditions - no wind, wind opposing the exhaust flow and wind aiding the exhaust flow (exhaust with the wind).

Should any production of GESS ducts be entered into in the future, the changes in fastening on the sides of the duct which are discussed in section 2.4 of this report should be made if compatibility with the adapters developed in this effort is desired.

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