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ENGINEERING EVALUATION AND ANALYSIS FOR THE IMPROVEMENT OF
MILITARY STANDARD GENERATORS

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31 July 1987

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Fort Belvoir, VA 22060-5606

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<p>This report presents the analyses and design of specific modifications to the MIL Standard Diesel Engine Driven (DED) generator sets (15,30 and 60 KW). Design improvements targeted towards improving reliability and maintainability are presented. Heavy duty slides were added to the battery tray to allow an extension of 12" out from the existing design. Tee handle latches have been selected to improve door sealing after repeated use. Soft isolation mounts were selected to withstand the impact of an 8 mph rail impact. The throttle was relocated to the control panel to facilitate noise attenuation modifications. A low coolant impedance sensor was added to the set to prevent damage to the set from operation with low coolant levels.</p> <p>Use of a different engine exhaust muffler for reduced sound signatures has an accompanying new exhaust outlet location and orientation (vertical).</p>			
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After evaluation of manufacturers' engine data obtained during a market surveillance, the Hercules D3400-T engine was recommended for installation & testing as a replacement engine for the 60 KW DED set.

Modifications resembling the Regency Net Sound attenuation design were adapted to the 15, 30, & 60 KW DED sets. These modifications include sound insulation, engine air intake silencer, engine exhaust muffler, and cooling air intake and exhaust baffling.

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Summary

This report presents the analyses and design of specific modifications to the MIL Standard Diesel Engine Driven (DED) generator sets (15, 30, and 60kw).

Design improvements targeted towards improving reliability and maintainability are presented. Heavy duty slides were added to the battery tray to allow an extension of 12" out from the existing design. Tee handle latches have been selected to improve door sealing after repeated use. Soft isolation mounts were selected to withstand the impact of an 8 mph rail impact. The throttle was relocated to the control panel to facilitate noise attenuation modifications. A low coolant impedance sensor was added to the set to prevent damage to the set from operation with low coolant levels. Use of a different engine exhaust muffler for reduced sound signatures has an accompanying new exhaust outlet location and orientation (vertical).

After evaluation of manufacturers' engine data obtained during a market surveillance, the Hercules D3400-T engine was recommended for installation and testing as a replacement engine for the 60kw DED sets.

Modifications resembling the Regency Net Sound attenuation design were adapted to the 15, 30, and 60 kw sets. These modifications include sound insulation, engine air intake silencer, engine exhaust muffler, and cooling air intake and exhaust baffling.

PREFACE

This engineering evaluation and analysis was prepared under Contract No. DAAK70-86-D-0023, Task Order No. 0076, for the Belvoir Research, Development and Engineering Center (Belvoir), Fort Belvoir, Virginia.

The required effort contained in the task order statement of work is quoted below.

"Review, analyze and evaluate GFD for the Military Standard 15 kW, 30 kW, and 60 kW Generator Sets identifying known or potential deficiencies and recommend solutions.

- (1) Battery compartment to improve maintenance.
- (2) Existing paddle latches on access doors.
- (3) Soft mounts to reduce noise and vibration. The design should allow generator set to withstand (without damage) the railroad impact test specified in MIL-STD-705, Test Method 740.5 up to and including 8 mph impact.
- (4) Exhaust outlet.
- (5) Relocation of Manual Throttle Control.
- (6) Low coolant protection.

Any recommended design or redesign shall conform to the Human Factors Engineering Design Criteria described in MIL-STD-1472, as applicable.

Perform a market survey to address the objectives of AR70-1 (paragraph 8-4) of commercial engines for the possible re-engining of the Military Standard 60 kW Diesel Engine Driven (DED) Generator Sets, MEP-006A, MEP-105A and MEP-115A. From information acquired from this market survey, select the best candidates for utilization as a replacement engine. In determining the adequacy of the candidate items the following criteria shall be considered:

- (1) Weight reduction
- (2) Improved reliability and maintainability
- (3) Vibration and noise level reduction
- (4) Low and high temperature operation
- (5) Electromagnetic interference
- (6) Control
- (7) Form and fit within existing generator envelope and interface with remaining generator components.

Review and analyze GFD on the sound attenuation design of the Regency Generator Set for application on the 30 kW and 60 kW DED, 60 and 400 Hz; and 30 kW DED, 400 Hz Military Standard Generator Sets. Identify design deficiencies and recommend solutions."

1.0 SCOPE

1.1 Scope. This evaluation and analysis of the Military Standard Generator Improvement Program considered generator set sizes 15 - 60 kW, Diesel Engine Driven (DED) configurations. The basis for the evaluation and analysis consists of Regency Net Sound Attenuation Data, equipment improvement recommendations (EIR's) from the field, quality deficiency reports (QDRs) and recommendations by industry based on VSE Corporation's survey letter to industry for the possible re-engining of the 60 kW Diesel Engine Driven (DED) Generator sets, MEP-006A, MEP-105A and MEP-115A. Generator set technical data reviewed included, but was not limited to technical manuals; military specification MIL-G-52884, their individual equipment subsets; military standards MIL-STD-633 and MIL-STD-1332.

1.2 Purpose. The purpose of this engineering evaluation and analysis is to identify designs/redesigns and/or improvements that are valid and feasible, both in time and cost effectiveness, which can be applied to the 15-60 kW generator sets with the goal of improving their operational reliability, availability, and maintainability (RAM), and enhancing survivability through the use of noise suppression.

1.3 Objectives. For the purpose of this evaluation and analysis the following tasks were considered for evaluation.

- o Market survey for the possible re-engining of the 60 kW Diesel Engine Driven (DED) generator sets.
- o Modification of the battery compartment for improved maintenance accessibility.
- o Replacement of existing paddle latches on access doors to improve sealing.
- o Installation of soft mounts to reduce noise and vibration.
- o Relocation of the exhaust outlet to correspond with the incorporation of a quieter muffler.
- o Relocation of the manual throttle control for ease of set operation.
- o Installation of a low coolant protective device for improved maintainability and availability.
- o Installation of improved sound attenuation baffles.

The design/redesigns under consideration are presented and the status of these installations/modifications are reviewed. Conclusion and recommendations will be provided upon completion of all tasks.

1.4 Background. The Army's MIL-STD Generator Improvement program is the on-going process of improving the development, procurement value, production engineering, and logistical support required to operate and maintain an effective mobile generator fleet. While there are numerous improvement programs of diversified scope and application, certain elements serve as baseline factors in all generator improvement programs. Among these are weight reduction, electromagnetic pulse protection (EMP), and enhanced survivability. Programs such as the Army's EIR and QDR maintenance documentation collection, industry surveys, and current requirements documents, all contribute in identifying valid potential changes for adaptation in the generator fleet. In order to effectively analyze and evaluate those ideas and suggestions which may have merit, conceptual exploration programs, prototype development, and limited production contracts are funded to investigate their potential for procurement. These programs, as this report will demonstrate, run the gamut from the replacement of items as simple as door latches to the complexity of sound attenuation techniques and the re-engining of military equipment. The ultimate goal of any of these programs, simple or complex, is to provide the Program Manager with a reliable analysis of potential improvements. This report details the preliminary results of VSE's analysis of those items detailed in paragraph 1.3. Each design/redesign change and/or modification is explained and the current status of the item is discussed. The intention of this report and its supporting documentation is to assist in the identification of those improvements suitable for adaptation to the overall military generator program.

2.0 TREATMENT DISCUSSION

2.1 60 kW DED Re-Engining Survey. It has been documented in numerous reports that the engine currently utilized in the 60 kW DED set is no longer available through the manufacturer, Allis-Chalmers. This non-availability, coupled with increasing maintenance and associated costs, resulted in the Program Manager directing a market survey be conducted to evaluate candidates for a replacement engine. In order to concentrate on those engine assemblies which offer the highest confidence level for successful integration, certain criteria were defined as mandatory program objectives. These included specific horsepower ranges at given operating rpm parameters, weight limitations, form and fit within the existing engine envelope, minimal

impact on the military supply system, and manpower requirements.

VSE Corporation, on behalf of the U.S. Army Belvoir Research, Development and Engineering Center (Belvoir), Fort Belvoir, Va, contacted fifty-four potential engine suppliers for the purpose of identifying candidate replacement engines for the 60 kW DED generator set. Each supplier was sent a letter request, including performance specifications and a dimensional envelope drawing. Sixteen suppliers responded to the survey either by letter or telephonically. Eight of the sixteen respondents had engines which were selected for further analysis and evaluation on the basis of meeting minimum horsepower requirements and weighing less than the original engine. These engines were further weighted against the following criteria:

- o Engine must fit in envelope.
- o Engine must fit existing mounting points.
- o Engine must have a 24 volt dc cranking system.
- o Engine must have a variable speed mechanical governor.

As a result of this analysis, reported in detail in Appendix 1, the Hercules, model D-3400T was the only engine that best met all criterions used for selection.

VSE Corporation recommended the acquisition, installation and testing of the Hercules D-3400T to determine the suitability of this unit as the potential replacement engine for the 60 kW DED generator fleet.

2.1.1.1 Human Factors Engineering 60 kW Engine Replacement Evaluation. As the existing engine for the MIL-STD 60 kW DED was no longer in production an extensive market survey was performed to find a suitable replacement. The White (Hercules) D-3400T was selected as the most suitable candidate. This engine, as currently proposed, will fit the existing envelope of the current housing and mates with the existing generator set trunnion mount without special modification. The selection of this model also has the desirable feature of being listed within the government supply system. Spare and repair parts are currently listed and maintained in the supply system.

There are areas that require additional evaluation (after further testing and analysis) once the engine is procured and the prototype is developed. The items listed below are representative of the areas which will require further study:

- o How do noise levels compare between the existing unit and the Hercules?
- o How extensive are the modifications required to mate existing housing/frame components with their respective fittings and mounting locations on the new engine? (i.e. exhaust routing, fuel fittings and lines, silencers, wiring harnesses)
- o Are special tools and/or test equipment required?
- o Are personnel protected from safety hazards? (i.e. rotating equipment, exposed circuitry)
- o Will special and/or additional training be required for operation and maintenance?

At this stage of the program the Hercules engine appears to be a suitable replacement for the 60 kW generator sets while presenting no new safety/HFE hazards.

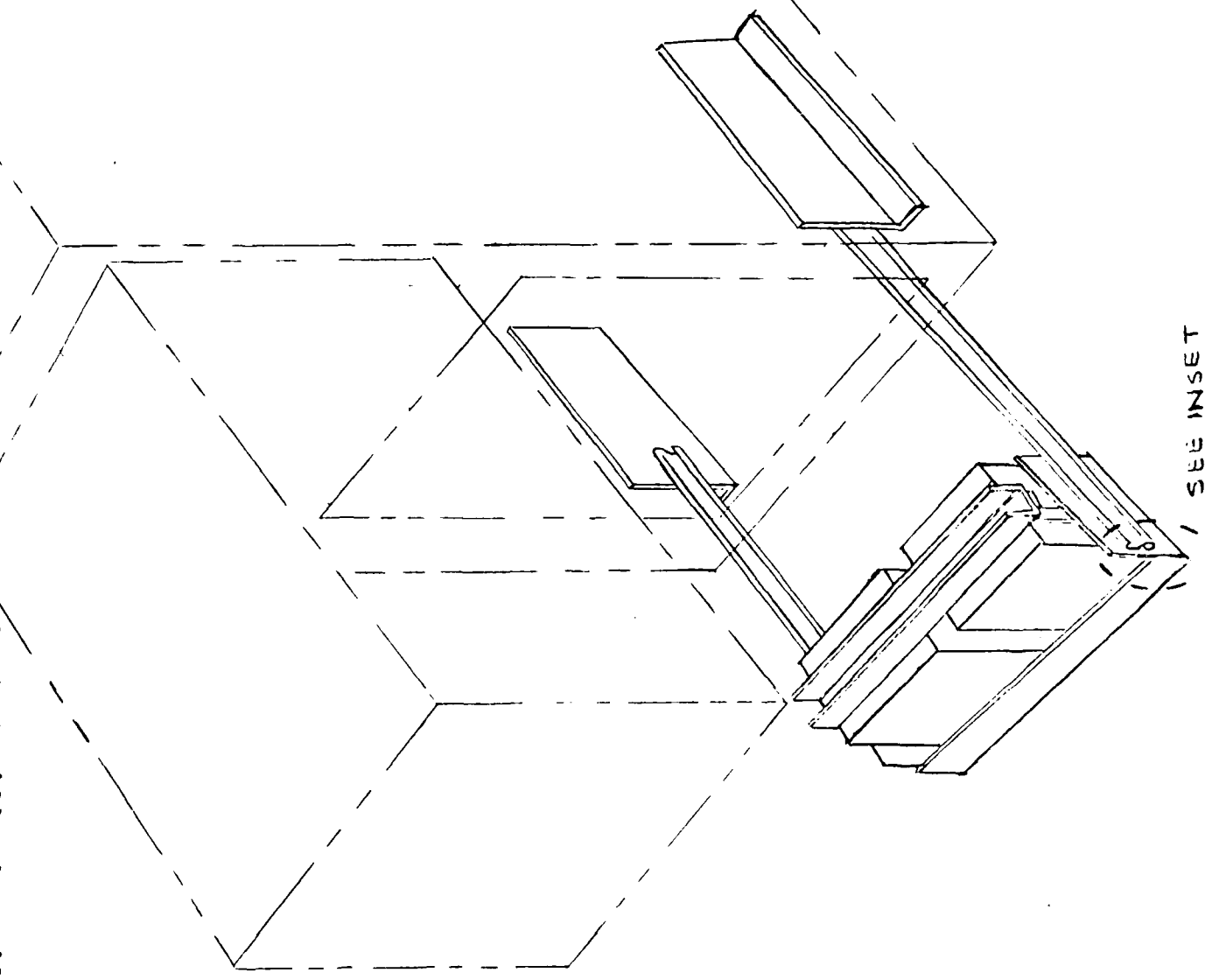
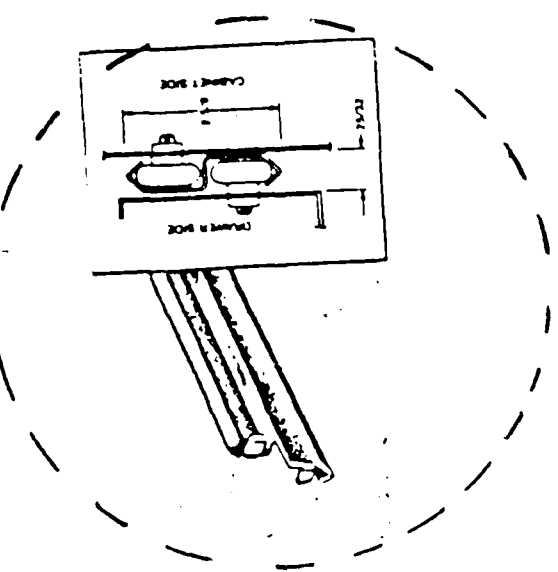
2.2 Battery Compartment Modification 15 and 30 kW Units. Modifications to the exterior housing of generator sets for sound suppression purposes has complicated service and maintenance accessibility. This in turn could conceivably contribute to increased unscheduled maintenance actions due to limited accessibility. In an effort to increase battery accessibility three concepts were considered.

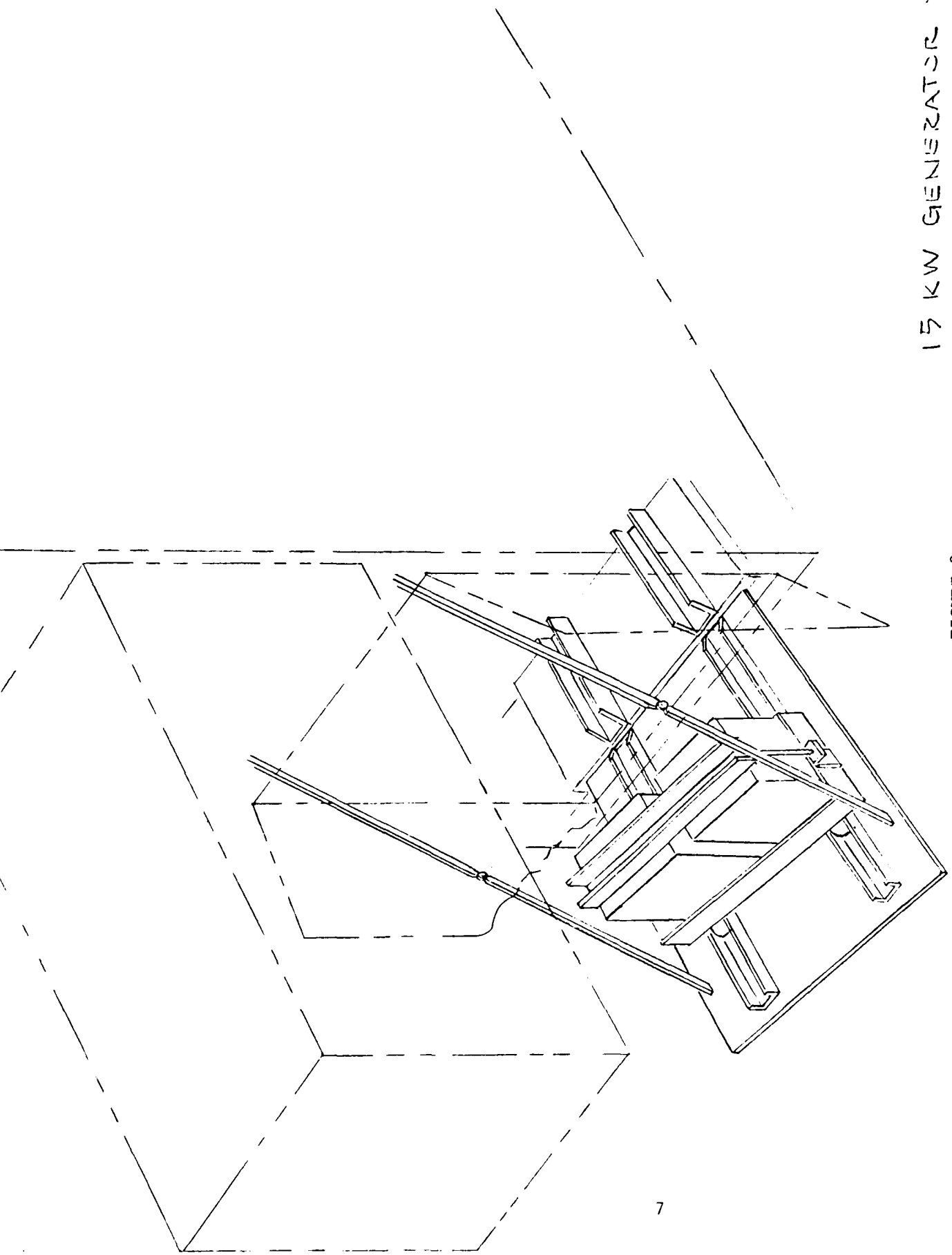
2.2.1 Concept I. As shown in figure 1 this approach utilizes drawer slides extending outward from the battery compartment. The battery assemblies are mounted in a tray which is affixed to the slide assembly. This approach was eventually selected for adaptation and is discussed in detail in para 2.2.4.

2.2.2 Concept II. This concept utilizes the addition of a drop-down door, see figure 2. Two guide tracks would be mounted directly to the drop-down door and two additional tracks would be mounted on the internal floor of the battery compartment. Wheel mounts would mount on the underside of the battery tray. Upon opening the outer battery doors maintenance personnel could pull the drop-down door open to access the battery tray. The tray could then be pulled forward for service. Although this approach did offer improved access to the battery compartment, it also had two significant problem areas.

15 KW GENERATOR SET
BATTERY COMPARTMENT
CONCEPT I

FIGURE 4





15 KW GENERATOR SET
BATTERY COMPARTMENT
CONCEPT II

FIGURE 2

Operational concerns were expressed pertaining to sandy or dusty environmental conditions. It is felt that the wheel assemblies and slides could perform unreliably in any environment that exposes the unit to sand. Sand would tend to destroy the roller's assemblies and outer wheel covering. The main objection to this approach is the drop-down door. This door would require fabrication and could possibly contribute to structureborne noise.

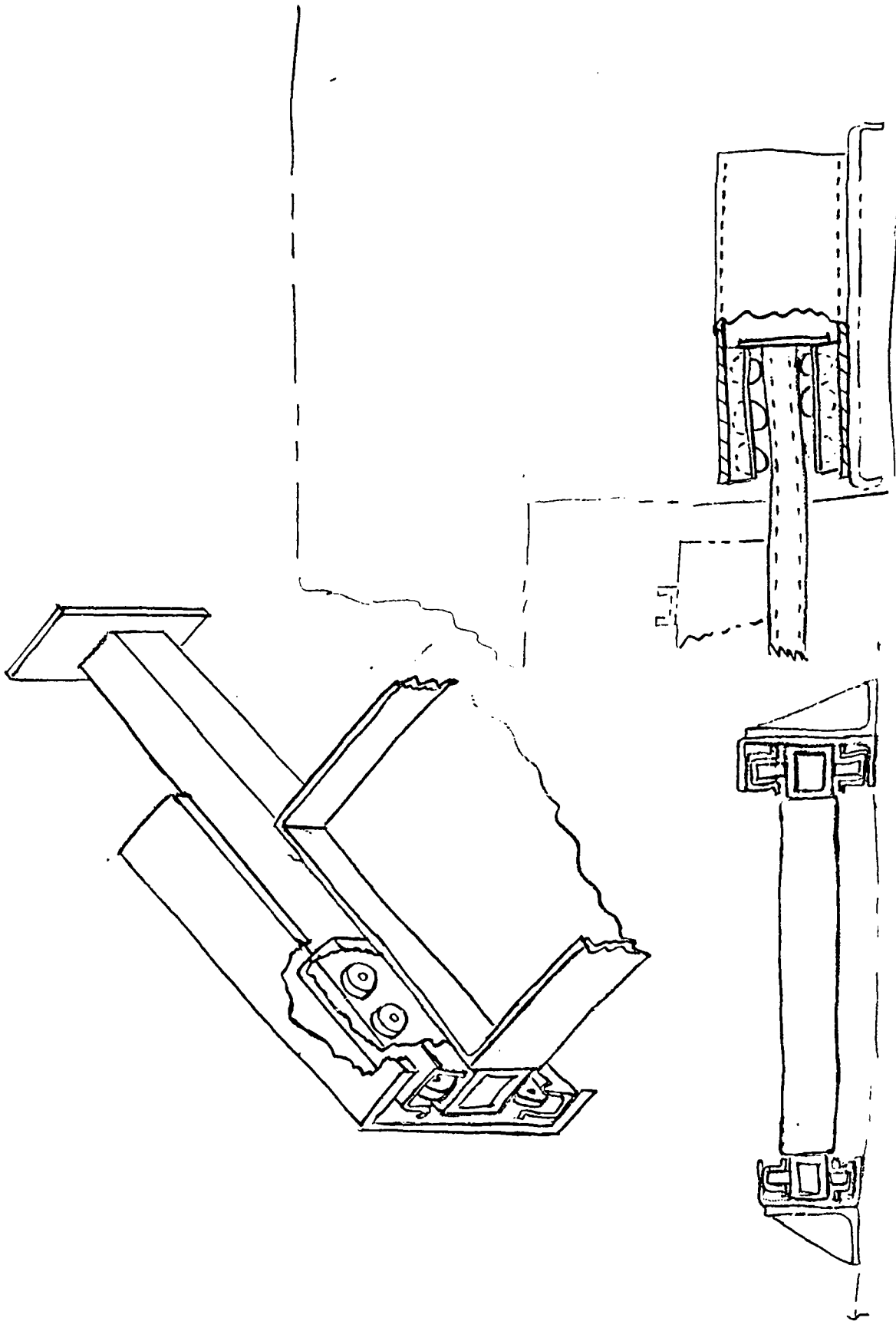
2.2.3 Concept III. This approach, figure 3, proposed mounting box tubing to the outside edges of the battery tray. These two pieces would serve as roller extensions, which, when fully extended out of the battery compartment, would adequately support the batteries. Two conveyor rail sections would be mounted on each side of the box tubing in a manner which would allow internal wheels, mounted on the conveyor rail, to roll freely along the top and bottom of the box tubing as the tray is extended. This approach was eliminated due to the limit of battery tray travel, 6 to 8 inches maximum.

2.2.4 Battery Compartment Modification (Concept I). As briefly described in paragraph 2.2.1 this approach involved the installation of heavy duty drawer slides. The drawer slide extension arms and their associated rollers are constructed of stainless steel. The rollers will not bind up in operation due to sand dirt and moisture intrusion, because the clearances are large.

The unit as installed will allow operating personnel to pull the battery tray forward 11 to 13 inches and provides 10 inches of clearance between the top of the battery compartment and the bottom of the exhaust unit baffles. All pertinent dimensions used for this installation are the same for the 15 kW and 30 kW sets which will enable a standardized installation kit to be developed for adaptation.

2.2.5 Human Factors Engineering (Battery Compartment). Safety and HFE's investigation and analysis of this installation yielded the following information.

MIL-STD-759, states that the sliding tray must provide automatic stop/locking positions in both the fully extended servicing mode and in the normal closed door operating position. Additionally, the battery assemblies must be secured inside of the compartment tray. This will be accomplished by the installation of two straps, non-conductive/non-ceramic material which will project from the front retaining bar to the rear of the compartment and be locked into place by retaining pins. It must also be noted that MIL-STD-1472, requires the retaining pins must be of the captive hardware type.



15 KW GENERATOR SET
BATTERY COMPARTMENT
CONCEPT III

FIGURE 3

Battery cables installed must be capable of reaching the full travel of the tray when in the extended position and be suitably protected from chaffing. Further MIL-STD-759, paragraph 5.24.1, requires that rubber dust caps, clearly marked positive and negative, be provided for the cables.

VSE Corporation was provided with a GFE set of batteries and found them to weigh 73 lbs each. The combined weight of the batteries, tray, retaining straps and extension arms is approximately 155 lbs. Thus operating personnel must reach into the battery compartment and pull 155 lbs forward approximately 1 foot. MIL-STD-1492 states that the left arm of operating personnel has 222 Newtons of pull force and the right has 231 Newtons. The actual pull force required to perform this action must be measured by a dynamometer.

2.3 Door Paddle Latch Replacement. Current MIL Generator sets utilize paddle latches to secure compartment doors. Numerous problems have been repeatedly documented during the years of their usage. After a short period of operation the various seals and gaskets installed on the generator doors and compartments begin to compress. As this compression and normal deterioration occur air gaps and improper sealing develops. This eventually leads to vibration noise and thermal leakage, both which contribute significantly to increased detectability by enemy forces.

In order to correct these deficiencies the paddle latch assemblies have been targeted for replacement. The defined criteria for the new latch assemblies is as follows:

- o Latch mechanism must be adjustable.
- o Adjustment must be lockable after setting.
- o Must replace the existing unit without extensive modifications to doors.

Two different types of latch assemblies were investigated, lift and turn flush latches and heavy duty flush cup latches with fold away handles.

2.3.1 Lift and Turn Flush Latch. Lift and turn latches, as represented by Southco No.62 in figure 4, were considered as replacement items.

As shown in figure 4 operation of the latch is accomplished by pressing in on the top of the lever to pop the handle out. Operator personnel then lift the handle to relax compression and then twist to open.

This assembly was deemed to be unsuitable due to numerous potential problems. The unit due to its small dimensions, 11/16" X 1 5/8", will require backing plates be fabricated as the existing opening is 5 1/2" X 4 1/4". The units are subject to extreme vibrations.

2.3.2 Heavy Duty Flush Cup With Fold Away Handles. Southco flush cup latches, figure 5, offer the best potential for replacing existing paddle latch units. The fold away handle offers ease of use and the units are adjustable. As shown in figure 5, self-adjusting style, operating personnel pull the fold away handle out, turn 90° to unlatch. Additional turns of the handle will provide additional compression to reduce vibration and ensure proper sealing. This latch, when used with a pawl stop (keeper) as depicted in figure 6, will result in effective sealing and ease of use. This cam action (of the keeper) will help to draw the door in tight as the latch is turned onto the pawl keeper.

Analysis and testing of the unit has revealed a few potential problem areas. This unit is 4 1/2" X 3 1/2" compared with the paddle latch's 5 1/2" X 4 1/4" dimensions. Southco has been contacted concerning the availability of a unit more closely matching the existing opening used by paddle latch assemblies. It was also noted that the depth of the unit will cause interference with internal components in some areas of the generator set. Although alternate mounting locations can be used in various compartment doors this approach is not recommended. VSE has contacted the manufacturer concerning the availability of shallower depth units or modifying the existing unit. It has been determined that if the overall depth (4 5/16") can be shortened to 2 9/16" the lock will clear all internal generator parts. The self adjusting mechanism could also cause problems due to the additional time needed to turn each latch to secure the doors.

2.3.3 Human Factors Engineering (Paddle Latch). There are no new safety/human factor ramifications associated with this proposed change. Existing human factor considerations are that personnel wearing artic gloves and mittens can operate this equipment without undue constraints. The design in section 2.3.1 meets this consideration. The handles in Sect 2.3.2 offer difficulty in working them with mittens due to the fold-away design and rotation for adjustment purposes.

2.4 Relocation of Exhaust Outlet. Current generator design has the exhaust muffler outlet exiting through the top of the generator housing. In an effort to decrease the outer envelope dimension of the generator the muffler exhaust outlet was relocated and the exhaust exit recessed.

FIGURE 4

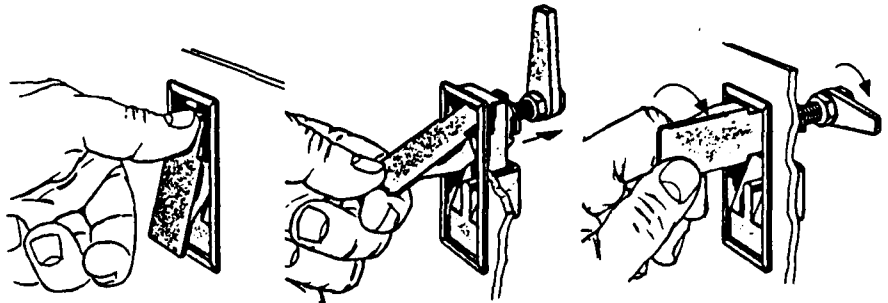
Lift-and-Turn Flush Latches

(Southco No. 62)



available
with black
finish

See 700 Series part number table below and 400 Series part number table on next page.



Press in top of lever to pop handle out.

Lift handle to relax compression.

Twist to open.

700 Series

GRIP RANGE		PART NUMBERS			Wt. per set
MIN.	MAX.	polished chrome cup and lever	brushed chrome cup and lever	black organic coating cup and lever	
3/8	7/8	62-10-701-10*	62-10-701-20*	62-10-701-50*	.097
1/2	7/8	62-10-702-10‡	62-10-702-20‡	62-10-702-50‡	.094
3/4	1 1/8	62-10-702-10‡	62-10-702-20‡	62-10-702-50‡	.094
1 1/8	1 7/8	62-10-701-10*	62-10-701-20*	62-10-701-50*	.097

Not available with lock.

*The same assembly is supplied for both short and long grips. For short grip, deep offset pawl curves back toward panel. For long grip, reverse pawl.

‡Shallow offset pawl is supplied for intermediate grips. For shorter grip, shallow offset pawl curves back toward panel, reverses for longer grip.

MATERIAL and FINISH
COMPRESSION LEVER and CUP: Die-cast zinc, see table for finishes. SPRINGS: Stainless steel. OTHER PARTS: Steel, DACROTIZED† or zinc plated.

See Section N, page N-1 for additional finish information.

†Registered trademark of Metal Coatings International, Inc.

specifications:

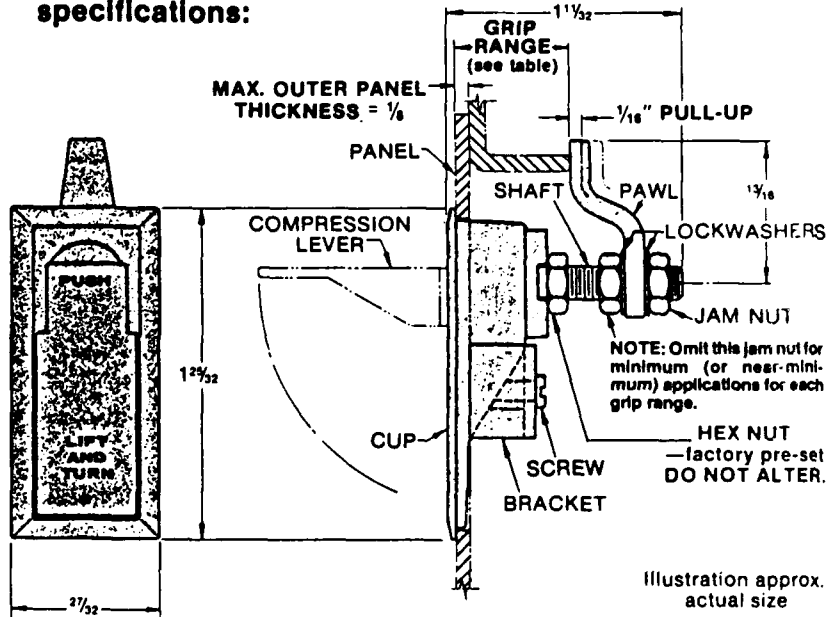
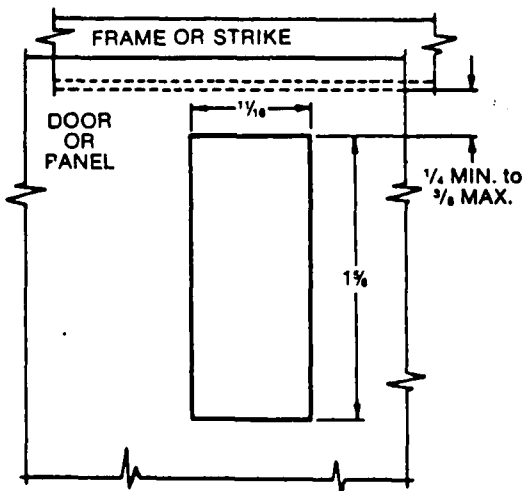


Illustration approx. actual size

PANEL PREPARATION AND INSTALLATION



Prepare a rectangular opening in door or panel as shown at left. Note the location limits with respect to frame or strike.

Seat latch into opening from front side of panel; position bracket over latch from the back side and secure with screw provided.

Latching pawl may be positioned for left or right hand operation at sides, top or bottom of door.

NOTE: For proper adjustment of pawl, first measure your GRIP. This is the distance between the OUTER surface of the door or panel and the INNER surface of the frame or strike when the door is CLOSED. The pawl should be adjusted to that measurement with the door OPEN and handle in LATCHED (down) position only. Use a wrench to hold one jam nut and a second wrench to tighten the other jam nut hard against lockwasher and pawl. If inner jam nut is omitted (see specifications drawing above), use second wrench to hold pawl while tightening jam nut.

Operate latch through latching and unlatching sequence to insure proper adjustment.

Southco Heavy Duty Flush (cup) Latch with Fold-away handle

(Southco No. 24)

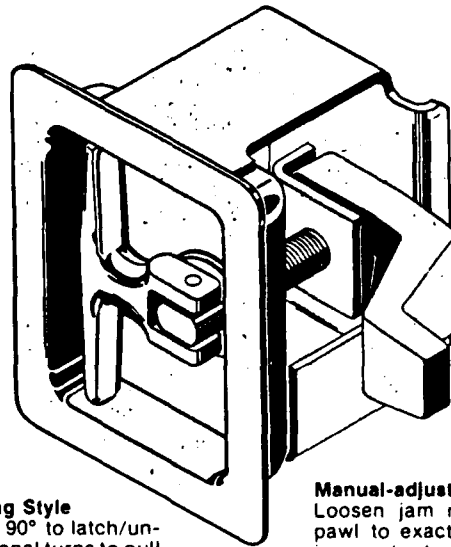
Now there are two basic styles.

Self-adjusting — pawl can be drawn up tightly against frame to suppress vibration; compress a gasket.

Manual-adjusting — select the exact grip you need, set it and lock it in.

Each style is offered with integral mounting studs for fast, simple installation (locknuts are supplied). Or — without studs; latch can be welded or riveted to your panel.

All models have rugged spring-positioned, fold down handles, sized for a comfortable grip, even with heavy work gloves.

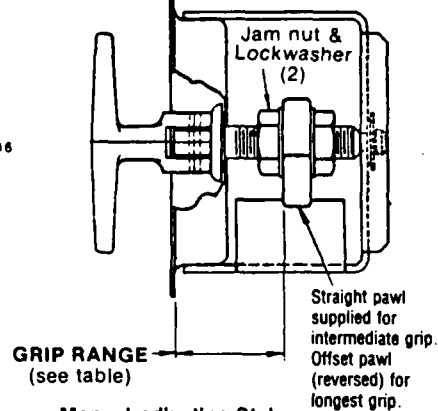
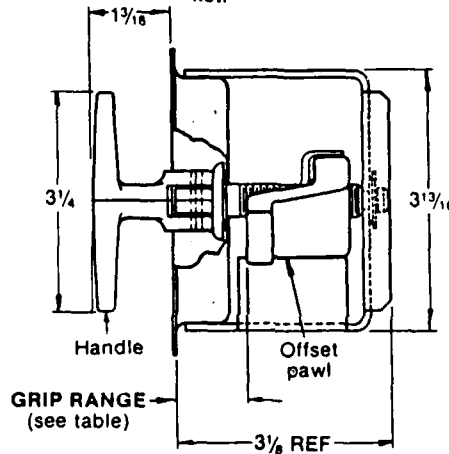
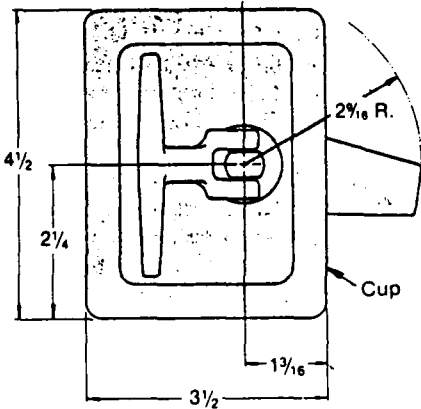


Self-adjusting Style
Turn handle 90° to latch/un-latch. Additional turns to pull up tighter; compress a gasket.

Manual-adjusting Style
Loosen jam nuts to adjust pawl to exact grip. Tighten jam nuts to lock pawl in position.

Dimensionally the same as self-adjusting style (left), except as shown.

specifications:



MATERIAL and FINISH
Handle: die-cast zinc, DACROTIZED†. Offset pawl: die-cast zinc with protective chemical film. Wear washer: thermoplastic. Pin, spring, jam nuts, locknuts, lockwashers: steel, zinc plated. All other parts: steel, DACROTIZED†.

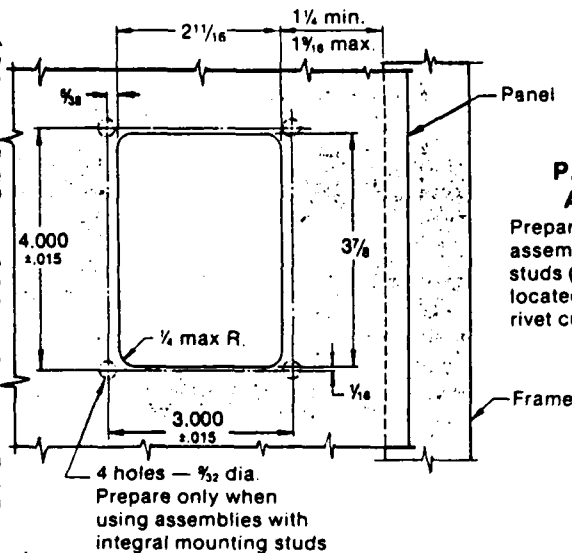
Self-adjusting Style

Grip range		Part Numbers	
MIN.	MAX.	For weld or rivet mounting (no studs)	With integral mounting studs
3/4	1 1/8	24-10-601-10	24-20-601-10
1 1/8	2 1/8	24-10-602-10	24-20-602-10

Manual-adjusting Style

Grip range		Part Numbers	
MIN.	MAX.	For weld or rivet mounting (no studs)	With integral mounting studs
1 1/16	1 3/8	24-10-621-10	24-20-621-10
1 1/4	1 5/8	24-10-622-10	24-20-622-10
2 1/32	2 1/8	24-10-623-10	24-20-623-10

†Registered trademark of Metal Coatings International, Inc.

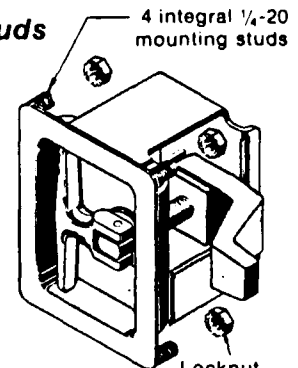


PANEL PREPARATION AND INSTALLATION

Prepare cutout in panel as shown. For assemblies with integral mounting studs (only), prepare four 5/32 dia. holes located as shown. Otherwise, weld or rivet cup flange to panel.

No. 24 Flush Latches with integral mounting studs

see tables above for part numbers.



NOTE: 3/8 max. panel thickness ONLY when using assemblies with integral mounting studs

FIGURE 5

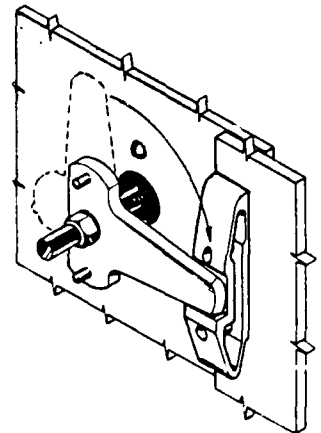
Pawl stop (keeper)

A spring-action striking surface
for Southco latches.

For optional use with the following Southco latches:

Product class No.	Description	Use Keeper Size (series):	See Southco Handbook Section:
01	Flush Cup Latch	500 Series	Section F
36	Adjustable-grip Latch	500 Series	Section O
61	Cabinet Latch	500 Series	Section J
65	Adjustable-grip Latch	300 Series	Section D
66	Adjustable-grip Latch	300 Series	Section D
68	Bail Handle Latch	500 Series	Section DD
68	"T"-handle Latch	500 Series	Section DD
92	"L" & "T"-handle Latches	500 Series	Section I

- Optional detent-type pawl stop accessory
- Molded in one piece from tough, highly resilient, engineering thermoplastic
- Offered in two sizes
- Quickly, easily installed



Specifications:

All part numbers listed on this page represent stock items subject to prior sale.

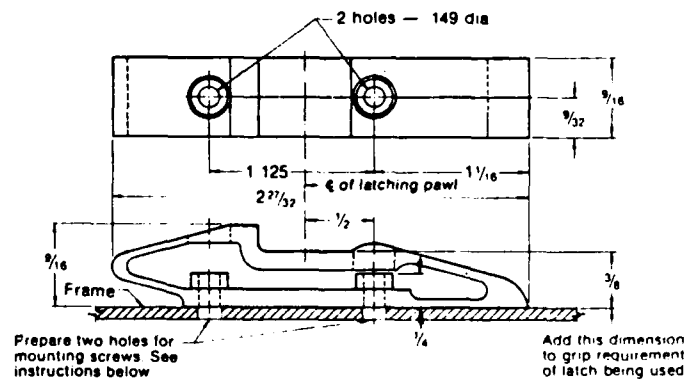
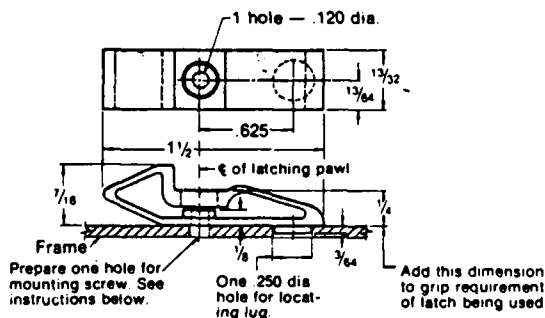
300 Series

Part Number
22-11-301-12

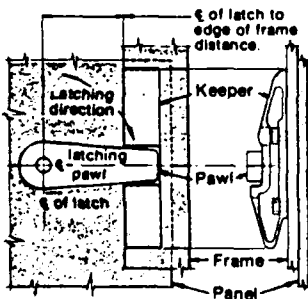
Material and Finish
Engineering thermoplastic, black.

500 Series

Part Number
22-11-501-12



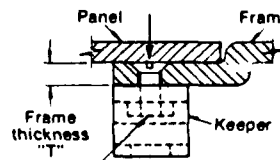
To Install keepers:



VIEWED FROM INNER SIDE OF PANEL AND FRAME

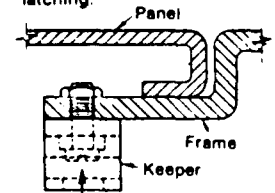
1. Refer to Southco Fasteners Handbook (see upper right) for installation data for specific latch being used.
2. With keeper oriented as shown at left, and with edge of keeper flush with edge of frame, locate mounting holes with respect to centerline of latching pawl (see drawings above for dimensions).
3. Select applicable mounting method ("A" or "B") and screw size, type and length from diagrams and table at right.
4. Secure keeper to frame. Mounting screws are not supplied by Southco.

Method "A"
When panel directly abuts frame at point of latching.



Flat head thread forming or machine screw. See table for size and length.

Method "B"
When there is space between panel and frame at point of latching.



Pan head machine screw. Use nuts or tap into frame. See table for size.

Keeper size (series)	No. Req'd.	Mounting screw		Screw length (Method "A" only)	
		Size and type		Min.	Max.
300 Series	1	No. 6 Flat head	No. 4 Pan head	"T" • 094	"T" • 188
500 Series	2	No. 8 Flat head	No. 6 Pan head	"T" • 125	"T" • 250

FIGURE 6

The EN5Y series multi-chamber silencers, 2 1/2" (15kW and 30kW) and 3" (30kW), were installed. The exhaust (rain cap) is recessed 1 1/2" below the outer housing with a flapper valve installed to seal the exhaust from the elements when not in use. As of the date of this report the silencer for the 60 kW unit has not been finalized, but appears to be an EN5Y SERIES 3".

2.4.1 Human Factors Engineering (Exhaust Outlet). Preliminary Safety/HFE analysis has indicated that the proposed modification will eliminate the potential for operating personnel to burn themselves by touching or coming into contact with exposed exhaust system components. However, further analysis is continuing to ensure that this modification has no other Safety/HFE implications.

2.5 Low Coolant Protection Problem. Generator sets currently use a coolant high temperature light located on the fault indicator panel to alert the operator to critical temperatures. A sensor installed in the engine's thermostat alerts the operator that coolant temperature is high and automatically shuts the generator off.

While the high temperature indicator will detect "hot" coolant it does not sense a loss of coolant. There is no protection afforded the engine assembly during a sudden loss of coolant or if the unit was placed ON SERVICE without the proper level of coolant. In both of these situations the present system would not detect a fault condition unit steam developed to heat the sensor. Before this could occur the engine will probably be severely damaged. To preclude these potentially damaging situations from occurring a low coolant protection device was installed.

2.5.1 Low Coolant Protective Device. To alleviate the low coolant problem VSE installed a low coolant SENSOR. The unit, part #613NLUTD12-C, is manufactured by Robert Shaw Controls Inc., Knoxville, TN. The unit as installed will utilize the existing wiring harness and fault indicator used for the high temperature warning. The SENSOR has a built-in time delay which precludes premature alarm activation in the event that air bubbles are momentarily present in the cooling system. During an occurrence of low coolant the sensor, installed in the thermostat housing, will alert the operator and automatically shut the system down. This system will now alert operators to high temperature, low coolant and sudden loss of coolant situations.

2.5.2 Human Factors Engineering (Low Coolant Protective Device). Safety/HFE agrees with the installation of the low coolant protective device as a added measure of engine protection. It is strongly recommended that the fault indicator panel be labeled to reflect the dual function, both high temperature and low coolant, the indicator light now serves. This information should also be issued to holders of Technical Manuals pertaining to this equipment.

2.6 Manual Throttle Control Knob Relocation. With the addition of sound attenuation packages the position of the manual throttle control is partially obscured from the operator's sight, thus posing a potential safety hazard. In order to relocate the throttle, the circuit breaker and parallel receptacle must also be repositioned. (See Figure 7). As shown in Figure 7, provision for a fuel burning winterization kit is provided for on the panel. The circuit breaker was relocated to the area between the fault indicator panel and winterization kit location.

A welded insert was fabricated, 5 1/4" X 6 1/4", and located directly beneath the fault indicator panel. With the throttle control installed and in full operation there is minimum clearance of 1/2" from the door. The new location required the re-routing of the throttle cable assembly (Figure 7). The new location of the manual throttle control knob and related cable assembly functions properly and eliminates a potential safety hazard.

2.6.1 Human Factors Engineering (Manual Throttle Control Knob). This new location locates the knob 5'4" off the ground. The trailer mounted operators platform is 1'2" off the ground. The distance from the platform to the top of the air intake is 4'2". The straight arm distance from the normal operator's standing position is 2'. Both of these measurements fall well within the parameters outline in MIL-STD-759 and 1492 anthropometric 5/95 guidelines.

The existing throttle cable is routed on a direct line with two points securing it in place, one located directly behind the throttle knob and the other at the engine end of the cable. The new routing is not on direct line and must run over a control box, under an exhaust pipe, and into the engine. For this reason two securing points will not be sufficient. The new cable routing will require securing at intervals of 10" to prevent the cable from shifting and becoming entangled. The relocation of the manual throttle control knob and its associated cable assembly poses no Safety/Human Factor problems as long as the cable assembly is properly secured.

CIRCUIT BREAKER

PARALLEL RECEPTACLE

RELOCATIONS

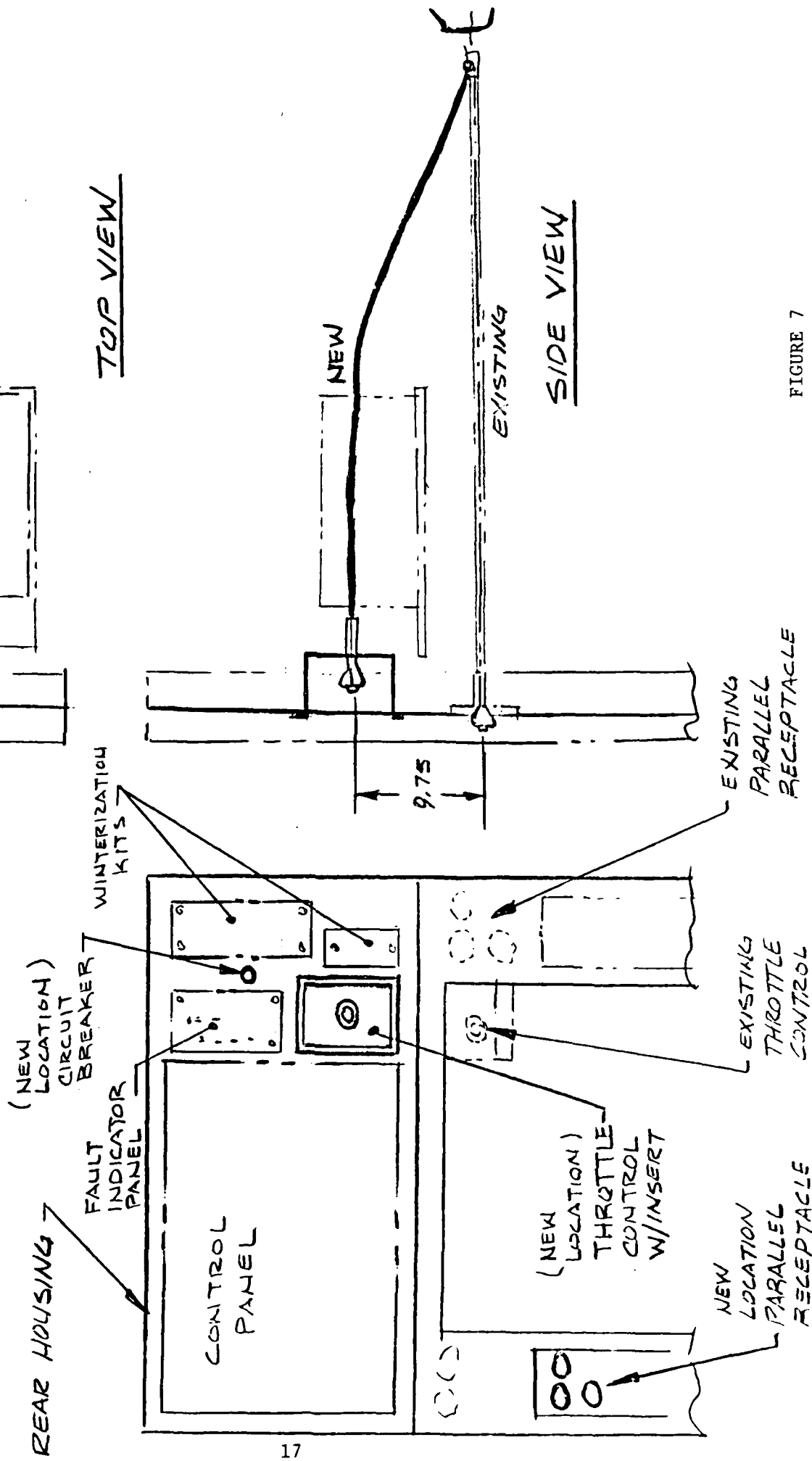


FIGURE 7

2.8 Noise Reduction and Vibration Isolation. Efforts to reduce the noise levels emanating from MIL-STD generators have demonstrated that the problem can only be rectified by identifying and eliminating internal component generated noise, airborne and structureborne noises. Current noise reduction programs are attacking the problems using a variety of treatments that include such items as:

- o Improved engine exhaust mufflers.
- o Silencers for air intake and discharge openings.
- o Improved engine cooling fans.
- o Sound absorption treatments for internal generator housings.
- o Improved vibration and dampening material.

While the installation of engine dampening material and/or shock mounting devices would surely aid in eliminating some of the sources of noise and vibration, other factors must be considered. These include retaining the present envelope dimensions of the generator housing, the difficulty of retrofit actions involving engine removal and the requirement to withstand a railroad impact test IAW MIL-STD-705B, method 740.5b. The purpose of the test is to ensure the capability of the generator set to withstand shifting stress loading brought on during railroad shipping and other types of transportation movements.

While the problems associated with the difficulty involved in removing the generator engine from the housing and mounting beams cannot be overcome, envelope dimension and the requirements of MIL-STD-705B can be satisfied.

2.8.1 Soft Mount Vibration Isolation Treatment. The current design of the frame and mounting beams of generator sets now in use require the generator set be bolted directly to the mounting beams within the skid base of the housing. This design affords no vibration isolation between the generator set and frame mounting assembly. This type of mounting allows vibration and noise from the diesel engine to radiate throughout the set. In order to effectively isolate and reduce this noise source the installation of resilient isolators between the frame and generator assembly is necessary. In order to retain the generator set in its present position and maintain the "Center Line" it is necessary to perform slight modifications to the mounting beams.

The rear generator mounts must be modified by fabricating weldments. Four holes are bored, two on each side. The vibration isolation units used are center bonded mounts manufactured by Lord Industrial Products. The model type and mounting hole diameter for each generator size is listed below for the rear mounts.

<u>Generator</u>	<u>Model</u>	<u>Mounting Hole Diameter</u>
15 kW	CBA20-300	1.250"
30 kW	CBA24-650	1.380"
60 kW	CBA28-800	1.500"

The units are secured by means of a specified high strength steel bolt which passes from the top of the generator mounting plate through the center of the soft mount, secured by a nut against a flat washer on the underside of a fabricated weldment. As stated above, the steel securing bolt has specified torque values. As the bolt is torqued to a particular value, the soft mount compresses to a corresponding value of resiliency.

The front engine mounts are installed by drilling two mounting holes in a weldment to the sizes listed below, by mount model and generator size.

<u>Generator</u>	<u>Model</u>	<u>Mounting Hole Diameter</u>
15 kW	CBA20-300	1.250"
30 kW	CBA20-400	1.250"
60 kW	CBA24-500	1.380"

Initial evaluation of the vibration-isolated generator set supplied by the rail hump vendor suggest that it will easily perform the 8 MPH test IAW MIL-STD-705B.

2.8.2 Human Factors Engineering (Soft Mount). Soft mount installation in the 15, 30 and 60 kW generator sets will contribute considerably in reducing structureborne noise. This will reduce the risk to operating personnel through safer noise levels.

2.9 Regency Net Sound Attenuation Background. The Regency Net Generator program's purpose was to reduce the noise levels present during generator operation to acceptable levels, both in the tactical sense and for health/safety considerations. The generators baseline noise level prior to modifications was established at 86dBA, with a design objective of 65dBA at 7 meters.

Modifications included a new engine fan, engine intake and exhaust silencers, fan shrouds, improved air cleaner/silencer, and smaller water pump drive pulley.

Additional modifications included sound coat insulation on door panel; top housing lined with 2 inch Owens-Corning 703 fiberglass, (in areas not in close proximity to the muffler) wrapped in 0.5 mil mylar and held in position with perforated aluminum. Two roof sections were replaced to allow adequate clearance for the engine exhaust/intake silencers, which raised the overall height 13 inches.

The success of efficient sound attenuation programs, such as Regency Net, tend to follow tried and proven sound attenuation engineering techniques that have proven their value in field use and testing. These include:

- o Reevaluating major noise source components (i.e. fans, mufflers/silencers, etc
- o Utilization of specially designed sound absorptive materials, air inlet/outlet baffles and traps to isolate and control specific noise sources.
- o Installation of soft mounts and dampers to isolate vibration caused by engine assemblies transmitting noise through skid mounts, mounting beams and housing assemblies.
- o Lining interior areas of the housing with sound absorptive materials.

This methodology has proven its value in reducing noise emanated from the generator set. As further prototyping and testing has been accomplished additional improvements and conceptual ideas have been evaluated for potential application.

2.9.1 15 kW Generator Sound Improvements. (See Figures 8 and 10) The present sound attenuation package developed for this set, resulting from Regency Net, has proven its success. Evaluation and analysis of components and conceptual approaches used in the development of Regency Net revealed several areas where potential improvements might be incorporated.

The existing engine exhaust silencer was replaced to provide increased sound attenuation. The new model is a 12" diameter unit versus the 9" diameter currently used. The increased capacity and lagging will provide better sound attenuation and retain heat more efficiently.

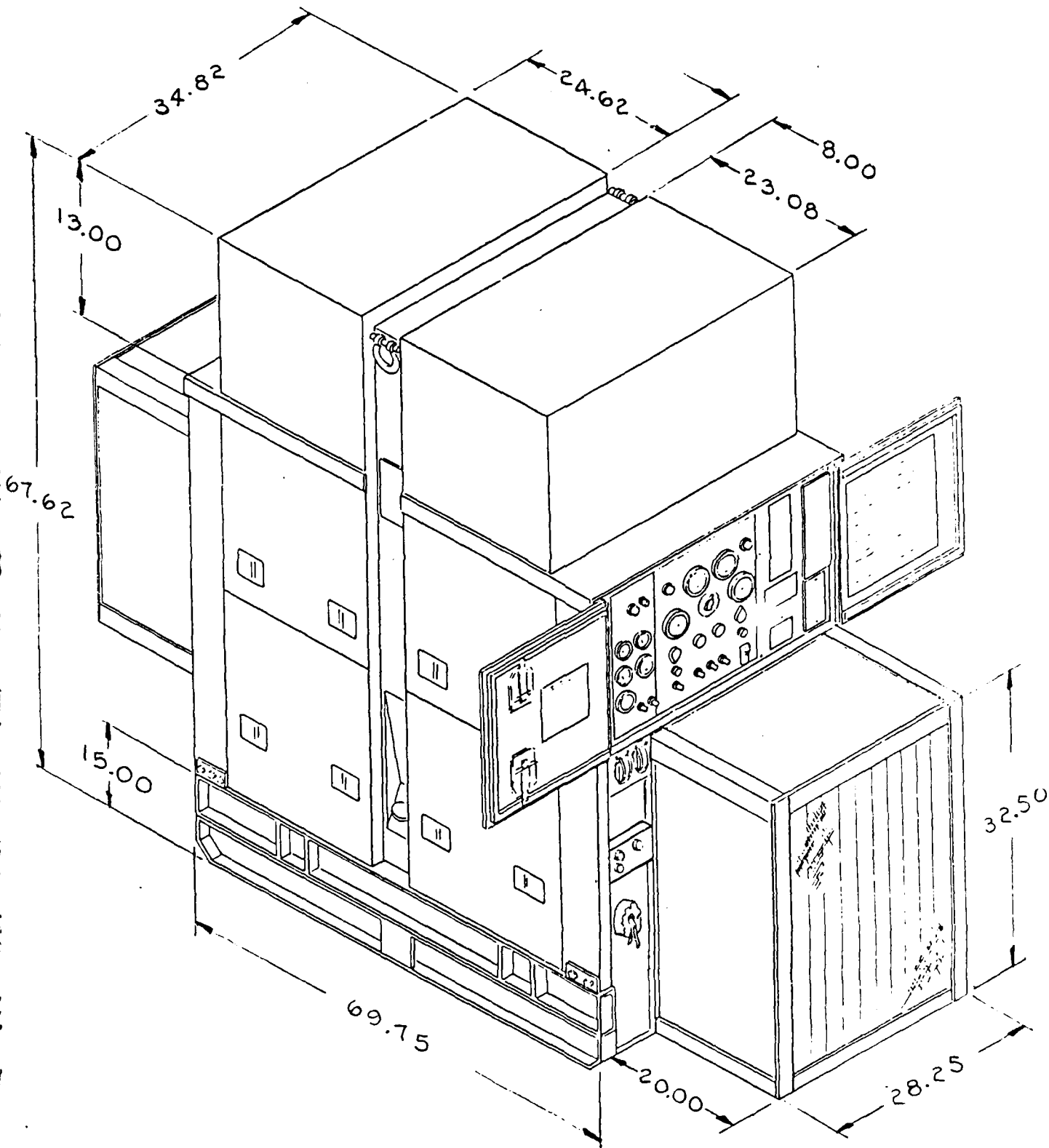


FIGURE 8 SOUND ATTENUATED GEN SET (15 KW), AIR INTAKE END

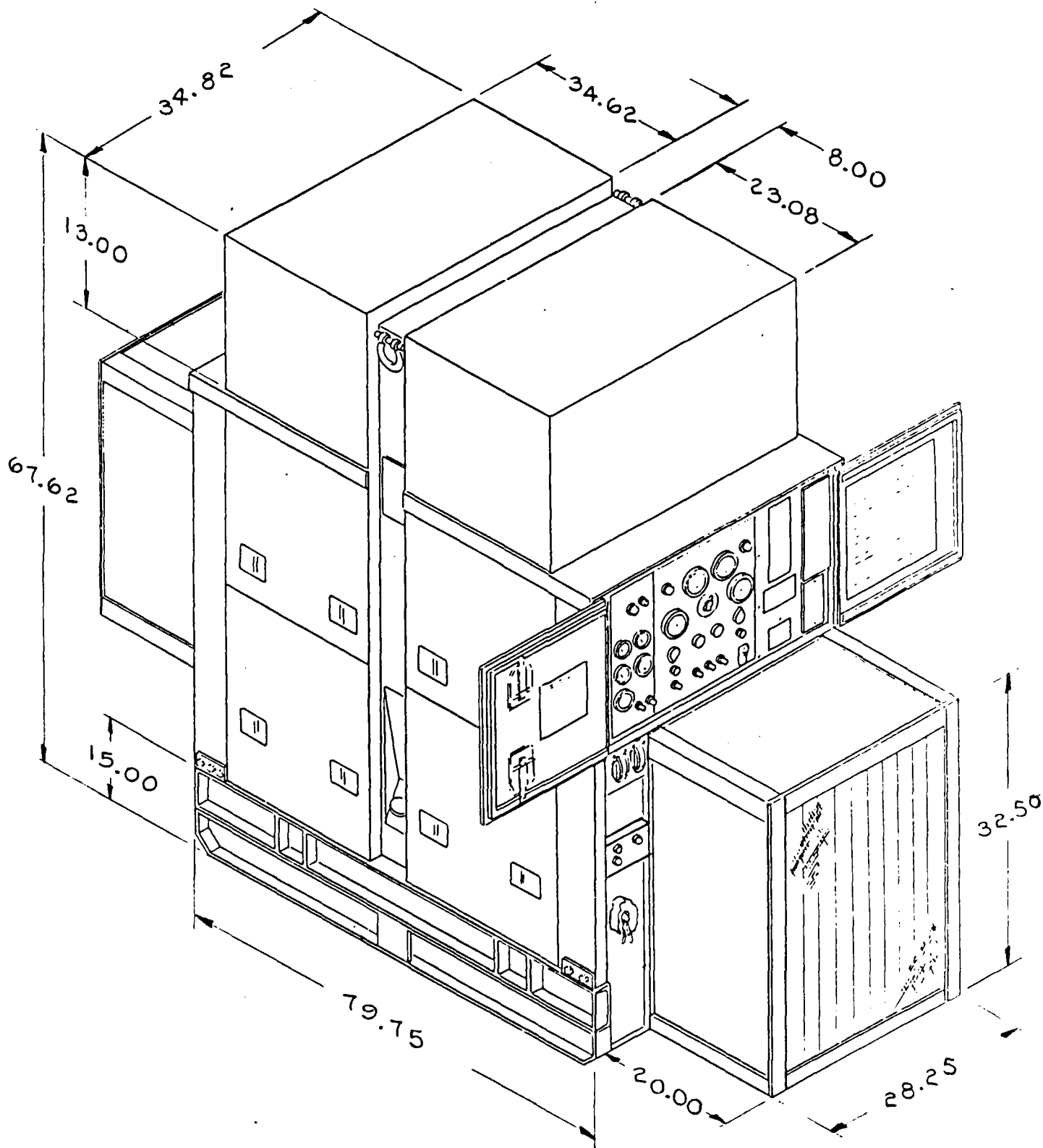


FIGURE 9. SOUND ATTENUATED GEN SET (30 KW), AIR INTAKE END

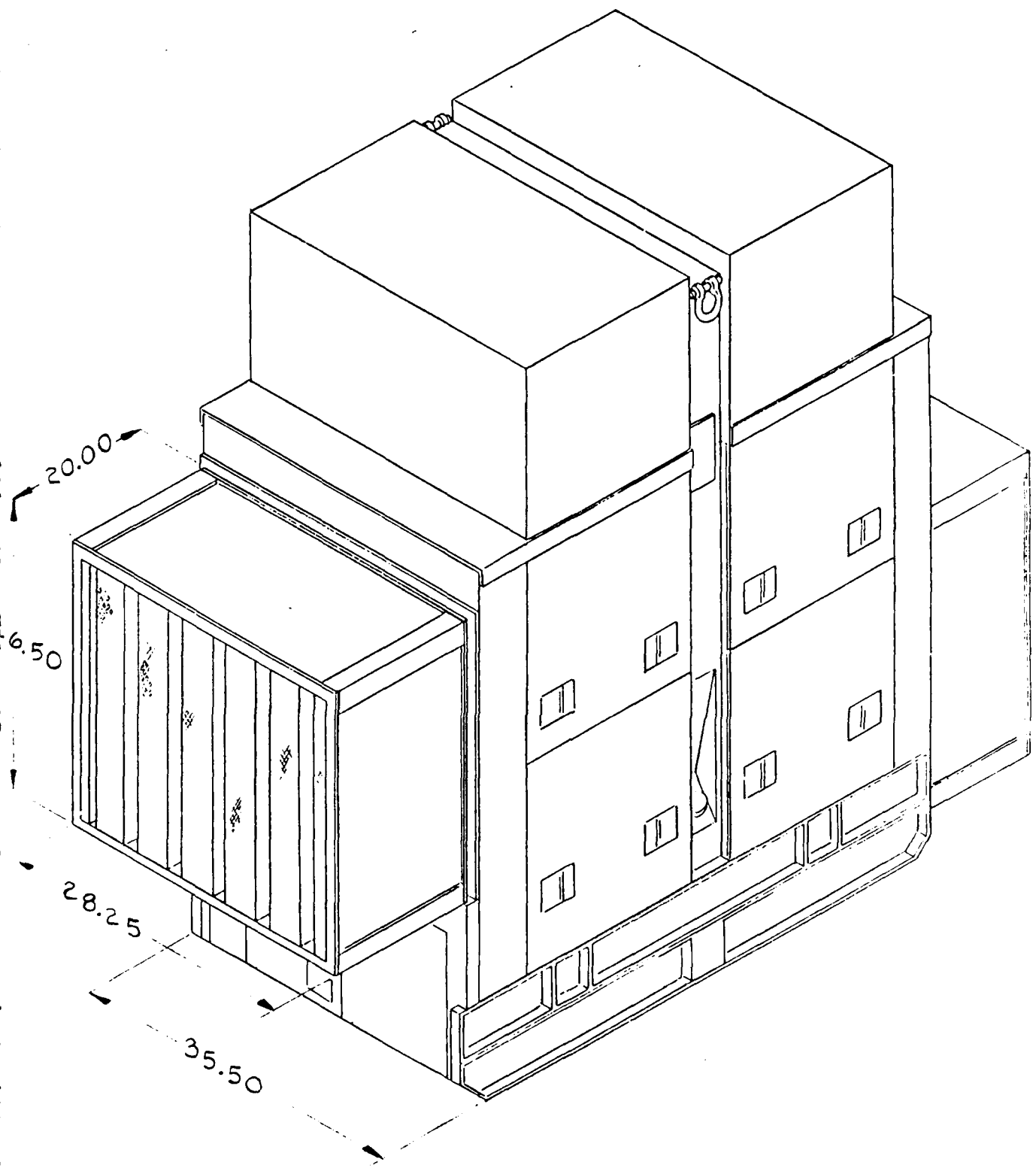


FIGURE 10. SOUND ATTENUATED SETS (15 & 30KW), EXHAUST END

The modifications and design/redesign changes for the improved battery compartment, paddle latch replacements, soft mount installation, exhaust outlet relocation, throttle control relocation, and low coolant protection device discussed previously have been incorporated in the 15 kW unit. These improvements are currently being tested and the results of this testing along with specific conclusions and recommendations will be reported at a later date, following subsequent investigations.

2.9.2 30 kW Generator Sound Improvements (See Figures 9 and 10). In addition to the modifications/improvements detailed in previous paragraphs, potential improvement for the 30 kW set are being evaluated in the following areas.

- o Improved silencers
- o Cooling fan and drive pulley configurations
- o Auxiliary cooling air intake
- o Internal housing improvements

Improved flow "lagged" silencers are being evaluated for both intake and exhaust areas. The use of lagged silencers will aid in reducing engine noise. Particular emphasis is being placed on the air intake as this has consistently demonstrated high noise levels.

The cooling fan is also one of the higher noise sources. Various concepts have been tested in an attempt to reduce the level of noise. These include using various sized pulleys to lower the fan speed and replacing the fan with different designed units. Testing has shown that fan speed can be reduced without exceeding engine temperature operating limits. It is possible to reduce the fan speed sufficiently to reduce the noise level while by improving air flow, if the current speed is close to the 'stall' condition.

VSE is currently designing an auxiliary cooling air intake with built-in baffling. The unit will be installed above the generator control panel. The generator set will be tested with all improvements in place and a blank panel covering the intended auxiliary intake area. Measurements will be taken of both noise and air flow. The auxiliary intake will then be installed and measured for noise and air flow. Various fan speeds and pulley arrangements can be validated during this same period.

Additional modifications include testing baffle construction and internal insulation installation. In attempting to standardize the thickness of insulating material, to

1", some areas of the set are in close proximity to internal components. To insulate all areas to 1" would require custom fitting, which would drive cost up too high. Testing performed by BBN Labs, Cambridge, MA. has indicated that it is not necessary to cover all bare areas. Placement of the insulating material is easily compensated for in the volume of material used. Soft mount installation as described in paragraph 2.8.1 will significantly reduce vibration and structureborne noise. These improvements are currently being tested and the results of this testing, along with specific conclusions and recommendations will be reported at a later date, following subsequent investigations.

2.9.3 60 kW Generator Sound Improvements. The 60 kW set will benefit from the modifications and improvements previously discussed in this report. There are however areas that cannot be conclusively evaluated at this time.

While modifications and improvements to 60 kW set are essentially the same as those performed for the 15 kW and 30 kW sets, re-engining the set could possibly alter some of these changes. The placement of the new engine within the frame and the relation of the internal components to the existing housing could alter the pattern of insulation used on the internal housing. Further baffle/silencer analysis should be performed after establishing baseline noise and air flow calculations for the prototype engine.

Although the replacement engine might require alteration of the changes/improvements utilized for the 15 kW and 30 kW sets, the new engine could also lead to potential improvements due to its inherent design.

3.0 CONCLUSIONS

The modifications and improvements designed for the 15, 30, and 60 KW generator sets under the task order covered by this final report have been targeted to increase reliability and maintainability, while decreasing deductibility through sound attenuating treatments. In conclusion, the modifications/treatments presented in this report can be applied to the 15, 30 and 60 KW.

4.0 RECOMMENDATIONS

It is recommended that each of the modifications and improvements discussed in this report be procured and/or manufactured and installed in prototype assemblies. These assemblies should be tested in order to determine the extent of reliability improvement, as well as survivability (in accordance with original MIL-SPEC generator set design requirements).

5.0 MATERIEL DETERIORATION PREVENTION AND CONTROL

Documentation of materials and supplies used in this task to provide protection from corrosion and other forms of material deterioration in the intended operating and storage environment will be provided upon completion of the final analysis and testing.

6.0 REFERENCE DOCUMENTS

6.1 Government Documents. The following government documents were used in the preparation of this report.

SPECIFICATIONS

MIL-G-52884 Generator Sets, Diesel Engine Driven, 15 thru 200 kilowatts, 50/60 and 400 (Tactical), Hertz, General Specification For

STANDARDS

MIL-STD-633 Mobile Electric Power Engine, Generator Set, Family Characteristic Data Sheets

MIL-STD-705 Generator Sets, Engine Driven, Methods of Test and Instructions

MIL-STD-1332 Definitions of Tactical, Prime, Precise Utility Terminologies for Classification of the DOD Mobile Electric Power Engine Generator Set Family

MIL-STD-1472 Human Engineering Design Criteria for Military Systems, Equipment and Facilities.

6.2 Miscellaneous. A Compact Treatment Package for Acoustic Suppression of the Standard U.S. DOD 30 kW Diesel Engine-Driven Generator Set, Report No. 6255, dtd May 86, BBN Laboratories Incorporated.

"APPENDIX A"

VSE/EPPSG/0076-87/25RD

MARKET SURVEILLANCE - REPLACEMENT DIESEL ENGINE FOR MILITARY STANDARD 60 KW
DIESEL ENGINE DRIVEN GENERATOR SETS MEP-006A, MEP-105A, AND MEP-115A

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22303-1499

11 August 1987

Interim Report for Period 3 June 1987 through 17 July 1987

Approved for public release; distribution unlimited.

U.S. Army Belvoir Research, Development and Engineering Center
Power Generation Division (STRBE-FGP)
Fort Belvoir, VA 22060-5606

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

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10	02		Mobile Electric Power (MEP)		
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The Allis-Chalmers 3500A engine drives military standard 60 kW Diesel Engine Driven (DED) Generator Sets MEP-006A, MEP-105A, and MEP-115A. As Allis-Chalmers no longer manufactures diesel engines, a replacement engine for these generator sets will be required in the near future. A market surveillance of commercial off-the-shelf diesel engines yielded 16 candidates. After evaluation and analysis of manufacturer's engine data, the Hercules D-3400-T engine was recommended for acquisition, installation and testing in 60 kW DED generator sets.					
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22a. NAME OF RESPONSIBLE INDIVIDUAL Mr. Noel Bishop			22b. TELEPHONE (Include Area Code) (703) 664-5596	22c. OFFICE SYMBOL STRBE-FGP	

SUMMARY

Military standard 60 kW diesel Engine Driven (DED) Generator Sets MEP-006A, MEP-105A, and MEP-115A are currently powered by an Allis-Chalmers 3500A engine. Allis-Chalmers no longer manufactures engines, spare and repair parts. Consequently, in the near future a replacement engine will be required for the 60 kW DED generator sets.

A market surveillance action was requested by the Power Generation Division, Belvoir Research, Development and Engineering Center (Belvoir) and performed by VSE Corporation. Fifty-four potential engine suppliers were sent letter requests, including specifications, for candidate replacement engine data and specifications. Fourteen replies yielded 16 engines for evaluation and analysis. After an initial evaluation of the 16 engines, eight were selected for further analysis.

The conclusion of the market surveillance was that the Hercules (White) D-3400-T engine should be selected as the replacement engine for the 60 kW DED, sound suppressed prototype generator sets MEP-006A, MEP-105A, and MEP-115A.

The recommendation of the market surveillance was that the Hercules D-3400-T engine be acquired, installed, and tested for use in the 60 kW DED, sound suppressed prototype generator sets MEP-006A, MEP-105A, and MEP-115A.

PREFACE

This report was prepared under the authority of task order 0076 to Belvoir Research, Development and Engineering Center (Belvoir) Contract DAAK70-86-D-0023. Contract 0023 requires VSE Corporation to provide engineering and technical support for a wide range of projects being performed at Belvoir. Task order 0076 is concerned with improved military standard generators.

The authors of this report wish to acknowledge the very valuable contributions provided by Mr. Noel Bishop of Belvoir.

1. INTRODUCTION

1.1 Statement of problem. A replacement engine must be identified for use in 60 kW Diesel Engine Driven (DED) Generator Sets MEP-006A, MEP-105A, and MEP-115A.

1.2 Background. Diesel Engine Driven Generator Sets MEP-006A, -105A, and -115A were manufactured with an Allis-Chalmers 3500A liquid cooled diesel engine installation. Allis-Chalmers no longer manufactures diesel engines, spares, and repair parts. New production generator sets will require a replacement engine for the discontinued Allis-Chalmers model(s). Engine spares and replacement parts must be obtainable for the replacement engine. A market surveillance was performed to identify a suitable replacement engine. The market surveillance was limited to commercial, off-the-shelf, liquid-cooled diesel engines.

1.3 Purpose of report. This interim report documents a market surveillance (market survey) performed to identify a replacement commercial diesel engine for use in 60 kW DED Generator Sets MEP-006A, -105A, and -115A. The requirement for this report was established by paragraph 1.b of Task Order 0076 to U.S. Army Belvoir Research, Development and Engineering Center (Belvoir) Contract DAAK70-86-D-0023. Other parts of this task order relate to identification and correction of known or potential deficiencies in 15 kW, 30 kW, and 60 kW Military Standard Generator Sets.

1.4 Scope of report. This report covers the time period of June 03, 1987 through July 17, 1987. It discusses market surveillance results, draws a conclusion, and recommends an engine for use in 60 kW DED Generator Sets MEP-006A, -105A, and -115A.

1.5 Reference to related work. Task Order 0076 is related to task order 0067 of contract DAAK70-86-D-0023. Data presented in the final report for 0067, "Engineering Evaluation And Analysis For The Improvement Of Military Standard Generators", will be used during the performance of 0076.

1.6 Disposition instructions. Destroy this report when no longer needed. do not return it to the originator.

2. MARKET SURVEILLANCE

2.1 Scope of market surveillance. The market surveillance was limited to commercial, off-the-shelf, liquid-cooled diesel engines. A liquid-cooled engine is required because of the anticipated convenience of using the existing DED generator set heat exchanger and connections. More importantly, liquid cooled engines lend themselves more readily to the proven sound attenuation modifications to be installed on the DED generator sets in the near future.

2.2 Market surveillance procedure. The market surveillance procedure consisted of three steps:

- o Step 1. Identify potential engine suppliers. Send letter requests for engine data.
- o Step 2. Receive and review engine supplier responses. Telephonically obtain additional data as necessary. Eliminate replies that: (1) say for whatever reason, that an engine cannot be supplied; (2) show an engine to be obviously unsuitable for the intended purpose. Identify candidate engines for further analysis in step 3.
- o Step 3. Analyze candidate engine data, draw conclusion(s), make recommendation(s).

2.3 Step 1 data requests, step 2 review, and step 3 analysis

2.3.1 Step 1 data request. The Thomas Register listing for diesel engine suppliers was reviewed, and contacts were made with persons knowledgeable of the diesel engine industry. Appendix A is a list of potential engine suppliers contacted by letter. Appendix B is a sample of the letter sent to the suppliers shown in Appendix A.

2.3.2 Step 2 engine review process. Three criterion were used to review the supplier responses, shown in Appendix C, and to identify candidate engines for the step 3 data analysis process. These criterion were:

- o Identify self-eliminating letters (see paragraph 2.3.2.1).
- o Identify engines that do not produce specified horsepower (see Appendix B and paragraph 2.3.2.2).
- o Identify engines that exceed the maximum specified weight limitation (see Appendix B and paragraph 2.3.2.3).

2.3.2.1 Self-eliminating letters. This criterion was used to eliminate supplier responses which clearly stated that they would not be able to participate in the replacement engine project.

2.3.2.2 Specified horsepower. The horsepower specified in Appendix B was obtained from the MEP drawing 30554-70-1049, for the Allis-Chalmers engine currently used in the 60 kW DED generator set. It had been well established through field use of this equipment that the Allis-Chalmers engine had a large reserve horsepower capacity. The printed horsepower requirements had this added reserve capacity. Because of the correlation between engine horsepower and engine weight (i.e. increases in engine horsepower are often accompanied by an increase in engine weight), a decision was made to revise the horsepower specified in Appendix B to a new rating of a minimum 108 continuous horsepower at 1800 rpm when tested in accordance with MIL-STD-1400, "Engines, Gasoline and Diesel, Methods of Test". The required continuous horsepower rating of 108 was obtained from the Belvoir Purchase Description (PD) for Generator Sets, Diesel Engine, 15 KW, 50/60 Hertz and 400 Hertz, Type I (Tactical).

This value represents the minimum horsepower development that a replacement engine should have, with an adequate safety margin. Engines not meeting the 108 continuous horsepower requirement would be dropped from further consideration.

2.3.2.3 Maximum specified weight. The maximum specified weight was very important for identifying candidate engines. The current Allis-Chalmers DED generator set is weight critical, as it comes very close to exceeding the weight limitation for its trailer mounting while carrying its supply of ancillary equipment. A pending sound attenuation kit installation will force the generator set weight over the trailer weight limit. The 650 pound maximum weight limitation set forth in Appendix B, was derived from QPL-11276-6 for diesel engines. Since the weight of the sound attenuation package is expected to be anywhere from 600-1000 pounds additional, an attempt was made initially to target (as a weight savings) a 600 lbs or more weight savings with a new commercial engine. After an initial market sampling, it was found that no engine came close to making the weight limit. This limit was then relaxed to equal the weight of the current Allis-Chalmers engine. Therefore, with this value of 1375 lbs (actual weight as reported by Belvoir), any engines meeting this criteria would represent a weight savings. Engines exceeding the 1375 lb weight would be dropped from further consideration.

2.3.3 Step 3 engine analysis criterion. The following criterion was used to analyze the step 2 candidate engines (see paragraph 3.3.1):

- o Modifications to the replacement engine must be minimal. The ideal replacement engine would interface without any modifications whatsoever. It would attach directly to the current 60 kW DED generator housing and the existing front trunnion engine mount, and would fit into the specified engine envelope (see Appendix B).

3. DISCUSSION

3.1 Step 1 results. Requests for data were sent to 54 potential engine suppliers (see Appendix A).

3.2 Step 2 results. Sixteen engine suppliers responded to the step 1 data request. Fourteen responses were by letter, and two telephonic responses declined to provide data (see Appendix C).

3.2.1 Response review. Supplier responses were reviewed according to the criteria discussed in paragraph 2.3.2 inclusive. Suppliers were identified, and a brief of their responses follow:

- o Baldwin-Hamilton Co.. Their telephonic reply said they could not supply an engine as required.
- o Caterpillar Tractor Co.. A review of the Caterpillar technical data shows their 3114 Turbocharged Industrial Engine to have 106 hp at 1800 rpm, and to weigh approximately 880 pounds. This engine does not meet the minimum horsepower requirement. Therefore, this engine is dropped from further consideration.

- o Cummins Wisconsin, Inc. The Cummins 6BT5.9 engine produces 110 hp at 1800 rpm, and weighs 882 pounds. It is a candidate for further review. The Cummins 6BT5.9G1 engine produces 135 hp at 1800 rpm, and weighs 882 pounds. It is a candidate for further review.
- o Detroit Diesel Allison Div. The 6359T (John Deere) engine produces 125 hp at 1800 rpm, and weighs approximately 1274 pounds. It is a candidate for further review. The 6414T (John Deere) engine produces 131 hp at 1800 rpm, and weighs approximately 1324 pounds. It is a candidate for further review. The 4-71N engine produces 121 hp at 1800 rpm, and weighs 1780 pounds. It exceeds the 1375 pound weight limit, and is dropped from further consideration. The 4-71T engine produces 144 hp at 1800 rpm, and weighs 1830 pounds. It exceeds the 1375 pound weight limit, and is dropped from further consideration.
- o Deutz Corp. Their air-cooled engines do not meet the requirement for a liquid-cooled engine. Therefore, their engines are dropped from further consideration.
- o Hercules (White Engine, Inc.). The Hercules D-3400-T engine produces 112 hp at 1800 rpm, and weighs 1025 pounds. It is a candidate for further consideration.
- o International Harvester (Navistar Int'l.). Their letter said they cannot offer a replacement diesel engine. However, in view of changes to weight requirements, a review of their technical data shows their DT 360 engine produces 130 hp at 1800 rpm, and weighs 1200 pounds. This engine is a candidate for further consideration.
- o J. I. Case Co. Their letter said they were unable to participate in the engine replacement program at this time.
- o John Deere & Co. Their letter said that Detroit Diesel Allison Division had marketing responsibility for the Government sector for John Deere engines, and a reply would come from that company (see Detroit Diesel 6359T and 6414T engines).
- o Johnson & Towers Inc. Their Isuzu QD-145T engine produces 108 hp at 1800 rpm, and weighs 1091 pounds. It is a candidate for further consideration.
- o North American Diesel, Inc. Their letter said that their Slanzi diesels are suitable for only 30/45 kW max at 1500/1800 rpm.
- o Onan. Their telephonic reply said their engines exceeded the maximum specified rpm.
- o Perkins Great Lakes. The Perkins T6.3544 engine produces 108 hp at 1800 rpm, and weighs 1221 pounds. It is a candidate for further review.

- o Teledyne Continental (Total Power). Their letter said they cannot meet specifications at this time.
- o Volkswagen of America, Inc. The 075.1 VW industrial engine produces approximately 37 hp at 2000 rpm, and weighs approximately 420 pounds (191 kg). The 075.2 VW industrial engine produces 52 hp at 2000 rpm, and weighs 431 pounds (196 kg). Both engines do not meet the required horsepower. Therefore, they are dropped from further consideration.
- o Waukesha Engine Div. Their VRD330S engine produces 93 hp at 1800 rpm, and weighs 1100 pounds. This engine does not meet the horsepower requirement. Therefore, it is dropped from further consideration.

3.2.2 Candidate engines. Candidate engines to be further analyzed in step 3 are:

- o Cummins 6BT5.9
- o Cummins 6BT5.9G1 (400 Hz)
- o Detroit Diesel (John Deere & Co.) 6359T
- o Detroit Diesel (John Deere & Co.) 6414T
- o Hercules D-3400-T
- o International Harvester DT360
- o Isuzu QD-145T
- o Perkins T6.3544

3.3 Step 3 candidate engine analysis

3.3.1 Analysis criteria. The criteria used to analyze the candidate engines concern basic engine modifications needed to install and operate the replacement engine. Criteria used, and a brief of each, follow:

- o Engine must fit in envelope (see Appendix B). The replacement engine must fit into the available engine space. Where manufacturer's technical data does not show overall engine length with a fan attached, 8-inches were added to engine length to allow for the width of the fan attachment.
- o Engine must fit on trunnion mount. The current front engine mount is a center trunnion. The ideal engine would fit the current mount without modification of an off-the-shelf design.
- o Engine must have a 24 volt dc cranking system. Military engines use 24 volt dc cranking systems. Engines modified to use 24 volts dc starters would be acceptable.
- o Engine must have a variable speed mechanical governor. A variable speed governor will allow an engine operator to adjust engine at 1500 rpm for 50 Hz, 1800 rpm for 60 Hz, and 2000 rpm for 400 Hz power. The mechanical governor should meet the requirements for utility power.

3.3.2 Individual engine analyses. Table 1 shows a comparison of the candidate engines (see paragraph 3.2.2). An analysis for each candidate, based upon available information follows:

3.3.2.1 Cummins 6BT5.9. This engine will not fit into the required envelope, and it lacks a trunnion mount. It does have a variable speed mechanical governor.

3.3.2.2 Cummins 6BT5.9G1. This engine will fit into the required envelope. It will not fit a trunnion mount, but it has a variable speed mechanical governor.

3.3.2.3 Detroit Diesel 6359T. This engine will not fit into the required envelope. It will not fit a trunnion mount, and has no 24 volt dc starter system. It has a variable speed mechanical governor.

3.3.2.4 Detroit Diesel 6414T. Comments for the 6359T engine apply to this engine.

3.3.2.5 Hercules D-3400-T. This engine will fit into the required envelope. It will attach to a trunnion mount, has a 24 volt dc starter, and a variable speed mechanical governor.

3.3.2.6 International Harvester DT360. This engine will not fit into the required envelope. It has a variable speed mechanical governor. Other information is not available at this time.

3.3.2.7 Isuzu QD-145T. This engine will not fit into the required envelope. It does not have a 24 volt dc starter. No further information is available at this time.

3.3.2.8 Perkins T6.3544. This engine will not fit into the required envelope. It does not have a 24 volt dc starter, but it does have a variable speed mechanical governor. Other information is not available at this time.

3.3.3 Manufacturer's engine data. The manufacturer's engine data often was not wholly responsive to the data request. Table 2 contains a comparison of manufacturer's engine weight and horsepower, gleaned from the data sheets submitted during the period of this market surveillance. It should be noted that this table is not valid for a one-to-one comparison. The horsepowers reported are based on varying testing standards (i.e. SAE J1349, DIN6271, etc.) and not all ratings are based on "continuous" output. The weights reported in the manufacturer's data are vague with regard to what accessories are included in this engine weight. Due to the variety of standard accessories, it was difficult to make a direct comparison. There was no attempt made to obtain additional data or clarifications after an engine was found to be unable to meet one or more of the envelope, trunnion mount, and starter requirements.

TABLE 1. Comparison of candidate engines.

Analysis Criteria (see paragraph 3.3.1)	Cummins		Detroit Diesel		Hercules D-3400-T	Intl DT360	Isuzu QD-145T	Perkins T6.3544
	6BT5.9	6BT5.9G1	Diesel 6359T	Diesel 6414T				
Fit envelope								
length	NO	YES	NO	NO	YES	NO	NO	NO
width	YES	YES	YES	YES	YES	NO	NO	NO
height	YES	YES	YES	NO	YES	NO	YES	YES
Fit trunnion mount	NO	NO	NO	NO	YES	UNK	UNK	UNK
has 24 volt dc starter	YES	YES	NO	NO	YES	UNK	NO	NO
Has variable speed mechanical governor	YES	YES	YES	YES	YES	YES	UNK	YES
Operate on 15° inclined plane	ASSUMPTION - ALL ENGINES CAN OPERATE ON 15° INCLINED PLANE							
12-foot fuel pump lift	ASSUMPTION - ALL ENGINES HAVE 12-FOOT FUEL PUMP LIFT							
NOTE: As brake specific fuel consumption was not presented for the 60 kW rated load condition by all engine suppliers, an equitable fuel consumption comparison could not be made.								

TABLE 2. Engine Weights and Horsepower Ratings

Engine Mfr.	Model #	Dry Weight (Lbs)	Weight does not include:	Brake HP at 1800 RPM	Output does not include consumption from:	Test Reference Conditions
Caterpillar	3114T	880	fan, alternator, flywheel	106	Alternator & fan	SAE J1349, intermittent rating
Cummins	6BT5.9-G1	882	(Total Wgt)	135	Alternator & fan	ISO 3046, continuous rating
Cummins	6BT5.9	882	(Total Wgt)	110	Alternator & fan	ISO 3046, continuous rating
Detroit Diesel Allison	6414T	1324	Fan	131	Fan	Unknown, intermittent rating
	6359T	1274	Fan	125	Fan	Unknown, intermittent rating
	4-71T	1830	Unknown	144	Any accessories	Unknown, continuous rating
	4-71	1780	Unknown	121	Any accessories	Unknown, continuous rating
Deutz	BF6L 913	1133	Unknown	112	Fan	DIN 6271, continuous rating
Hercules	D3400-T	1025	(Total wgt)	112	Fan	107°F @ 5000 ft continuous rating

TABLE 2. Engine Weights and Horsepower Ratings (Continued)

Engine Mfr.	Model #	Dry Weight (Lbs)	Weight does not include:	Brake HP at 1800 RPM	Output does not include consumption from:	Test Reference Conditions
Int'l	DT360	1200	Fan & Alternator	130	Fan & alternator	SAE J1349, unknown rating
Isuzu	QD-145T	1091	Unknown	108	Fan, muffler, air cleaner	SAE J816b, continuous rating
Perkins	T6.3544	1221	(Total wgt)	108	Alternator & fan	SAE J1349, continuous rating
Volkswagen	075.1	420	Unknown	37 @ 2000 RPM (min)	Fan	DIN 70020, unknown rating
	075.2	431	Unknown	52 @ 2000 RPM (min)	Fan	DIN 70020, unknown rating
Vaukesha	VRD 330S	1100	Unknown	93	Alternator & fan	Unknown, continuous rating

4. CONCLUSION

- o The Hercules D-3400-T is the only engine that meets all criterions for engine selection.

5. RECOMMENDATION

- o The Hercules D-3400-T engine should be acquired, installed, and tested for use in the prototype 60 kW DED sound attenuated Generator Set.

APPENDIX A
Potential Engine Suppliers

Potential Engine Suppliers

Alco Power Inc.
100-T Orchard Street
Auburn, NC 13021

American M.A.N. Corp.
50 Broadway
New York, NY 10004

American MARC Inc.
8831 S. Aviation Blvd.
Inglewood, CA 90301

Baldwin-Hamilton Co.
One Country View Road
Malvern, PA 19335

Briggs & Stratton
Lombardini Diesel In
3402 Oakcliff Road
Doraville, GA 30340

Cain Industries Inc.
P.O. Box 189
Mequon Road
Germantown, WI 53022

Caterpillar Tractor Co.
Engine Division
100 N.E. Adams Street
Peoria, IL 61629

Central Power Engineering Co.
656-T Arrow Hwy.
LaVerne, CA 91750

Chrysler Marine & Industrial Div.
Gas & Diesel Engines
6565 T E. Eight Mile Road
Warren, MI 48091

Continental Motors Inc. (Teledyne)
205 Market Street
Muskegon, MI 49942

Cummins Wisconsin, Inc.
1921 S. 108th Street
Milwaukee, WI 53227

Detroit Diesel Allison Division
13400-T Outer Drive, W.
Detroit, MI 48239

Deutz Corporation
7585-T Ponce deLeon Circle
Atlanta, GA 30340

Domestic & International Technology
100 S West Avenue
Jenkintown, PA 19046

Dresser Industries
1000 W Street Paul Avenue
Waukesha, WI 53187

Engineered Cooling System Inc.
201 W. Carmel Drive
Carmel, IN 46032

Fairbanks/Morse Engine Div.
701 Lawton Avenue
Beloit, WI 53511

Ferguson Diesels
258 McKinnley Street
Bristol, PA 19007

Ford Industrial Engines Operations Div.
3000-T Schaefer Road
P.O. Box 6011-T
Dearborn, MI 48121

General Motor Corp.
Diesel Engine Div.
3044 T W. Grand Blvd.
Detroit, MI 48202

Industrial Engines & Equipment
Box 538
311 N. Polk Street
Pineville, NC 28134

International Diesel Electric Co. Inc.
100 Midland Ave Extension
Middletown, NY 10940

International Harvester/Engine Div.
401-TN Michigan Avenue
Chicago, IL 60611

J. I. Case Co.
700 State Street
Racine, WI 53404

John Deere & Co.
John Deere Road
Moline, IL 61265

Johnson & Tower Inc.
Rt. 38 & Briggs Road
Mount Laurel, NJ 08054

Kubota Tractor Corp., Engine Div.
125 E. Commerce Dept. T48
Schaumburg, IL 312884-0212

Lister Diesel Inc.
556 E. 56 Highway P
P.O. Box 1160
Olathe, KS 66061

Mack Trucks Inc.
2100 Mack Blvd.
Allentown, PA 18105

Mercedes-Benz of North America
1T Mercedes Drive
Montvale, NJ 07645

MMW/Murphy Diesel Co.
5317 W. Burnhams Street
Milwaukee, WI 53219

MTU of North America Inc.
10450 Corporate Drive
Sugarland, TX 77478

MWM Diesel Inc.
3200 Pointe Pkwy
Norcross, GA 30092

Navistar International Corp.
401 N. Michigan Ave. 19
19th Floor
Chicago, IL 60611

NKK America Inc.
Heavy Industries Dept.
Engines/Turbines/Boilers
444 S. Flower St., Suite 2430
Los Angeles, CA 90017

North American Diesel Inc.
1611 94th Lane, NE
Minneapolis, MN 55434

Onan
1400 73rd Avenue, N.E.
Minneapolis, MN 55432

Penn-Detroit Diesel Allison
8330 State Road
Philadelphia, PA 19136

Perkins Engine Inc.
Dept. T, 32500 Van Born Road
Wayne, MI 48184

Perkins Great Lakes, Inc.
4695 Branciforte Drive
Santa Cruz, CA 95065

Petter Diesels
Dept. BG-10, 4761 Hugh Howell Rd.
Tucker, GA 30084

Pleasure Craft Marine Engine
Hwy 76 East P.O. Box 175
Little Mountain, SC 29075

Sterling Engines Co. Inc.
3600 NW North River Dr.
Miami, FL 33142

Stewart & Stevenson Services Inc.
4516 Harrisburg Blvd.
Houston, TX 77011

Teledyne Continental Motors
General Products Div.
76 Getty Street
Muskegon, MI 49442

Teledyne Inc/Teledyne
Wisconsin Motor
1910 S. 53rd Street
Milwaukee, WI 53219

Thermo Electron Corp.
Crusader Engines Div.
7100 E. 15 Mile Road
Sterling Heights, MI 48077

TransAmerica DeLaval Inc.
Engine & Compressor Div.
Enterprise Way & 85th Ave.
P.O. Box 2161
Oakland, CA 94621

VM Group of America Inc.
2400 Fountain View Drive
Houston, TX 77057

Volkswagon of America Inc.
Industrial Engine Div.
420 Barcaly Blvd.
Lincolnshire, IL 60069

Waukesha Engine Div.
1000-T W. St. Paul Avenue
Waukesha, WI 53187

Westerbeke (JH) Corp.
Avon Industrial Park
Avon, MA 02322

White Engine, Inc.
101-T 11th Street, S.E.
Canton, OH 44707

Whiteley Industrial, Inc.
14-T Everbery Road
Woburn, MA 01801

APPENDIX B

Sample Letter Request for Engine Data

VSE CORPORATION

2550 HUNTINGTON AVENUE
ALEXANDRIA, VIRGINIA 22303-1499

AST/HPW

June 8, 1987
0500.0076

MMW/Murphy Diesel Co.
5317 W. Burnhams Street
Milwaukee, WI 53219

Subject: Improved Military Standard Generators - 60 kW Set Engine
Replacement, Contract No. DAAK70-86-D-0023, Task 0076

Gentlemen:

VSE Corporation, on behalf of the US Army Belvoir Research, Development and Engineering Center (Belvoir), Fort Belvoir, VA, is conducting a market survey to assess the suitability and availability of a diesel engine for replacement to the DOD tactical 60 kW generator sets (MEP-006A, MEP-115A and MEP-105A). The enclosed performance/specification sheet and dimensional envelope drawing indicate the salient features that are desired in the replacement engine. The engine submitted for consideration should be as-manufactured or manufacturer's standard product.

Please forward catalogs and/or data sheets describing your products that meet these general requirements, at your earliest convenience, to my attention, Garry Perkins, at the above address. I would be pleased to answer any further questions or requests. This information will be evaluated to determine the suitability of your equipment to meet the Department of Defense needs.

This request is for information only. Your response will not constitute any contractual arrangement with VSE Corporation and it is to be understood that whatever information is provided will be at no cost to VSE or the Government.

LTR - Improved Military
Standard Generators (Con't)

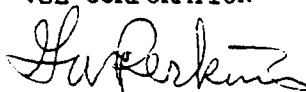
-2-

June 8, 1987

Your rapid response is appreciated not later than 19 June 1987.

Very truly yours,

VSE CORPORATION



G. W. Perkins, Project Engineer
Environmental, Power and Physical
Security Group



L. S. Hay, Manager
Environmental, Power and Physical
Security Group

GWP/LSH:krd

Enclosures

ENGINE PERFORMANCE/SPECIFICATION SHEET

I. Governing Spec: MIL-STD-1410 and the following options:

Type Engine: Diesel

Class: Class II, modified commercial end item

II. Testing:

A) Preproduction - Per MIL-STD-1400, Test Method 2000

B) In-process - Per MIL-STD-1400, Test Method 3000

III. Characteristics:

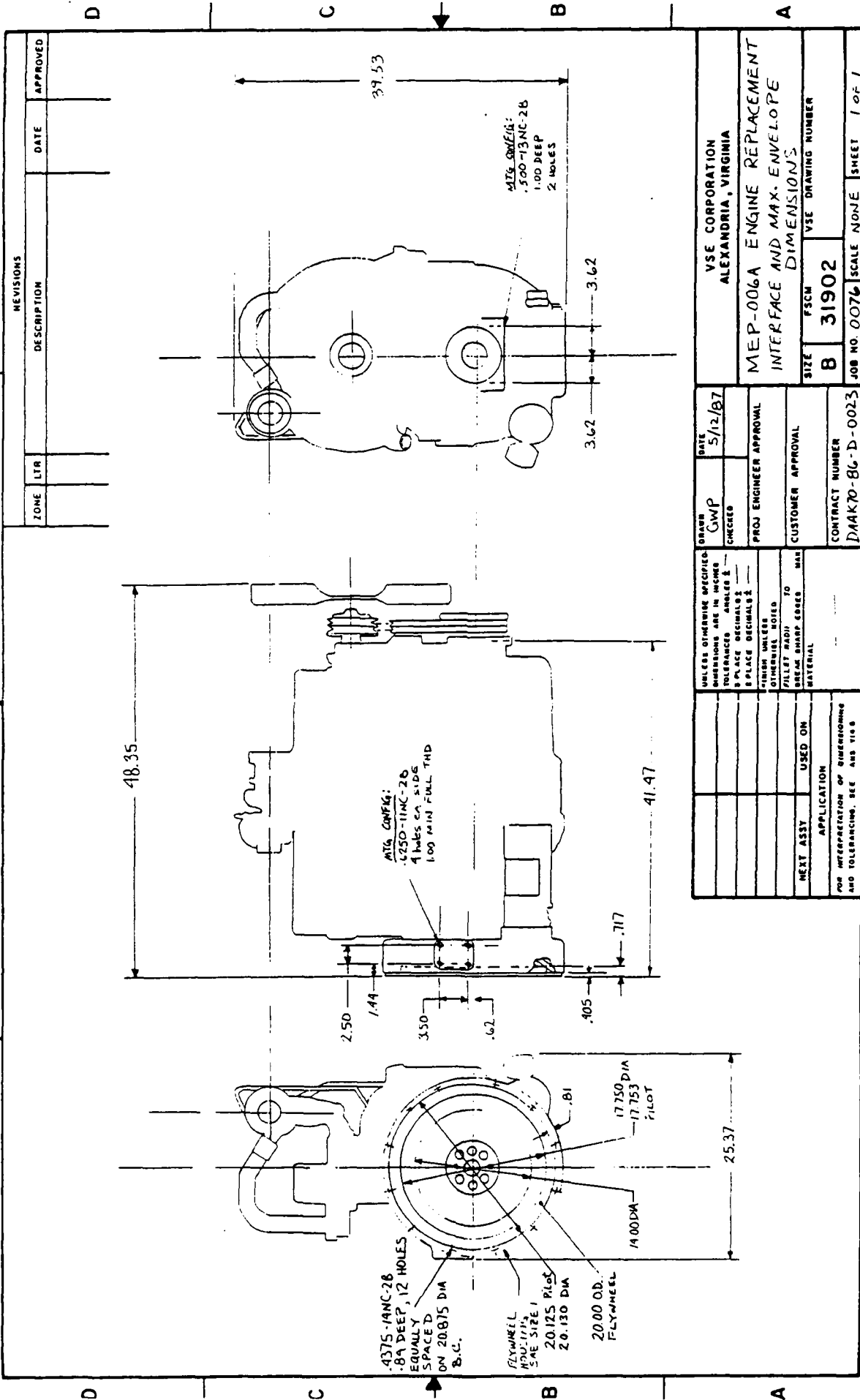
A) Performance:

- i) Operating Speed -
 - 60 Hz - 1800 RPM (max)
 - 50 Hz - 1500 RPM (max)
 - 400 Hz - 2000 RPM (max)
- ii) Continuous BHP* (rated condition, up to 5000 ft altitude)
 - at rated speed (60 Hz) - 120
 - at rated speed (50 Hz) - 100
 - at rated speed (400 Hz) - 130
- iii) Maximum rated load fuel consumption - 6 gals/hr
- iv) Required fuel pump lift - 12 ft.
- v) Cooling - liquid cooled
- vi) Environmental operating conditions
 - a) Temp range at rated load and sea level -- -25°F to +125°F
 - b) Temp range at rated load and 5000 ft -- -25°F to +107°F
- vii) Inclined Operation - up to a maximum of 15° from level

B) Physical:

- i) Weight - 650 lbs max
- ii) Dimensions - maximum envelope and required interface dimensions in accordance with attached drawing sheets.
- iii) Governing system - centrifugal, variable speed
- iv) Cranking system - 24 volt DC, electric start

*BHP - Maximum flywheel horsepower available for end item operation (having subtracted off parasitic loads such as cooling fans, battery charging alternators, etc.)



APPENDIX C

Engine Supplier Responses

NOTE: Engine suppliers technical data packages are on file with the Belvoir Research, Development and Engineering Center's Power Generation Division (STRBE-FGP). Questions concerning this data should be directed to STRBE-FGP (ATTN: Mr. Noel Bishop), (703) 664-5596.

IMPORTANT MESSAGE

TO Dary Perkins
DATE 6-09-87 TIME 10:04 ~~PM~~ ^{A.M.}

WHILE YOU WERE OUT

M _____

OF Baldwin - Hamilton
Area Code _____
& Exchange _____

TELEPHONED	<input checked="" type="checkbox"/>	PLEASE CALL	<input type="checkbox"/>
CALLED TO SEE YOU	<input type="checkbox"/>	WILL CALL AGAIN	<input type="checkbox"/>
WANTS TO SEE YOU	<input type="checkbox"/>	URGENT	<input type="checkbox"/>
RETURNED YOUR CALL		<input type="checkbox"/>	<input type="checkbox"/>

Message Cannot help you
Do not work in
required equipment.

Operator BLS

IMPORTANT MESSAGE

TO VSE-Dary Perkins

DATE 6-01-87 TIME _____ A.M.
P.M.

WHILE YOU WERE OUT

M M. K. MacPhail

OF Caterpillar Inc.

Area Code & Exchange (309) 675-6595

TELEPHONED	<input checked="" type="checkbox"/>	PLEASE CALL	
CALLED TO SEE YOU		WILL CALL AGAIN	
WANTS TO SEE YOU		URGENT	
RETURNED YOUR CALL		<input checked="" type="checkbox"/>	

Message Will send engine
data as requested
under separate cover.

Operator Sub 5

Cummins Engine Company, Inc.
Box 3005
Columbus, Indiana
47202-3005



June 29, 1987

G. W. Perkins
Project Engineer
Environmental, Power and Physical Security Group
VSE Corporation
2550 Huntington Avenue
Alexandria, Virginia 22303-1499

REF: Improved Military Standard Generators - 60 kW Set Engine
Replacement, Contract No. DAAK70-86-D-0023, Task 0076

Dear Mr. Perkins:

Enclosed you will find technical data on the products available from Cummins Engine Company, Inc. The data submitted is based on the power range and specifications listed in your 6/8/87 request for engine data. Most of the requirements on the Engine Performance/Specification Sheet can be met by our 6BT(A) series engines. A few exceptions should be noted and are listed below:

1. Governing Spec: The engines proposed meet MIL-STD-1410 as a Class II modified commercial end item. Commercial experience data is available on the Cummins 6 cylinder B Series engines.

NOTE: The Engine Performance/Specification Sheet lists 'Class III, modified commercial item'. MIL-STD-1410 lists Class II as a modified commercial item. (See attached excerpt)

2. Testing: Cummins would take exception to testing per MIL-STD-1400, Test Methods 2000 and 3000.
3. Characteristics: Engine performance characteristics are summarized below -

Operating Speed/Continuous BHP**

MODEL	HZ	REQ RPM	REQ BHP	CUMMINS RATINGS BHP RPM
6BT5.9-G	60	1800	120	135 @ 1800
6BT5.9-G	50	1500	100	115 @ 1500
*6BT 5.9	400	2000	130	140 @ 2000

*Requires a customer supplied electric governor; Standard rating on the 6BT 5.9 engine is 152 BHP at 2500 RPM.

**Please note Cummins definition for Continuous BHP on applicable data sheet.

Phone: 812-377-5000

Fuel Consumption

The 6BT 5.9 engine would experience the most fuel consumption:
Fuel consumption based on 140 HP @ 2000 RPM = 6.90 gal/hr

Fuel Pump Lift

Data will be forwarded, unable to verify at this time.

Environmental Operating Conditions

See data sheets and performance curves.

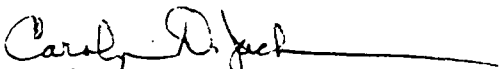
Inclined Operation

Angularity: 35 degrees

Physical characteristics (weight/dimensions) differ from drawing.

Please contact the undersigned if you have questions regarding these engines.

Regards,


Carolyn D. Jackson
Manager-Government Business

MEMORANDUM FOR RECORD

14 Jul 87

PER telecon w/ C. Jackson, weight listed on brochure (500#)
includes alternator & flywheel. ADD approx. 25# for fuel.
They do not offer a transition mtg.

G.W. Perkins



Detroit Diesel Allison
Division of General Motors Corporation

General Offices

13400 Outer Drive, West
Detroit, MI 48239-4001
Phone: (313) 592-5000
Telex: 4320091
TWX: 810-221-1649

June 15, 1987

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22303-1499

Attention: Mr. G. W. Perkins, Project Engineer
Environmental, Power and Physical Security Group

Dear Mr. Perkins:

Subject: Improved Military Standard Generators
60 kW Set Engine Replacement
Contract No. DAAK70-86-D-0023, Task 0076

Thank you for your June 8 inquiry on the above project.

I have enclosed two copies of industrial engine specification sheets for the following engines which could be used as replacement prime movers:

- 6359T.
- 6414T
- 4-71N
- 4-71T

In addition, I have included copies of our fuel and lube oil specification for your information.

The dependability of a generator set rests largely in the prime mover. The rugged engines I have proposed are built to exacting quality criteria that ensure both the dependability and durability of the equipment in which they are installed.

If you require additional information, please call me at (313) 592-3799. I am ready to work with you to help develop a suitable replacement engine package.

Very truly yours,

A handwritten signature in cursive script that reads "Robert T. Ragan".

Robert T. Ragan

/cc
Encl.

Deutz Corporation



June 19, 1987

Mr. G. W. Perkins,
Project Engineer
VSE Corporation
2550 Huntington Avenue
Alexandria, Virginia 22303-1499

Re: Military Standard Generators 60 kW Engine Replacement.

Dear Mr. Perkins:

Enclosed is a catalogue showing our complete product line of 5-525 HP air-cooled diesel engines and a listing of U. S. Military Applications Currently Powered by Deutz AirCooled Engines.

Specifically for the 60 kW Generator Repower effort, we suggest our Model BF6L 913 and have enclosed an installation drawings of this engine. We further would incorporate some modifications to this engine to improve the installation and maintainability.

We would like to visit with you at your convenience to discuss these improvements.

Sincerely,

DEUTZ CORPORATION

A handwritten signature in cursive script, appearing to read "R. O. Barton".

R. O. Barton
Manager, Government Programs

ROB:jef

Enclosure

cc: W. Steinbuechel, G. Kramer
L. S. Hay/VSE Corp.



HERCULES ENGINES, INC.

June 25, 1987

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22302-1499
ATTN: Mr. Gary W. Perkins, Project Engineer

Re: VSE Letter, dated 8 June 1987, Subject: Imported Mil-Std
Generators - 60 KW Set Engine

Gentlemen:

Pursuant to the above referenced letter, the following attachments (1-4) are enclosed for your use.

Hercules Engines has for considerable time, as the attachments reflect, been under the opinion that our standard D-3400T engine could better meet the 60 KW generator set requirements than the current engine. As you will note, considerable design and test has been directed toward that end all of which is directly applicable to today's 60 KW generator. The D-3400T is a drop-in unit, incorporates significant logistic standardization with the current Army 15 and 30 KW generator sets, has been thoroughly tested for this requirement and, is a production diesel engine. It is also very cost effective to procure and operate.

In addition to addressing the repowering of current configured 60 KW sets, we would like to share with you one of our new engine developments which we strongly feel will become a principle candidate for the new family of 10-60 KW generators. This engine, the 3.7 L Series II, employs diesel engine technology and provides rugged durability, ultimate fuel economy and performance to outperform any other engine in its class. Attachment 5 provides additional specification data for your use. Hercules Engines intends to actively promote this engine series for the Army's future MEP program.

Should questions arise or you need additional information on either of these engine systems, please contact the undersigned, or, Mr. William Summerson at (703) 978-3324.

Sincerely,

Lawrence R. Hawkins
Director,
Business Planning & Development

Navistar International
Corporation

10400 West North Avenue
Melrose Park IL 60160
312 865 3731

June 16, 1987

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22303-1499

ATTENTION: Mr. G. W. Perkins, Project Engineer



INTERNATIONAL

This is to acknowledge your correspondence of June 8, 1987 and to advise that Navistar International (International Harvester Company) cannot offer a diesel engine for replacement to the DOD tactical 60 KW generator sets. Based on your required engine performance and specifications our available diesel engines will not meet your requirements.

As a matter of additional information; it should be noted that our present marketing strategy is to consider potential high volume engine requirements built to basic fan hub to flywheel specifications. For engines requiring specifications deviations, such as engine pump settings and governing; you may contact the Engine And Equipment Company, 11125 Palmer Avenue, South Gate, California 90280. Telephone Number (213) 773-4206.

I have included copies of our on-highway engine truck spec sheets for information only.

Sincerely,

R. C. Nichol

pab/2635M

Enclosure

NAVISTAR

J I Case
A Tenneco Company

Marketing Group



700 State Street
Racine, Wisconsin 53404
(414) 636-6011

June 10, 1987

VSE Corporation
Attn: Mr. G. W. Perkins
Environmental, Power and
Physical Security Group
2550 Huntington Avenue
Alexandria, VA 22303-1499

Ref: Your letter 8 June 1987, 0500.0076

Subject: 60KW Engine Replacement
DAAK70-86-D-0023, Task 0076

J I Case Company is unable to participate in the engine replacement program at this time.

Thank you for considering our company.

Sincerely,

A handwritten signature in cursive script, appearing to read "R. P. Scott".

R. P. Scott
Manager
Federal Marketing

RPS: lb



DEERE & COMPANY

JOHN DEERE ROAD, MOLINE, ILLINOIS 61265-8098 U.S.A.



Government Products

9 June 1987

Mr. G. W. Perkins
Project Engineer
Environment, Power and Physical Security Group
VSE Corporation
2550 Huntington Avenue
Alexandria, Virginia 22303-1499

Subject: Improved Military Standard Generators - 60 kW Set Engine
Replacement, Contract No. DAAK70-86-D-0023, Task 0076

Dear Gary:

Thank you for your inquiry about the suitability and availability of a diesel engine for the DoD tactical 60 kW generator sets. Deere does manufacture and market engines appropriate for this application.

Currently we have a marketing agreement with the Detroit-Diesel Allison Division of GM. They have marketing responsibility for Deere diesel engines including Department of Defense opportunities. Therefore, information about Deere engines will be provided to you through the Government Sales office of DDA. Mr. John Syzmanski (313/592-5870) also received a copy of your inquiry. I spoke with him and he agreed to respond appropriately.

Additionally, I have sent a copy of your inquiry to Dan Cummings, Program Manager Utility Systems in our Rotary Engine Division. Dan (201/470-7097) is responsible for managing the development of SCORETM Rotary Engine powered generator sets. This includes providing rotary engines to generator set manufacturers. The information Dan provides can also be helpful to you in future programs.

Thank you for this opportunity to respond.

Sincerely,

Travis B. Unterzuber
Division Manager
Phone 309/752-4474

mgm

c: D. E. Cummings
J. D. Spuller





JOHNSON & TOWERS, INC.



June 22, 1987

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22303-1499

Attn: Mr. Garry Perkins

REFERENCE: Isuzu Diesel Engine, Model QD145T

Dear Mr. Perkins:

Please consider the attached spec sheet. It is a bit heavier than your request indicated, but is very close in performance.

I was unable to establish whether you require engines only or complete power units. If the Isuzu meets your criteria, please contact me for additional data and pricing.

Regards,

JOHNSON & TOWERS, INC.

David Beling
Industrial Sales Department

DB:dp

Enclosure

POWER SPECIALISTS

Rt. 38 and Briggs Road, Mt. Laurel, New Jersey 08054 / (609) 234-6990
P.O. Box 4000, Mt. Laurel, New Jersey 08054
INTERNATIONAL TELEX: 6853047 JTMTL UW
FAX (609) 234 3635



NORTH AMERICAN DIESEL, INC.

Slanzi: Air Cooled Diesel Engines • Pump Sets • Generator Sets

June 19, 1987

VSE CORPORATION
2550 Huntington Avenue
Alexandria, Virginia 22303-1499

ATTENTION: G.W. Perkins & L.S. May: EPPS Group
(PH: 703-960-4600)

SUBJECT : Improved MIL-STD 60 KW Gen Sets

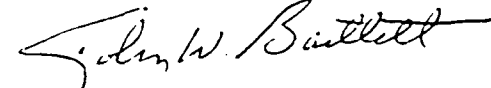
Thank you for your 8 June, 1987 inquiry as to the suitability of SLANZI air cooled diesel engines for 60 KW MIL-STD generator sets.

Regretfully, SLANZI diesels are suitable for only 30/45 KW MAX output at 1500/1800 RPM.

Thanks for considering us anyway. Please keep us on your potential bidders list.

Very truly yours,

NORTH AMERICAN DIESEL


John W. Bartlett
Manager

/ma

IMPORTANT MESSAGE

TO Dary Perkins

DATE _____ TIME _____ A.M.
P.M.

WHILE YOU WERE OUT

M _____

OF Oran

Area Code _____
& Exchange _____

TELEPHONED	<input checked="" type="checkbox"/>	PLEASE CALL	
CALLED TO SEE YOU		WILL CALL AGAIN	
WANTS TO SEE YOU		URGENT	
RETURNED YOUR CALL			

Message Said they exceeded
the maximum specified
rpm.

Operator Bob S

Perkins

Great Lakes

June 24, 1987

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22303-1499

Attn: G. W. Perkins, Project Engineer
Environmental, Power & Physical Security Group

Subject: Improved Military Standard Generators - 60 kW Set Engine
Replacement, Contract No. DAAK70-86-D-0023, Task 0076

Dear Mr. Perkins:

With reference to our conversation today regarding the replacement diesel engine to the DOD tactical 60 kW generator sets (MEP-006A, MEP-115A and MEP-105A), please find enclosed the data sheets and catalogues on our model T.6.354.4 engines.

You will note the width dimension as shown on Drawing NTU 33422 exceeds the 25.37" due to the fitting of the coil cooler arrangement, but this can be accommodated with an arrangement to remote mount the oil cooler. I will send you a drawing showing the arrangement which reduces the width by 4" which has been done in a number of applications successfully.

We can provide pre-production engines in 10 days in quantities of 4 units and normal lead time for production quantities is 90 days.

We would like to call you on Monday, June 29, 1987 to answer any questions you may have regarding this engine and we appreciate the opportunity for consideration of our products.

Sincerely yours,

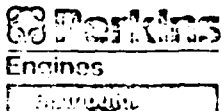


William D. Winemaster
President
Perkins Great Lakes, Inc.

WDW:dsl
Encl.

cc: A. Windsor Company (AWC)
4695 Branciforte Drive
Santa Cruz, CA 95065

PS - I have just noticed the drawing shows a #1 SAE physical laboratory and my data sheet is #3 SAE indicating a #1 housing / physical laboratory we could accommodate a model.



1125 McCabe Avenue • Elk Grove Village, IL 60007
(312) 228-9400



Parts
& Service

BERT GALLOWAY, Vice President-Military Marketing

TELEDYNE TOTAL POWER

3409 DEMOCRAT ROAD

P.O. BOX 181160

MEMPHIS, TENNESSEE 38181-1160

(901) 365-3600 TELEX 462-1058 (ITT)

JUNE 9, 1987

VSE CORPORATION
2550 HUNTINGTON DR.
ALEXANDRIA, VA 22303-1499

ATTENTION: MR. G.W. PERKINS

DEAR MR. PERKINS AND MR. HAY:

WE APPRECIATE YOUR INTEREST IN TELEDYNE TOTAL POWER. AT THIS TIME I'M SORRY TO SAY THAT WE CANNOT MEET THE SPECIFICATIONS YOU HAVE OUTLINED. WE ARE WORKING ON A 6 CYLINDER DIESEL/GASOLINE ENGINE THAT WHEN TURBO CHARGED COULD MEET YOUR SPECIFICATIONS AT SOME LATER DATE.

THANKS AGAIN FOR KEEPING US IN MIND.

SINCERELY

Bert Galloway

BERT GALLOWAY
V.P. MARKETING

 **Industrial Engines**

June 23, 1987

Mr. G.W. Perkins/Mr. L.S. Hay
VSE Corporation
2550 Huntington Avenue
Alexandria, Virginia 22303-1499

Dear Mr. Perkins & Mr. Hay:

We are pleased to enclose with this letter the information you requested. Please feel free to contact us if you require any additional information or assistance.

Your interest in Volkswagen industrial engine products is greatly appreciated, and we look forward to hearing from you.

Sincerely,



Thomas B. (Toby) Newcomb
Engineer

TBN/bkp

Enclosures

Industrial Engine Division, Volkswagen of America, Inc.

420 Barclay Boulevard, Lincolnshire, Illinois 60069 Phone: (312) 634-5290 TWX: 910 692 2149

Waukesha

WAUKESHA ENGINE DIVISION
DRESSER INDUSTRIES, INC.
1000 WEST ST. PAUL AVENUE • WAUKESHA, WISCONSIN 53188

In Reply Refer to
VEL SER 82-87
June 16, 1987

VSE Corporation
2550 Huntington Avenue
Alexandria, Virginia 22303-1499

Subject: Improved Military Standard Generators
60 KW Set Engine Replacement
Contract No. DAAK70-86-D-0023, Task 0076

Reference: G. W. Perkins Letter Dated 8 June 1987
Serial 0500.0076

Gentlemen:

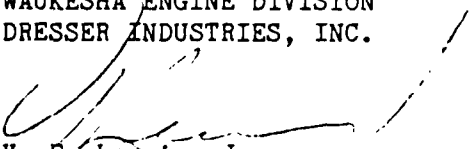
The intent of this letter is to advise you that the engine which Waukesha manufactures and is the closest to your requirements is our Model VRD330S diesel. This engine falls short of horsepower and in addition is 450 pounds too heavy; however, we are still forwarding Bulletin 1124A to give you an indication of the type of engines that we manufacture. In addition, please find enclosed two copies of Waukesha Bulletin 1088D. This bulletin depicts the rest of our product line.

We do thank you for your inquiry and hope to do business with you at a future date.

Regards,

Regards,

WAUKESHA ENGINE DIVISION
DRESSER INDUSTRIES, INC.


V. E. Lewein, Jr.
Government Marketing Manager

kke

encls.

cc: WED/Baltimore

Engines and Energy Systems . . . Diesel Natural Gas Gasoline

Circle 41 on Reader Service Card • Telex: 26769 • Telephone: (414) 547-2211