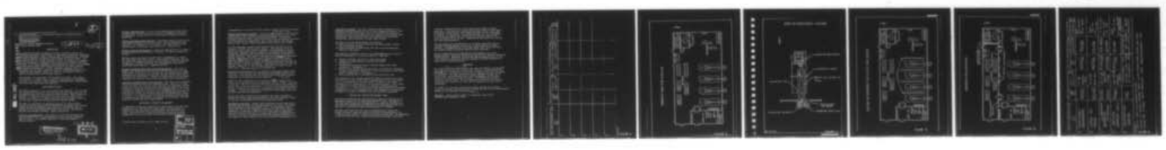
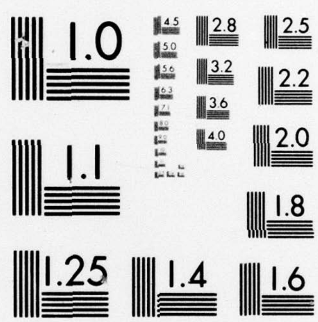
AD-A054 182   NAVAL FACILITIES ENGINEERING COMMAND NORFOLK VA ATLA--ETC F/G 20/1
DOLLARS PER DECIBEL -- A COMMON SENSE APPROACH TO EVALUATING NO--ETC(U)
1977   R R PARADIS

UNCLASSIFIED   NL

| OF |
AD
A054182



END
DATE
FILMED
6-78
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(6) DOLLARS PER DECIBEL -- A Common Sense Approach to Evaluating Noise Reduction Alternatives,

(10) by Richard R./Paradis
Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia 23511

(11) 1977 (12) 11p.

INTRODUCTION

An inumerable quantity of magazine articles, technical reports, and conference papers have been written on controlling, predicting, measuring, and preventing noise. Reams of catalog data and manufacturers' literature is readily available on materials and equipment for noise control. All this information is, indeed, necessary. And it is usually well prepared and well presented and sometimes even interesting and thought provoking. In spite of all this, something is still missing for those of us attempting to apply noise control engineering principles to our daily problems. That missing something is -- a good, reasonably foolproof method of evaluating the cost effectiveness of several recommended solutions to a practical noise problem. After all, isn't it the engineer's goal to achieve maximum benefit with minimum expense?

Which brings us to the reason for presenting this paper. This paper will develop, in "table" form, a method for evaluating the recommended solutions to a particular noise problem by comparing their implementation cost with their predicted noise reduction.

DEVELOPMENT OF TABLE

This simple approach is one I call "Dollars per Decibel". In it we take the recommended alternatives for reducing noise and compare the cost of implementing them with their predicted effectiveness. Maybe "Francs per Decibel" or "Pounds for Decibel" do not have quite the same ring as "Dollars per Decibel", but getting the most for one's money is what we are all after, regardless of the country or monetary system.

The Table was developed for analyzing solutions to noise problems related to hearing conservation in industrial environments, but could be easily adapted to evaluating other areas of noise control, such as methods of achieving property line noise level limits. The Table is divided into columns as follows: (Refer to Figure 1)

<u>Column 1, Recommendations</u>: Each method of noise reduction which has been determined to be a sound engineering solution to the problem at hand is listed, e.g., Complete Enclosure -- Add Intake Muffler -- Relocate Machine.

Column 2, Estimated Cost: This sum is an engineering estimate which includes labor and materials costs required to implement a particular Recommendation, usually escalated to anticipate a projected contract award date.

Column 3, Estimated Noise Reduction: This figure should be based on the most reliable predictions of noise reduction from calculations, past experience, or research in the literature. The area affected by the reduction must be indicated, e.g., Near Field -- General area.

Column 4, Cost Per DB Reduction: Divide the "Estimate Cost" of Column 2 by the "Estimated Noise Reduction" of Column 3 to obtain "Dollars Per Decibel".

This may seem to be enough to decide which recommendation to choose. But let's expand the Table further. Very possibly funds that "just do not exist" are suddenly available when the facts are clearly presented to show that a certain combination of recommendations will yield a substantial noise reduction. Therefore, we add:

Column 5, Predicted Noise Level After Implementation: This value is based on the "Estimated Noise Reduction" and the results of the sound level survey, e.g., we may want to show that the combination of adding suspended sound absorbers and isolating the noise source would reduce the noise level below 90dBA. Whereas, no single solution nor any other combination of solutions would achieve the same results economically.

Column 6, Allowable Exposure Time Increase: Many times we are concerned with noise reduction to protect employee hearing. Therefore, in this column, we insert the allowable noise exposure time determined from the sound level survey and the allowable noise exposure time for the value in column 5, "Predicted Noise Level After Implementation", e.g., if the original noise level was 100 dBA and the recommended solution reduced that level to 95 dBA, the allowable exposure time doubled from 2 hours to 4 hours. If it happened that the job only required 4 hours per day to accomplish, and the "dollars per decibel" was acceptable, then this would be a viable solution to the problem.*

DISCUSSION OF REPORT TO BE ANALYZED

An independent acoustical consultant was contracted to study the noise problem at a U.S. Navy facility's power plant. Reducing noise to conserve the plant personnel's hearing ability was the goal of the study. The scope of the consultant's work was to make an on-site investigation of the power plant noise levels and provide detailed

* These values are based on U.S.A. OSHA criteria.

recommendations to correct the noise problem, complete with cost estimates.

General Description of Facility: The power plant consists of an untreated prefabricated metal building of approximately 10,800 square feet [1003 square meters]. This building houses four diesel engine driven generators, a separately enclosed maintenance shop, an enclosed control room, and related electrical power switchgear, air compressors, motor control center, and storage battery room. Figure 2 shows the general floor plan for the facility.

The four generators, rated at 1000 kilowatts each, are driven by 16 cylinder, 1440 BHP, 720 rpm diesel engines. The generator units are mounted on steel I-beam skids set directly on the building's concrete floor slab. Exhausts from the engines are individually piped outside, through penetrations in the south wall of the building, to effective exhaust silencers. Each engine is equipped with two roots blowers which provide combustion air for the engine. These blowers have a rated capacity of 2900 CFM at 7.5 inches of Hg [87 cubic meters at 25.5 kilopascals] and at a speed of 2200 rpm. Inlet air to the blowers is taken from the building interior through oil bath filters -- one for each blower -- mounted on the inlet ports of the blowers. Makeup air to the building is provided via louvers in the south wall.

Recirculated cooling water for the engines is supplied by induced draft radiators located outside the building approximately 30 feet [9 meters] from the south wall. The radiator fans are driven by electrical motors mounted underneath the horizontally mounted radiators.

Within the area designated as the maintenance ~~shop~~ Room on Figure 2 are a repair and maintenance shop, the supervisor's office, a locker room, and a tool room. The walls separating this area from that of the generators are of concrete block construction. A concrete slab overhead provides a balcony, accessible by stairs from the generator area, which is used for storage. A double door arrangement separates the maintenance shop from the area containing the generators.

The control room is fabricated from modular type sound attenuating panels with double glazed viewing windows. For noise reduction, access to the area of the generators is also through double doors.

Operation of the Plant: Typical load requirements on the power plant are such that two units are required on-line at all times. The normal staff compliment at the power plant is 15. The consultant's report showed that sound levels ranged from 103 dBA in areas remote from the generators to a maximum of 108 dBA in the near field of a generator. Area sound levels varied little no matter which pair of generators was on-line. The report estimated that the staff averaged 60 percent of each eight-hour shift exposed to the sound levels in the generator area.

Consultant's Analysis: The wall, ceiling and floor surfaces in the generator room are practically void of sound absorbing materials. This acoustically "hard" environment results in a build up of noise both directly radiated from the generators and indirectly from multiple path reflections. Both one-third octave band analysis and acceleration reading were used to identify the major noise sources:

(1) Inlet air to the diesel engine roots blowers.
(2) Direct radiation of sound energy from the diesel engine casings and roots blower housing.
(3) Direct radiation of sound energy from the 16 air box inspection covers on each engine.

The consultant submitted a list of five recommendations in an order in which he determined to be the most effective. They were:

A. Install functional absorbers on walls and ceiling.
B. Install air intake piping to outside of building. See Figure 3.
C. Install barriers between engines (partial height either fixed or movable). See Figure 4.
D. Install a full height concrete block wall to isolate the switchgear and work area from the generators. This would be done in conjunction with Recommendation A. See Figure 5.
E. Gasket existing doors to maintenance shop and control room.

The consultant's cost estimate showed the intake air piping to be three times the cost of any of the other recommendations, yet it only yielded a 3 to 4 dB reduction in the near field. In addition, the report concluded that "no combination of the alternatives listed....will reduce near field noise levels adequately to eliminate hearing protection requirements....". Since it was certain that funds would not be available to implement all five recommendations, it was necessary to evaluate the findings of the report to determine the more effective approaches.

APPLYING THE "DOLLARS PER DECIBEL" TABLE

The data was extracted from the consultant's report and inserted in the appropriate columns of the "Dollars per Decibel" Table. See Figure 6. The Table readily shows that Recommendation A, functional absorbers, is cost effective considering the doubling of allowable exposure time and a decrease in reverberation time from 10 seconds to 2.1 seconds.

The Table also shows that the cost of Recommendation B, Intake Air Piping, is several magnitudes above all the other recommendations, yet it does little by itself to reduce the hazardous noise levels. Recommendation C, Partial Height Barriers, although achieving only minimal sound level reduction, eliminates direct line-of sight noise radiation between generators. This would aid in reducing the noise levels to which plant personnel are exposed while performing maintenance on one engine while an adjacent one is running. The movable barriers, Cb, were considered to be worth the expense since they could be used where needed, then could be wheeled out of the way. Permanent barriers would cause clutter and reduce maneuverability.

The full height wall, Recommendation D, is highly acceptable since it eliminates hearing damaging sound levels in 40 percent of the plant interior. Recommendation E, as the Table shows, will insure that doors are properly sealed to maintain effective noise reduction.

Since no combination of recommendations would eliminate the noise problem entirely, achieving optimum noise reduction for hearing conservation became the goal. Therefore, we concluded that Recommendations A, D, Cb, and E would be acoustically effective measures for which expenditure of funds could be easily justified.

CONCLUSION

As we have seen, the Table considers more than just "Dollars per Decibel". The criteria to be met, how close to this criteria a recommendation will bring us, and how economical an approach is compared with other approaches are displayed. The Table presents an easily digestible summary of the noise survey, the recommended noise reduction methods, and the cost estimate of a possibly voluminous report. The "Dollars per Decibel" Table can also be a useful tool for managers and administrators who are responsible for financing, but have little background in noise control engineering.

In summary, one can make wiser decisions about funding noise control projects by having a simple method of weighing the cost of each recommendation along with its predicted effectiveness.

Reference: "Noise Control Report for Transmitter Power Plant", Contract Number N62470-74-C-1723.

RECOMMENDATION (1)	ESTIMATED COST (2)	ESTIMATED NOISE REDUCTION (3)	COST PER dB REDUCTION (4)	PREDICTED NOISE LEVEL AFTER IMPLEMENTATION (5)	ALLOWABLE EXPOSURE TIME INCREASE (6)
A					
B					
C					
D					
E					

NOTES:

FIGURE 1

TRANSMITTER POWER PLANT FLOOR PLAN

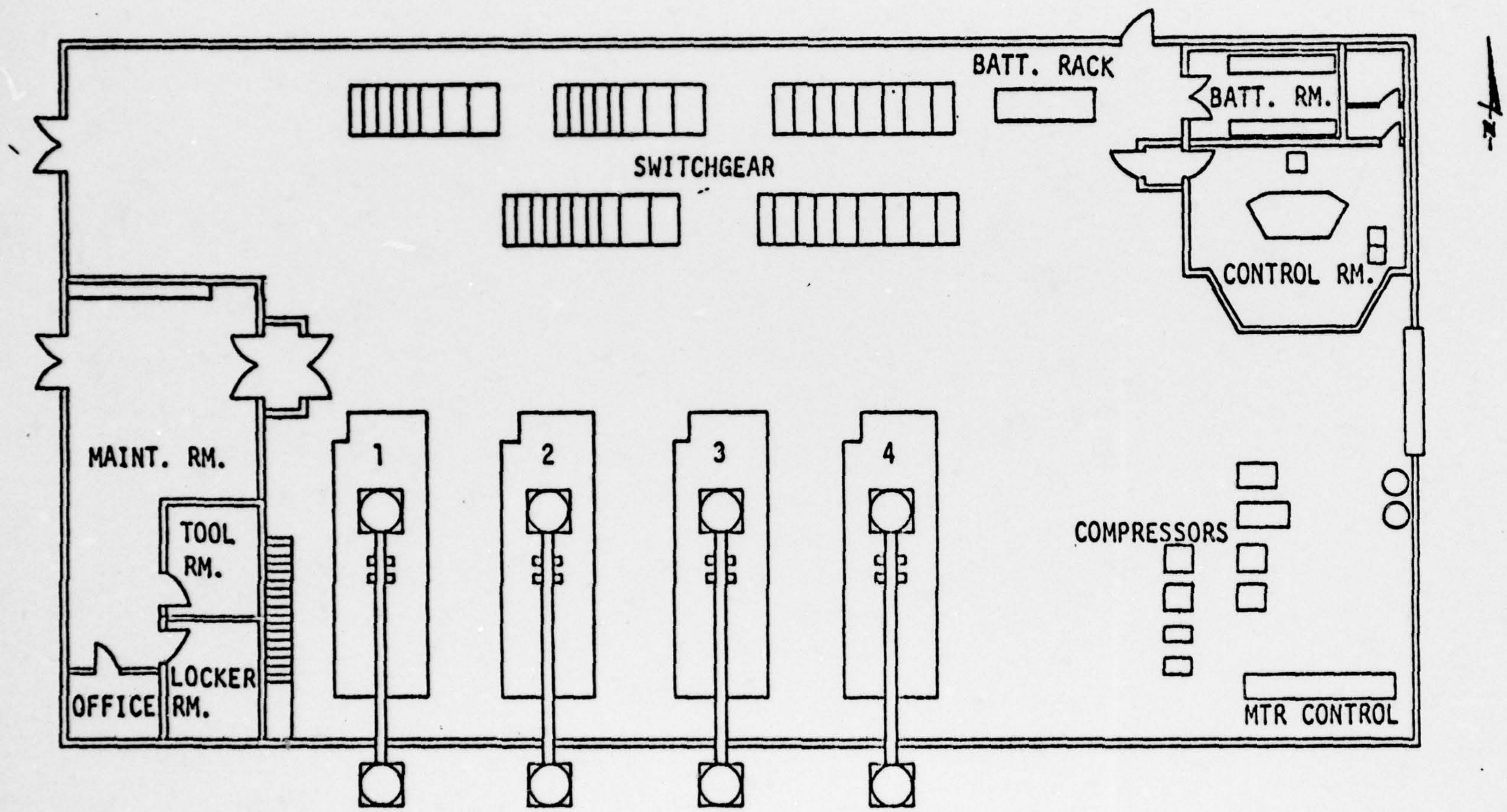
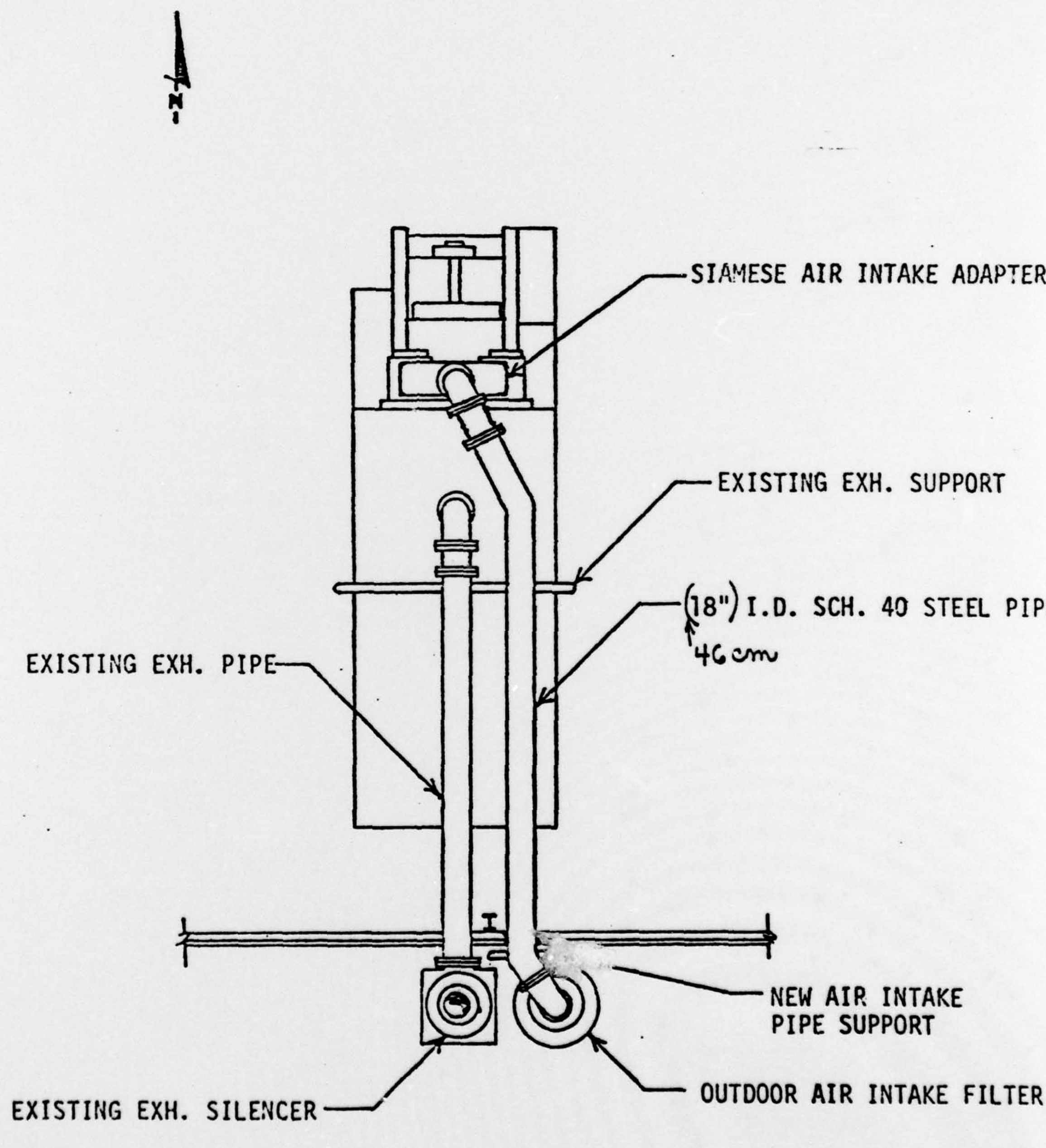


FIGURE 2

INTAKE AIR PIPING DETAILS - PLAN VIEW



NOT TO SCALE

FIGURE 3

[redacted]

LOCATIONS FOR RECOMMENDED PARTIAL HEIGHT SOUND BARRIERS

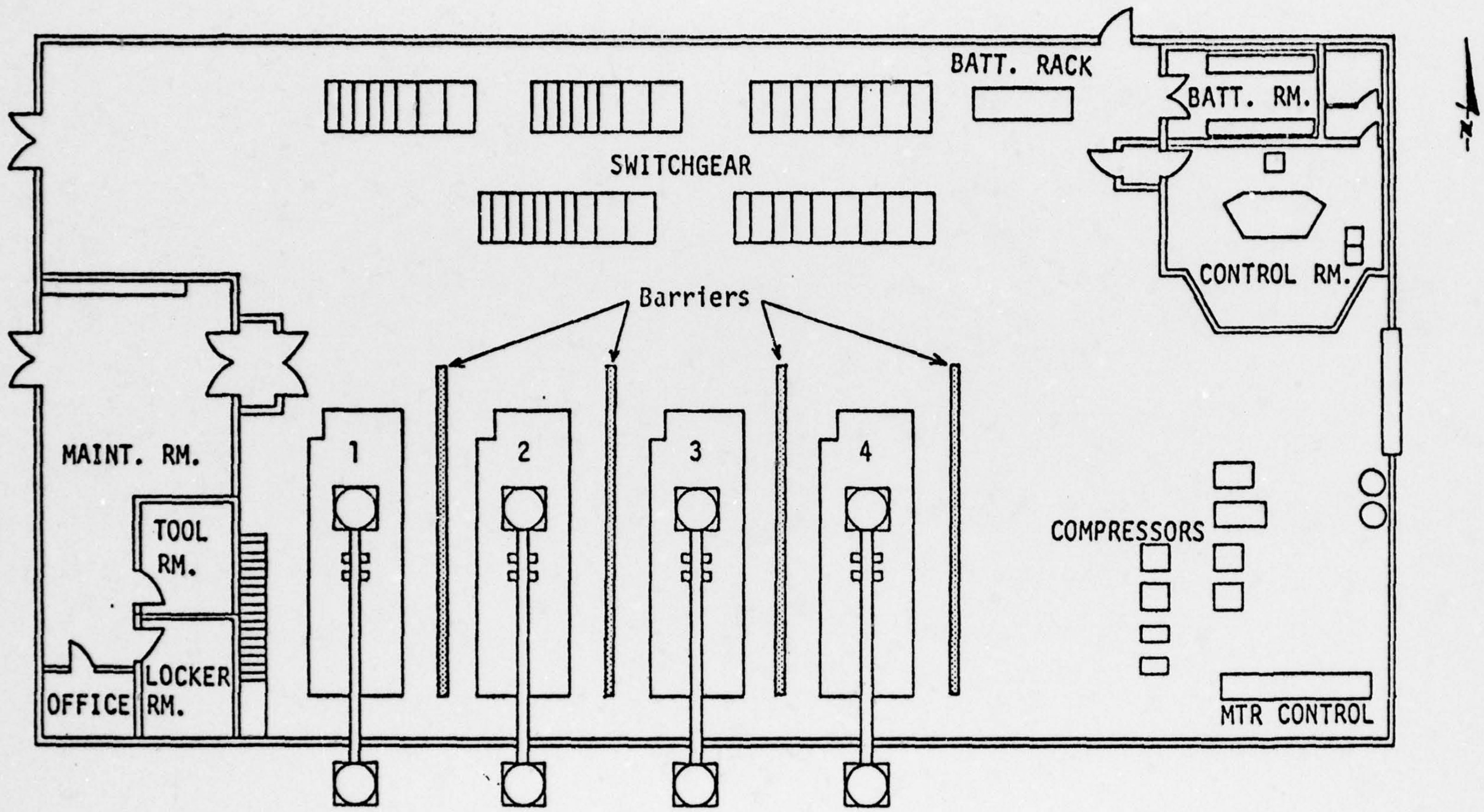


FIGURE 4

RECOMMENDED SOUND BARRIER WALL

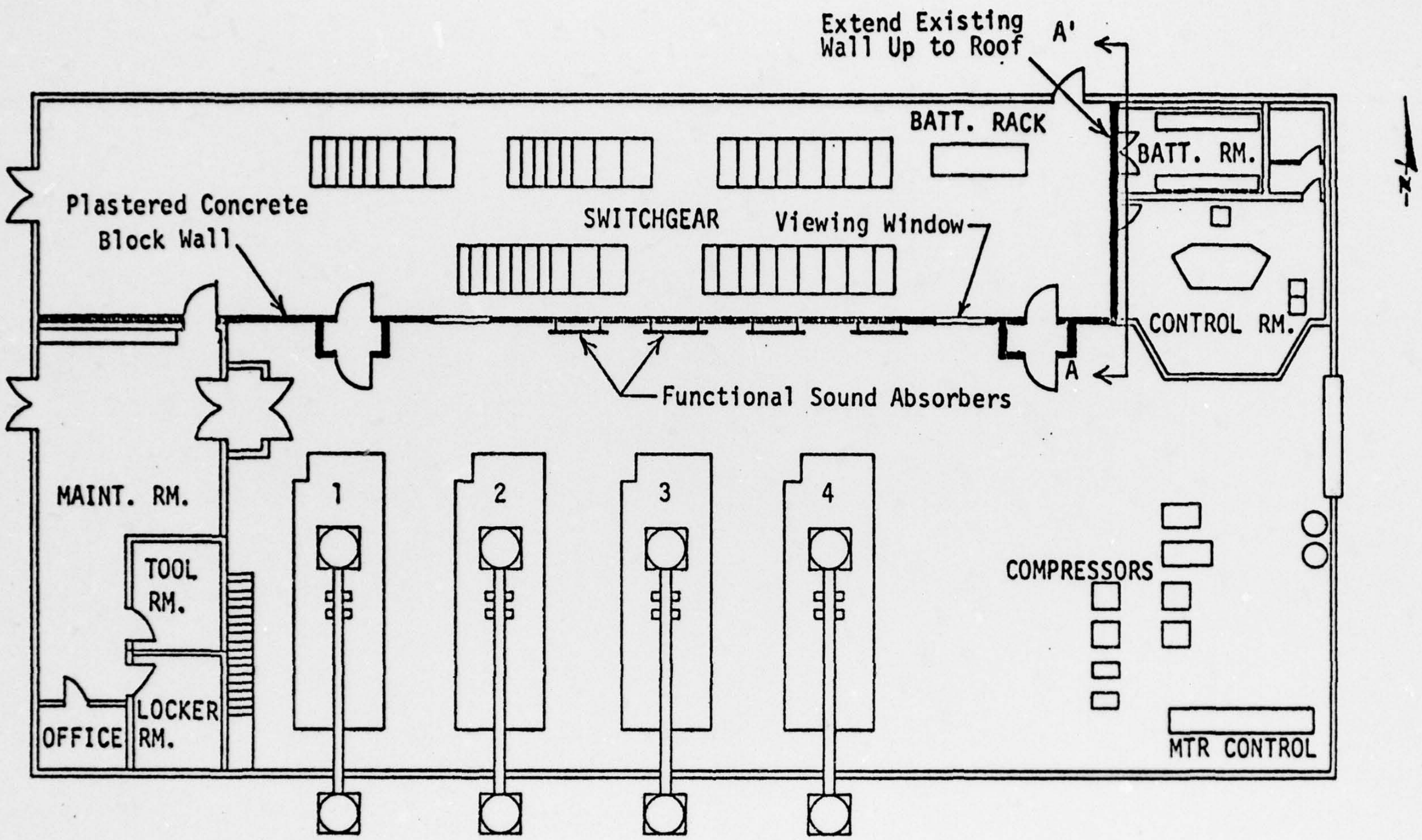


FIGURE 5

RECOMMENDATION ①	ESTIMATED COST ②	ESTIMATED NOISE REDUCTION ③	COST PER dB REDUCTION ④	PREDICTED NOISE LEVEL AFTER IMPLEMENTATION ⑤	ALLOWABLE EXPOSURE TIME INCREASE ⑥
A FUNCTIONAL ABSORBERS	$1200.	5 dB GENERAL AREA	$240/dB	98 dBA	FROM 1 HR - 20 MIN TO 2 HR - 40 MIN
B INTAKE AIR PIPING	$27,490.	3 TO 4 dB NEAR FIELD	$6873/dB	100 dBA	FROM 42 MIN TO 2 HR
C BARRIER a. PERMANENT	$3120.	3 TO 4 dB NEAR FIELD	$780/dB	104 dB(A)	TO 1 HR - 10 MIN
C BARRIER b. MOVABLE	$1210.	3 dB	$403/dB	105 dBA	FROM 42 MIN TO 1 HR
D SOUND BARRIER WALL	$9805.	20 TO 25 dB REMOTE AREAS	$392/dB	83 dBA	FROM 1 HR - 20 MIN TO NO HEAR. PROT REQUIRED
E GASKETING DOORS	$40.	IMPLEMENTING THIS RECOMMENDATION WILL INSURE THAT DOORS ARE PROPERLY SEALED TO MAINTAIN EFFECTIVE NOISE REDUCTION.			

NOTES:
COLUMN 3Cb: THIS ENGINEER'S ESTIMATE,
COLUMN 5: ORIGINAL MEASURED LEVELS, 103 dBA REMOTE AREAS, 108 dBA NEAR FIELD.
COLUMN 5B: INCLUDES NOISE REDUCTION FROM RECOMMENDATION #1.

FIGURE 6