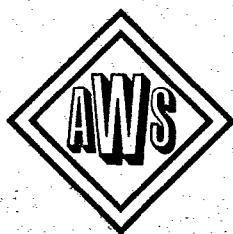
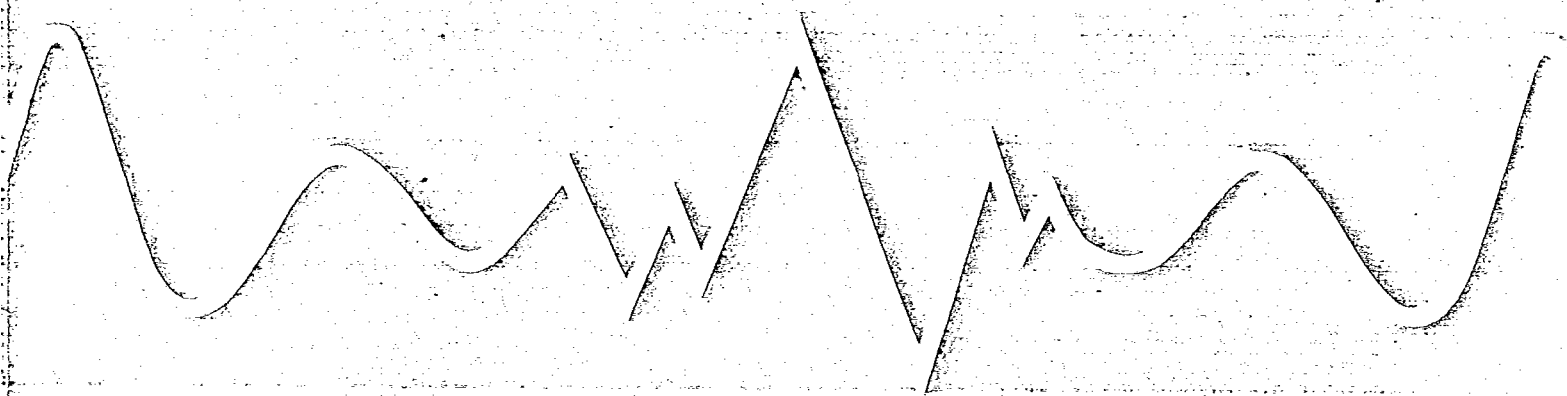


ARC WELDING AND CUTTING

NOISE



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Arc Welding and Cutting Noise

**A research report on one aspect
of the welding environment**

Based on research performed at Battelle-
Columbus Laboratories under contract
with The American Welding Society and
supported by industry contributions

Under the direction of the AWS Committee
on Safety and Health, Project Committee
VI on Noise

Edited by Frank Y. Speight, Secretary,
and Hallock C. Campbell, Consultant

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This report was prepared by Charles W. Rodman, Lynn Faulkner, and Donald Skaggs of Battelle-Columbus Laboratories, dated November 4, 1977. For publication it was edited by Frank Y. Speight and Hallock C. Campbell to AWS style, and the final version of AWS F6.1-78, Method for Sound Level Measurement of Manual Arc Welding and Cutting Processes, has been substituted for the draft version supplied to Battelle.

Arc Welding and Cutting Noise

SUMMARY

Measurements of the noise produced by four arc welding processes and one arc cutting process were evaluated under standardized measurement conditions now incorporated in AWS F6.1-78, Method for Sound Level Measurement of Manual Arc Welding and Cutting Processes. Several important areas were surveyed or reviewed:

- (1) Measurement equipment and calibration procedures
- (2) Qualification of the measurement space acoustically
- (3) Evaluation of the sound measurement procedures in the qualified space

The conclusions regarding these items are as follows:

(1) **Equipment.** Manufacturer's procedures and recommendations must be followed with regard to calibration of sound measuring instruments, microphone placement (relative to observer and reflecting surfaces), microphone orientation (angular orientation of microphone axis in relation to sound source), and wind screen corrections. Using the recommended procedures, repeatable measurements within stated limits can be obtained.

(2) **Measurement space.** Qualification of the measurement space was found to be less difficult than anticipated. The major criteria are background sound levels due to other sources in the space, reflection of sound

from room surfaces, and physical size of the space. The background sound levels should be a minimum of 10 dB below the levels to be measured from the welding process. Acoustically reflecting surfaces, particularly walls, must be covered temporarily during measurements. This can be easily achieved by using 4 ft x 8 ft x 2 in. (1.22 x 2.44 x 0.05 m) high-density glass fiber panels to completely surround the measurement location. These panels need not be permanently attached to walls. The room within which the acoustic measurements are to be taken must be large enough to allow microphone positioning at specified locations that will not be close to room surfaces; that is, walls or ceiling. It is recommended that at least 8 ft (2.44 m) of clear space be available on all sides and above the welding table.

(3) **Measurement procedure.** The measurement procedure described in the proposed standard was found to be acceptable for determination of noise levels from welding processes. It is important to maintain the welding process as nearly as possible in a stationary location while making noise measurements. A stationary source and a moving workpiece are recommended.

Recommendations are made for future investigation of the procedure sensitivity to small variations in location of microphones, and to variations in spectra of the process noise and the ambient sound. Conducting a round robin test of this method is also recommended.

INTRODUCTION

As part of an overall program to investigate the influence of welding operations on the environment of the workplace, Battelle-Columbus Laboratories carried out a series of noise measurements designed to quantify the noise generated by arc welding and cutting processes. The measurement procedure was selected by the American Welding Society's Safety and Health Project Committee VI on Noise. The processes to be measured were selected by Project Committee VIII on Research.

In addition to obtaining data on process noise, one of Battelle's objectives, as specified by AWS, was to evaluate the effectiveness of the proposed AWS F6.1-78, Method for Sound Level Measurement of Manual Arc Welding and Cutting Processes, at that time not yet approved for publication.

Over half of the Battelle effort consisted of participation in the deliberations of the Committee on the draft procedure and in preliminary evaluation of the room qualification requirements of the procedure. The ad hoc task group charged with drafting the procedure released the procedure to Battelle on July 19, 1977, and the list of processes to be measured was received from the Research Committee approximately one week later. Measurements were started on August 9, 1977, and completed August 16, 1977.

TECHNICAL DISCUSSION

The proposed Method for Sound Level Measurement of Manual Arc Welding and Cutting Processes was followed as closely as possible in order to evaluate the effectiveness of the document. In some cases additional measurement locations and process settings were used to provide insight into the sensitivity of the results to these variables. No attempt was made to analyze the results obtained since this was not included in the scope of the research program. However, comments on the results are included, where appropriate.

The format for the following discussion of the standard and its application consists of statements of each section, alternating with descriptions of the manner in which Battelle used each section in carrying out the measurements.

AWS Method for Sound Level Measurement of Manual Arc Welding and Cutting Processes

The draft standard, as finally presented to Battelle, was essentially the same as the standard now published. The experimental conditions to be tested were chosen by the AWS Committee on Noise and were those listed in the standard, plus readings with the microphone at the position occupied by the welder or welding operator.

Following are sections of the draft procedure used by Battelle in performing the noise measurements. The approved standard procedure appears as Appendix A.

6. Equipment

6.1 Sound level measurements shall be made using a sound level meter configuration conforming with the requirements of ANSI S1.4 (paragraph 2.1) for type 1 meters.

6.2 Equipment shall be located in accordance with Fig. A1 in Appendix A, p. 18.

6.3 The equipment shall be used in a test site that meets the requirements of 9.1 (for outdoor locations), or 9.2 (for semianechoic test rooms), or 9.3 (for in-plant locations).

6.4 Octave band filter sets, if used, shall meet the requirements of ANSI S1.11-1966 for Class II filters. The octave band frequencies shall be those tabulated in ANSI S1.4-1971.

Note: The octave band filter set is required only for the evaluation of the acoustic environment occurring at the test site.

Comments on Section 6

6.1 The sound level meter used by Battelle was the GenRad Model 1933 Precision Sound Level Meter with Octave Band Analyzer. A one inch (25.4 mm) electret microphone with a foam wind screen recommended by GenRad was used for the measurements. The wind screen introduces less than -0.5 dB error at frequencies up to 5 kHz, and approximately 2 dB in the range 5 kHz to 12 kHz. The effect of the wind screen on A-weighted broad band sound cannot be predicted unless the spectral content of the sound is known; however, the error should not exceed 2 dB.

6.2 Figure 1, p. 3, shows the layout of the measurement area used. The sound level measurements of manual arc welding and cutting processes were conducted in a simulated in-plant location. The test site was a laboratory space in a steel frame building with corrugated steel panel walls. The acoustical absorption of the thermal insulation on the inside of the walls was augmented by placing 4 ft by 8 ft by 2 in. (1.22 x 2.44 x 0.05 m) high-density¹ acoustical glass fiber panels around the perimeter of the measurement space. The dimensions of the building, consisting of a single open area, are 18 ft by 60 ft (5.49 by 18.29 m) long, by 14 ft (4.27 m) high. The measurement space, as defined by the acoustically absorbent panels, was 24-1/2 ft by 17-1/4 ft (7.47 x 5.26 m). The test site had a concrete floor extending the width of the room. The glass fiber panels were at a distance of no less than 5 ft (1.52 m) from any measurement point.

1. The panels used have a density of 0.375 lb/ft (1.83 kg/m).

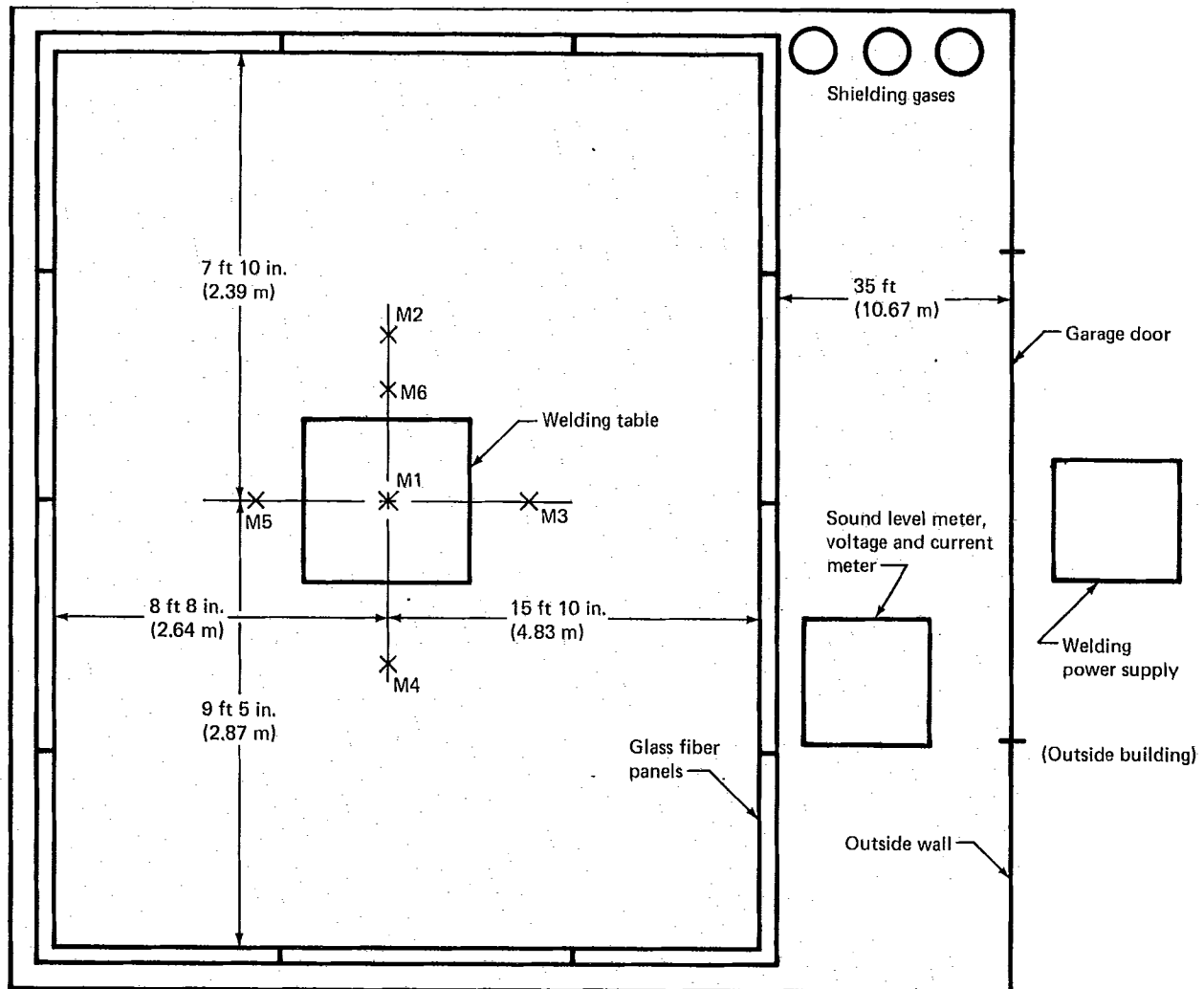


Fig. 1—Layout of test site

Note: Not to scale

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6.3 The acoustic environment at the measurement points was determined to be free field by measuring the rate of decrease of the sound level along imaginary lines passing through the measurement points. A calibrated ILG fan, used as the sound source, was placed on the floor at the nominal location of the arc. No welding table was present. Octave band sound level measurements were made along four radial lines (through points M2, M3, M4, and M5 of Fig. 1, p. 3) at distances of 39 in. (1 m) and 79 in. (2 m) from the arc. Measurements were made at octave bands having center frequencies at 125 Hz through 8000 Hz. The results of the sound level measurements at points on each of the four radial lines are shown on pp. 4 to 6, Fig. 2 through Fig. 5.² Except for one direction, the decrease in octave band sound level with doubling of distance from the fan to the microphone was at least 5 dB. A difference of this magnitude is indicative of a suf-

ficiently free field acoustic condition. One direction, M4, was deficient at 8 kHz with a decrease of only 3 dB. The data are summarized in the Appendix, Table B1.

7. Precautions

7.1 Technical Precautions

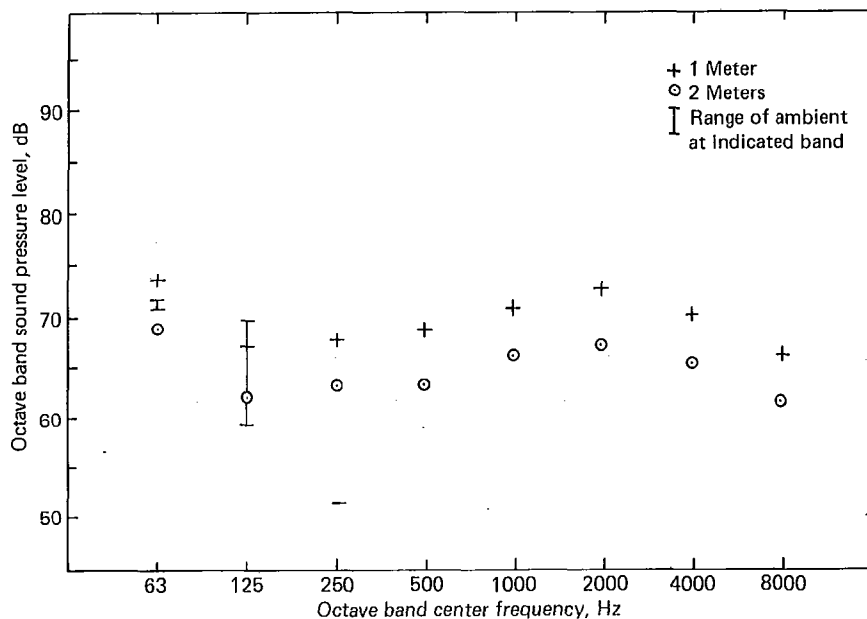
7.1.1 The sound level meter and the meter calibrator shall be stabilized at the ambient test site conditions before calibration and use.

7.1.2 The ambient sound level (including wind effects) shall be at least 10 dB lower than the level produced by the arc processes under test. A calibrated wind-screen is recommended for outdoor measurements.

7.1.3 Outdoor measurements are not recommended when the wind velocity exceeds 12 mph (5.4 m/sec.)

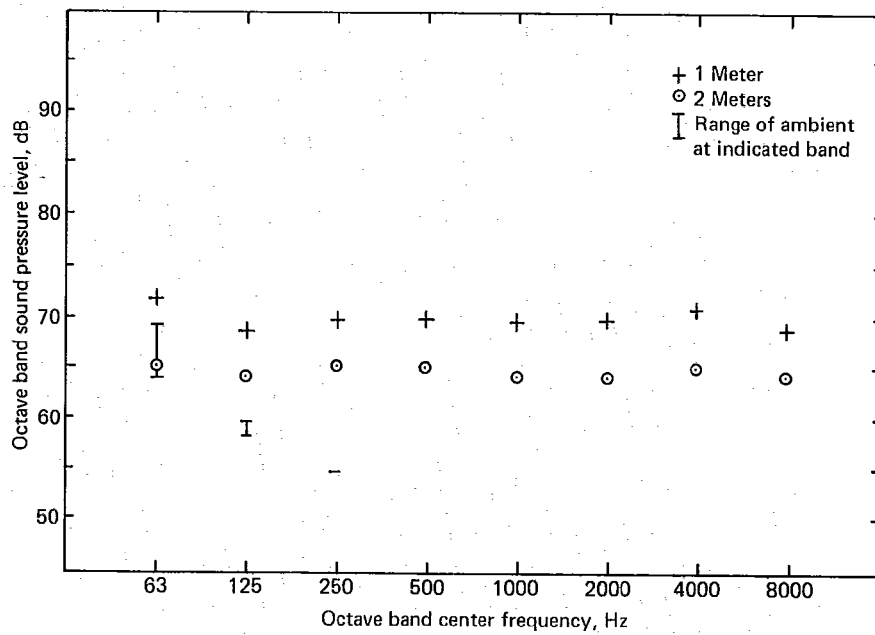
7.1.4 CAUTION: Heat and spatter associated with the arc process may damage the measurement equipment. It is recommended that the microphone be protected by a calibrated windscreen. It should be recognized that damage may be sustained by the windscreen.

² Optional readings at 63 Hz have been plotted in the figures but not included in Table B1.



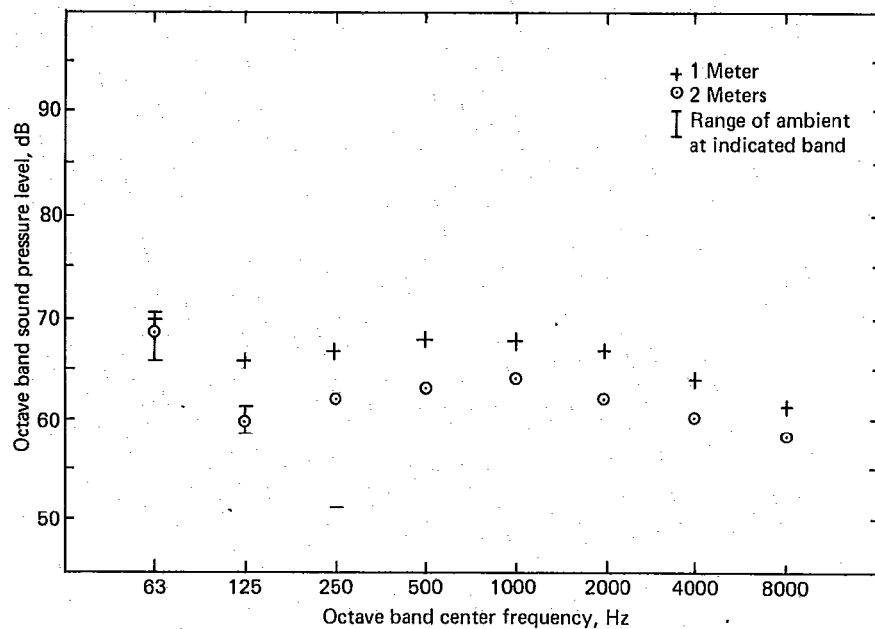
(Data shown in Figs. 2-5 are presented in tabular form in Table B1.)

Fig. 2—Acoustic environment along measurement direction 2



(Data shown in Figs. 2-5 are presented in tabular form in Table B1.)

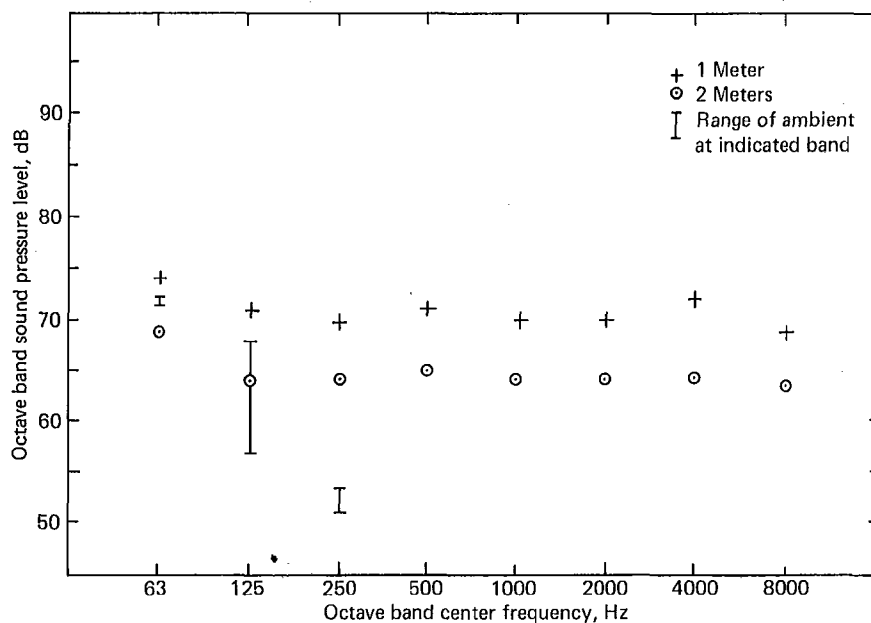
Fig. 3—Acoustic environment along measurement direction 3



(Data shown in Figs. 2-5 are presented in tabular form in Table B1.)

Fig. 4—Acoustic environment along measurement direction 4

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(Data shown in Figs. 2-5 are presented in tabular form in Table B1.)

Fig. 5—Acoustic environment along measurement direction 5

7.1.5 The test site (paragraph 6.3) shall be free from all equipment, personnel, or other objects not directly involved with the test. It is recommended that, if available, a microphone extension cable be used and the body of the sound level meter be located remote from the measurement point.*

7.1.6 Orient the microphone in accordance with the manufacturer's instructions in order to yield the best possible frequency response at free field conditions.

7.1.7 Follow the meter manufacturer's recommendations for avoiding errors due to stray electromagnetic radiation or humidity and temperature.

7.2 Safety Precautions

CAUTION: Certain arc processes generate high sound levels which may be hazardous to the hearing of personnel in the test site. Hearing protection, such as earplugs or muffs, should be worn unless it has been determined that the arc process under test is not hazardous to hearing. All other work practices shall be in accordance with ANSI Z49.1 (paragraph 2.8).

*If a microphone extension cable is used, it shall conform to the recommendations of the meter manufacturer for maintaining the integrity of a Type 1 measurement.

Comments on Section 7

7.1.1 The sound level meter and calibrator were left in the test area at all times during the measurement program to assure that they were stabilized to room temperature.

7.1.2 For the majority of the measurements, it was possible to comply with the requirement to have the ambient sound level at least 10 dB lower than the process noise; however, for one set of measurements (GTAW), the process noise level was so low it was not feasible to do so.

7.1.4 The wind screen was inspected frequently for damage by weld splatter. No damage was incurred during the measurement program.

7.1.5 All sound level measurements were made with the welding power supply placed outside the building in which the test room was located. The sound level meter (except for the microphone) and the voltage and current meters were placed outside the boundaries of the test area, beyond the absorbant panels. A microphone extension cable conforming to the recommendations of the meter manufacturer was used. The only person inside the test area at the time of the measurements was the welder. When GMA and FCA welding were performed,



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a wire feeder was located in the test area. The wire feeder gun was rigidly supported above the table at the correct distance for the test being conducted. (It should be noted that the wire feeder was in the test area only when GMA and FCA welding were performed.)

7.1.6 The microphone, with an approved windscreen, was oriented in accordance with the manufacturer's instructions in order to yield the flattest possible frequency response at free field conditions.

7.1.7 A series of measurements was made with a dummy microphone installed on the microphone pre-amplifier. The meter indication remained at 22 dBA when the arc was operating, indicating no influence by the arc or cable fields on the preamp or the line leading to the remote sound level meter.

7.2 The welding operator was an experienced welder on the Battelle technical staff. He is familiar with the requirements of ANSI Z49.1 and the need to comply with the special requirements of the draft procedure. He is the same operator who assisted with the ventilation tests and the fume tests conducted as part of the overall AWS/Battelle program. Other personnel remained outside the test area, behind the acoustic panels.

8. Sampling

8.1 Measurements shall be made at locations specified in Fig. 1,³ p. 15.

8.2 Measurements shall be recorded on a form essentially similar to that shown in Fig. 2,³ p. 16.

8.3 Case conditions shown on Fig. 2,³ p. 16.

8.3.1 Case A.—All equipment operating but without arc initiation. This may require relocation of some equipment outside of the test site, in order to meet the requirements of paragraph 7.1.

8.3.2 Case B—Maximum recommended operating parameters for the process being measured when the equipment range is adequate to supply process power. Otherwise maximum recommended equipment setting is used to establish the process operating parameters. Refer to paragraphs 2.6 and 2.7.

8.3.3 Case C—Minimum recommended operating parameters for process being measured when the equipment range is adequate to supply the process power. Otherwise minimum recommended equipment setting is used to establish the process operating parameters. Refer to paragraphs 2.6 and 2.7.

Comments on Section 8

8.1 The sound level measurements were made at the five locations shown in Fig. 1 of AWS F6.1-78, see p. 15, and at the level of the welder's ear (M6), see Fig. A1, p. 18.

3. See complete standard in Appendix A.

8.3 Three case conditions were investigated for each type of welding. Case A measurements were ambient readings with the equipment operating but with no arc. Case B measurements were made with maximum recommended operating conditions for the process being measured. When the equipment range was not adequate to supply process power, maximum recommended equipment settings were used to establish the process operating conditions. Case C measurements were made within minimum recommended operating conditions for the process being measured. When the equipment range was not adequate to supply the specified process power, the minimum recommended equipment setting was used to establish the process operating conditions. On some occasions, a Case D measurement was taken. Case D measurements were made with average or normal operating conditions for the process being measured, as defined by the operator.

9. Preparation of Equipment

9.1 An outdoor location may be used as the test site if it is a flat area free of any large reflecting surfaces, such as buildings, signboards, or hillsides, within 50 ft (15 m) of the arc. The surface of the ground must be free from snow, long grass, loose rock, ashes, or other absorptive material within 4.4 ft (1.4 m) of any measurement point.

9.2 A semianechoic test room may be used as the test site if it meets the following requirements:

9.2.1 The floor shall be hard and shall extend the width of the test room. The average sound absorption coefficient of the hard floor shall not exceed 0.1 (a concrete floor is suitable). The sound absorptive treatment of the other surfaces shall be uniformly distributed and their average sound absorption coefficient shall be equal to or greater than 0.99 over the frequency range of 125 to 8000 Hz.

9.2.2 The room dimensions shall be sufficient so that no measurement point is closer than 26 in. (670 mm) to an absorptive surface or wall.

9.2.3 There shall be no acoustically reflecting surfaces other than the floor and obstacles associated with the test.

9.3 An in-plant location may be used as the test site if it meets the following requirements:

9.3.1 The floor shall be acoustically reflective. A concrete, sealed asphalt, or similar hard floor material is suitable.

9.3.2 There shall be no hard reflective surface other than the floor within 4.4 ft. (1.4 m) of any measurement point.

9.3.3 The acoustic environment at the measurement points shall be approximately free field. The existence of a free field condition shall be determined by measur-



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ing the rate of decay of the sound level at the measurement points. A sound source⁴ shall be placed at the location of the arc. Octave band sound level measurements shall be made along four radial lines at distances of 39 in. (1 m) and 79 in. (2 m) from the arc. Measurements shall be made at octave bands having center frequencies at 125 Hz through 8000 Hz. To be classified as approximately free field, the difference in sound pressure level measured at the two distances should be 4 dB or greater.⁵

Comments on Section 9

The test location used is typical of an in-plant location, with overhead duct work and a high ceiling. The concrete floor had a shallow pit directly under the work table. The pit was partially covered with plywood and two adjacent sides were lined with glass fiber acoustical material to suppress the formation of acoustic standing waves in the cavity. As mentioned earlier, the metal walls of the building were lined with thermal insulation batting and additional acoustic panels were installed temporarily. The minimum distance from any measurement point to absorbent panel was 94 inches. The minimum overhead distance was 99 inches.

9.3 As described in the comment for section 6.3, the measurement space was satisfactory from the standpoint of free field performance.

10. Calibration

10.1 All sound measurement equipment shall have been calibrated as specified by the manufacturer, but in no case shall the period between calibrations be longer than one year. Calibration shall be performed by the manufacturer, his designated representative, or a calibration laboratory.

10.2 The sound level meter calibration shall be field checked according to the manufacturer's recommendations.

4. Suitable sound sources are the calibrated ILG fan available from ILG Industries, Chicago, Illinois, or the type 4204 Reference Sound Source available from B&K, Cleveland, Ohio.

5. Free-field conditions occur when the difference in the sound level at 39 in. (1 m) vis-a-vis that at 79 in. (2 m) is 6 dB. A difference of less than 6 dB is an indication that some reverberation is occurring. It is recommended that in-plant locations having a difference of less than 4 dB not be used as measurement sites because the measured values would be higher than would be produced by the same arc under purely free field conditions such as would occur in outdoor locations.

Comments on Section 10

The sound level meter and acoustic calibrator used for the measurements were calibrated by the manufacturer, GenRad, in September, 1976. The sound level meter was calibrated, using the GenRad Model 1562-A 5-frequency calibrator, at the beginning and end of each measurement series. (A series consists of all the measurements required for a specific process.)

11. Procedure

11.1 Set up the arc welding or arc cutting process as illustrated in Fig. 1, p. 15.

11.2 Field check the sound level meter (refer to 10.2) calibration.

11.3 Set the sound level meter to A-weighting, slow response.

11.4 Measure the ambient sound level at each of the measurement points shown in Fig. 1 (omit point M6).

11.5 For each of the arc operating conditions of 8.3, measure the sound level at measurement points shown on Fig. 1, p. 15. The measured sound level shall be the value of central tendency during a five (5) second time period, rounded off to the nearest even integer, when the meter fluctuation is 3 dB or less. When the fluctuation is greater than 3 dB, the recorded value shall be 3 dB less than the maximum value observed.

11.6 Repeat 11.5 two times for a total of three runs.

11.7 Repeat the ambient sound measurements and field check of the sound level meter calibration.

Note: Field check of the sound level meter calibration and measurement of ambient sound level shall be performed immediately before and after each period of testing. If the above testing is interrupted, then additional field checks and ambient sound measurements shall be performed if required.

Comments on Section 11

At the beginning of each test period, the sound level meter was checked for calibration, using the 5-frequency acoustic calibrator. The sound level meter was then set to A-weighting, slow response. The ambient sound level was taken at each of the six measurement points. Then, for each arc process, the sound level was measured over a five (5) second time period with the actual reading being the central tendency during that time rounded off to the nearest even integer. If the meter fluctuation happened to be greater than 3 dB, then the recorded value was 3 dB less than the measured value observed. The measurement at each location was repeated two additional times for a total of three runs. The calibration was then re-checked.

