

Measurement of Noise From Fired Process Heaters

API RECOMMENDED PRACTICE 531M
FIRST EDITION, MARCH 1980

American Petroleum Institute
2101 L Street, Northwest
Washington, D.C. 20037



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Refining Department

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FOREWORD

This recommended practice is based on the accumulated knowledge and experience of petroleum refiners, fired heater manufacturers, and engineering contractors. The objective of this publication is to provide a standard test procedure for the measurement of noise emanating from fired process heaters.

The metric system is used exclusively in this book because it is the universally accepted system and was the system used in the CONCAWE report (see Acknowledgment) that served as the basis for this recommended practice.

Although it is recognized that the purchaser may desire to modify, delete, or amplify sections of the practice, it is strongly recommended that all such changes be made by supplementing this practice rather than by rewriting or by incorporating sections into another complete practice.

Suggested revisions are invited and should be submitted to the director of the Refining Department, American Petroleum Institute, 2101 L Street, N.W., Washington, D.C. 20037.

ACKNOWLEDGMENT

Acknowledgment is made to CONCAWE Report No. 2/76, "Determination of Sound Power Levels of Industrial Equipment, Particularly Oil Industry Plant," prepared by Mueller-BBM GmbH for CONCAWE Special Task Force; and to the CONCAWE Report No. 3/77, "Test Method for the Measurement of Noise Emitted by Furnaces for Use in Petroleum and Petrochemical Industries," which was prepared for the CONCAWE Noise Advisory Group by Special Task Force No. 5: Furnace Noise. These CONCAWE reports form the basis for this recommended practice. The name CONCAWE is an acronym for Conservation of Clean Air and Water-Europe and is an organization to which several European oil companies belong.

CONTENTS

	PAGE
SECTION 1—GENERAL	
1.1 Introduction	1
1.2 Purpose	1
1.3 Scope	1
1.4 Instrumentation	1
1.5 Nomenclature and Definitions	2
1.5.1 Nomenclature	2
1.5.2 Definitions	2
SECTION 2—REQUIRED ORIENTATION PRIOR TO MAKING FIELD MEASUREMENTS	
2.1 General Requirements	2
2.2 Recommended Standard Test Conditions	3
2.3 Noise-Level Measuring Techniques	3
2.4 Vibration Measuring Techniques	3
SECTION 3—PROCEDURES FOR SOUND LEVEL MEASUREMENT	
3.1 General Procedures	3
3.2 Correction for Background Noise	4
3.3 Floor-Fired Heaters—Burner Area	5
3.4 External Walls With Burners	5
3.4.1 The Wall as a Radiating Surface	5
3.4.2 Burner Rows as Line Sources	6
3.4.3 Burners as Point Sources	6
3.5 Heater Walls Without Burners	6
3.5.1 Noise Measurements	7
3.5.2 Vibration Measurements	7
3.6 Multiple-Cell Fired Heaters: Areas Between Heater Sections	7
3.7 Forced-Draft Fans	8
3.8 Exhaust Ducting	9
3.9 Convection Section	9
3.10 Special Cases	9
3.10.1 Natural-Draft Heaters With Both Wall and Floor-Fired Burners ...	9
3.10.2 Forced-Draft Heaters With Unsilenced Fans	10
3.10.3 Fired Heaters With Noise Control	10
3.10.4 Roof-Fired (Down-Flow) Heaters	10
SECTION 4—EVALUATION OF MEASUREMENTS	
4.1 Calculation of Mean Sound-Pressure Level	11
4.2 Calculation of Octave Band Sound Power Levels	11
4.3 Addition of Octave Band Sound Power Levels	11
4.4 Calculation of Vibratory-Velocity Levels	11



SECTION 5—REPORTING OF DATA

5.1 General Requirements	11
5.2 Summary	11
5.3 Requirements for Data Sheet	11

APPENDIX A—MODEL FORMAT FOR NOISE TEST REPORT	13
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APPENDIX B—ILLUSTRATIVE EXAMPLE WITH COMPLETED NOISE TEST REPORT	19
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LIST OF ILLUSTRATIONS

Figures

1—Measuring Positions and Surfaces for Burner Areas and Walls Without Burners on Cabin-Type Heaters	4
2—Measuring Positions and Surfaces for Burner Areas and Walls on Vertical Cylindrical Heaters	5
3—Typical Measuring Positions—Walls With Burners	6
4—Measuring Positions and Surfaces for Annular Area Between Fired Heater Sections	7
5—Measuring Positions for Suction Openings of Forced-Draft Fans	8
6—Typical Measuring Positions for Exhaust Ducting	9
B-1—Example Sketch of Generalized Crude Heater—Showing Microphone Measuring Positions and Dimensions for Illustrative Example	19

Tables

1—Corrections for Measured Noise Level	4
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Measurement of Noise From Fired Process Heaters

SECTION 1—GENERAL

1.1 Introduction

Fired process heaters are significant sources of noise not only in operating areas of refineries but also in surrounding areas. Obtaining noise levels on this equipment is difficult because of size, shape, and the many variations in design. In addition, background noise levels are difficult to establish because the heater cannot operate at design capacity without the rest of the refinery also being in full operation.

Recognizing these problems, the CONCAWE test method and work referenced in the report (see acknowledgment) utilized a large-source method for noise measurement. This method considers the possibility of inherent errors due to measurements taken in the geometric near-field (1 to 3 meters from the radiating surfaces) in order to minimize the effects of background noise. Theoretical considerations and practical experience in using the large-source method indicate possible overestimation of sound-power level of radiating areas. This recommended practice, therefore, incorporates corrections for these possible errors whenever it is appropriate.

One of the most difficult areas of noise measurement and estimation is the furnace wall itself. Noise emitted from the wall is frequently lower in level than background noise; however, it may be a significant contribution to the surrounding environments because of its large radiating area. Recommended procedures based on the best theoretical and practical approach are presented for these wall situations. In addition, an alternative procedure is discussed as a possibility for estimating noise from measurement of vibratory velocity. This alternative, however, does not at this time have sufficient reliability to fully recommend it.

In this recommended practice the noise emitted from a fired heater is divided into a number of areas, and the noise emission from each area is measured separately. The total noise from the heater is obtained from a summation of noise emissions from its component areas. Appendix A has been included as a guide for reporting the measured and calculated information, and Appendix B is illustrative of a typical example.

This recommended practice is intended to establish a standard approach for measuring noise from fired heaters and not a comprehensive step-by-step treatise to cover all of the many possible situations involved. Also, it is intended

to form a basis of comparison for noise information from different heaters and to accomplish acceptance testing for fired heater noise levels in a satisfactory manner for both the manufacturer and user.

1.2 Purpose

This recommended practice establishes a standard test procedure for the measurement of noise emanating from fired process heaters.

1.3 Scope

This test procedure defines (a) the geometrical envelope which is recommended for near-field noise measurement and (b) the analytical methods applicable for computational analysis of the total sound-power level of a fired heater.

It is intended for use with direct-fired equipment and associated ancillaries which might reasonably be expected to be installed in a petroleum process plant. It is based on the use of a portable precision sound-level meter, an octave band filter, microphone, and compatible vibration transducer with signal conditioning equipment. The metric system of units is used in this recommended practice because it is the universally accepted system.

1.4 Instrumentation

The following are the required instrumentation and applicable specifications to be used to perform the measurements required by the test procedures described in 1.3.

Instrument	Specification
Sound-Level Meter, Including	
Microphone, Type I, Precision	ANSI S1.4-1971
Octave Band Filter, Type E, Class II	ANSI S1.11-1971
Acoustic Calibrator of Coupler Type	ANSI S1.4-1971
Optional Instruments	
Vibration Transducer (Accelerometer)	For Use With Sound-Level Meter
Signal Conditioner (Integrator)	For Use With Sound-Level Meter

1.5 Nomenclature and Definitions

1.5.1 NOMENCLATURE

The following abbreviations are used in this recommended practice:

	UNIT
D	Diameter or diagonal of suction opening meter
d	Horizontal distance (in Figure 3A, distance between burners along row) meter
dB	Decibel, unit of measure for sound level decibel
dB(A)	Decibel, weighted to correspond to standard "A" frequency response characteristics decibel
E	Geometric near-field correction (numerical values given in text) decibel
H	Width or height of circumferential suction opening meter
h	Vertical distance (in Figure 3A, distance between rows of burners) meter
Hz	Hertz, sound frequency cycle/second
i	Surface-element subscript
L	Length meter
L_v	Vibratory-velocity level decibel
$\overline{L_v}$	Mean vibratory-velocity level decibel
(M)	Microphone position
N	Number of burners (sources)
n	Number of measurement positions per source
p	Sound pressure Newton/square meter
p_0	Reference sound pressure (see 1.5.2) Newton/square meter
PWL	Sound-power level decibel
r	Measurement radius or distance meter
S	Surface area (measuring surface) square meter
s_0	Reference area of 1 square meter square meter
SPL	Sound-pressure level decibel
$\overline{SPL}$	Mean sound-pressure level decibel

SPL_b	Sound-pressure level associated with burners decibel
v	Vibratory velocity meter/second
v_0	Reference velocity (see 1.5.2) meter/second
W	Sound power watt
W_0	Reference sound power (see 1.5.2) watt
z	Measuring distance to microphone meter
log	Logarithm to base 10

1.5.2 DEFINITIONS

The following terms are used in this recommended practice:

Geometric near field is the region near a noise source where the perpendicular measuring distance from the surface is less than the maximum linear dimensions of the source or surface element. Corrections are necessary when using SPL values to calculate PWL .

Measuring surface is the imaginary surface over which noise measurements are made.

Octave bands refer to the preferred frequency bands (63, 125, 250, 500, 1000, 2000, 4000, 8000 Hz).

Sound-power level is defined as

$$PWL = 10 \log_{10} W/W_0$$

Where:

W_0 = the reference sound power of 10^{-12} watt

Sound-pressure level is defined as

$$SPL = 20 \log_{10} p/p_0$$

Where:

p_0 = the reference sound pressure of 2×10^{-5} Newton/square meters (or 20 micropascals)

Vibratory-velocity level is defined as

$$L_v = 20 \log_{10} v/v_0$$

Where:

v_0 = the reference velocity¹ of 5×10^{-8} meter/second

¹ Other values of reference velocity may be found in the literature, but for convenience in the calculation of radiated sound power the above value should be used.

SECTION 2—REQUIRED ORIENTATION PRIOR TO MAKING FIELD MEASUREMENTS

2.1 General Requirements

It is assumed that the fired heater will be operating in a refinery in the open air and will be adjacent to other noise-emitting equipment. Normally it is not possible for a heater

to be operated at full-load conditions without other equipment in the refinery operating at the same time. Therefore, an estimate of the background noise without the test heater operating may be difficult or impossible to obtain. Measurements of the noise from the test heater, therefore, will

have to be made at positions close enough to its surfaces to reduce the influence of the background noise as much as possible.

2.2 Recommended Standard Test Conditions

The measurements shall be made when the fired heater is operating at design capacity. Heaters which can be dual fired with gas or oil burners shall be operated for the design conditions using either all-gas or all-oil firing. All burners shall be operated at design conditions of supply pressure, fuel/air ratio, air pressure, and so forth. Testing at other than design conditions shall be on a basis agreed upon in advance between the user and manufacturer.

2.3 Noise-Level Measuring Techniques

For noise-level measurements the terms "readings" or "measurements" will at all times imply separate sound-pressure level measurements in dB(A) and in dB for each of the eight octave bands centered on 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.

The instrument manufacturer's information on the required orientation of the microphone with respect to the sound field should receive special attention so that it gives the flattest response. Instrument manufacturer's information on the temperature and humidity sensitivity of the microphone and the presence of strong magnetic fields should also be given particular attention.

For all sound-level readings, the meter will be set to "slow" response and a wind screen will be fitted over the microphone. The preferred method of taking readings is with an isolated microphone and a tripod. When hand-held instruments are used, the manufacturer's recommendations for body and microphone orientation should be followed to minimize reflective errors.

An acoustic check of the sound-level measuring equipment shall be made immediately before and after making test measurements using an external calibrator. This check shall be made at least once every 3 hours during a lengthy run of test measurements. Frequent battery checks should also be made. Site checks shall be supplemented by more detailed laboratory calibrations of the whole measuring equipment system at least once every 2 years.

2.4 Vibration Measuring Techniques

Since this technique has not been adequately justified, it can only be used where valid SPL readings are unattainable and then only to give an indication of probable area SPLs.

The terms "readings" or "measurements" will at all times imply measurements of the root-mean-square value of vibratory velocity level in dB(A) and in dB for the eight octave bands up to the frequency limit of the transducer or to 8000 Hz.

Measurements shall be made with the precision sound-level meter fitted with the vibration transducer and signal conditioning equipment. Instructions for using the equipment are followed to ensure that the intended degree of precision is maintained.

The vibration transducer shall be attached to the surface under test by a magnetic head or by a suitable adhesive. It shall not be hand held against the surface. The test report shall indicate the method of mounting used and include the manufacturer's data on the frequency limitation of the transducer head for this method. Readings above this limiting frequency shall not be reported.

The measuring equipment shall be calibrated according to the manufacturer's instructions before and after making test measurements or at least once every 3 hours during a lengthy run of measurements.

SECTION 3—PROCEDURES FOR SOUND-LEVEL MEASUREMENT

3.1 General Procedures

The following sections describe the positions at which measurements should be made for various types of fired heaters. It may be necessary to vary some positions, or even to eliminate them, if they are influenced by the noise from another source or even by another component of the heater itself (for example, a forced-draft fan). Before selecting the measuring positions, therefore, it is advisable to carry out a quick preliminary survey of the heater subjectively by ear and with the sound-level meter on the dB(A) setting.

Measuring positions should be selected where the sound level from the heater source under investigation is estimated to be at least 3 dB(A) in excess of the background noise levels from all other sources.

To survey between fired-heater sections or to investigate background noise, it may be necessary to mount the microphone on a pole by using an extension cable (making corrections for its attenuation). If, for example, there is another heater near the test heater, it may be possible to determine the noise pattern around the neighboring heater by noting

the dB(A) levels at increasing distances from its remote side. If the symmetry of the fired heater and the absence of other sources permits, it may be possible to assume the same pattern on the side of the test heater. The background level at the measuring position on the test heater may then be estimated by extrapolation, and the test readings may be corrected.

All corrections to test readings for background noise contribution shall be included in the test report and shall be supported by suitable evidence to justify them. Corrections shall be made in each octave band.

In the procedure for large sources, the total surface of the fired heater is divided into separate noise-emitting areas, and the sound-power level is determined for each area individually. The choice of areas depends on the type of heater; some may be actual surfaces such as heater walls or ducting walls while others may be the areas between the pillars of a floor-fired heater. If it is not possible to measure the noise emission from a particular surface because of high background noise, it must be estimated by reference to a similar surface.

In estimating the noise levels in neighboring areas, the height of the source must be considered to allow for ground attenuation. It may often be necessary, therefore, to treat a fired heater as two or more individual sources with different heights—each source being made up of several component-emitting areas.

All estimated sound-power levels that have not been derived from direct measurements on the surfaces concerned shall be clearly indicated in the test report.

In general, the following components of fired heaters can be considered as separate sources, and the total noise emission for each shall be obtained from the summation of the individual contributions of their component areas.

1. The area between the furnace floor and the ground (for floor-fired heaters)
2. External walls without burners
3. External walls with burners
4. Exhaust ducting to stack
5. The annular area between sections of multiple-cell fired heaters
6. The forced-draft fans and ducting external to the fired heater
7. The convection section

3.2 Correction for Background Noise

When the difference between a measured noise level and the background level at the same position (whether the background level is measured or estimated) is less than 10 dB, the measured noise level shall be corrected according to Table 1.

Table 1—Corrections for Measured Noise Level

Difference Between Total Noise Level and Background	Decibels to be Subtracted From the Total Measured Noise Level
3	3
4 to 5	2
6 to 9	1

When corrections of 3 dB are applied, the corrected levels shall be reported in parentheses. When the differences between the total noise level and the background is less than 3 dB, the measurements cease to have any significance.

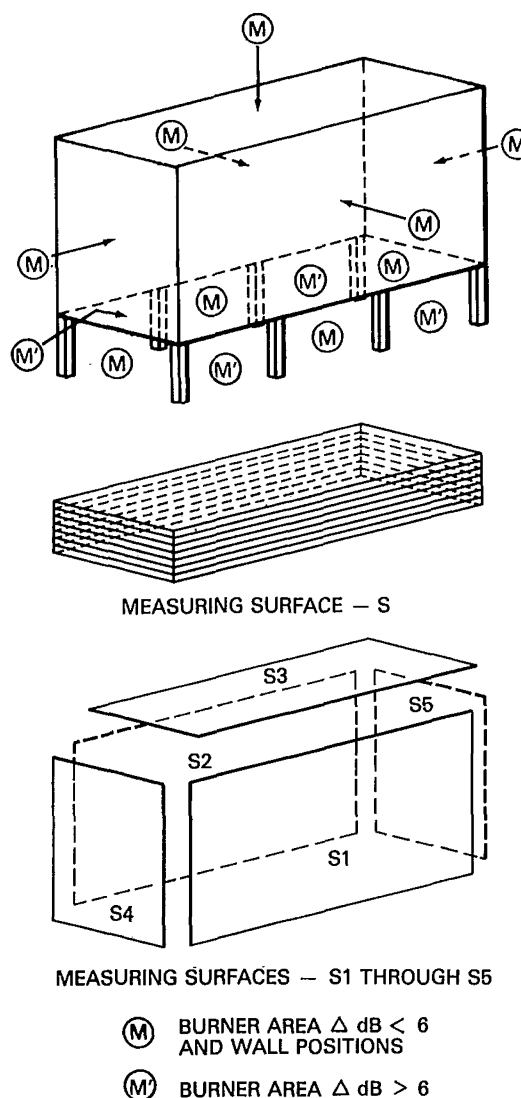


Figure 1 — Measuring Positions and Surfaces for Burner Areas and Walls Without Burners on Cabin-Type Heaters

3.3 Floor-Fired Heaters—Burner Area

Measurements shall be made around the perimeter of the fired heater between the walls and the ground. Normally, the measuring positions should be midway between the furnace floor and the ground. For cabin-type heaters, at least one position shall be selected under each wall at the midpoint (see Figure 1). For cylindrical surfaces, a minimum of four equally spaced positions shall be selected, preferably midway between pillars (see Figure 2).

If the preliminary noise survey with the noise meter set on dB(A) around the perimeter shows a variation from the lowest to the highest reading of 6 dB(A) or greater, it is mandatory to investigate the reason. If it is determined that the source is burner oriented and impossible to attenuate, then the resulting sound-pressure levels and the associated area must be included in the summation. If the perturbation is caused by another source, the readings should be eliminated and the resulting burner source area estimated by the similar area method.

Where more than one reading is taken for a specific area, the readings shall be averaged. The total sound-power level for each octave band shall be derived from the following equation:

$$PWL = SPL_i + 10 \log S_i/s_0 - E$$

Where E is taken as 3 dB. The surface area, S_i , shall be the vertical area between the floor and the ground and the pillars. The PWL for the total burner area is obtained by adding the individual PWL s for each surface by using the equation in 4.3.

For the purpose of calculating noise in the surrounding areas, the burner area shall be considered as an individual point source whose height is equal to one-half the distance between the burner floor and the ground.

3.4 External Walls With Burners

A preliminary noise survey should be made over the wall surface with the sound-level meter set to dB(A) to determine whether the burners are to be treated as individual point sources, line sources, or incoherent radiating areas. If a scan running normal to burner rows at 1 meter from the heater wall surface indicates noise-level differences less than or equal to 3 dB(A) opposite and between burner rows, the wall may be treated as a single radiating surface. If the differences are greater than 3 dB(A), a second scan along a row of burners should be made. If this second scan indicates that the noise level differences are less than or equal to 3 dB(A) opposite and between burners, the row may be

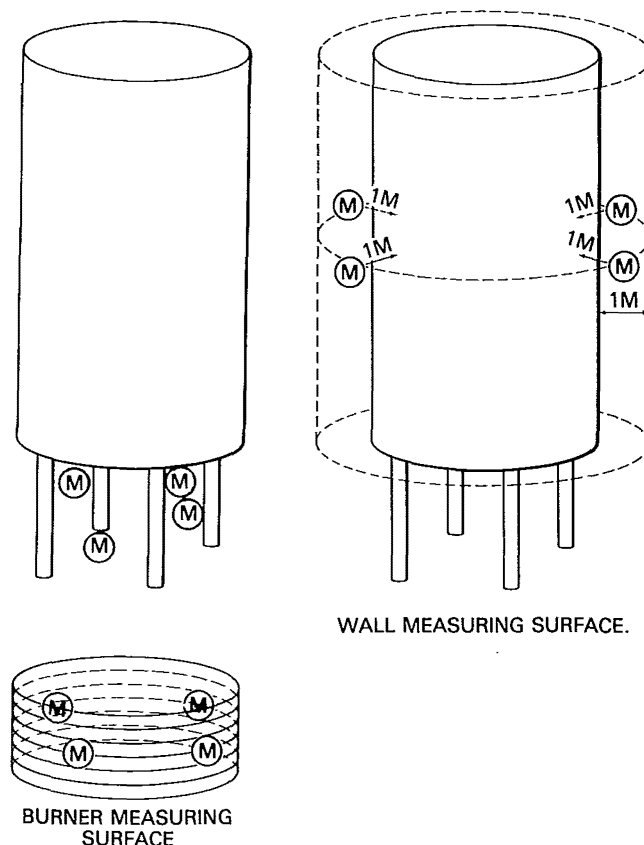


Figure 2 — Measuring Positions and Surfaces for Burner Areas and Walls on Vertical Cylindrical Heaters

treated as a line source; otherwise the burners must be treated as point sources.

The total sound-power levels of the walls shall be obtained from the sum of the sound-power levels of individual walls by using the method in 4.3. For noise calculations of the surrounding areas, the height of the wall source shall be taken as the height of its midpoint.

3.4.1 THE WALL AS A RADIATING SURFACE

Measurements shall be made at four positions 1 meter distant from the wall. Two of these positions shall be opposite a row of burners and two between rows of burners (see Figure 3A). The readings in each octave band shall be calculated from the following equation:

$$PWL = \overline{SPL}_i + 10 \log S_i/s_0 - E$$

Where E is taken as 3 dB. The area S_i shall be taken as: