Measurement of Noise From Fired Process Heaters

API RECOMMENDED PRACTICE 531M
FIRST EDITION, MARCH 1980

American Petroleum Institute
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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

SECTION 5—REPORTING OF DATA

LIST OF ILLUSTRATIONS

Figures

Tables

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
Ⓜ	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 velocity[1] 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

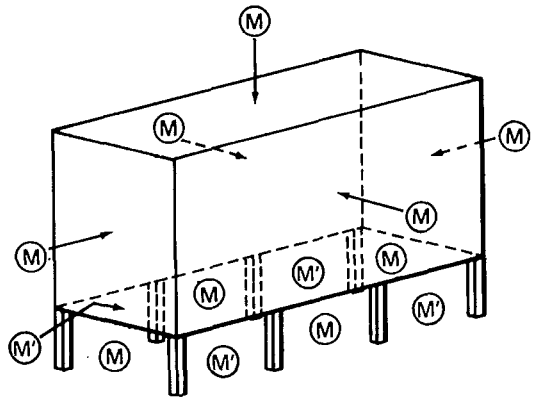
3.2 Correction for Background Noise

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.

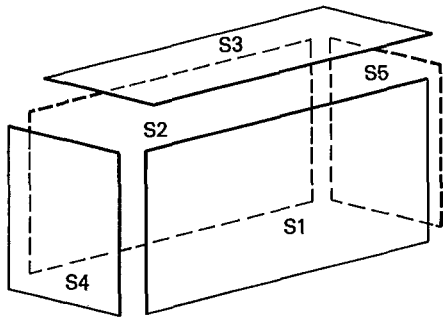
Table 1—Corrections for Measured Noise Level

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.



MEASURING SURFACE — S



MEASURING SURFACES — S1 THROUGH S5

(M) BURNER AREA Δ dB < 6 AND WALL POSITIONS

(M') BURNER AREA Δ dB > 6

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 PWLs 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.

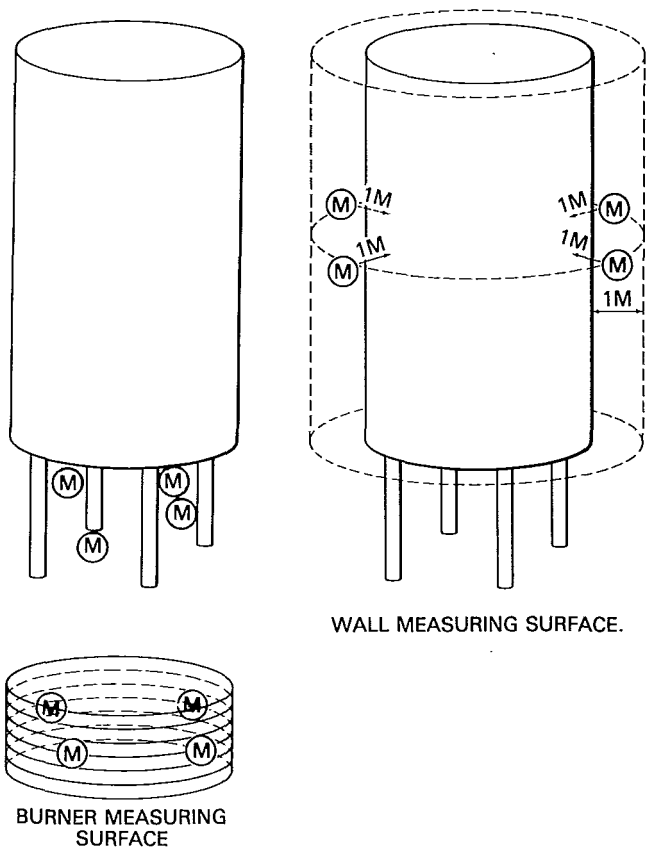


Figure 2 — Measuring Positions and Surfaces for Burner Areas and Walls on Vertical Cylindrical Heaters

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 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:

$$S_i = Ndh$$

Where:

N = the number of burners.
d = the horizontal distance between burners along row (see Figure 3A).
h = the vertical distance between rows of burners (see Figure 3A).

3.4.2 BURNER ROWS AS LINE SOURCES

Measurements shall be made at two positions on each of two rows at a distance of 1 meter from the walls; at roughly one third and two thirds along the line of burners (see Figure 3B). If the wall has more than three rows of burners, measurements shall be made at two positions on every second row. The sound-pressure levels in each octave band shall be averaged, and the sound-power level of each row shall be calculated from the following equation:

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

Where E is taken as 2 dB. The area S_i shall be taken as:

$$S_i = \pi r L$$

Where:

L = the length of the burner row.
r = the measurement surface is a semicylinder with a radius (r) of 1 meter.

The noise from the remaining area of wall outside the burner zone shall be measured according to 3.5. The sound-power levels of each burner row shall be summed as in 4.3 to derive the total noise emission of the wall.

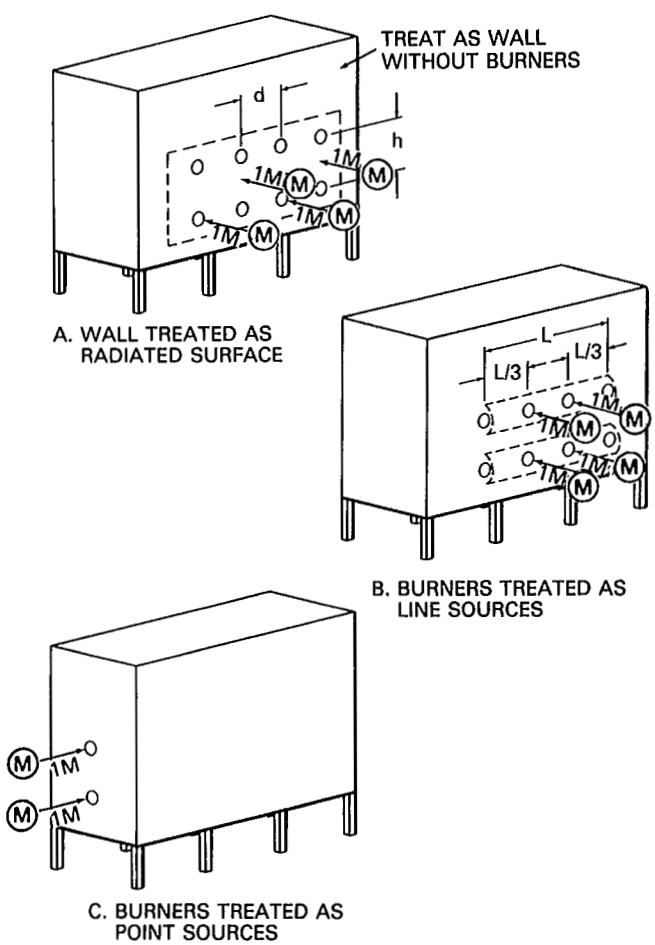


Figure 3 — Typical Measuring Positions—Walls With Burners

3.4.3 BURNERS AS POINT SOURCES

Measurements shall be made at positions 1 meter distant from four or more burners randomly situated in the wall (see Figure 3C). The sound-pressure levels in each octave band shall be averaged, and the sound-power level for the wall shall be derived from:

$$PWL = \overline{SPL_i} + 10 \log S_i/s_0 + 10 \log N$$

Where:

N. is the number of burners in the wall. The area S_i shall be taken as:

$$S_i = 2\pi r^2$$

Where:

r = the measuring surface is a hemisphere with a radius (r) of 1 meter.

The noise from the remaining area of wall outside the burner zone shall be measured according to 3.5.

3.5 Heater Walls Without Burners

The noise emission from the walls should be determined by noise measurements whenever possible. If the background noise is too high, it may be determined by vibration measurements if desired. A preliminary noise survey should be made to establish how the noise emission is to be determined.

When the "smallest dimension" of the wall (height or width) is less than 6 meters, the noise level should be observed at distances of 1 meter and 3 meters from the walls at their midpoint. If the difference in noise level is greater than 3 dB(A), valid noise measurements may be made at 1 meter from the wall according to 3.5.1. When the "smallest dimension" of the wall (height or width) is greater than the 6 meters, the survey measurements should be made at dis-

tances of 1 meter and one-half the "smallest dimension" from the wall. If the difference in noise level is greater than 3 dB(A), valid noise measurements may be made at 1 meter from the wall according to 3.5.1.

If the difference is less than 3 dB(A), the noise emission from the walls may be estimated by using results from a similar surface or determined from vibration measurements according to 3.5.2.

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

3.5.1 NOISE MEASUREMENTS

The measuring positions shall be at the midpoints of each of the walls of cabin-type fired heaters (see Figure 1). For cylindrical heaters there shall be four equally-spaced measuring positions around the perimeter half way up the walls (see Figure 2). Where the arrangement of walkways makes these positions inaccessible, the nearest possible positions shall be chosen. A further reading may be taken on the roof in a position which is not influenced by ducting noise. All the measuring positions shall be at a distance of 1 meter from the surfaces.

When the preliminary survey indicates variations greater than 3 dB(A), the total surface shall be divided into smaller areas and the individual *PWL*s determined. These values are then added to obtain the total surface sound-power levels.

For cabin-type heaters, the sound-power level of each wall shall be assessed separately and then summed to give the total sound-power level of the walls. The sound-power level for each octave band shall be derived 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 the area of the appropriate wall or wall section.

For cylindrical heaters the mean sound-pressure level, $\overline{SPL_i}$, shall be calculated at the four measuring positions, and the area, S_i, shall be taken as the "imaginary cylinder 1 meter greater than the radius of the cylindrical heater shell" (see Figure 2).

3.5.2 VIBRATION MEASUREMENTS

Although this technique is not fully recommended for noise measurement, it may be used in a qualitative manner to assess noise characteristics and levels of the heater.

Measurements may be made at the center of each stiffened section. The vibration transducer with a signal conditioning integrator shall measure vibratory-velocity level on the sound-level meter.

To determine the sound-power level of the wall on which the vibration transducer is mounted, the following equation shall be used:

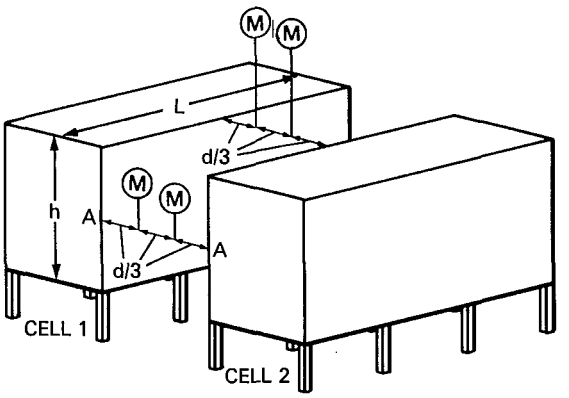
$$PWL = \overline{L_{vi}} + 10 \log S_i/s_0$$

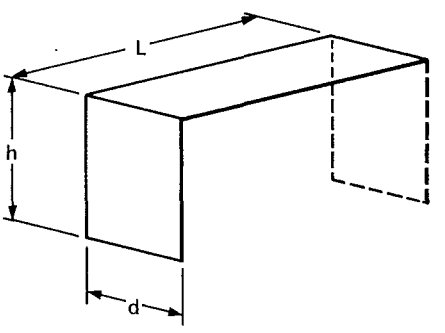
Where S_i is the area of the appropriate wall element and $\overline{L_{vi}}$ is the mean velocity level of the positions. The mean velocity level shall be calculated from the equations in 4.4.

This estimate of sound-power level should be checked by making noise measurements as in 3.5.1. If the noise measurements give a lower sound-power level, they should be used in preference to that derived from vibration measurements even though the noise measurements may be biased by other noise sources.

3.6 Multiple-Cell Fired Heaters: Areas Between Heater Sections

If the preliminary noise survey indicates that the noise level varies by more than 6 dB(A) in horizontal scans between fired heater cells, the cells shall be treated as separate heaters. But if the variation is less than 6 dB(A), the noise field in the intervening zone may be regarded as diffuse (see





ANNULAR MEASURING SURFACE
1. SURVEY ALONG LINE A–A
2. IF Δ SPL < 6 dB USE POSITION (M)

Figure 4 — Measuring Positions and Surfaces for Annular Area Between Fired Heater Sections

Figure 4). The noise emitted from this zone shall be determined from noise measurements made at the annular area between the end walls and roofs of the sections. This area is made up of vertical areas at each end of the zone and a horizontal area (if there is no common roof to the heater cells). For the vertical areas, two measuring positions shall be selected at points roughly one third and two thirds of the distance between the sections on a horizontal line at roughly half the height of the sections. For the horizontal area, the measuring positions shall be at similar distances between the sections on a line at roof level halfway along the sections.

The readings in each octave band shall be averaged, and the sound-power level of the area shall be determined from the following equation:

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

Where E is taken as 3 dB. The surface area, S_i, shall be the total area of the two vertical and one horizontal surfaces (if there is no common roof).

For noise calculations of surrounding areas the height of the source shall be taken as the height of the midpoint of the heater walls.

3.7 Forced-Draft Fans

Measurements of the fan noise shall be made at a single position at a distance of 1 meter from the center of the suction opening or at a distance of 1 diameter or diagonal of the opening if this is less than 1 meter. If the fan has a circumferential suction opening, measurements shall be made at two diagonally opposite positions at a distance of 1 meter from the opening (see Figure 5). The sound-power level of the fan shall be calculated from:

$$PWL = \overline{SPL} + 10 \log S/s_0$$

Where:

$S \cong \pi(z^2 + D^2/4)$ for a planar opening[2]

or

$S \cong \pi(D + 2z)^2 H/D$ for a circumferential opening[3]

See Figure 5 for conceptual indication of measuring surface.

In the above equations, D is the diameter or diagonal of the opening, z is the measuring distance, and H is the height (or width) of the circumferential opening.

Measurements of the driver noise preferably should be made when it is uncoupled from the fan. Where possible,

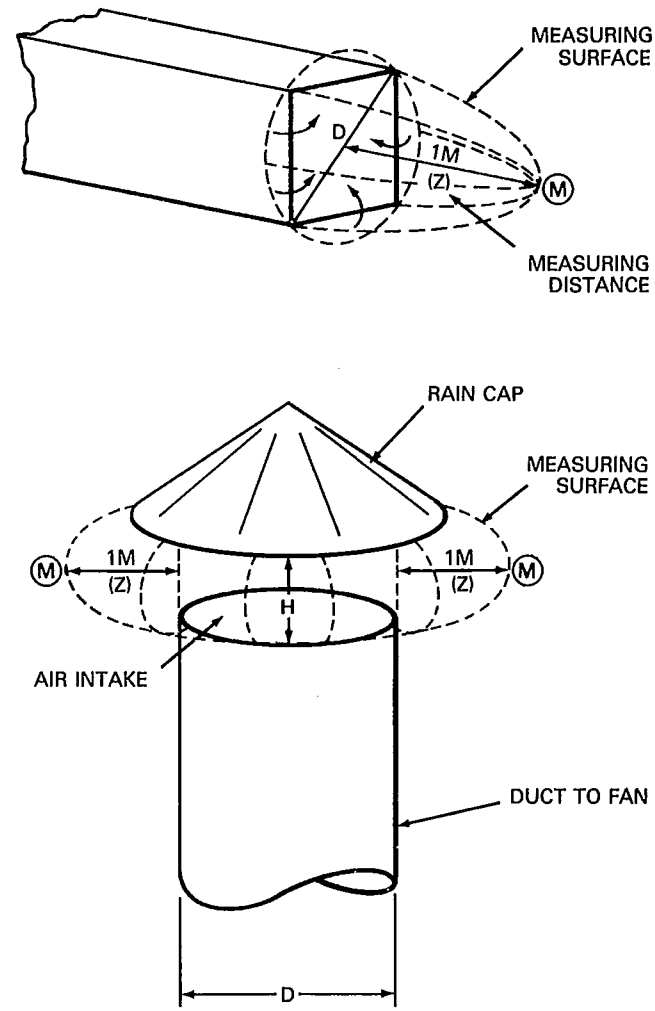


Figure 5 — Measuring Positions for Suction Openings of Forced-Draft Fans

the measurement points should be selected to conform with an accepted small-source procedure. If it is not practical to uncouple the driver, it may be necessary to make measurements at a distance of ½ meter from the driver to ensure that the driver noise is higher than the background. A preliminary survey should be made with the sound-level meter set to dB(A) to find suitable measuring positions where this condition is met. In many cases it may not be possible to make significant noise measurements of the driver noise because of the background noise, and as a first approximation it may be ignored as a noise source.

The sound-power level of the ducting associated with the fan may be investigated using vibratory-velocity level measurements. These measurements shall be made at positions roughly every 5 meters along the ducting as a maximum and, at each position, one measurement shall be made at the

[2] This is a practical approximation. It represents a hemispherical surface when $D = 2z$ (or $z = D/2$). Therefore $S = \pi\ (D^2/4 + D^2/4) = ½\ \pi D^2$

[3] This equation is also a practical approximation. It represents a spherical surface adjusted by the ratio of H/D (which in normal design would be approximately ¼).

center of a plate area and one near the edge. A minimum of six measurements shall be made on any ducting. To determine the sound-power level, the following equation shall be used:

$$PWL = \overline{L_{vi}} + 10 \log S/s_0$$

Where:

S = the total area of the walls of the ducting.

$\overline{L_{vi}}$ = the mean velocity level of the measuring positions calculated from the equations in 4.4.

Only those parts of the ducting outside the fired heater shall be regarded as part of the fan. Ducting underneath the heater will be included in the measurement of noise from the burner area.

3.8 Exhaust Ducting

A preliminary survey of the noise from the ducting should be made with the sound-level meter set to dB(A). If the ducting noise is significantly higher than the background, a set of measurements shall be made at two positions on either side of the ducting at a distance of 1 meter from the surface. Where there are multiple ducts, the noise measurements shall be made at four positions around the entire ducting section (see Figure 6). The readings of sound-pressure level shall be averaged. The sound-power level of the ducting 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 the area of all the walls of the ducting from the heater to the stack or to the convection section if this is a separate section.

For the purpose of noise calculations for surrounding areas, the height of the midpoint of the ducting between the heater and the stack shall be taken as the effective point source height.

If the background noise is too high for significant noise measurements to be made, the sound-power level of the ducting may be determined from measurements of vibratory-velocity level. These shall be made at positions roughly every 5 meters along the ducting as a maximum (where it is accessible). At each position, measurements shall be made at the center of a plate area and near the edge. A minimum of six measurements shall be made on any ducting.

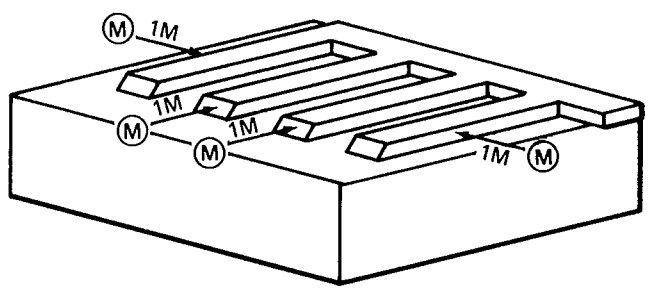


Figure 6 — Typical Measuring Positions for Exhaust Ducting

To determine the sound-power level of the ducting, the following equation shall be used:

$$PWL = \overline{L_{vi}} + 10 \log S_i/s_0$$

Where:

S_i = the surface element area of all the walls of the ducting from the furnace to the stack or to the convection section.

$\overline{L_{vi}}$ = the mean velocity level of the measuring positions, calculated from the equations in 4.4.

3.9 Convection Section

If the fired heater has a separate convection section, the external facing walls shall be treated in the same way as heater walls without burners, as in 3.5. The area between the convection section and the burner section should be tested with a preliminary noise survey and treated according to the procedure in 3.6.

3.10 Special Cases

3.10.1 NATURAL-DRAFT HEATERS WITH BOTH WALL AND FLOOR-FIRED BURNERS

3.10.1.1 External Walls With Burners

A preliminary noise survey should be made on the wall surface with the noise-level meter set to dB(A). A vertical scan should be made up the vertical centerline of the wall, 1 meter in front of the wall burners. Readings should be taken from the horizontal centerline of the floor burner open area up to the horizontal centerline of the top row of wall burners. This scan is to determine the influence of the noise from the floor-fired burner zone. If the vertical variation of noise level is less than 6 dB(A), the wall and the floor-fired burner zone may be treated as a single radiating area. Otherwise, the wall and floor burners must be treated as separate sources. The survey should then continue to determine whether the wall burners are to be treated as line sources or point sources as in 3.4.

If the wall is to be treated as a single radiating surface, the procedure of 3.4.1 shall be followed except that an additional measuring position shall be included. This position shall be under the wall at the midpoint of the open area between the floor and the ground.

If the wall burners are to be treated as line sources or as point sources, the procedures of 3.4.2 and 3.4.3, respectively, shall be followed except that measurements shall only be made on the top line of burners.

3.10.1.2 Areas Between Fired-Heater Sections

The procedure of 3.6 shall be followed except that the measuring positions for the vertical areas shall be at a height roughly two thirds the height of the walls.

3.10.1.3 Perimeter Area Around the Floor Burners

Measurements shall be made around the perimeter of the heater between the walls and the ground. At least one measuring position shall be selected under each of the outward-facing walls at the midpoint. Intermediate positions shall be selected if the noise level differs by more than 6 dB(A) around the perimeter.

The sound-pressure levels measured under a row of wall burners shall be corrected for the wall-burner noise SPL_b, which shall be calculated from the following equation:

$$SPL_b = PWL_b - 10 \log S_b/s_0$$

The area S_b shall be taken as:

$$S_b = \pi rL$$

Where:

PWL_b = the sound-power level of the line of burners (calculated according to 3.4.2).

r = the perpendicular distance from the line to the measuring position.

L = the length of the burner row.

The corrected values of sound-pressure level in each octave band shall be averaged and the total sound-power level of the floor burner zone shall be calculated according to 3.3.

3.10.2 FORCED-DRAFT HEATERS WITH UNSILENCED FANS

If the forced-draft fans are not silenced, they may be the dominant source of noise in the fired heater and may give rise to high background levels all around the heater. Therefore, a preliminary survey of the noise field around the heater is essential and should preferably be done when the heater is down but the fans are operating on their own. If high background noise from the fans is indicated, detailed measurements in octave bands should be made at the measurement positions to be used for the other sources. Subsequent noise measurements when the fired heater is operating should be corrected or eliminated according to their level with respect to the background.

When it is not possible to measure the fan noise on its own, the preliminary noise survey should be used to indicate the extent of the influence of the fan noise. This may be done by observing the fall in fan noise with distance, or by measuring for any narrow-band characteristic of the fan as an indicator. It may be necessary to eliminate measurement positions where the fan noise is significant.

Alternatively, measurements of the burner area noise may be made when the fired heater is operating at low load on fuel oil and at high load on gas firing. If there is no significant difference, it may be assumed that the fan noise is dominant. A possible technique to minimize the influence of the fans would be to construct temporary acoustic screens around them in order to reduce the background level at the measurement positions.

If none of these techniques is feasible, it may not be possible to make valid noise measurements of the other sources and their noise emission should then be estimated where practicable by vibration measurements. The noise from the burner area must then be ignored.

The noise from the fan shall be measured according to 3.7. Only those parts of the ducting outside the fired heater shall be regarded as part of the fan. Ducting underneath the heater will be included in the measurement of noise from the burner area.

3.10.3 FIRED HEATERS WITH NOISE CONTROL

For most types of noise control, such as plenum chambers around the burners or individual muffles on burners, the noise field at the periphery of the burner area will still be diffused. The noise emission from the burner area may then be measured by the procedure of 3.3.

A preliminary noise survey is especially important in order to ensure that the variation in noise levels around the perimeter is less than 6 dB(A). If it is, four equally spaced measuring positions may be used. If the variation in levels is greater than 6 dB(A), intermediate positions will be required.

3.10.4 ROOF-FIRED (DOWN-FLOW) HEATERS

When the burners are on a fired-heater roof without any weather protection, the roof shall be treated as an external wall with burners according to 3.4.

When the burners are under a roof for weather protection, the noise emitted by the open or louvered areas at the perimeter of the roof shall be measured according to the procedure for floor-fired heaters in 3.3.

SECTION 4—EVALUATION OF MEASUREMENTS

4.1 Calculation of Mean Sound-Pressure Level

The mean sound-pressure level for each octave band shall be calculated from the results of the measurements at all the test positions by means of the equation:

$$\overline{SPL} = 10 \log \left(1/n \left(\text{antilog} \frac{SPL_1}{10} + \text{antilog} \frac{SPL_2}{10} + \ldots \right. \right. \\ \left. \left. \ldots \text{antilog} \frac{SPL_n}{10} \right) \right)$$

If the variation in sound-pressure levels is less than 6 dB the arithmetic mean may be used:

$$\overline{SPL} = 1/n \, (SPL_1 + SPL_2 + \ldots . SPL_n)$$

4.2 Calculation of Octave Band Sound-Power Levels

The sound-power level for each octave band shall be calculated from the mean sound-pressure level by means of the equation:

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

Where E is the geometric near-field correction defined numerically in the applicable paragraphs of this recommended practice.

4.3 Addition of Octave Band Sound-Power Levels

The total sound-power level for each octave band for a source shall be calculated from the sound-power levels of its components by means of the equation:

$$PWL = 10 \log \left(\text{antilog} \frac{PWL_1}{10} + \text{antilog} \frac{PWL_2}{10} + \ldots \right. \\ \left. \ldots \text{antilog} \frac{PWL_n}{10} \right)$$

If it is not possible to measure the noise emission from a particular surface because of high background noise, it can be derived by reference to a similar surface. All derived sound-power levels that have not been calculated from direct measurements on the surfaces concerned shall be clearly indicated in the test report.

4.4 Calculation of Vibratory-Velocity Levels

The vibratory-velocity level can be calculated by using the relationships in 4.1.

SECTION 5—REPORTING OF DATA

5.1 General Requirements

The noise test report shall include a summary sheet with the main results, a description of the fired-heater equipment tested, operating conditions, and noise test data. Appendix A gives a model format for noise test reports. Appendix B includes a sample calculation and a completed noise test report.

5.2 Summary

The summary shall make reference to this API recommended practice.

The principal results of the survey are to be reported on one sheet. These results are to be supported by the test data, calculations, and sketches that follow. All calculations and interpretation of data shall be in accordance with Section 4. The calculations shall be included in an appendix.

The test results shall include the following:

1. The calculated overall average sound-power levels and the average octave band sound-power levels for separate components of the fired heater which are assumed to be separate sources. (The effective height for each component shall be given.)
2. The total heater sound-power level and total octave band sound-power levels calculated from the results in item 1 with the location of the noise center.
3. Results of data taken at special locations for noise control purposes.

5.3 Requirements for Data Sheet

1. A sketch of the fired heater is required with positions of burners, auxiliary equipment, and measurement positions noted.

2. The operating conditions of the heater including the number of burners that are firing oil and gas are required. Complete operating data for the burners shall be given including fuel properties.

If the heater is equipped with forced-draft or induced-draft fans, or both, the design data shall be recorded.

3. All noise and vibration measurements taken shall be recorded, including background measurements. Any corrections made to measurements and the reasons for making such corrections shall be noted. If noise emission from a particular surface cannot be obtained due to high background noise, it should be noted on the data sheet. Data from a similar surface should be referenced for use in estimating noise levels.

4. Details of the measuring equipment used shall be recorded.

APPENDIX A
MODEL FORMAT FOR NOISE TEST REPORT

Job. No. _____
Date of Report _____
Page 1 of _____

NOISE TEST REPORT

I. SUMMARY

For the measurement and calculation procedures used in this report, reference is made to API RP 531M, *Measurement of Noise From Fired Process Heaters*.

Author(s): _____

Department: _____

Date of measurements: _____

Date of report: _____

Fired heater identification: _____

Type of fired heater: _____

Design heat absorption: _____

Operating conditions: (% of design load) _____

Fuel fired: _____

Calculated Sound-Power Levels (dB re 10^{-12} watt)

Octave Band Center Frequencies (Hz)	63	125	250	500	1000	2000	4000	8000	Height (m)
Total Heater									
Peripheral area, heater to ground									
External walls with burners									
External walls without burners									
Exhaust duct to convection section									
Exhaust duct to stack									
Peripheral area between sections									
Fans and ducting									
Convection section									

Job. No. _____
Date of Report _____
Page 2 of _____

NOISE TEST REPORT

II. DESCRIPTION OF FIRED HEATER AND OPERATING CONDITIONS

1. Sketch of Fired Heater (Indicate positions of burners and measurement locations.)

2. Burners.

Number of burners: _____

Type of burners: _____

Burner adjustments (swirl control, atomizer, and so forth): _____

_____

Nonstandard items on burners: _____

3. Fan(s).

Design flow: _____ Design pressure: _____

Type of driver: _____ rpm: _____

Power of driver: _____ Power consumption: _____

4. Burner operating conditions.

Fuel pressure @ burner: _____

Atomizing steam pressure: _____

Job. No. _____
Date of Report _____
Page 3 of _____

NOISE TEST REPORT

Combustion air temperature: _____ % Excess air _____

Fuel flow: _____

5. Fuel data.

Density or molecular weight: _____

Viscosity: _____

Temperature: _____

Heating value: _____

6. Flue gas.

Temperature: _____ % Heater efficiency _____

O_2, volume percent (dry/wet): _____

Measurement point: _____

7. Silencing measures already installed: _____

_____

_____

_____

_____

III. MEASURING EQUIPMENT AND CHOICE OF MEASURING POSITIONS

1. Measuring equipment.

Sound-level meter: _____

Octave band filter: _____

Optional instruments: _____

_____

2. Choice of measuring positions.

Describe chosen positions per source and how background noise was measured or estimated.

_____

_____

_____

_____

_____

Job. No. _____
Date of Report _____
Page 4 of _____

NOISE TEST REPORT

IV. MEASUREMENTS

Weather conditions: _____

Wind speed: _____

Wind direction: _____

Presence of narrow-band noise: _____

V. COMMENTS

_____

_____

_____

_____

_____

_____

_____

_____

VI. NOISE AND BACKGROUND DATA SHEET

All noise and vibration measurements including background measurements are recorded on page 5 of this report on the noise and background data sheet.

VII. CALCULATIONS

The calculations made to prepare this report are appended to this report and appear on pages _____ through _____.

Job. No. ______________________________
Date of Report ______________________________
Page ___5___ of ______________

NOISE TEST REPORT

NOISE AND BACKGROUND DATA SHEET											
Point No.	Description		dB								
			A	63	125	250	500	1000	2000	4000	8000
		Measured									
		Background									
		Corrected									
		Measured									
		Background									
		Corrected									
		Measured									
		Background									
		Corrected									
		Measured									
		Background									
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		Corrected									
		Measured									
		Background									
		Corrected									
		Measured									
		Background									
		Corrected									
		Measured									
		Background									
		Corrected									

Job. No. _____
Date of Report _____
Page 6 of _____

NOISE TEST REPORT

VI. CALCULATIONS

APPENDIX B

ILLUSTRATIVE EXAMPLE WITH COMPLETED NOISE TEST REPORT

Appendix B contains an illustrated example of the calculations described in this recommended practice. For ease of reading, the calculations and a descriptive commentary are presented first. On an actual noise test report the calculations normally would appear under Section VI.

Also included in this appendix is a completed noise test report prepared from the calculations.

Sample Calculations

A typical box-type, fired heater with side-wall firing is shown in Figure B-1.

Measurements should be taken at locations specified in 3.1, items 2, 3, 4, and 7.

Since a prime source of heater noise is the burner area itself, reference is made to 3.4, External Walls with Burners, and more specifically to 3.4.3, Burners as Point Sources. Four sets of octave band readings are taken and entered on the data sheet. Positions 1 through 4 are shown as the microphone locations on Figure B-1.

To illustrate the effect of background noise, typical values measured prior to startup of the heater are shown on the data sheet for each microphone position.

Before the octave band sound-pressure level can be averaged, the readings must be corrected for background effects as described in 3.2. The corrected values are entered on the data sheet for the four microphone locations, and the values are used to average the *SPL*s for each octave band. Either one of two methods may be used, as described in 4.1 and illustrated below for the 1000-Hz octave band.

Method 1

$$\overline{SPL}_{1000} = 10\log\left[\frac{1}{n}\left(\text{antilog}\frac{SPL_1}{10} + \text{antilog}\frac{SPL_2}{10} + \text{antilog}\frac{SPL_3}{10} + \text{antilog}\frac{SPL_4}{10}\right)\right]$$

$$= 10\log\left[\frac{1}{4}\left(\text{antilog}\frac{76}{10} + \text{antilog}\frac{71}{10} + \text{antilog}\frac{75}{10} + \text{antilog}\frac{75}{10}\right)\right]$$

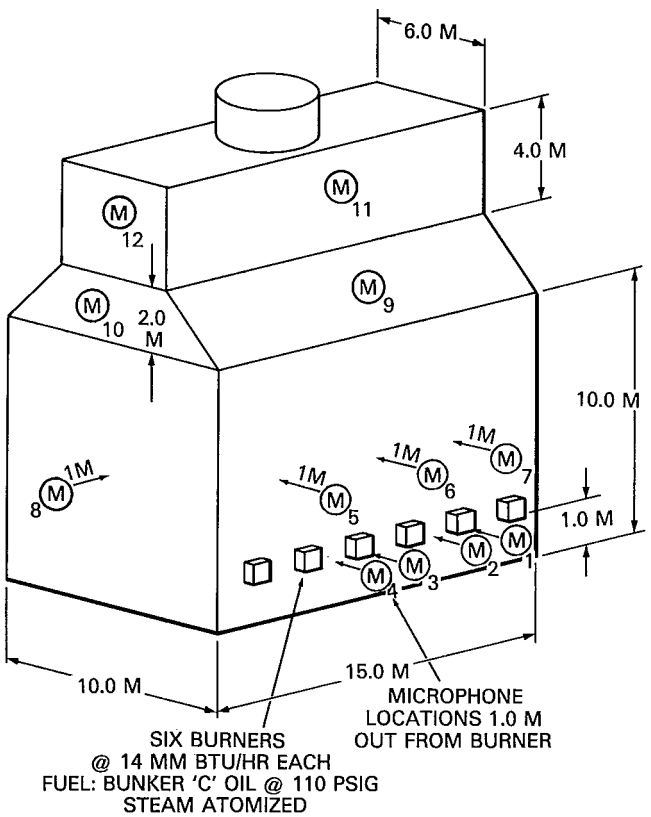


Figure B-1 — Example Sketch of Generalized Crude Heater — Showing Microphone Measuring Positions and Dimensions for Illustrative Example

$$= 10 \log \left[\frac{1}{4} (39.8 \times 10^6 + 12.59 \times 10^6 + 31.62 \times 10^6 + 31.62 \times 10^6) \right]$$

$$= 10 \log (28.91 \times 10^6)$$

$$= 10 \times 7.46$$

$$= 74.6 \text{ dB}$$

This same procedure would be followed on each of the sets of readings for each octave band.

Method 2

The second method of averaging is described in 4.1 for situations where the variation in *SPL* for any octave band is less than 6 dB. Under these circumstances the arithmetic averages are used. For the same 1000 Hz band:

$$\overline{SPL}_{1000} = \frac{1}{n} (SPL_1 + SPL_2 + SPL_3 + SPL_4)$$

$$= \frac{1}{4} (76 + 71 + 75 + 75)$$

$$= \frac{1}{4} (297)$$

$$= 74.25 \text{ dB}$$

The values as calculated by Method 1 are recorded on the Data Sheet as Point "A." With the $\overline{SPL}$ for each octave band now calculated, the burner area *PWL* can be determined by 3.4.3 where:

$$PWL = \overline{SPL} + 10 \log \frac{S_t}{s_0} + 10 \log N$$

$$PWL_{1000} = \overline{SPL}_{1000} + 10 \log \frac{2\pi \times 1^2}{1} + 10 \log 6$$

$$= 74.6 + 10 \log 6.28 + 10 \log 6$$

$$= 74.6 + 8.0 + 7.8$$

$$= 90.4 \text{ dB}$$

The opposite wall is considered a duplicate due to its similarity to the measured wall. Therefore, the total burner PWL_{1000} can be determined as in 4.3 (or in this special case, as follows: PWL_{1000} is 90.4 plus 90.4 which adds 3 dB for a total of 93.4 or rounded to 93 dB for the 1000-Hz band). Similarly, all other octave band *PWL* values can be calculated, and the resulting values recorded on the Noise Test Report in the appropriate space captioned "External walls with burners" on the summary page.

The next area of consideration is the vertical walls of the heater without burners (radiant section) as covered in 3.5. Due to the proximity of the burner noise source to the midpoint of the radiant section walls, the direct measurement of sound is nearly impossible. Accordingly, the vibratory-velocity method in 3.5.2 should be considered. Values in this

example, however, are reported on the data sheet for sound-pressure level for locations 5, 6, and 7 on the side wall and 8 on the end wall. The procedure to obtain $\overline{SPL}$ is the same as previous work and merely repeats the method of 4.1. The average $\overline{SPL}$ for the side wall is shown as Point "B," averaged as per Method 1 above.

From 3.5.1 the $PWL = \overline{SPL} + 10 \log \frac{S_i}{S_0} - E$ (Where $E = 3$ dB).

For the side walls:

$$PWL_{1000} = \overline{SPL}_{1000} + 10 \log \frac{S_i}{S_0} - 3$$

$$= 61 + 10 \log \frac{8 \times 15}{1} - 3$$

$$= 61 + 10 \log 120 - 3$$

$$= 61 + 20.8 - 3$$

$$= 61 + 17.8$$

$$PWL = 78.8 \text{ or } 79 \text{ dB}$$

For the end walls:

$$PWL_{1000} = \overline{SPL}_{1000} + 10 \log \frac{S_i}{S_0} - 3$$

$$= 60 + 10 \log \frac{10 \times 10}{1} - 3$$

$$= 60 + 20 - 3$$

$$= 77 \text{ dB}$$

Summation of one side wall and one end wall by method of 4.3:

$$= 10 \log \left[\text{antilog} \frac{PWL}{10} \text{ (side)} + \text{antilog} \frac{PWL}{10} \text{ (end)} \right]$$

$$PWL_{1000} = 10 \log \left(\text{antilog} \frac{79}{10} + \text{antilog} \frac{77}{10} \right)$$

$$= 10 \log (79.4 \times 10^6 + 50.12 \times 10^6)$$

$$= 81.1 \text{ or } 81 \text{ dB}$$

Since opposite sides and ends are similar, total wall $PWL = PWL$ (5,6,7,8) + 3 = 81 + 3 = 84 dB. The PWL values for all the remaining octave bands are calculated similarly and are recorded on the test report in the area "External walls without burners."

Due to noise emissions which more closely approach the level of background noise, the transition section between the radiant zone and the convection section is measured in this example by using the vibratory-velocity method in 3.5.2. The PWL values are calculated with the appropriate equation for this method. (NOTE: There is no correction for near-field effect.) Since the side-wall surfaces are sloped, the horizontal projected area should be used for S_i instead of the total surface area. PWL values are entered on the noise report in the area, "Exhaust duct to convection section."

The convection section walls in this example utilize the same methods as the transition section for determination of $\overline{L_{ri}}$ data. The calculated *PWL* values from the measured $\overline{L_{ri}}$ data are entered on the data sheet as locations 11 and 12. *PWL*s are calculated from the individual single $\overline{L_{ri}}$ reading in each octave band. The same relationship of opposite sides and ends (which are similar) exists in the convection section and can be treated like previous work. The *PWL*s are therefore increased by 3 dB. These values are entered on the Noise Test Report in the area entitled "Convection section."

For these four sound emitting areas of the heater, the *PWL* values in each octave band are summarized by the standard method of 4.3 to obtain the total heater *PWL* and are tabulated in the appropriate area of the test report.

Job. No. *Sample Report*
Date of Report *1/5/80*
Page 1 of 7

NOISE TEST REPORT

I. SUMMARY

For the measurement and calculation procedures used in this report reference is made to API RP 531M, *Measurement of Noise From Fired Process Heaters*.

Author(s): *Name*

Department: *Department Name*

Date of measurements: *1/5/80*

Fired heater identification: *Generalized crude heater*

Type of fired heater: *Side-fired box heater*

Design heat absorption: *135 MM Btu/hr*

Operating conditions (% of design load): *100*

Fuel fired: *Bunker 'C' oil @ 110 psig (steam atomized)*

Calculated Sound-Power Levels (dB re 10^{-12} watt)

Octave-Band Center Frequencies (Hz)	63	125	250	500	1000	2000	4000	8000	Height (m)
Total Heater	*113.1*	*109.5*	*101.6*	*100.4*	*93.7*	*91.2*	*92.8*	*98.2*	
Peripheral area, heater to ground									
External walls with burners	*111*	*103*	*99*	*99*	*93*	*90*	*92*	*98*	*2*
External walls without burners	*108*	*108*	*96*	*94*	*84*	*84*	*85*	*85*	*6*
Exhaust duct to convection section	*97*	*94*	*89*	*82*	*75*	*74*	*No Readings*		*11*
Exhaust duct to stack									
Peripheral area between sections									
Fans and ducting									
Convection section	*100*	*96*	*92*	*85*	*77*	*76*	*No Readings*		*14*

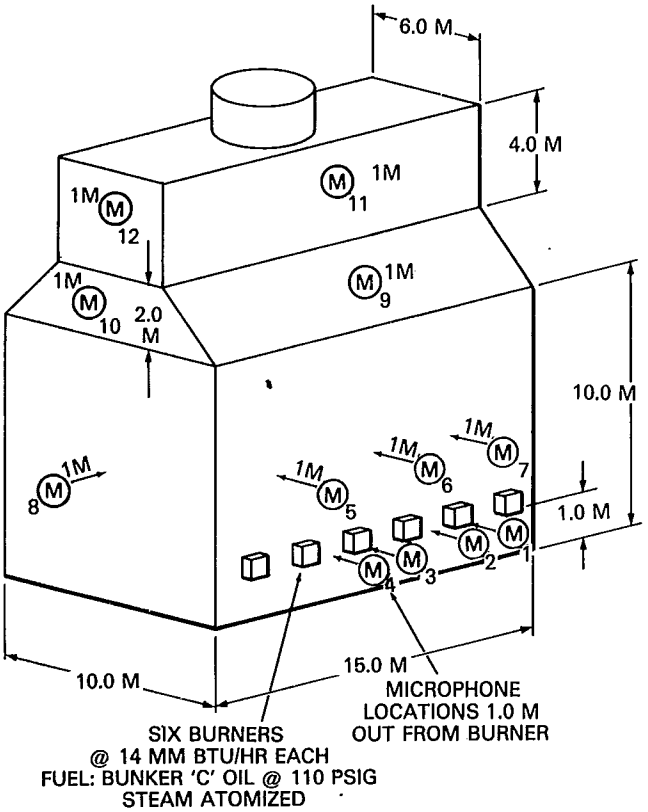
Job. No. *Sample Report*
Date of Report *1/5/80*

NOISE TEST REPORT

Page *2* of *7*

II. DESCRIPTION OF FIRED HEATER AND OPERATING CONDITIONS

1. Sketch of Fired Heater (Indicate positions of burners and measurement locations.)



2. Burners.

Number of burners: *12 burners — 6 on each side*

Type of burners: *Combination oil and gas — burning oil only*

Burner adjustments (swirl control, atomizer, and so forth): *Primary and secondary air control, quick change oil guns*

Nonstandard items on burners: *Pilots*

3. Fan(s). *(Heater is natural draft with no fans installed.)*

Design flow. *N/A* Design pressure: *N/A*

Type of driver: *N/A* rpm: *N/A*

Power of driver: *N/A* Power consumption: *N/A*

4. Burner operating conditions.

Fuel pressure @ burner: *Bunker C at 110 psig*

Atomizing steam pressure: *130 psig*

Job. No. *Sample Report*
Date of Report *1/5/80*
Page *3* of *7*

NOISE TEST REPORT

Combustion air temperature: *Ambient 58 to 63 °F* % Excess air *25%*

Fuel flow: *19.5 gpm (1.6 gpm per burner)*

5. Fuel data.

Density or molecular weight: *10° API*

Viscosity: *30 SSF*

Temperature: *195°F*

Heating value: *17,300 Btu/lb (LHV)*

6. Flue gas.

Temperature: *760°F* % Heater efficiency *80% (LHV)*

O_2, volume percent (dry/wet): *4.0% Volume, wet*

Measurement point: *Stack*

7. Silencing measures already installed: *None on this heater*

III. MEASURING EQUIPMENT AND CHOICE OF MEASURING POSITIONS

1. Measuring equipment.

Sound-level meter: *Type I, Precision (Manufacturer, Model No., Serial No.) including microphone*

Octave band filter: *Type E, Class II (Manufacturer, Model No., Serial No.)*

Optional instruments: *Vibration transducer (Manufacturer, Model No., Serial No.)*

Integrator (Manufacturer, Model No., Serial No.)

2. Choice of measuring positions.

Describe chosen positions per source and how background noise was measured or estimated.

Points 1 through 8 are all taken at 1 meter from the surface as shown on sketch. A pole mounted microphone was used for points 5 through 8. Points 9 through 12 are taken with an accelerometer magnetically mounted (response limited above 3000 hertz) on steel heater plates at positions indicated on sketch. Corresponding points on opposite sides of heater are assumed to be the same as measured values. Background noise was measured at each point with sound level meter when heater was shut down.

Job. No. *Sample Report*
Date of Report *1/5/80*
Page 4 of 7

NOISE TEST REPORT

IV. MEASUREMENTS

Weather conditions: *Cloudy*
Wind speed: *Approximately 3 mph*
Wind direction: *From the south (lengthwise of heater)*
Presence of narrow-band noise: *None*

V. COMMENTS

Burner noise and heater wall noise measurements were taken with a sound level meter. The transition to the convection section and the convection section itself were measured using vibration equipment (accelerometer - integrator - sound level meter). Properly designed burner mufflers could attenuate noise levels possibly 10 dB at low frequencies and more at higher frequencies.

VI. NOISE AND BACKGROUND DATA SHEET

All noise and vibration measurements including background measurements are recorded on page 5 of this report on the noise and background data sheet.

VII. CALCULATIONS

The calculations made to prepare this report are appended to this report and appear on pages 7 through X.

Job. No. *Sample Report*
Date of Report *1/5/80*
Page 5 of 7

NOISE TEST REPORT

NOISE AND BACKGROUND DATA SHEET

Point No.	Description		dB								
			A	63	125	250	500	1000	2000	4000	8000
1	Burner Row Left Side in Front of Burner	Measured	86	94	85	80	82	76	74	75	84
		Background	73	74	74	68	62	65	68	65	58
		Corrected		94	85	80	82	76	73	75	84
2	Burner Row Left Side Between Burner	Measured	81	91	82	80	77	72	71	72	77
		Background	73	74	75	64	62	66	68	66	57
		Corrected		91	81	80	77	71	(68)	71	77
3	Burner Row Right Side in Front of Burner	Measured	83	93	86	74	80	76	74	74	74
		Background	73	75	76	68	64	67	69	66	62
		Corrected		93	86	73	80	75	72	73	74
4	Burner Row Right Side Between Burner	Measured	82	92	83	82	78	76	74	72	74
		Background	73	75	76	68	64	67	69	66	62
		Corrected		92	82	82	78	75	72	71	74
A	Average $\overline{SPL}$ for Microphone Positions 1 through 4.	Measured									
		Background									
		Corrected		92.6	84.0	79.8	79.7	74.6	71.6	72.8	79.4
5	Side Wall Panel Left Side Elevation 6 m	Measured	83	85	74	72	66	65	66	63	
		Background	73	75	65	62	63	62	63	57	
		Corrected		83	85	73	72	(63)	(62)	(63)	62
6	Side Wall Panel Center Elevation 6 m	Measured	86	85	74	71	63	63	65	63	
		Background	74	74	64	62	60	60	62	57	
		Corrected		86	85	74	70	(60)	(60)	(62)	62
7	Side Wall Panel Right Side Elevation 6 m	Measured	84	83	73	71	62	63	63	62	
		Background	73	73	64	62	59	60	60	54	
		Corrected		84	83	72	70	(59)	(60)	(60)	61
B	Average $\overline{SPL}$ for Microphone Positions 5, 6, 7	Measured									
		Background									
		Corrected		84.5	84.4	73.1	70.8	61.0	60.8	61.8	61.7
8	End Wall Left Panel Elevation 6 m	Measured	84	84	73	70	63	63	64	62	
		Background	73	74	64	61	60	60	61	56	
		Corrected		84	84	72	69	(60)	(60)	(61)	61

Job. No. *Sample Report*
Date of Report *1/5/80*
Page 6 of 7

NOISE TEST REPORT

NOISE AND BACKGROUND DATA SHEET

Point No.	Description		dB								
			A	63	125	250	500	1000	2000	4000	8000
9	Transition Duct Side Panel Elevation 11 m	Measured		*78*	*75*	*70*	*63*	*55*	*54*	*NR*	*NR*
		Background									
		Corrected									
10	Transition Duct End Panel Elevation 11 m	Measured		*75*	*71*	*68*	*60*	*55*	*54*	*NR*	*NR*
		Background									
		Corrected									
11	Convection Section Side Panel Elevation 14 m	Measured		*78*	*75*	*70*	*63*	*55*	*54*	*NR*	*NR*
		Background									
		Corrected									
12	Convection Section End Panel Elevation 14 m	Measured		*75*	*71*	*68*	*60*	*55*	*54*	*NR*	*NR*
		Background									
		Corrected									
		Measured									
		Background									
		Corrected									
		Measured									
		Background									
		Corrected									

Note: NR indicates no reading.

Job. No. *Sample Report*
Date of Report *1/5/80*
Page 7 of 7

NOISE TEST REPORT

VI. CALCULATIONS

The sample calculations done in the first part of Appendix B normally would be appended to the noise test report under this section.