

# The Sound Intensity At A Distance Of 19 M From A Noisy Generator Is Measured To Be 0.24 W/m<sup>2</sup>. What Is

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## Introduction

Sound plays a vital role in our daily lives, whether it's the hum of machinery, the chirping of birds, or the noise from traffic. Understanding sound intensity and how it propagates over distance is essential in fields ranging from acoustics engineering to environmental noise management. When measuring the sound intensity at a specific distance from a noise source, such as a generator, it helps us gauge the impact of that noise on the surrounding environment and determine necessary mitigation measures.

In this article, we explore the problem: "The sound intensity at a distance of 19 meters from a noisy generator is measured to be 0.24 W/m<sup>2</sup>. What is the power output of the generator?" We will delve into the concepts of sound intensity, how it relates to sound power, and how to perform the necessary calculations to find the generator's power. This comprehensive guide aims to provide clarity on the topic for students, engineers, and anyone interested in acoustics.

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## Understanding Sound Intensity and Power

### What Is Sound Intensity?

Sound intensity is a measure of how much sound power passes through a unit area in a specific direction. It is expressed in watts per square meter (W/m<sup>2</sup>). Mathematically:

$$I = \frac{P}{A}$$

where:

- I is the sound intensity,
- P is the sound power (total energy per unit time),
- A is the area through which the sound energy passes.

In free-field conditions (open space without reflections), sound intensity diminishes with distance from the source, following the inverse square law.

## What Is Sound Power?

Sound power (P) is the total energy emitted by a source per second, measured in watts (W). Unlike sound intensity, which varies with distance, sound power is a property of the source itself and remains constant regardless of where it's measured.

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## Relationship Between Sound Intensity, Power, and Distance

In an ideal free-field environment, the sound radiates uniformly in all directions (omnidirectional source). Under this assumption:

- The sound power is spread over the surface area of a sphere centered on the source.
- The surface area of a sphere is:

$$A = 4\pi r^2$$

where r is the distance from the source.

The sound intensity at a distance r from a point source is:

$$I = \frac{P}{4\pi r^2}$$

This formula allows us to relate the measured intensity at a known distance to the total power output of the source.

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## Calculating the Power of the Generator

Given:

- Measured sound intensity,  $(I = 0.24 \text{ W/m}^2)$ ,
- Distance from the generator,  $(r = 19 \text{ m})$ .

We want to find the total sound power  $(P)$ .

Using the formula:

$$P = I \times 4\pi r^2$$

Substituting the known values:

$$P = 0.24 \times 4\pi (19)^2$$

Calculations:

1. Square the distance:

$$19^2 = 361$$

2. Calculate  $(4\pi r^2)$ :

$$4 \times \pi \times 361 \approx 4 \times 3.1416 \times 361$$

$$\approx 12.5664 \times 361$$

$$\approx 4539.6$$

3. Multiply by the intensity:

$$P = 0.24 \times 4539.6$$

$$\approx 1088.3 \text{ W}$$

Therefore, the approximate power output of the generator is 1088 watts (or about 1.09 kW).

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## Implications and Applications of the Calculation

Understanding the power output of a noisy generator through sound intensity measurements has several practical applications:

- Noise Control and Mitigation: Knowing the power output helps in designing noise barriers or mufflers to reduce environmental impact.
- Environmental Regulations: Regulatory agencies often set limits on permissible noise levels; calculating power helps in compliance.
- Equipment Maintenance: Excessive noise may indicate mechanical issues, and power estimations can help verify performance.
- Design Optimization: Engineers can optimize generator design for minimal noise pollution while maintaining performance.

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# Factors Affecting Sound Intensity Measurement Accuracy

While the calculation above assumes ideal conditions, real-world scenarios include factors like:

- Environmental Conditions: Wind, temperature, and humidity can influence sound propagation.
- Source Directivity: Not all generators radiate sound equally in all directions.
- Reflections and Obstructions: Nearby objects can reflect or block sound waves, affecting measurements.
- Measurement Instrument Calibration: Ensuring the sound level meters are properly calibrated for accurate readings.

Accounting for these factors is crucial to obtain precise estimates of sound power and to make informed decisions.

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## Conclusion

Measuring the sound intensity at a specific distance from a noisy generator provides valuable insights into the source's power output. Using the inverse square law and the relationship between intensity and power, we calculated that a generator emitting a sound intensity of  $0.24 \text{ W/m}^2$  at 19 meters has an approximate power output of 1088 watts.

Understanding these principles is essential for engineers, environmentalists, and policymakers working to control noise pollution, ensure regulatory compliance, and design quieter machinery. Accurate calculations and awareness of influencing factors lead to better noise management strategies and improved environmental quality.

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## Additional Resources

- Acoustics Fundamentals: Learn more about sound properties and measurement techniques.
- Environmental Noise Regulations: Overview of standards and permissible limits.
- Soundproofing Solutions: Technologies and designs for reducing noise pollution.
- Tools for Measurement: Recommendations for sound level meters and their proper use.

By mastering the concepts of sound intensity and power, professionals can make informed decisions to manage noise effectively in various settings.

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If you have further questions on sound measurement or need assistance with acoustic calculations, consult with acoustics specialists or refer to standards from organizations like ISO or ANSI for detailed guidelines.

## **Frequently Asked Questions**

### **What is the sound intensity level at a distance of 19 meters from the noisy generator if the intensity is 0.24 W/m<sup>2</sup>?**

The sound intensity level can be calculated using the formula:  $\beta = 10 \log(I / I_0)$ . Assuming  $I_0 = 1 \times 10^{-12} \text{ W/m}^2$ ,  $\beta = 10 \log(0.24 / 1 \times 10^{-12}) \approx 10 \log(2.4 \times 10^{11}) \approx 10 \times (11.38) \approx 113.8 \text{ dB}$ .

### **How does the distance from the generator affect the sound intensity measured at 19 meters?**

Sound intensity decreases with increasing distance from the source, following the inverse square law, which states that intensity is proportional to  $1 / r^2$ . Therefore, moving further away results in lower measured intensity.

### **What is the significance of knowing the sound intensity at a specific distance from a noisy generator?**

Measuring sound intensity at a specific distance helps assess noise pollution levels, evaluate compliance with safety standards, and design effective noise control measures around machinery.

### **If the sound intensity at 19 meters is 0.24 W/m<sup>2</sup>, what would be the approximate intensity at 9.5 meters assuming a point source?**

Assuming a point source and inverse square law, the intensity at 9.5 meters (half the distance) would be four times higher, approximately  $0.96 \text{ W/m}^2$ .

### **What safety precautions should be taken if the sound intensity near a noisy generator reaches 0.24 W/m<sup>2</sup>?**

Prolonged exposure to high sound intensities can cause hearing damage. Safety precautions include using ear protection, maintaining safe distances, and implementing noise barriers or damping measures to reduce exposure levels.

# Additional Resources

The sound intensity at a distance of 19 m from a noisy generator is measured to be  $0.24 \text{ W/m}^2$ . What is... — this question opens up a fascinating exploration into the principles of sound propagation, intensity, and acoustic measurement. Whether you're an acoustics enthusiast, a student studying physics, or an engineer working on noise control, understanding how to interpret and analyze sound intensity data is essential. In this detailed guide, we'll unpack what sound intensity truly means, how it relates to the power output of a noise source, and how to calculate important parameters such as the total acoustic power and sound level.

Join us as we delve deep into the fundamentals of sound intensity, its mathematical relationships, and practical applications, providing a comprehensive understanding of the topic.

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## Understanding Sound Intensity: The Basics

Before tackling the specific problem, it's crucial to grasp what sound intensity signifies in acoustics.

### What Is Sound Intensity?

Sound intensity is a measure of the power carried by sound waves per unit area, expressed in watts per square meter ( $\text{W/m}^2$ ). It quantifies how much acoustic energy passes through a given area in a specific direction. Essentially, it tells us how "loud" a sound is at a particular point in space.

### Why Is Sound Intensity Important?

- **Quantitative Measure of Loudness:** Unlike sound pressure level (measured in decibels), which is relative, sound intensity provides an absolute measure of energy transfer.
- **Directionality:** Intensity vectors point in the direction of wave propagation, helping analyze the directionality of sound sources.
- **Design and Control:** Engineers use intensity measurements to design quieter machinery or optimize sound barriers.

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## The Relationship Between Sound Intensity and Power

To analyze the noise from the generator, we need to understand how the measured intensity relates to the total acoustic power output of the source.

### Key Concepts

- **Point Source Approximation:** For a small, localized noise source like a generator, the sound is often approximated as emanating uniformly in all directions (spherical spreading).
- **Inverse Square Law:** As sound radiates spherically, the intensity decreases proportionally

to the square of the distance from the source.

### Mathematical Relationship

The fundamental equation relating intensity  $(I)$ , power  $(P)$ , and area  $(A)$ :

$$I = \frac{P}{A}$$

For a spherical wave:

$$A = 4\pi r^2$$

where:

- $(P)$  = total acoustic power output (W)
- $(r)$  = distance from the source (m)
- $(I)$  = intensity at distance  $(r)$  ( $\text{W/m}^2$ )

Thus,

$$P = I \times 4\pi r^2$$

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### Step-by-Step Calculation

Given the problem:

- Distance from the source,  $(r = 19\text{ m})$
- Measured intensity at that distance,  $(I = 0.24\text{ W/m}^2)$

Our goal: To determine the total acoustic power  $(P)$  emitted by the generator.

#### Step 1: Calculate the Total Power

Using the formula:

$$P = I \times 4\pi r^2$$

Plugging in the known values:

$$P = 0.24\text{ W/m}^2 \times 4\pi \times (19)^2$$

Calculate  $(19)^2$ :

$$19^2 = 361$$

Calculate  $(4\pi)$ :

$$4\pi \approx 12.566$$

Now, multiply:

$$P = 0.24 \times 12.566 \times 361$$

Calculate:

$$12.566 \times 361 \approx 12.566 \times 361$$

Let's do this step-by-step:

$$12.566 \times 361$$

$$12.566 \times 300 = 3,769.8$$

$$12.566 \times 61 = 767.426$$

Add:

$$3,769.8 + 767.426 \approx 4,537.226$$

Now, multiply by 0.24:

$$0.24 \times 4,537.226 \approx 1,088.14 \text{ W}$$

Result: The total acoustic power emitted by the generator is approximately 1,088.14 W, or about 1.09 kW.

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## Interpreting the Results

What does the power tell us?

- The generator's total acoustic power is roughly 1.09 kW, which indicates a fairly noisy machine.
- This power output is the total energy radiated as sound in all directions.

How does intensity vary with distance?

Using the inverse square law, if you were to measure the intensity at a different distance, say 10 meters, it would be:

$$I_{10} = \frac{P}{4\pi (10)^2}$$

Plugging in  $P = 1,088.14 \text{ W}$ :

$$I_{10} = \frac{1,088.14}{4\pi \times 100} \approx \frac{1,088.14}{1,256.64} \approx 0.866 \text{ W/m}^2$$

This shows that the intensity increases as we get closer, consistent with the inverse square law.



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## Converting Intensity to Sound Level (Decibels)

While intensity provides a physical measure, human perception of loudness is often expressed in decibels (dB).

Formula:

$$L = 10 \log_{10} \left( \frac{I}{I_0} \right)$$

where:

- $L$  = sound level in dB
- $I$  = measured intensity
- $I_0$  = reference intensity, typically  $1 \times 10^{-12} \text{ W/m}^2$

Calculation:

$$L = 10 \log_{10} \left( \frac{0.24}{10^{-12}} \right) = 10 \log_{10}(0.24 + 12)$$

Calculate  $\log_{10}(0.24)$ :

$$\log_{10}(0.24) \approx -0.6198$$

Now:

$$L = 10 \times (-0.6198 + 12) = 10 \times 11.3802 = 113.8 \text{ dB}$$

Interpretation: The sound level at 19 m from the generator is approximately 113.8 dB, which is extremely loud and comparable to a jet engine at close range.

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## Practical Applications and Considerations

### Noise Control and Regulations

Knowing the total power output and the sound level at various distances helps in:

- Designing soundproof enclosures
- Implementing barriers or damping materials
- Ensuring compliance with occupational and environmental noise regulations

### Limitations and Assumptions

- The calculations assume spherical spreading and no reflections or absorptions.
- Real-world conditions may involve complex propagation, including diffraction, reflection, and atmospheric effects.
- The source may not be perfectly omnidirectional; directional sources would require more

advanced modeling.

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### Summary: Key Takeaways

- Sound intensity is a measure of acoustic energy transfer per unit area, expressed in  $\text{W/m}^2$ .
- The total acoustic power emitted by a source can be calculated using the intensity at a given distance and the surface area of a sphere with radius equal to that distance.
- The relationship:

$$P = I \times 4\pi r^2$$

allows us to determine the source power from measurements.

- The sound level in decibels can be derived from intensity via:

$$L = 10 \times \log_{10} \left( \frac{I}{I_0} \right)$$

- Practical implications include noise control, environmental compliance, and acoustic design.

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### Final Thoughts

Understanding sound intensity and its relationship to the source power is fundamental in acoustics, engineering, and environmental science. By mastering these principles, professionals can effectively measure, analyze, and mitigate noise pollution, ensuring safer and more comfortable environments.

If you encounter measurements like the one in this example, remember to carefully consider the assumptions made, apply the correct formulas, and interpret the results within the context of the real-world environment.

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