International Society of Explosives Engineers

# ISEE PERFORMANCE SPECIFICATIONS FOR BLASTING SEISMOGRAPHS 2017

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This edition of *ISEE Performance Specifications for Blasting Seismographs* was revised by the ISEE Standards Committee on May 9, 2017, and supersedes all previous editions. It was approved by the Society's Board of Directors in its role of Secretariat of the Standards at its July 20, 2017, meeting.

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[1]This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred.

**Committee Scope:** This Committee shall have primary responsibility for documents on the manufacture, transportation, storage, and use of explosives and related materials. This Committee does not have responsibility for documents on consumer and display fireworks, model and high power rockets and motors, and pyrotechnic special effects.

**Origin and Development of ISEE Standards for Blasting Seismographs**

One of the goals of the ISEE Standards Committee is to develop uniform and technically appropriate standards for blasting seismographs. The intent is to improve accuracy and consistency in vibration and air overpressure measurements. Blasting seismograph performance is affected by how the blasting seismograph is built and how it is placed in the field.

In 1994, questions were raised about the accuracy, reproducibility and defensibility of data from blasting seismographs. To address this issue, the International Society of Explosives Engineers (ISEE) established a Seismograph Standards Subcommittee at its annual conference held in February 1995. The committee was comprised of seismograph manufacturers, researchers, regulatory personnel and seismograph users.
In 1997, the Committee became the Blast Vibrations and Seismograph Section. The initial standards were drafted and approved by the Section in December 1999. Subsequently, the ISEE Board of Directors approved two standards in the year 2000: 1) ISEE Field Practice Guidelines for Blasting Seismographs; and 2) Performance Specifications for Blasting Seismographs.

In 2002, the Society established the ISEE Standards Committee. A review of the ISEE Field Practice Guidelines and the Performance Specifications for Blasting Seismographs fell within the scope of the Committee. Work began on a review of the Field Practice Guidelines in January 2006 and was completed in February 2008 to produce the 2009 edition. A revision to the Performance Specifications was started in 2009 and completed in 2011.

The ISEE Standards Committee takes on the role of keeping the standards up to date every 5 years. This document is the result of the latest effort by the ISEE Standards Committee to keep the standards up to date with current field techniques and technology.

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**Disclaimer:** These performance specifications are intended to provide design guidelines for blasting seismograph manufacturers. It is incumbent on the blasting seismograph operator to evaluate field conditions, identify the appropriate field criteria and select the proper blasting seismograph for the field application. The operator is responsible for documenting the field conditions and setup procedures in the permanent record for each blast.

# ISEE Performance Specifications for Blasting Seismographs

**Preface:** Blasting seismographs are used to establish compliance with regulations that have been established to prevent damage to public and private property. The disposition of the rules is strongly dependent on the accuracy of ground vibration and air overpressure data. One goal of the ISEE Standards Committee is to ensure consistent and accurate recording of ground vibrations and air overpressure between all blasting seismographs.

## PART I. GENERAL GUIDELINES

**A. General:** Blasting seismographs are deployed in the field to record the levels of blast-induced ground vibration and air overpressure. Accuracy of the recordings is essential. These guidelines define the manufacturers' responsibilities when building and calibrating blasting seismographs for outdoor field use to measure ground vibrations and air overpressures. The measurements must allow for comparison to limiting criteria presented in United States Bureau of Mines RI 8507 and RI 8485, which often form the basis of regulations for blast vibrations. Blasting seismographs should be deployed in the field according to the ISEE "Field Practice Guidelines for Blasting Seismographs" (ISEE 2015). The following specifications are considered minimums.

1. **Digital Sampling Rate:** 1000 samples/sec or greater, per channel
2. **Operating Temperature Range:** 10 to 120$^0$F (-12 to 49$^0$C)
3. **Electrical Cross-Talk:** Less than 2% of the input signal appears on any other channel

## PART II. GROUND VIBRATIONS MEASUREMENT

**A. Ground Vibration Sensor:** The response characteristics should conform to the following minimum values:

1. **Frequency Range:** 2 to 250 Hz
2. **Accuracy:** 2 to 4 Hz ..... +5% to -3 dB of an ideal flat response
   4 to 125 Hz ..... ±5 % or ±0.5 mm/sec (±0.02 in/sec), whichever is larger
   125 to 250 Hz ... +5% to -3 dB of an ideal flat response
3. **Phase Response:** Phase shift from 2.5 Hz to 250 Hz shall not cause an error of more than 10% to the maximum absolute value of two superimposed harmonic vibrations.
4. **Cross-talk Response**: Less than 5% of the excited axis indication on any of the mutually perpendicular channels when excited at the natural frequency of the sensor or at 10 Hz for sensors with a natural frequency greater than 250 Hz.
5. **Density of Sensor:** < 2405 kg/m3 (150 lbs/ft3) (should be reported for user consideration).

## PART III. AIR OVERPRESSURE MEASUREMENT

**A. Air Overpressure Microphone:** The response characteristics should conform to the following minimum values:

1. **Frequency Range:** 2 to 250 Hz
2. **Accuracy**: 2 Hz ..... -3dB, ±1 dB
   3 Hz ..... -1dB, ±1 dB
   4 to 125 Hz ... ±1 dB
   200 Hz ..... +1 dB to -3 dB
   250 Hz ..... +1 dB to -4 dB

3. **Microphone Seismic Sensitivity**: Microphone response to a mechanical vibration of 50 mm/s (2 in/s) at 30 Hz, from any angle, must be less than 40 dB below the maximum microphone output, or 106 dB, whichever is lower.

## PART IV. CALIBRATION

**A. General:** The calibration documentation must provide evidence that each channel of the seismograph being calibrated meets or exceeds the ISEE Performance Specification for Blasting Seismographs. To achieve this, the seismograph must be tested against the above specifications across the entire frequency range of 2 to 250 Hz. Some of these specifications, like the cross-talk response, the sensor density and the microphone's response to mechanical vibration, will not change over time and therefore will generally be found on product specification sheets. However, the frequency, amplitude and phase responses will directly affect the accuracy of the recorded events and therefore must be checked as part of the calibration process.

The frequency, amplitude and phase responses are directly affected by the individual components used in the circuit design. These components may change, drift over time or fail altogether, which could affect the response and accuracy of the blasting seismograph. To ensure each seismograph is performing as intended, the seismograph and its ground vibration and air overpressure sensors are to be calibrated prior to initial use, annually thereafter, and after each repair that could affect its response. As the calibration procedures may be different for each manufacturer, it is recommended that the seismograph be returned to the manufacturer or a calibration facility authorized by the manufacturer for the annual calibration.

1. **Frequency:** Annually.
2. **Traceability:** Calibration equipment accuracy must be traceable to National Institute of Standards and Technology, National Research Council or equivalent.
3. **Ground Vibration Sensor:** Calibration must be of the assembled sensor. Component calibrations of individual sensors are not appropriate.

**B. Documentation Required:** To help ensure consistency the following documentation must be provided by the calibration facility for each blasting seismograph. The specific format of these documents may vary; however, the main content of each of these documents is outlined below.

**1. As Found Report:** The As Found report is to be produced prior to any adjustments or repairs of the equipment being calibrated. This report will measure and document the initial response of the seismograph and its sensors to a series of calibrated reference signals. This report can then be used to help assess the validity of previously recorded events. The report should be dated and must clearly identify the specific sensor it is related to (i.e., serial number 12345 - Vertical channel). To help ensure consistency, it is recommended that the signals used to produce the As Found report be the same as the signals used during the final calibration process. Samples of a tabular As Found report can be found in Appendix 1 and the

graphical As Found report in Appendix 2.

**2. Reference Equipment:** The reference equipment used during calibration is a critical aspect of the calibration process. All of the reference equipment must be calibrated on an annual basis and their traceable reference standard noted. The specific equipment used in the calibration process must be identified on the calibration certificate, along with its traceable standard. If the list of equipment is extensive, a test system identification number may be used instead. The calibration records for the reference equipment should be made available to the end user upon request.

**3. Test Signals and Results:** To ensure full compliance to these ISEE specifications, the amplitude and frequency response of each sensor and the phase response of the three ground vibration channels must be tested at enough points to verify their response across the entire ISEE specified frequency range of 2 to 250 Hz. The results of the frequency, amplitude and phase response tests can be provided in a tabular or graphical format. The minimum number of test points for the amplitude and frequency response can be found in Table 1 of Appendix 1. The phase response is used to measure the phase shift between the reference signal and the response of the ground vibration sensor being tested. This could be measured and recorded at each of the test points across the specified frequency range. However, the phase response can also be verified using specific amplitude and frequency measurements. As a minimum, using a mid-range amplitude and frequency response, like 30 Hz, as a reference, the frequency roll-off at both the low and high frequencies can be verified against this mid-range response. This procedure is described in the "Measuring the Phase Response" section of Appendix 1.

**NOTE:** As this procedure to measure the phase response is based on the measured amplitude at 30 Hz, it is recommended that the final amplitude and frequency response table be completed prior to measuring the phase response. This will allow the seismograph, ground vibration and air overpressure sensors to be calibrated/adjusted, if required, prior to measuring the phase response.

When using the tabular method to document the amplitude and frequency, the reference signals must be documented along with the actual response of each of the sensors. The results must clearly indicate a pass or fail at each of the test points. Samples of the tabular reports can be found in Appendix 1, while samples of the graphical reports can be found in Appendix 2.

Any additional information that the calibration facility may want to include can be provided in a "Calibration Remarks" section of each report. As an example, if a calibration facility was to use an electronic method or statistical analysis to verify specific ground vibration frequencies instead of shaking the sensor on a shake table, these notes should be included as Calibration Remarks. These notes must also be included or referenced on the calibration certificate. The calibration facility may also choose to include the technical justification for their alternative methods. As an example, the calibration certificate could read; *"This seismograph meets or exceeds the ISEE Performance*

*Specifications for Blasting Seismographs 2017 edition, exceptions as noted."* This statement could be followed by the following example note: *"1) Ground vibration sensors exception: The ground sensors were electronically verified from 125 to 250 Hz."*

Then, somewhere in the documentation, describe how the electronic testing was done; or, if the procedure has already been documented, indicate where the procedure can be found…… *"A signal generator was connected to the input of each ground channel and the amplitude response verified from 125 to 250 Hz"* or *"The electronic testing procedure can be found in test specification "ABC123".*

**4. Calibration Certificate:** The calibration certificate for a blasting seismograph should include at least the following items:

- **a.** Name, physical address and phone number of the calibration facility
- **b.** The serial numbers of the equipment being calibrated (seismograph, vibration and air overpressure sensors)
- **c.** The model number and description of the equipment being calibrated
- **d.** The date the calibration was performed
- **e.** A list of reference equipment used to calibrate the seismograph
- **f.** The standard(s) that the reference equipment is traceable to
- **g.** The tabular and/or graphical reports of the calibration results,
- **h.** A statement that the equipment tested meets the ISEE 2017 Performance Specifications for Blasting Seismographs (including any calibration remarks),
- **i.** Any calibration remarks, and
- **j.** The name and signature of the technician who performed the calibration.

## PART V. MEASUREMENT PRACTICES

**A. Field Deployment:** In addition to the Performance Specifications described above, blasting seismograph setup or installation in the field is crucial for accurate defensible data acquisition. Set-up or installation practices are specified in the ISEE Field Practice Guidelines for Blasting Seismographs (2015).

**B. Equipment:** Some blasting seismograph field needs are specific to an operator, an application, or a region. For example, blasting seismograph use in arctic-type conditions may require good performance at low temperatures or for close-in construction blasting extended frequency ranges might be necessary.

**C. Operator Responsibility:** The operator is responsible for confirming that the blasting seismograph selected for measurement of ground vibrations and air overpressure in conditions not specifically covered by this standard, has performance characteristics to record data consistent with the tolerances described herein.

**REFERENCES**


**1.** American National Standards Institute, Characteristics to be Specified for Seismic Transducers. ANSI S2.46-1989, R-2005.

**2.** Deutsches Institut fur Normung (DIN), Mechanical Vibration and Shock Measurement, DIN-45669-1, 1995.

**3.** International Society of Explosives Engineers, ISEE Field Practice Guidelines for Blasting Seismographs, 2015.

**4.** Siskind, D. E., Stachura, V. J., Stagg, M. S., Kopp, J. W. Structure Response and Damage Produced by Airblast From Surface Blasting. US Bureau of Mines Report of Investigations 8485, 1980.

**5.** Siskind, D. E., Stagg, M. S., Kopp, J. W., Dowding, C. H. Structure Response and Damage by Ground Vibration From Mine Blasting. US Bureau of Mines Report of Investigations 8507, 1980.

**6.** Stachura, V. J., Siskind, D. E., Engler, A. J., Airblast Instrumentation and Measurement for Surface Mine Blasting, US Bureau of Mines Report of Investigations 8508, 1981.

**7.** Stagg, M. S., Engler, A. J., Measurement of Blast –Induced Ground Vibrations and Seismograph Calibration, US Bureau of Mines Report of Investigations 8506, 1980.

# ISEE Performance Specifications for Blasting Seismographs

## APPENDIX I

**Calibration Documentation with Tabular Results**
When using the tabular method to ensure compliance to the ISEE Performance Specifications for Blasting Seismographs 2017 Edition, the following tables must be completed. These tables will provide a consistent and repeatable set of test points for each blasting seismograph, its ground vibration sensor and the air overpressure microphone.

**Ground Vibration Sensor**
Some calibration facilities may choose to provide additional test points; however, the specific frequencies listed in Table 1 are the minimum test points required. It is recommended that the same table be used for the As Found and Final calibration results, to allow for a direct comparison of any adjustments or repairs made to the equipment. The reference signal should be nominally 25.4 mm/s (1.00 in/s).

| Frequency | Reference Signal | Amplitude Response □ As Found or □ Final Results | | | | |
|---|---|---|---|---|---|---|
| Hertz | Amplitude | Transverse | Vertical | Radial/ Longitudinal | Tolerance | Pass/Fail |
| 2 | | | | | +5% to -3 dB | |
| 4 | | | | | +/- 5 % or +/-0.5 mm/sec (+/-0.02 in/sec) whichever is larger | |
| 10 | | | | | +/- 5 % or +/-0.5 mm/sec (+/-0.02 in/sec) whichever is larger | |
| 30 | | | | | +/- 5 % or +/-0.5 mm/sec (+/-0.02 in/sec) whichever is larger | |
| 60 | | | | | +/- 5 % or +/-0.5 mm/sec (+/-0.02 in/sec) whichever is larger | |
| 125 | | | | | +/- 5 % or +/-0.5 mm/sec (+/-0.02 in/sec) whichever is larger | |
| 200 | | | | | +5% to -3 dB | |
| 250 | | | | | +5% to -3 dB | |

**Table 1.** Sample Ground Vibration Sensor Amplitude and Frequency Test Results.
**Calibration Remarks:** This is a sample of a tabular test report for the ground vibration sensor.

**Measuring the Phase Response**

This method of measuring the phase response is based on the frequency multiplication factors and amplitude percentages that were obtained from the amplitude-versus-frequency response graph of a velocity pick-up that has been damped by 70.7% as described in the DIN 45669-1 standard. Other procedures may also be acceptable, as long as documentation is provided to support that the procedure will show compliance with the ISEE Performance Specifications for Blasting Seismographs for a phase response between 2.5 and 250 Hz. The precision of all measured frequencies should be no larger than 0.1 Hz.

In this procedure, the signal used to drive the shake table will be adjusted to produce a 25.4 mm/s (1.00 in/s), 30 Hz signal from the calibrated and traceable reference sensor. If the shake table cannot be driven at 25.4 mm/s (1.00 in/s) for all frequencies, the drive signal can be lowered to an appropriate level. This procedure assumes the reference amplitude will remain the same for all of the following measurements.

With the ground vibration sensor mounted on the shake table, adjust the frequency and amplitude of the signal used to drive the shake table as described above. In Table 2, record the frequency and amplitude that the seismograph is reporting for this signal. This will be called reference frequency “F” and reference amplitude “A”.

To verify the phase response for the low-frequency roll-off, maintain the same amplitude output from the calibrated reference sensor and lower the frequency of the signal driving the shake table to find the frequency where the amplitude reported by the seismograph drops to 0.707 of the “A” amplitude value. This frequency point will be called the “F1” frequency and cannot be greater than 2.0 Hz. Record the frequency and the amplitude of the “F1” value in Table 2.

Multiply the “F1” frequency value by 1.270 to obtain the value for the “F2” frequency. With the same amplitude from the calibrated reference, set the shake table frequency to the “F2” frequency. Record the frequency and amplitude values in Table 2. The amplitude should be 85% of the “A” amplitude value, +/- 10%.

Multiply the “F1” frequency value by 0.760 to obtain the value for the “F3” frequency. With the same amplitude from the calibrated reference, set the shake table frequency to the “F3” frequency. Record the frequency and amplitude values in Table 2. The amplitude should be at 50% of the “A” amplitude value, +/- 10%.

To verify the phase response for the high-frequency roll-off, maintain the same amplitude output from the calibrated reference sensor and increase the frequency of the signal driving the shake table to find the frequency where the amplitude reported by the seismograph drops to 0.707 of the “A” amplitude value. This frequency will be called the “F4” frequency and cannot be lower than 250 Hz. Record the frequency and amplitude of the “F4” value in Table 2.

Multiply the “F4” frequency value by 0.787 to obtain the value for the “F5” frequency. With the same amplitude from the calibrated reference, set the shake table frequency to the “F5” frequency. Record the frequency and amplitude values in Table 2. The amplitude should be at 85% of the “A” amplitude value, +/- 10%.

Multiply the “F4” frequency value by 1.316 to obtain a value for the “F6” frequency. With the same amplitude from the calibrated reference, set the shake table frequency to the “F6” frequency. Record the frequency and amplitude values in Table 2. The amplitude should be at 50% of the “A” amplitude value, +/- 10%.

**Examples of Measuring the Phase Response**

The following examples provide results based on an F reference of 30 Hz, with amplitudes of 25.4, 25.25 mm/s, (1.00, 1.01 in/s) and -3dB (0.707) frequencies of 1.6, 2.0, 250 and 255 Hz.

Metric Examples

For an F amplitude of 25.4 mm/s, an F1 frequency of 2.0Hz and an F4 frequency of 250 Hz

| Reference | F3 | F1 | F2 | F | F5 | F4 | F6 |
|---|---|---|---|---|---|---|---|
| Frequency (Hz) | 1.52 | 2.00 | 2.54 | 30.00 | 196.75 | 250.00 | 329.00 |
| Amplitude (mm/s) | 12.70 | 17.96 | 21.59 | 25.40 | 21.59 | 17.96 | 12.70 |

For an F amplitude of 25.25 mm/s, an F1 frequency of 1.6 Hz and an F4 frequency of 255 Hz

| Reference | F3 | F1 | F2 | F | F5 | F4 | F6 |
|---|---|---|---|---|---|---|---|
| Frequency (Hz) | 1.22 | 1.60 | 2.03 | 30.00 | 200.69 | 255.00 | 335.58 |
| Amplitude (mm/s) | 12.63 | 17.85 | 21.46 | 25.25 | 21.46 | 17.85 | 12.63 |

**Imperial Examples**

For an F amplitude of 1.00 in/s, an F1 frequency of 2.0Hz and an F4 frequency of 250 Hz

| Reference | F3 | F1 | F2 | F | F5 | F4 | F6 |
|---|---|---|---|---|---|---|---|
| Frequency (Hz) | 1.52 | 2.00 | 2.54 | 30.00 | 196.75 | 250.00 | 329.00 |
| Amplitude (mm/s) | 0.500 | 0.707 | 0.850 | 1.00 | 0.850 | 0.707 | 0.500 |

For an F amplitude of 1.01 in/s, an F1 frequency of 1.6 Hz and an F4 frequency of 255 Hz

| Reference | F3 | F1 | F2 | F | F5 | F4 | F6 |
|---|---|---|---|---|---|---|---|
| Frequency (Hz) | 1.22 | 1.60 | 2.03 | 30.00 | 200.69 | 255.00 | 335.58 |
| Amplitude (mm/s) | 0.505 | 0.714 | 0.859 | 1.01 | 0.859 | 0.714 | 0.505 |

The frequency and amplitude values for F1 to F6 will vary between units and between each of the ground vibration sensors. Therefore, these values will need to be recorded for each of the individual ground vibration sensors.

It is also possible to use other multipliers of the F1 and F4 frequencies as long as they meet the requirements described in the DIN 45669-1 standard. Some of these multipliers and scale factors are listed below. This table also includes the multipliers and scale factors noted above.

| F1 Multiplier | Scale F Amplitude By | F4 Multiplier |
|---|---|---|
| 1.438 | 90% | 0.696 |
| 1.270 | 85% | 0.787 |
| 1.155 | 80% | 0.866 |
| 1.000 | 70.7% | 1.000 |
| 0.866 | 60% | 1.154 |
| 0.812 | 55% | 1.232 |
| 0.760 | 50% | 1.316 |
| 0.661 | 40% | 1.523 |

Other Frequency and Amplitude Multipliers

| Ground Channel □ Transverse □ Vertical □ Longitudinal | | | | | |
|---|---|---|---|---|---|
| Frequency | Frequency (Hz) | Amplitude (mm/s or in/s) | Deviation (%) | Tolerance | Pass/Fail |
| Reference F (30Hz 25.4mm/s) | | | | N/A | N/A |
| F1 (0.707 x A) | | | | F1 < 2.0 Hz | |
| F2 (1.270 x F1) | | | | F amplitude x 0.85 +/- 10% | |
| F3 (0.760 x F1) | | | | F amplitude x 0.50 +/- 10% | |
| F4 (0.707 x A) | | | | F4 > 250 Hz | |
| F5 (0.787 x F4) | | | | F amplitude x 0.85 +/- 10% | |
| F6 (1.3165 x F4) | | | | F amplitude x 0.50 +/- 10% | |

**Table 2.** Sample ground vibration sensor phase response test results (one required for each of the three ground channels).
**Calibration Remarks:** This is a sample of a tabular test report for the phase response of the ground vibration channels. The table must be completed for each of the three ground channels.

**Air Overpressure Microphone**

The air overpressure microphone can be verified by subjecting it and the calibrated and traceable reference microphone to specific frequency and amplitude signals. Some calibration facilities may choose to provide additional test points; however, the specific frequencies listed in Table 3 are the minimum test points required. It is recommended that the amplitude of the reference signal remain the same for each frequency tested. The same table should be used for the As Found and Final Results to allow for a direct comparison of any adjustments or repairs made to the equipment. The reference amplitude should be nominally between 127 and 134 dB.

| Frequency | Reference signal amplitude | Amplitude Response □ **As Found** or □ **Final Results** | | Pass/Fail |
|---|---|---|---|---|
| Hertz | dB | Air Overpressure | Tolerance | |
| 2 | | | -3 dB, +/-1dB | |
| 3 | | | -1 dB, +/-1dB | |
| 4 | | | +/-1 dB | |
| 10 | | | +/-1 dB | |
| 30 | | | +/-1 dB | |
| 60 | | | +/-1 dB | |
| 100 | | | +/-1 dB | |
| 125 | | | +/-1 dB | |
| 200 | | | +1 dB to -3 dB | |
| 250 | | | +1 dB to -4 dB | |

**Table 3.** Sample air overpressure sensor frequency and amplitude test results

**Calibration Remarks:** This is a sample of a tabular test report for the air overpressure microphone.

# ISEE Performance Specifications for Blasting Seismographs

## APPENDIX II

**Calibration Documentation with Graphical Results**
When using a graphical method to ensure compliance to the ISEE Performance Specification for Blasting Seismographs 2017 edition, the calibration facility must provide an amplitude-versus-frequency response for each of the ground vibration and air overpressure sensors as well as a phase-versus-frequency response for each of the ground vibration sensors. Exceeding the tolerance limit lines on any of the graphs will indicate a failure to meet the ISEE Performance Specifications for Blasting Seismographs.

**Ground Vibration Sensor**
The amplitude-versus-frequency and phase-versus-frequency response data are obtained by comparing the output of the calibrated and traceable reference sensor to that of the ground vibration sensor being tested when they are excited at the same level. The recommended minimum number of data points for the amplitude-versus-frequency and phase-versus-frequency response graphs is 1 Hz resolution below 10 Hz, 10 Hz resolution from 10 to 100 Hz and 25 Hz resolution from 100 to 250 Hz. However, some calibration facilities may choose to provide additional data points to improve the resolution of the response graphs. The same response graphs should be used for the As Found and Final calibration results to allow for a direct comparison of any adjustments or repairs made to the equipment.

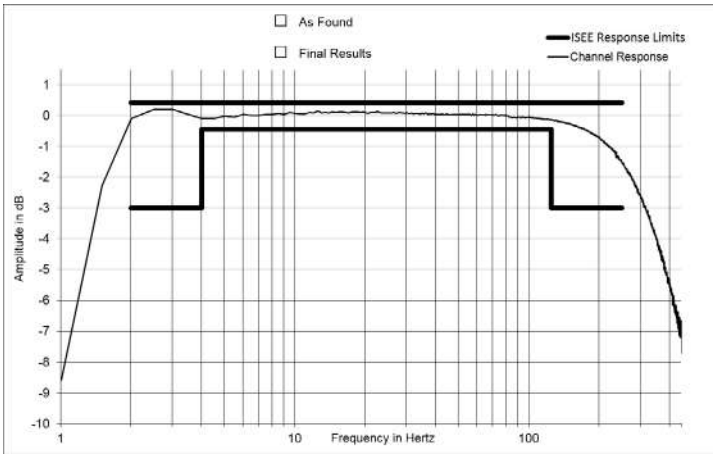


**Figure 1.** Sample amplitude-versus-frequency response graph.

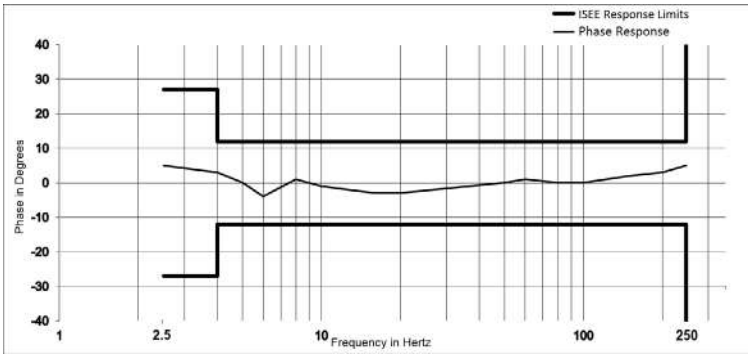


**Figure 2.** Sample phase-versus-frequency response graph.

**Calibration Remarks:** This is a sample of a graphical response for one of the ground vibration sensors.

**Air Overpressure Microphone**

The amplitude-versus-frequency response data are obtained by comparing the output of the calibrated and traceable reference sensor to that of the air overpressure microphone being tested when subjected to the same pressure source. The recommended minimum number of data points for the amplitude-versus-frequency response graphs is 1 Hz resolution below 10 Hz, 10 Hz resolution from 10 to 100 Hz and 25 Hz resolution from 100 to 250 Hz. However, some calibration facilities may choose to provide additional data points to improve the resolution of the response graphs. The same response graphs should be used for the As Found and Final calibration results to allow for a direct comparison of any adjustments or repairs made to the equipment.

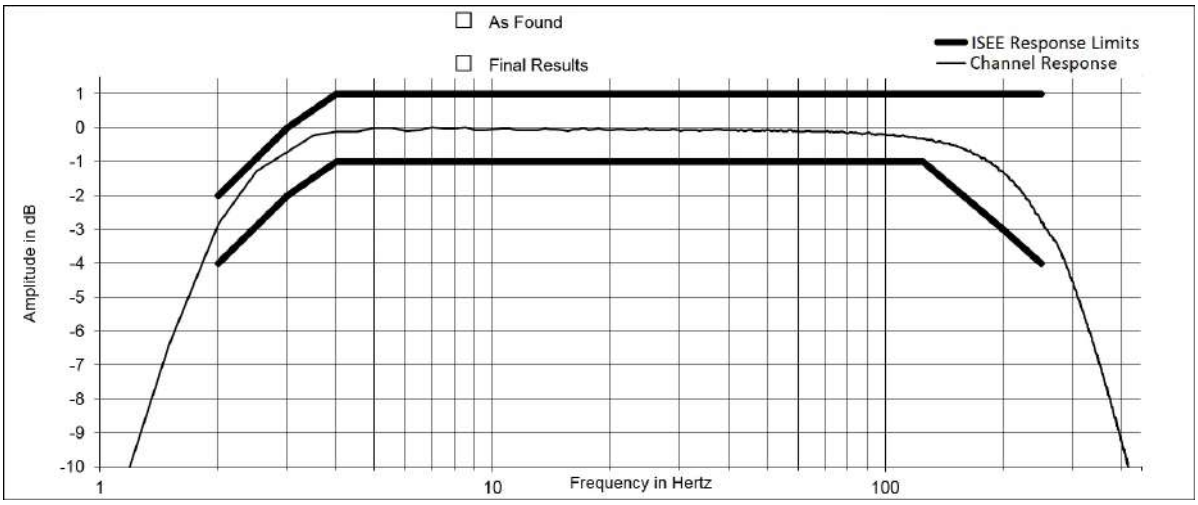


**Figure 3.** Sample air overpressure sensor amplitude-versus-frequency response.
**Calibration Remarks:** This is a sample of a graphical response for the air overpressure channel.

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