

ISEE
Field Practice Guidelines For
Blasting Seismographs
2009 Edition

ISEE
Performance Specifications For
Blasting Seismographs
2011 Edition



30325 Bainbridge Road, Cleveland, OH 44139
To Order, Call 440 349 4400 or Visit Our Online
Blasters' Library at www.isee.org



Published by
International Society of Explosives Engineers
30325 Bainbridge Road
Cleveland, Ohio USA 44139-2295
<http://www.isee.org>

The authors and publisher have used their best efforts in preparing this book and make no warranty of any kind, express or implied, with regard to its content.

This booklet is protected by Asian, European, Pan American and U.S.A. Copyright Law. All rights, including that of translation into other languages, are reserved. Neither this book nor any part may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, recording, or otherwise, without prior written permission from the publisher.

Copyright © 2011 Society of Explosives Engineers, Inc.
All Rights Reserved

International Society of Explosives Engineers - Standards Committee Members*

Chairman, Kenneth K Eltschlager, US Office of Surface Mining Reclamation and Enforcement
Douglas Bartley, DBA Consulting
Steven DelloRusso, Simpson Gumpertz & Heger Inc.
Alastair Grogan, Davey Bickford Canada, Inc.
Alan Richards, Terrock Consulting Engineers
Douglas Rudenko, Vibra-Tech Engineers, Inc.
Mark Svinkin, Vibraconsult
Robert Turnbull, InstanTel
Randall Wheeler, White Industrial Seismology
Board Liaison, John Wiegand, Vibronics, Inc.

**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. A key to classifications is found at the back of the document.*

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.

Table of Contents

	Page
ISEE Field Practice Guidelines for Blasting Seismographs	
I. General Guidelines	1
II. Ground Vibration Monitoring	2
A. Sensor Placement.....	2
B. Sensor Coupling.....	3
C. Programming Considerations.....	4
III. Air Overpressure Monitoring	4
A. Microphone Placement.....	4
B. Programming Considerations.....	5
REFERENCES.....	6

ISEE Performance Specifications for Blasting Seismographs

I. General Guidelines	8
II. Ground Vibrations Measurement	8
III. Air Overpressure Measurement	9
IV. Calibration	9
V. Measurement Practices	9
REFERENCES.....	10

Disclaimer: These field practice recommendations are intended to serve as general guidelines, and cannot describe all types of field conditions. It is incumbent on the operator to evaluate these conditions and to obtain good coupling between monitoring instrument and the surface to be monitored. In all cases, the operator should describe the field conditions and setup procedures in the permanent record of each blast.

Preface: Blasting seismographs are used to establish compliance with Federal, state and local regulations and evaluate explosive performance. Laws and regulations have been established to prevent damage to property and injury to people. The disposition of the rules is strongly dependant on the accuracy of ground vibration and air overpressure data. In terms of explosive performance the same holds true. One goal of the ISEE Standards Committee is to ensure consistent recording of ground vibrations and air overpressure between all blasting seismographs.

ISEE Field Practice Guidelines For Blasting Seismographs



**International Society of
Explosives Engineers**
30325 Bainbridge Road
Cleveland, OH 44139

ISEE Field Practice Guidelines for Blasting Seismographs

International Society of Explosives Engineers

**ISEE Field Practice Guidelines
For
Blasting Seismographs
2009 Edition**

This edition of *ISEE Field Practice Guidelines for Blasting Seismographs* was revised by the ISEE Standards Committee on February 4, 2008 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 February 5, 2009 meeting.

**Origin and Development of
ISEE Field Practice Guidelines for Blasting Seismographs**

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 Guidelines were drafted and approved by the Section in December of 1999. The Section completed 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 of 2006 and was completed in February of 2008 with this edition.

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 ground and air vibration measurements. Blasting seismograph performance is affected by how the blasting seismograph is built and how it is placed in the field.

The ISEE Standards Committee takes on the role of keeping the standards up to date. These standards can be obtained by contacting the International Society of Explosives Engineers located at 30325 Bainbridge Road, Cleveland, Ohio 44139 or by visiting our website at www.isee.org.

ISEE Field Practice Guidelines for Blasting Seismographs

Part I. General Guidelines

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 user's responsibilities when deploying blasting seismographs in the field and assume that the blasting seismographs conform to the ISEE "Performance Specifications for Blasting Seismographs".

1. Read the instruction manual and be familiar with the operation of the instrument. Every seismograph comes with an instruction manual. Users are responsible for reading the appropriate sections and understanding the proper operation of the instrument before monitoring a blast.
2. Seismograph calibration. Annual calibration of the seismograph is recommended.
3. Keep proper blasting seismograph records. A user's log should note: the user's name, date, time, place and other pertinent data.
4. Document the location of the seismograph. This includes the name of the structure and where the seismograph was placed on the property relative to the structure. Any person should be able to locate and identify the exact monitoring location at a future date.
5. Know and record the distance to the blast. The horizontal distance from the seismograph to the blast should be known to at least two significant digits. For example, a blast within 1000 meters or feet would be measured to the nearest tens of meters or feet respectively and a blast within 10,000 meters or feet would be measured to the nearest hundreds of feet or meters respectively. Where elevation changes exceed 2.5h:1v, slant distances or true distance should be used.
6. Record the blast. When seismographs are deployed in the field, the time spent deploying the unit justifies recording an event. As practical, set the trigger levels low enough to record each blast.
7. Record the full time history waveform. Summary or single peak value recording options available on many seismographs should not be used for monitoring blast-generated vibrations. Operating modes that report peak velocities over a specified time interval are not recommended when recording blast-induced vibrations.
8. Set the sampling rate. The blasting seismograph should be programmed to record the entire blast event in enough detail to accurately reproduce the vibration trace. In general the sample rate should be at least 1000 samples per second.
9. Know the data processing time of the seismograph. Some units take up to 5 minutes to process and print data. If another blast occurs within this time the second blast may be missed.

ISEE Field Practice Guidelines for Blasting Seismographs

10. Know the memory or record capacity of the seismograph. Enough memory must be available to store the event. The full waveform should be saved for future reference in either digital or analog form.
11. Know the nature of the report that is required. For example, provide a hard copy in the field, keep digital data as a permanent record or both. If an event is to be printed in the field, a printer with paper is needed.
12. Allow ample time for proper setup of the seismograph. Many errors occur when seismographs are hurriedly set-up. Generally, more than 15 minutes for set-up should be allowed from the time the user arrives at the monitoring location until the blast.
13. Know the temperature. Seismographs have varying manufacturer specified operating temperatures.
14. Secure cables. Suspended or freely moving cables from the wind or other extraneous sources can produce false triggers due to microphonics.

Part II. Ground Vibration Monitoring

Placement and coupling of the vibration sensor are the two most important factors to ensure accurate ground vibration recordings.

A. Sensor Placement

The sensor should be placed on or in the ground on the side of the structure towards the blast. A structure can be a house, pipeline, telephone pole, etc. Measurements on driveways, walkways, and slabs are to be avoided where possible.

1. Location relative to the structure. Sensor placement should ensure that the data obtained adequately represents the ground-borne vibration levels received at the structure. The sensor should be placed within 3.05 meters (10 feet) of the structure or less than 10% of the distance from the blast, whichever is less.
2. Soil density evaluation. The soil should be undisturbed or compacted fill. Loose fill material, unconsolidated soils, flower-bed mulch or other unusual mediums may have an adverse influence on the recording accuracy.
3. The sensor must be nearly level.
4. The longitudinal channel should be pointing directly at the blast and the bearing should be recorded.
5. Where access to a structure and/or property is not available, the sensor should be placed closer to the blast in undisturbed soil.

ISEE Field Practice Guidelines for Blasting Seismographs

B. Sensor coupling

If the acceleration exceeds 1.96 m/s^2 (0.2 g), decoupling of the sensor may occur. Depending on the anticipated acceleration levels spiking, burial, or sandbagging of the geophone to the ground may be appropriate.

1. If the acceleration is expected to be:
 - a. less than 1.96 m/s^2 (0.2 g), no burial or attachment is necessary
 - b. between 1.96 m/s^2 (0.2 g), and 9.81 m/s^2 (1.0 g), burial or attachment is preferred. Spiking may be acceptable.
 - c. greater than 9.81 m/s^2 (1.0 g), burial or firm attachment is required (RI 8506).

The following table exemplifies the particle velocities and frequencies where accelerations are 1.96 m/s^2 (0.2 g) and 9.81 m/s^2 (1.0 g).

Frequency, Hz	4	10	15	20	25	30	40	50	100	200
Particle Velocity mm/s (in/s) at 1.96 m/s^2 (0.2 g)	78.0 (3.07)	31.2 (1.23)	20.8 (0.82)	15.6 (0.61)	12.5 (0.49)	10.4 (0.41)	7.8 (0.31)	6.2 (0.25)	3.1 (0.12)	1.6 (0.06)
Particle Velocity mm/s (in/s) at 9.81 m/s^2 (1.0 g)	390 (15.4)	156 (6.14)	104 (4.10)	78.0 (3.07)	62.4 (2.46)	52.0 (2.05)	39.0 (1.54)	31.2 (1.23)	15.6 (0.61)	7.8 (0.31)

2. Burial or attachment methods.
 - a. The preferred burial method is excavating a hole that is no less than three times the height of the sensor (ANSI S2.47), spiking the sensor to the bottom of the hole, and firmly compacting soil around and over the sensor.
 - b. Attachment to bedrock is achieved by bolting, clamping or adhering the sensor to the rock surface.
 - c. The sensor may be attached to the foundation of the structure if it is located within +/- 0.305 meters (1-foot) of ground level (RI 8969). This should only be used if burial, spiking or sandbagging is not practical.
3. Other sensor placement methods.
 - a. Shallow burial is anything less than described at 2a above.
 - b. Spiking entails removing the sod, with minimal disturbance of the soil and firmly pressing the sensor with the attached spike(s) into the ground.

ISEE Field Practice Guidelines for Blasting Seismographs

- c. Sand bagging requires removing the sod with minimal disturbance to the soil and placing the sensor on the bare spot with a sand bag over top. Sand bags should be large and loosely filled with about 4.55 kilograms (10 pounds) of sand. When placed over the sensor the sandbag profile should be as low and wide as possible with a maximum amount of firm contact with the ground.
- d. A combination of both spiking and sandbagging gives even greater assurance that good coupling is obtained.

C. Programming considerations

Site conditions dictate certain actions when programming the seismograph.

1. Ground vibration trigger level. The trigger level should be programmed low enough to trigger the unit from blast vibrations and high enough to minimize the occurrence of false events. The level should be slightly above the expected background vibrations for the area. A good starting level is 1.3 mm/s (0.05 in/s).
2. Dynamic range and resolution. If the seismograph is not equipped with an auto-range function, the user should estimate the expected vibration level and set the appropriate range. The resolution of the printed waveform should allow verification of whether or not the event was a blast.
3. Recording duration - Set the record time for 2 seconds longer than the blast duration plus 1 second for each 335 meters (1100 feet) from the blast.

Part III Air Overpressure Monitoring

Placement of the microphone relative to the structure is the most important factor.

A. Microphone placement

The microphone should be placed along the side of the structure, nearest the blast.

1. The microphone should be mounted near the geophone with the manufacturer's wind screen attached.
2. The microphone may be placed at any height above the ground. (ISEE 2005)
3. If practical, the microphone should not be shielded from the blast by nearby buildings, vehicles or other large barriers. If such shielding cannot be avoided, the horizontal distance between the microphone and shielding object should be greater than the height of the shielding object above the microphone.

ISEE Field Practice Guidelines for Blasting Seismographs

4. If placed too close to a structure, the airblast may reflect from the house surface and record higher amplitudes. Structure response noise may also be recorded. Reflection can be minimized by placing the microphone near a corner of the structure. (RI 8508)

5. The orientation of the microphone is not critical for air overpressure frequencies below 1,000 Hz (RI 8508).

B. Programming considerations

Site conditions dictate certain actions when programming the seismograph to record air overpressure.

1. Trigger level. When only an air overpressure measurement is desired, the trigger level should be low enough to trigger the unit from the air overpressure and high enough to minimize the occurrence of false events. The level should be slightly above the expected background noise for the area. A good starting level is 20 Pa (0.20 millibars or 120 dB).

2. Recording duration. When only recording air overpressure, set the recording time for at least 2 seconds more than the blast duration. When ground vibrations and air overpressure measurements are desired on the same record, follow the guidelines for ground vibration programming (Part II C.3).

ISEE Field Practice Guidelines for Blasting Seismographs

References:

1. American National Standards Institute, Vibration of Buildings – Guidelines for the Measurement of Vibrations and Evaluation of Their Effects on Buildings. ANSI S2.47-1990, R1997.
2. Eltschlager, K. K., Wheeler, R. M. Microphone Height Effects on Blast-Induced Air Overpressure Measurements, 31st Annual Conference on Explosives and Blasting Technique, International Society of Explosives Engineers, 2005.
3. International Society of Explosives Engineers, ISEE Performance Specifications for Blasting Seismographs, 2000.
4. 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 RI 8507, 1980.
5. Siskind, D. E., Stagg, M. S. Blast Vibration Measurements Near and On Structure Foundations, US Bureau of Mines Report of Investigations RI 8969, 1985.
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 RI 8508, 1981.

ISEE Performance Specifications For Blasting Seismographs 2011 Edition



**International Society of
Explosives Engineers**
30325 Bainbridge Road
Cleveland, OH 44139

ISEE Performance Specifications For Blasting Seismographs

International Society of Explosives Engineers (ISEE) Standards Committee

Chairman: Kenneth K. Eltschlager

Committee Members: Douglas Bartley, Steven DelloRusso, Alastair Grogan, Alan Richards, Douglas Rudenko, Mark Svinkin, Robert Turnbull, Randall Wheeler

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.

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 dependant on the accuracy of ground vibration and air overpressure data. One goal of the ISEE Standards Committee is to ensure consistent recording of ground vibrations and air overpressure between all blasting seismographs.

Part I. General Guidelines

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 blasting seismographs for outdoor field use to measure ground vibrations and air overpressures that will be suitable 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 2009). The following specifications are considered minimums.

Digital sampling rate.....	1000 samples/sec or greater, per channel
Operating temperature range.....	10 to 120F (-12 to 49C)
Electrical cross-talk	Less than 2% of the input signal appears on any other channel

Part II. Ground Vibrations Measurement

Ground vibration sensor response characteristics should conform to the following minimum values:

Frequency range.....	2 to 250 Hz, within zero to -3 dB of an ideal flat response
Accuracy.....	±5 pct or ±0.5 mm/sec (±0.02 in/sec), whichever is larger, between 4 and 125 Hz.
Phase response.....	Phase shift between 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.
Cross-talk response.....	Less than 5% of the excited axis indication on either 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.
Density of sensor	< 2405 kg/m ³ (150 lbs/ft ³) (should be reported for user consideration).

ISEE Performance Specifications For Blasting Seismographs

Part III. Air Overpressure Measurement

Air overpressure microphones should conform to the following minimum values:

Frequency range.....	2 to 250 Hz, -3 dB at 2 and 250 Hz, ± 1 dB
Accuracy.....	± 1 dB between 4 and 125 Hz.
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

To ensure proper operation, blasting seismographs should be calibrated annually by a facility authorized by the manufacturer.

Frequency.....	Annually
Traceability.....	Calibration equipment accuracy must be traceable to National Institute Standards and Testing, National Research Council or equivalent.
Certificate	Issued with each calibration and signed by the authorized service representative.
Documentation.....	List the frequencies tested along with input and output values at each frequency. Provide documentation of measured frequency response characteristics.
Ground Vibration Sensor	Calibration must be of the assembled sensor. Component calibrations of individual sensors are not appropriate.

Part V. Measurement Practices

In addition to the Performance Specifications described above, blasting seismograph setup or installation in the field is crucial for accurate defensible data acquisition. These measurement practices are specified in the ISEE Field Practice Guidelines for Blasting Seismographs (2009).

Furthermore, 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.

It is the responsibility of the operator to confirm 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.

ISEE Performance Specifications For Blasting Seismographs

References:

1. American National Standards Institute, Characteristics to be Specified for Seismic Transducers. ANSI S2.46-1989, R-2005.
2. Deutsches Institut für Normung (DIN), Mechanical Vibration and Shock Measurement, DIN-45669-1, 1995.
3. International Society of Explosives Engineers. ISEE Field Practice Guidelines for Blasting Seismographs, 2009.
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.