



ISEE

International Society
of Explosives Engineers

**ISEE FIELD PRACTICE
GUIDELINES FOR BLASTING
SEISMOGRAPHS 2020**



Published By

International Society of Explosives Engineers
26500 Renaissance Parkway
Cleveland, OH 44128 USA
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 © 2020 Society of Explosives Engineers, Inc.
All Rights Reserved.

This edition of *ISEE Field Practice Guidelines for Blasting Seismographs* was revised by the ISEE Standards Committee in 2020, 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 2020 meeting.

International Society of Explosives Engineers (ISEE) – Standards Committee Members¹

Chairman, Kenneth K Eltschlager, U.S. Office of Surface Mining Reclamation and Enforcement
Mark Dean, Texcel Pty Ltd
Steven DelloRusso, Simpson Gumpertz & Heger Inc.
Alastair Grogan, Grogan Rock Consulting Ltd.
Michael Mann, Ohio Department of Natural Resources
Douglas Rudenko, Vibra-Tech Engineers, Inc.
Pablo Segarra, Universidad Politécnica de Madrid
Robert Turnbull, Instantel
Randall Wheeler, White Industrial Seismology
Board Liaison, Douglas Hoy, Sayre Associates, Inc

¹This 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.

TABLE OF CONTENTS

| | |
|---|----|
| Preface | 4 |
| Part I. General Guidelines | 4 |
| Part II. Ground Vibration Monitoring | 5 |
| A. Sensor Placement | 5 |
| B. Sensor Coupling | 6 |
| C. Programming Considerations | 7 |
| Part III. Air Overpressure Monitoring | 8 |
| A. Microphone Placement | 8 |
| B. Programming Considerations | 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 important that the operator evaluate these conditions and obtain good coupling between the monitoring instrument and the surface to be monitored. In all cases, 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 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 dependent 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 2020 Edition

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" [3].

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 2.5 horizontal:1 vertical, 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.

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. Typical practice is to point the longitudinal/radial channel towards the blast site. However, other sensor orientations are allowed.

a. For blast-by-blast sensor deployment, the longitudinal/radial channel should be pointed towards the closest blast hole. Records should indicate if this condition is met.

b. For multiple-blast sensor deployment, the azimuth (0-360 degrees, +/- 5 degrees) of the longitudinal/radial channel relative to true north 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.

B. Sensor Coupling

If the acceleration exceeds 1.96 m/s² (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/s² (0.2 g), no burial or attachment is necessary.

b. Between 1.96 m/s² (0.2 g), and 9.81 m/s² (1.0 g), burial or attachment is preferred. Spiking may be acceptable.

c. Greater than 9.81 m/s² (1.0 g), burial or firm attachment is required [7].

The following table exemplifies the particle velocities and frequencies where accelerations are 1.96 m/s² (0.2 g) and 9.81 m/s² (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 [1], 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 [5]. 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.

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 1.3mm/s (0.05in/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 [2].
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.
4. If placed too close to a structure, the air overpressure 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. [6].
5. The orientation of the microphone is not critical for air overpressure frequencies below 1,000 Hz [6].

6. The microphone element must be kept dry to help maintain proper calibration and minimize the potential for corrosion. A common practice is to place a windscreen (typically provided by the manufacturer) on the microphone and cover it loosely with a thin plastic bag, or "rain shield." Other methods can be used to protect the microphone from moisture; however, the pressure around the microphone sensing element must be able to change in relation to the pressure change caused by the blast overpressure.

a. When using a plastic bag as a rain shield, the bag should be tied loosely around the microphone, allowing some exchange of air between the inside and outside of the shield. Completely sealing a rain shield could result in the following:

- i. **Condensation** – water accumulates inside the shield. A small hole in the bottom of the shield can help mitigate this issue.
- ii. **Static Pressure** – over time pressure could build in the shield.
- iii. **Rain Triggers** – rain drops striking a tightly sealed shield will cause pressure pulses that could trigger the seismograph.

b. It is acceptable to keep microphones inside security boxes or other protective covers as long as the pressure change in the enclosure reflects the pressure change outside of the protective cover in the surrounding environment.



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).

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., White, 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*, 2011.
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 8507, 1980.
5. Siskind, D. E., Stagg, M. S. *Blast Vibration Measurements Near and On Structure Foundations*, US Bureau of Mines Report of Investigations 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 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.

