Calibration Guide

Everything You Need to Know About Instantel's High-Resolution Calibration Process

Contents

The Basics

What Are Calibrations?

A properly calibrated monitoring unit ensures that the performance characteristics adhere to guidelines such as the International Society of Explosives Engineers (ISEE), Deutsches Institut für Normung (DIN)[1] or International Electrotechnical Commission (IEC) 61672-1 to measure ground vibration, air overpressure, and noise. In many countries, sensitive measuring devices that require a high degree of accuracy have regulatory authorities that enforce a mandatory annual calibration.

When monitoring equipment is purchased or re-calibrated, it is critical to ensure that the calibration is traceable to national or international standards. Instantel's calibration equipment follows the National Institute of Standards and Technology (NIST) and the National Research Council of Canada (NRC); both are recognized worldwide.

1. ISEE requires 2 to 250 Hz, 8 data points for tabular results and 24 data points for graphical results. The DIN 45669-1 requires 1 to 315 Hz and intervals between neighbouring frequencies to be no greater than one octave (typically 17 data points).

The Background

Instantel's Impact For Over 40 Years On The ISEE Performance Specifications

Renowned

For Our High-Resolution Calibration Reports

Instantel is renowned for our high-resolution calibration techniques and graphical reports. We plot the amplitude frequency and phase responses for quick visualization. Instantel was one of the first calibration facilities to add a curve to the ISEE Threshold Limits for the linear microphone calibrations, even before it was included in the ISEE Performance Specifications for Blasting Seismographs in 2017. With any Instantel calibrated equipment, you can trust that your recorded data will be accurate.

Recognized

For Our ISEE Involvement Since Its Inception

With close to 40 years of industry experience, Instantel understands the importance of accurate calibration. Instantel's presence as a member of the ISEE seismograph standards subcommittee, since its inception in 1995, testifies to our strong industry involvement. Our Chief Technology Officer (CTO) currently serves as the ISEE Seismograph Testing and Calibration Committee Chair and is also an ISEE Standards Committee member.

Respected

For Recommending New Updates To The ISEE Performance Specifications

Every five years, the committee reviews the ISEE's Performance Specification for Blasting Seismographs to determine if updates are required. Instantel continues to be an integral part of the review process. This longstanding commitment allows Instantel to regularly enhance our calibration testing techniques.

Two Industry Calibration Display Formats

Instantel's 993 (ISEE) and 856 (DIN) Data Points vs The Industry Standard of 8 - 24 Data Points

When Instantel calibrates your equipment, you are not just getting the bare minimum test procedure. Instantel calibrates far beyond the ISEE and DIN requirements for frequency and phase response. According to the 2017 ISEE Performance Specifications for Blasting Seismographs, calibration facilities may present their results in two separate formats:

- **Format One:** Calibration Documentation with Tabular Results (8 data points and "As Found" report)
- **Format Two:** Calibration Documentation with Graphical Results (24 data points and "As Found" report)

Instantel's calibration report includes the "As Found" report as a detailed graph (see Figure 4) and the final calibration response graphs for each of the three geophone channels and for the linear microphone (see Figure 7 and Figure 10). These graphs demonstrate, at a glance, if the equipment meets the specified response standard.

Format One: ISEE-2017 Tabular Results (8 Data Points Required for Measurement)

Frequency Hertz (Hz)	Reference Signal Amplitude(mm/s)	Amplitude Response				
		Transverse (mm/s)	Vertical (mm/s)	Longitudinal (mm/s)	Tolerance	Pass/Fail
2	25.4	25.67	25.88	25.44	+5% to -3 dB (-29.2%)	Pass
4	25.4	25.72	27.75	25.32	+/- 5 % or +/-0.5 mm/s (+/-0.02 in/s) whichever is larger	Fail
10	25.6	26.11	24.85	26.23	+/- 5 % or +/-0.5 mm/s (+/-0.02 in/s) whichever is larger	Pass
30	25.4	24.76	24.62	26.19	+/- 5 % or +/-0.5 mm/s (+/-0.02 in/s) whichever is larger	Pass
60	25.4	24.98	25.14	25.78	+/- 5 % or +/-0.5 mm/s (+/-0.02 in/s) whichever is larger	Pass
125	25.2	25.23	25.76	25.65	+/- 5 % or +/-0.5 mm/s (+/-0.02 in/s) whichever is larger	Pass
200	25.4	25.46	26.51	25.68	+5% to -3 dB (-29.2%)	Pass
250	25.4	25.72	25.95	25.45	+5% to -3 dB (-29.2%)	Pass

Figure 1. Example of the eight tabular results as required by the ISEE-2017 standard. The tabular values are filled in with one data point failing to meet the tolerance at 4 Hz. The standard allows for a +/- 5% tolerance (with a -3 dB rolloff) from an ideal flat response to compensate for real-world measurement variations.

Format Two: ISEE-2017 Graphical Results (24 Data Points Required for Measurement)

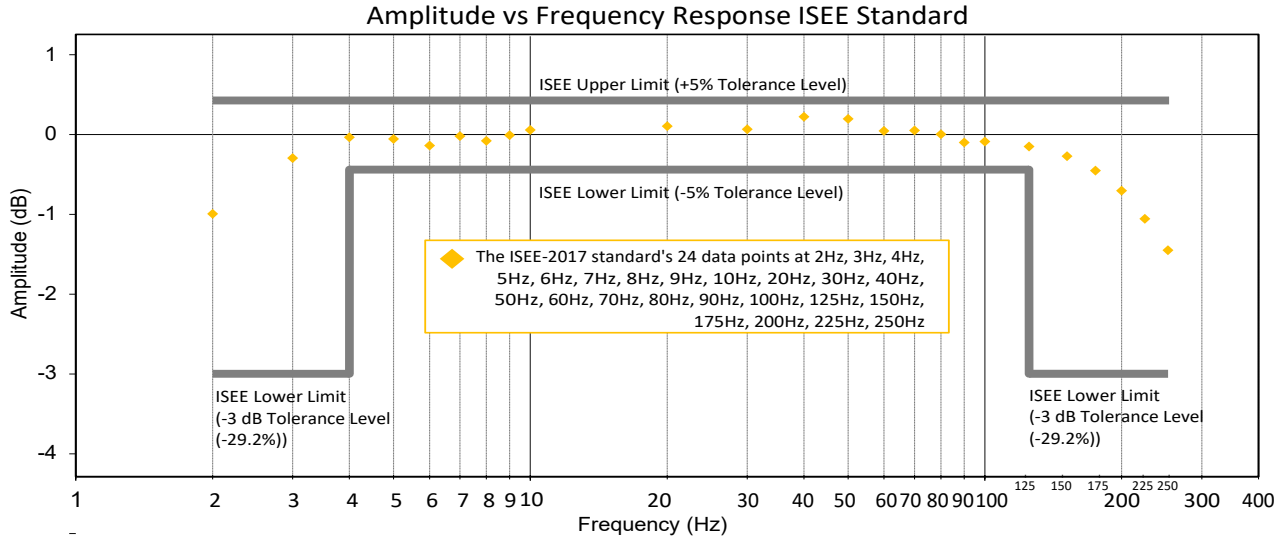


Figure 2. Example of an amplitude vs frequency response with 24 calibration data points according to the ISEE-2017 standard.

CRITICAL OBSERVATION

- **The ISEE-2017 tabular approach does not show the whole picture with a very limited set of test points.**
- **The ISEE-2017 graphical approach expands visibility, though remains limited in resolution. Exceedances outside the test points remain undetected.**

Both ISEE's tabular and graphical requirements are limited in scope. Eight (8) tabular data points (see Figure 1) and twenty-four (24) graphical data points (see Figure 2) are the minimum to meet the specification. An actual vibration event is comprised of a complex set of frequencies and amplitudes that may interfere and generate spikes that are not detectable using such a limited range of discrete reference points (see Figure 4).

One of the drawbacks when calibration documentation is presented in tabular form is that it lacks the insight one can have through the visual component. Graphical representations display threshold limits and can reveal signal exceedances with one glance. Tabular charts require an additional manual effort to determine how close or far the calibration results are from the allowed thresholds.

Instantel's High-Resolution Approach to Calibration Documentation

Instantel goes beyond the ISEE-2017 requirements for calibration documentation, using a high-resolution graphical format to display results. The ISEE linear microphone and triaxial geophones are calibrated from 1 to 500 Hz using a ~0.5 Hz (0.503 Hz) increment, this results in 993 calibrated data points. Additionally, Instantel includes the attenuation response for undesired frequencies below 2 Hz and above 250 Hz for the ISEE standard.

The DIN geophones are calibrated from 0.5 to 900 Hz using a ~0.5 Hz (0.469 Hz) increment below 7.5 Hz and a ~1 Hz (1.061 Hz) increment above 7.5 Hz, this results in 856 calibrated data points. Instantel includes the attenuation response for undesired frequencies below 1 Hz and above 315 Hz. This provides evidence that unwanted frequencies will be attenuated, thereby maintaining the recorded data's accuracy. This information is typically not offered by other vibration monitor manufacturers. These same data points are used to measure and plot the phase response (see Figure 7), providing further high-resolution evidence of compliance to the standard.

Instantel Calibrates With 993 Data Points to Present Graphical Results

Instantel's high-resolution calibration can detect exceedances that are otherwise missed when using the ISEE-2017 tabular or graphical standard. When these exceedances are detected, Instantel calibrates the device to ensure all frequencies remain within the upper and lower limits of the standard. As seen in Figure 3, this calibrated response is a very close match to an ideal flat response. This information is typically not offered by other vibration monitor manufacturers.

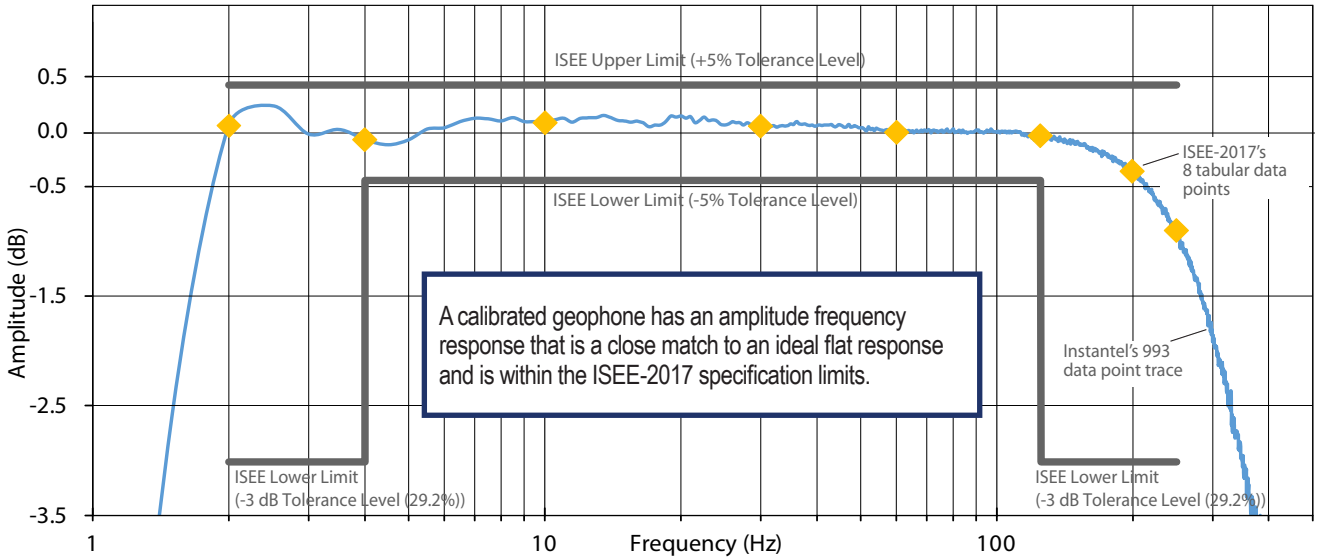


Figure 3. Instantel's amplitude vs frequency vibration response. The blue line traces Instantel's 993 calibration data points with ~0.5 Hz increments for an ISEE geophone. The yellow diamonds represent the minimum required test points according to the ISEE-2017 tabular standard.

KEY TAKEAWAYS

- **Instantel's high-resolution graphical method makes it easy to visualize your calibration results.**
- **Instantel's high data points provides proof that the device will monitor according to specification for the full frequency band of the standard.**
- **Instantel calibrations provide the highest degree of assurance that your monitoring device data is reliable.**

The Calibration Process: Measuring The "As Found" Condition

What Does "As Found" Mean?

"As Found" refers to the assessment of a monitoring unit's calibration data (for each channel) upon its arrival at Instantel. For every ISEE, DIN, Swedish Pile Driving and Swedish Blasting device, Instantel provides this information along with the calibration certificate.

The geophone is attached to a shake table capable of generating discrete vibrational frequencies. The shake table sweeps through the entire range of measurement frequencies and records the amplitude, and phase response.

Determining the "As Found" condition of a linear microphone is a similar process, using a microphone calibration chamber.

The "As Found" assessment is important to document as it can either:

1. Confirm the equipment's compliance,

2. Reveal the extent of its non-compliance.

Outcome 1. The "As Found" assessment determines that the monitoring equipment continues to record stable data from the previous calibration. The device's amplitude response kept its integrity over the entire frequency range. It can be assumed that all measurement data taken since the previous calibration is sound and within the regulatory standard.

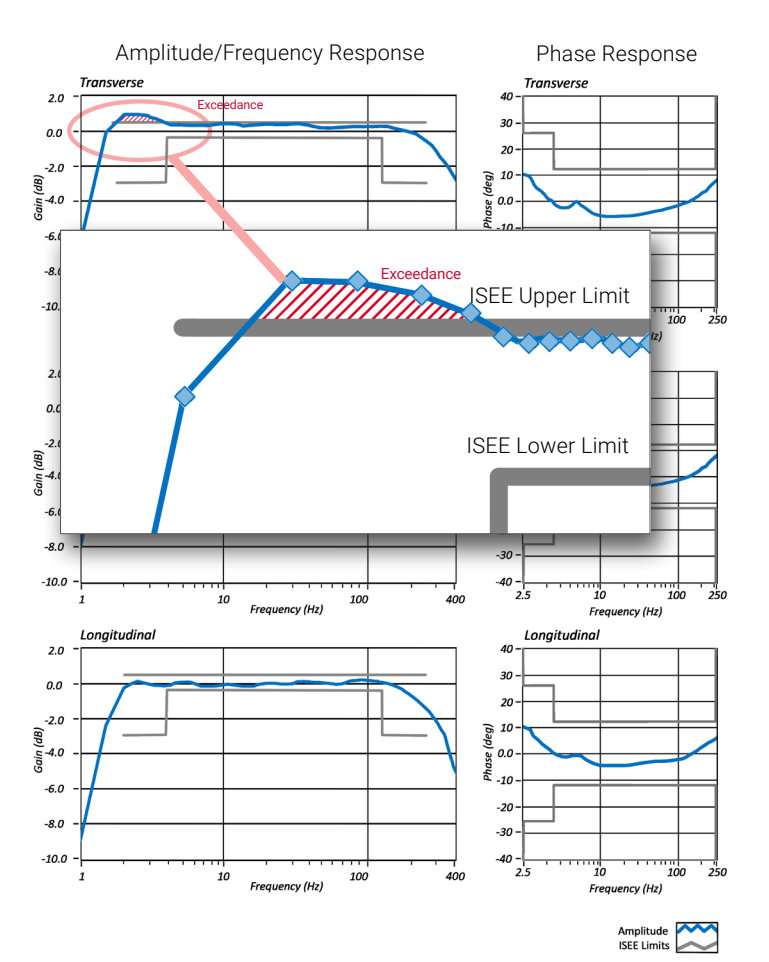


Figure 4. Sample of the "As Found" amplitude, frequency and phase response measurement of an ISEE geophone. The blue line shows a geophone that is out of the calibration limits for the ISEE standard. This can be seen where it momentarily exceeded the upper limit (grey line) around the 2 - 3.5 Hz range.

Outcome 2. The "As Found" assessment determines that the monitoring equipment records data outside the regulatory standard's boundaries. Recorded data has deviated from the previous calibration. In this case, the calibration will focus on re-centering any response that may have drifted off-center. This feedback may also encourage companies to consider reviewing any projects that recently used this monitoring equipment.

NOTE: The frequency response of Instantel's sensitive vibration monitoring equipment can change due to external factors, some of which are listed (right). Over time, this may cause the calibrated equipment to no longer comply with regulatory standards. For these reasons, Instantel strongly recommends an annual calibration of your monitoring equipment.

External factors which can impact frequency response:

- Transportation wear and tear
- Damage due to dropping, abuse or mishandling the equipment
- Opening and re-orienting sensors
- Using the equipment outside the product specifications

KEY TAKEAWAYS

- **When looking to purchase monitoring equipment for your next project, it is important to understand the impact of a quality calibration process.**
- **With Instantel's high-resolution data point calibration, you can be sure that your equipment is properly registering the full frequency range of a vibration event.**
- **Instantel's high-resolution 993 calibration data points at ~0.5 Hz increments for the ISEE standard, is part of our reputation as industry leaders for equipment calibration.**

Is a Sensor Check a Calibration?

No, the Sensor Check function is NOT the same as a calibration. A Sensor Check does not compare the measured result against an externally traceable reference sensor. Nor does it test the entire electronic circuit that is integral to the sensor's response. Under no means can a Sensor Check replace the annual calibration process.

Sensor Check is a function on Instantel vibration monitoring units that helps ensure that the sensors are properly connected, oriented, and installed. If, for example, a geophone is not level, or installed upside down, then the monitoring unit will indicate a failed Sensor Check. The most common reasons for a failed geophone Sensor Check are due to an improper leveling or connection. The most common reason for a failed linear microphone Sensor Check is due to an improper connection.

Note: The Minimate Pro Sensor Check compares the current Setup file with the attached sensors and indicates if there are any mismatches. If, for example, the pressure sensor channel is off, and a linear microphone is attached, or conversely, if it is on, and a linear microphone is not attached, then the Sensor Check will indicate "*Sensor Detection Error – Attached Sensors do not match setup*".

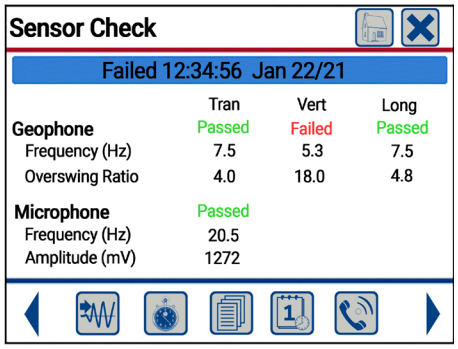


Figure 5. Sensor Check results as displayed on a Micromate monitoring unit. In this case the vertical channel's natural Frequency and Overswing Ratio test were out of their acceptable ranges.

How Does it Work?

Sensor Check measures a geophone's natural frequency and damping, indicated by an Overswing Ratio (OR). It does this by sending an electric pulse or series of pulses to the connected sensors and measures their response.

The Sensor Check results are accessible via the monitoring unit's user interface (see Figure 5) and are displayed on all event reports (see Figure 6).

Sensor Check also verifies the microphone by sending a signal to the microphone and measuring its frequency and amplitude response.

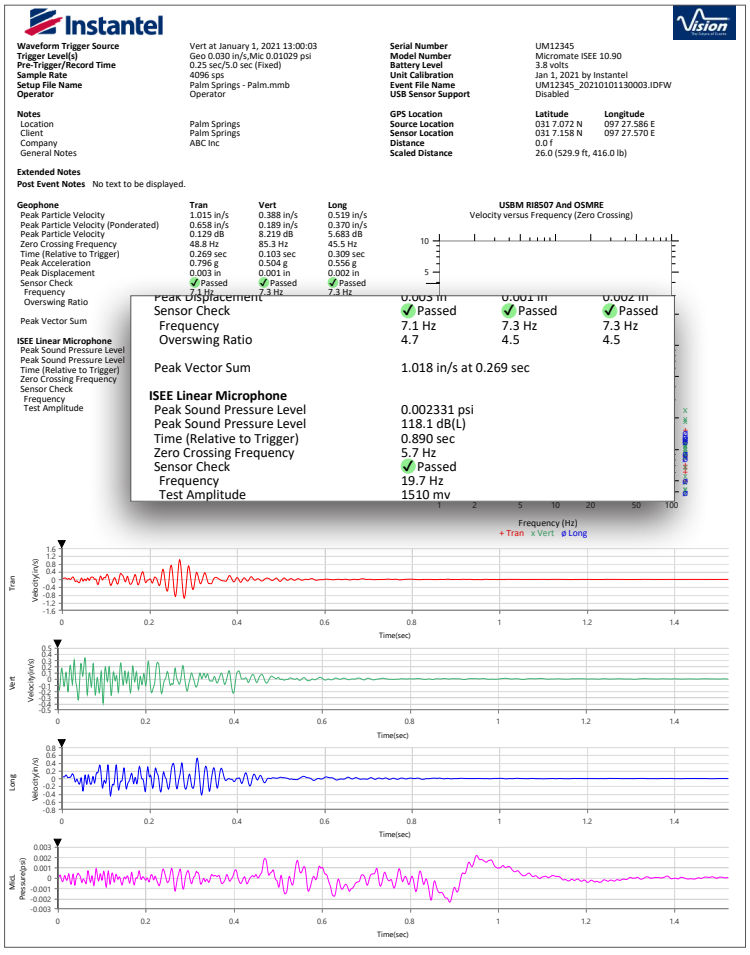


Figure 6. Sensor Check results as displayed on an event report.

How Often Must My Equipment Be Calibrated?

Instantel recommends an annual calibration for our seismographs, geophones, and microphones. Due to normal wear and tear, extreme conditions or misuse, their accuracy can be affected over time. Annual calibration is essential to ensure the monitoring unit measures accurately and performs according to design. During the calibration process, Instantel compares recorded measurements with calibrated reference equipment. Adjustments are made to the equipment being calibrated to ensure accurate recording. An up-to-date calibration provides you and any governing regulatory body confidence in the measured results.

Geophone Calibration Station

After the geophone is attached to the shake table and the "As Found" condition is determined, it is calibrated by adjusting the amplitude response to meet either of the ISEE, DIN, Swedish Blasting or Swedish Pile Driving standards.

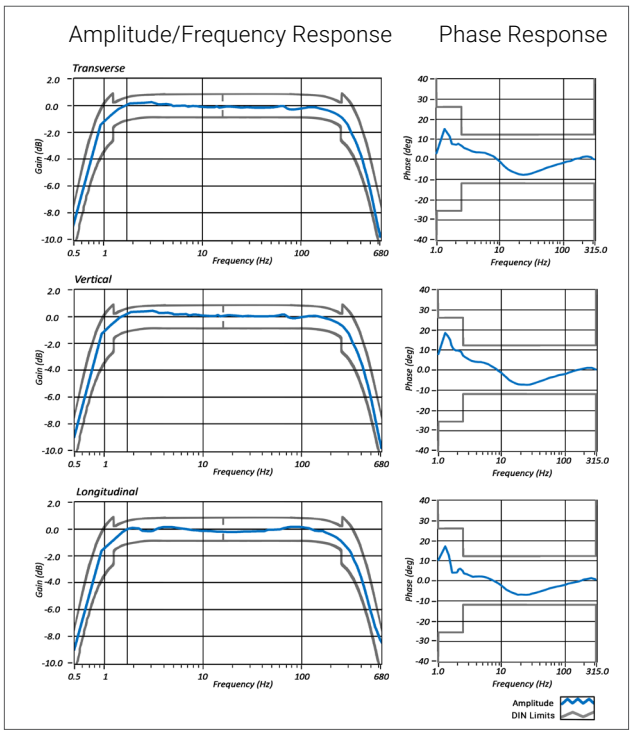
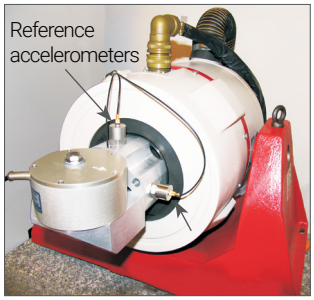
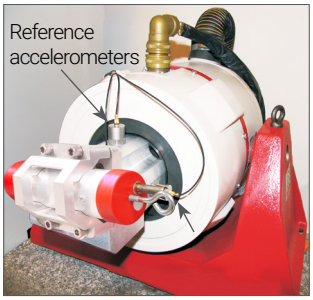


Figure 7. Calibrated DIN (1-315 Hz) geophone amplitude frequency and phase response graphs. Each blue line represents its respective calibrated response, the thick grey lines represent the upper and lower limits.

Triaxial geophones configured to international compliance standards. From left to right: ISEE, DIN, ISEE/DIN borehole, Swedish Pile Driving, Swedish Blasting.



ISEE geophone mounted on a shake table with reference accelerometers.



ISEE borehole geophone mounted on a shake table with reference accelerometers.

Phase Response: ISEE-2017 Tabular Requirements Versus Instantel's High-Resolution Graphical Results

The ISEE-2017 performance specification defines the phase response requirements as *"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." (ISEE Performance Specifications for Blasting Seismographs 2017)*

The ISEE-2017's tabular phase chart (See Figure 8) describes the minimum six data points that must be verified to ensure phase compliance.

Ground Channel: ☐ Transverse ☐ Vertical ☐ Longitudinal					
Frequency	Frequency (Hz)	Amplitude (A) (mm/s or in/s)	Deviation (%)	Tolerance	Pass/Fail
Reference Frequency	30.00	25.40	N/A	N/A	N/A
F1 (0.707 x A_{Ref})	1.61	17.96	N/A	F1 < 2.0 Hz	Pass
F2 (1.270 x F1)	2.04	20.75	82 %	F amplitude x 0.85 +/- 10%	Pass
F3 (0.760 x F1)	1.22	13.10	52 %	F amplitude x 0.50 +/- 10%	Pass
F4 (0.707 x A_{Ref})	345.67	17.96	N/A	F4 > 250 Hz	Pass
F5 (0.787 x F4)	272.04	21.16	83 %	F amplitude x 0.85 +/- 10%	Pass
F6 (1.3165 x F4)	455.07	12.27	48 %	F amplitude x 0.50 +/- 10%	Pass

Figure 8. Example of the six tabular results as required by the ISEE-2017 performance specification for phase response compliance.

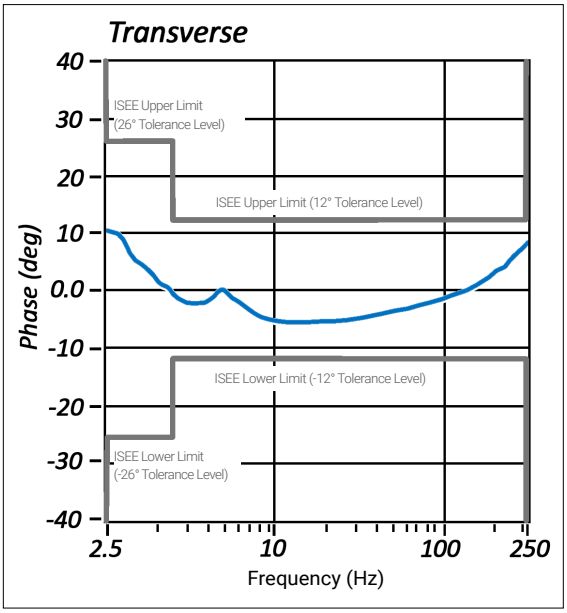


Figure 9. Example of a single channel (Transverse) graphical view from Instantel's 993 data points on the ISEE-2017 phase response requirements.

Tabular Method

- Tabular results are difficult to read and understand.
- Tabular results do not give insight in terms of the phase relationship of the signals.
- The tabular method only focuses on the phase behavior at the high and low ends of the frequency band.

Graphical Method

- Graphical results are simple to read with clearly defined upper and lower limits.
- The graphical method presents the phase response behavior across the entire frequency band.
- The graphical method simplifies detecting irregularities and exceedances across the entire frequency band.

Instantel's high-resolution (856 DIN and 993 ISEE) data points provide the same high-resolution accuracy for calculating phase response. This is seen in Figure 7, where Instantel's phase response is included on the DIN response graph and in Figure 9, where Instantel's phase response is included on the ISEE-2017 response graph.

KEY TAKEAWAY

- **Instantel's high-resolution data point calibration is plotted on a graphical chart for phase response.**
- **Compliance with the ISEE-2017's performance specification for phase response is easy to evaluate along the entire frequency band.**

Microphone Calibration Chamber

Instantel uses a calibration chamber for calibrating the linear microphone. The pressure and frequency in the chamber are monitored with a reference microphone. The linear microphone's amplitude response is adjusted accordingly, and a new calibrated graph is printed as part of the calibration certificate.

Example of the Instantel linear microphone.

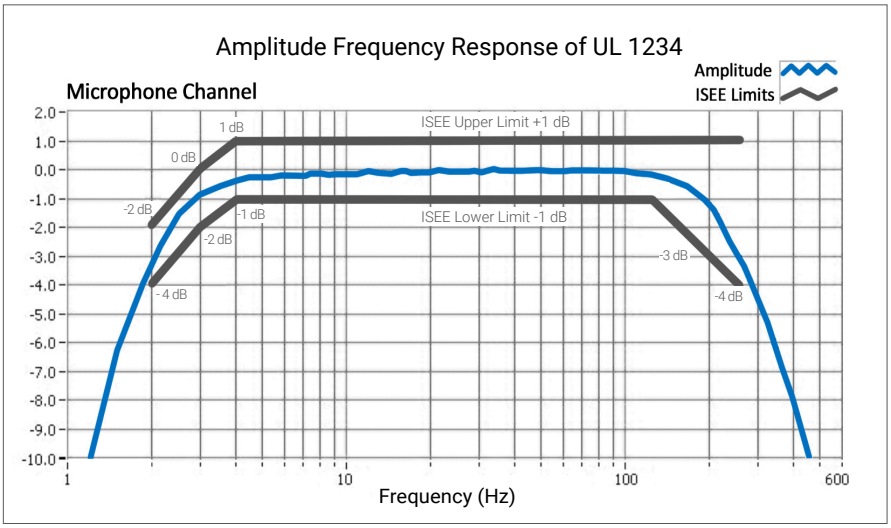
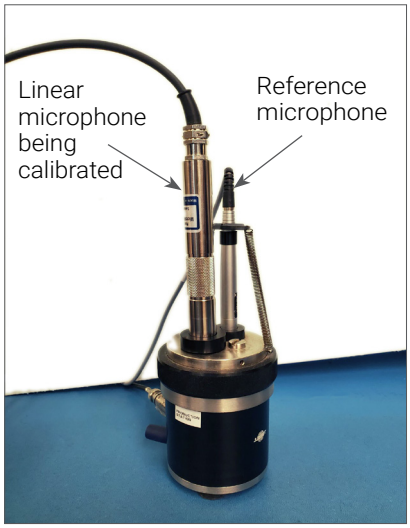


Figure 10. Linear microphone amplitude frequency response.



Example of a Microphone calibration chamber.

What Does the Calibration Certificate Mean?


Sample ISEE Calibration Certificate

Should an authority question your monitoring measurement records, a calibration certificate is the document that provides proof of a completed calibration. It also provides proof of the calibration date.

When monitoring equipment is calibrated at Instantel, a calibration certificate that follows industry guidelines such as the International Society of Explosive Engineers (ISEE-2017), is issued. This calibration certificate includes the following key elements:

- Name and address of the calibration facility
- Serial numbers of the equipment being calibrated
- Model number and a description of the equipment being calibrated
- Date on which the calibration was performed
- Graphical results of the calibration
- A list of the equipment used to perform the calibration and the standards they are traceable to
- Name and signature of the technician
- A separate "As Found" response graph

Why Use an Instantel Authorized Calibration Center?

Using an Instantel Authorized Calibration Center helps ensure that the proper procedures are followed when calibrating your monitoring equipment. This removes uncertainty associated with the reliability and measurement accuracy of your monitoring equipment and ensures the integrity of the measured record if it is ever requested as evidence in a court of law.

Instantel and all Authorized calibration centers include the updated calibration date on all event reports. Unauthorized calibration facilities cannot change this calibration date. Calibration facilities that are certified by Instantel have access to test specifications and procedures designed specifically for your monitoring equipment. They will also ensure that any replacement parts that are used meet the specifications for the equipment. If your equipment requires an extensive level of repair, the manufacturer has the best experience and knowledge to diagnose and fix the problem.

Unauthorized facilities do not have access to the proper test procedure and specifications, therefore it is in your best interest to have your vibration monitoring equipment calibrated by Instantel or one of Instantel's Authorized Calibration Centers. Please visit our website's Authorized Calibration Center Locator, to find a center near you.

Worldwide Authorized Calibration Centers

What Do You Need to Get Your Service/Calibration Request Started?

To better serve you, we require a few pieces of information to get your service request opened. We recommend having the information below available before you start your submission. The recommended information, such as the model and serial number, can be found on the Instantel product information sticker located on the outside of your Instantel equipment. Please see the image below for an example. If you have trouble locating this information, please email service@Instantel.com.

You will need the following information to submit a service request:

- Serial Number (Example: UM12345)
- Model (Example: Micromate)
- A Return Shipping Address
- Return Carrier Information – If you have a corporate shipping account with a specific carrier, please let us know. Otherwise, we will use one of our preferred carriers.
- Dealer Name

Where to Find the Product Information Sticker

Micromate (Unit Back)

Part # 721A2601
Micromate DIN Base Unit
Serial # UM14107
Made in Canada Instantel

Triaxial Geophone

Part # 721A2901
Micromate ISEE Triaxial Geophone with 2 m (6.5 ft) Cable
Serial # UM14572
Made in Canada Instantel

Linear Microphone

Part # 721A0201
Micromate Linear Mic (2-250Hz)
Serial # UL 12345
Made in Canada Instantel

How Do I Submit a Service/Calibration Request?

1. Login to the **Instantel Service Portal** at **https://www.instantel.com/service/schedule-service.**
2. Once you are logged in, click on **Create RMA Request. (Return Material Authorization)**
3. You will then have to fill in your **Contact Information**, your **Local Distributor's Contact Information** and the **Return Shipping Address**. (This information is required the first time you complete an RMA and saved for future RMA's.)
4. Click Continue.
5. Enter information about your Instantel equipment. There is also a section here to enter any details or items you would like our technicians to review.
6. Click **Continue**.
7. You will be provided with an RMA number – In addition to the RMA, providing your authorization tracking number, this is your service request number. An email with instructions on how to send your equipment to Instantel will be sent to the email address you submitted with the request. This email will also include a return shipping label with Instantel's corporate address and the RMA number.
8. Please use the shipping labels provided to return your equipment to Instantel.

Note: for multi-unit service calibration requests, please follow the procedure outlined on our website in the Service & Calibration section.

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