



Piezoelectric Modal Impact Hammer Operation Guide

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1. Introduction

Thank you for choosing an LNS impact hammer. To get the full performance from your hammer, please take a moment to read this general operation guide before use. If you have any questions, our engineers and sales representatives are always glad to help.

This guide applies to LNS IEPE impact hammers with measuring ranges of 500 N, 2000 N, and 5000 N, supplied with four interchangeable tip materials: stainless steel, aluminum alloy, nylon, and rubber. Impact hammers are used mainly for structural dynamic testing, such as modal analysis and natural-frequency identification. The excitation frequency range is set jointly by the tip material (hardness) and the hammer range (head mass). A harder tip and a smaller range give a shorter contact time and a higher usable frequency limit. A softer tip and a larger range give a lower frequency limit and more stable low-frequency excitation.

2. Scope of Application

This series of impact hammers and tips is intended for structural dynamic testing in civil engineering, machinery manufacturing, aerospace, automotive, and related fields. They can excite beams, plates, shells, frames, components, and similar objects to obtain key parameters such as natural frequencies, damping ratios, and mode shapes.

3. Key Parameter Definitions

- **Hammer range:** the maximum impact load the hammer can measure (500 N / 2000 N / 5000 N).

- **Tip hardness:** stainless steel > aluminum alloy > nylon > rubber. The harder the tip, the shorter the contact time with the test object.

- **Usable excitation frequency range:** the frequency band over which the test produces a valid signal (signal-to-noise ratio adequate for analysis). There is no strict lower limit (5 Hz and above is practical in engineering use); the upper limit is governed by contact time.

• **Impact contact time:** the duration for which the tip is in contact with the test object. This is the main factor that sets the upper frequency limit. Engineering estimate: usable upper frequency $\approx 1 / (2 \times \text{contact time})$.

4. Excitation Frequency Reference Table

The table below summarizes the typical contact time, usable frequency range, characteristics, and typical applications for each combination of hammer range and tip material.

Range	Tip material	Contact time	Frequency range	Key characteristics	Typical test objects
500 N	Stainless steel	0.1 to 0.3 ms	5 Hz to 20 kHz	Hardest tip and shortest contact time. Richest high-frequency content, sharp impact, best signal-to-noise ratio.	Small precision metal parts, piezoelectric elements, thin-walled structures, electronic devices, high-frequency modal tests
	Aluminum alloy	0.3 to 0.5 ms	5 Hz to 10 kHz	Balanced mid-to-high frequency, moderate impact energy, highly versatile, suits most routine tests.	Small metal structures, machine parts, motor housings, routine modal tests
	Nylon	0.5 to 1.0 ms	5 Hz to 3 kHz	Gentle excitation with weak high-frequency content. Avoids damaging the test object, good fit for low-to-mid frequencies.	Medium castings, thick-walled metal parts, plastic structures, equipment frames, low-to-mid frequency modal tests
	Rubber	1.0 to 3.0 ms	5 Hz to 1 kHz	Softest tip and longest contact time. Impact energy is spread out, no high-frequency noise, stable low-frequency excitation.	Local tests on large structures, composites, fragile parts, low-frequency natural-frequency tests

Range	Tip material	Contact time	Frequency range	Key characteristics	Typical test objects
2000 N	Stainless steel	0.2 to 0.4 ms	5 Hz to 15 kHz	Excellent high-frequency performance with moderate impact load. Balances high-frequency excitation against the load capacity of the test object.	Medium metal structures, aerospace components, precision equipment housings, mid-to-high frequency modal tests
	Aluminum alloy	0.4 to 0.6 ms	5 Hz to 8 kHz	Extremely versatile. Impact energy and contact time are well balanced, covering more than 80% of routine test scenarios.	Machine frames, automotive parts, motor assemblies, bridge models, routine modal and dynamic response tests
	Nylon	0.8 to 1.2 ms	5 Hz to 2 kHz	Soft excitation with moderate impact load. Avoids local overload on large structures, clean low-to-mid frequency signal.	Large castings, thick-walled pressure vessels, civil structural models, low-to-mid frequency dynamic tests
	Rubber	1.5 to 3.5 ms	5 Hz to 800 Hz	Smooth impact energy with no high-frequency interference. Suited to precise identification of low-frequency behavior in large structures.	Bridges, factory frames, large equipment bases, composite structures, low-frequency modal tests
5000 N	Stainless steel	0.3 to 0.5 ms	5 Hz to 10 kHz	Upper frequency limit slightly below the smaller ranges, but high impact load. Suited to high-frequency tests that need high energy.	Large metal structures, heavy machinery parts, thick-walled metal parts, high-energy high-frequency excitation

Range	Tip material	Contact time	Frequency range	Key characteristics	Typical test objects
	Aluminum alloy	0.5 to 0.8 ms	5 Hz to 6 kHz	Mainly low-to-mid frequency with ample impact energy. Suited to routine dynamic tests of large structures.	Heavy equipment frames, ship components, full-scale civil structures, routine modal tests
	Nylon	1.0 to 1.5 ms	5 Hz to 1.5 kHz	Gentle excitation with ample energy. Avoids damage to large structures, stable low-frequency signal.	Large concrete members, thick-walled composites, heavy equipment bases, low-to-mid frequency tests
	Rubber	2.0 to 4.0 ms	5 Hz to 500 Hz	Longest contact time. High-frequency content is almost absent, impact energy is evenly distributed, precise low-frequency excitation.	Dams, full-scale bridges, large industrial buildings, complete heavy machines, low-frequency natural-frequency tests

Note: the frequency ranges above are practical engineering values and will vary with the material, surface flatness, and stiffness of the test object, as well as impact force. Adjust as needed based on measured data.

5. Selection Guidelines

5.1 Range selection

- **500 N:** small, lightweight test objects, or applications that need high-frequency excitation while avoiding overload of the test object.
- **2000 N:** most test objects of ordinary size. Balances excitation energy with general-purpose versatility.
- **5000 N:** large, heavy test objects, or applications where high impact energy is needed to excite the structural dynamic response.

5.2 Tip material selection

Basic rule: hard tips for high frequencies, soft tips for low frequencies; light hammers for

high frequencies, heavy hammers for low frequencies. Specific recommendations:

- **High-frequency tests (above 3 kHz):** prefer stainless steel or aluminum alloy tips on a small- or medium-range hammer.
- **Mid-to-low frequency tests (1 kHz to 3 kHz):** prefer nylon tips on a medium- or large-range hammer.
- **Low-frequency tests (below 1 kHz):** prefer rubber tips on a large-range hammer.
- **Fragile test objects (thin-walled parts, precision components):** prefer nylon or rubber tips. Avoid stainless steel tips, which can damage the object.

6. Operating Procedure

6.1 Tip installation

1. Before installation, check that the tip thread matches the thread on the hammer head, and clean any debris or oil from the threads.
2. Thread the tip onto the hammer by hand and make sure it is fully tightened so it cannot loosen during impacts. Never use tools to force it tight, as this can damage the threads.
3. After installation, check that the tip is coaxial with the hammer head so that the impact force is applied evenly.

6.2 Impact technique

1. Select the hammer range and tip material to suit the expected natural-frequency range and load capacity of the test object.
2. Keep the hammer perpendicular to the surface of the test object and strike with consistent force. Avoid angled strikes, which introduce high-frequency noise and distort the data.
3. In routine tests, keep the impact force within 30% to 70% of the hammer range for the best signal-to-noise ratio. When high-frequency behavior must be excited, the

force may be increased moderately but should not exceed 90% of the range. For fragile objects, keep the force within 30% of the range.

4. Strike each test point 3 to 5 times and keep the impacts that give a stable signal.

This averages out the random variation of any single strike.

5. Never swing the hammer without striking a test object (a dry strike). Doing so can damage the internal force sensor.

6.3 Environmental requirements

1. Keep the test environment within -55 °C to +120 °C and relative humidity at or below 85% (non-condensing). Avoid high temperature, high humidity, and strong electromagnetic interference.

2. For outdoor tests, protect the hammer from rain and dust so that water and dirt cannot enter the tip or the hammer body.

3. At low temperatures (below -10 °C), prefer stainless steel or aluminum alloy tips, since nylon and rubber become brittle in the cold. Let the hammer acclimate before use to avoid faults in the internal electronics.

7. Precautions

- **Never exceed the hammer range.** An impact beyond the rated range will permanently damage the internal force sensor and the test data will be completely invalid.

- **Avoid impact damage to tips.** Stainless steel and aluminum alloy tips are hard and can chip or deform if dropped or struck against hard objects, which changes the contact time and frequency range. Store them carefully after use.

- **Nylon and rubber tip maintenance.** Replace these tips promptly if they show wear or cracking after prolonged use. Wear changes the contact time and shifts the frequency range.

- **Hammer calibration.** Calibrate once a year. Calibration should cover range accuracy, contact-time consistency, and frequency response to keep test data accurate.

- **Data acquisition.** Start the data acquisition system at the same time as the impact, and make sure the sampling rate is 2 to 3 times the upper excitation frequency (Nyquist sampling theorem) to avoid signal distortion.

8. Frequently Asked Questions (FAQ)

Q1: The signal is noisy after the impact and I cannot identify the natural frequencies.

What should I check?

Check three things first: (1) Is the tip tight, and was the strike perpendicular to the test object? (2) Is the tip material suitable? For example, a rubber tip used for a high-frequency test should be replaced with a stainless steel or aluminum alloy tip. (3) Was the impact force appropriate? Too little force introduces noise, while too much may exceed the range.

Q2: Why does the same tip material give a different frequency range on hammers of different ranges?

The larger the hammer range, the heavier the hammer head. A heavier head has more inertia and stays in contact with the test object longer. From the upper-frequency estimate, a longer contact time lowers the upper frequency limit, so for the same tip material a large-range hammer has a lower upper frequency limit than a small-range hammer.

Q3: How do I avoid damaging a fragile test object while still getting valid data?

Use a nylon or rubber tip (soft material, gentle excitation) on a small-range hammer and keep the impact force within 20% to 30% of the range. Strike perpendicular to the surface to reduce local impact stress. If necessary, attach a cushioning pad to the surface of the test object, provided it does not affect the dynamic response.

Q4: The rubber tip cannot be used at low temperature. What should I do?

Rubber becomes brittle below -10 °C. Switch to a nylon tip, which tolerates low temperatures better than rubber. Also leave the hammer in the test environment for at least 30

minutes beforehand so that its internal temperature matches the ambient temperature, which avoids signal drift caused by temperature differences.

Q5: Are there rules to help me choose the right modal hammer based on, for example, the size and weight of the test specimen?

There is no fixed rule that identifies which modal hammer is best for a given test. However, several factors must be considered before selecting a modal hammer:

Factor 1. Frequency bandwidth

A modal test with an impact hammer works by applying an impulse to the specimen, which excites vibration over a wide frequency band. The excited bandwidth depends on the duration of the impulse: the narrower the pulse, the higher the excited frequencies. The impulse duration can be changed by fitting tips of different stiffness. When the specimen is struck with the same energy, a modal hammer with different tips excites different bandwidths. The softer the tip, the wider the pulse and the narrower the excited bandwidth.

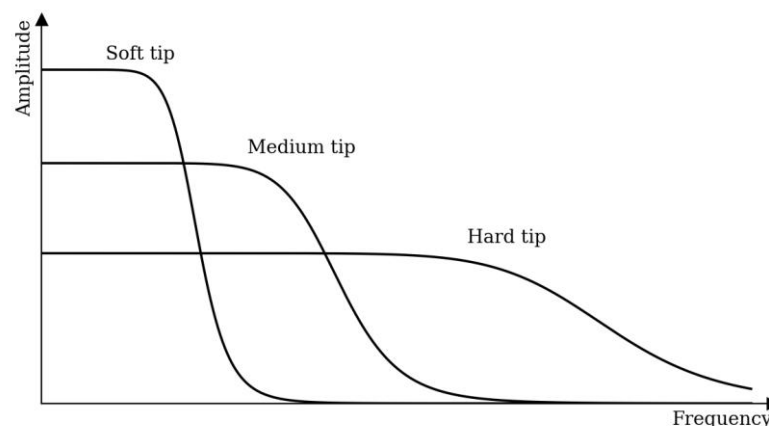


Figure 1: Excited frequency bandwidth for soft, medium, and hard tips

The final pulse duration also depends, in some cases, on the stiffness of the specimen being struck. With a hard tip the impact energy is spread over a wide bandwidth, which means the power spectral density of the excitation can be low, sometimes too low to excite the vibration modes or resonances of the specimen. In that situation one might strike the structure harder, either with a larger swing or by adding a mass extender to increase the weight of the hammer.

Unfortunately this also raises the risk of saturating the IEPE force sensor. A hammer with a larger measuring range may therefore be a better choice in some cases. The alternative is to use a softer tip, which concentrates the impact energy in the lower frequencies.

Factor 2. Pulse amplitude

The tip used has a strong influence on the shape of the impact pulse, affecting not only its duration but also its amplitude. The figure below shows the force pulses obtained with different tips when the same energy is applied to the specimen.

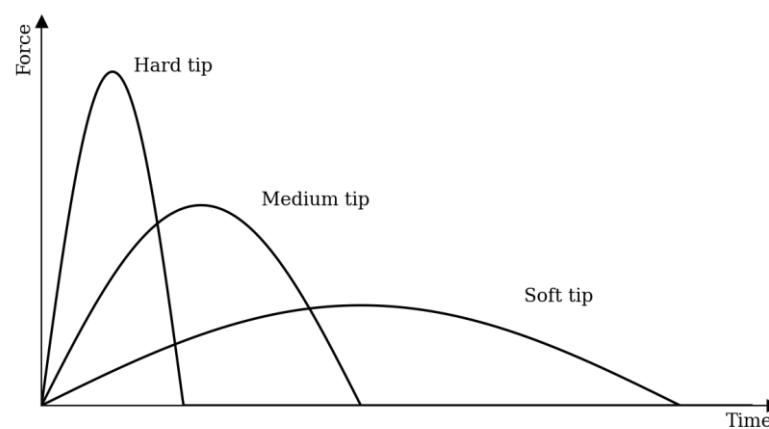


Figure 2: Force pulse shape for hard, medium, and soft tips at the same impact energy

Using a hard tip may therefore call for a modal hammer with a force sensor of higher measuring range. A force sensor with a lower measuring range may limit the use of hard tips and prevent high-frequency vibration from being excited.

Factor 3. Hammer weight and impact energy

Test objects of different shapes and weights, and with different properties such as stiffness or damping, require force pulses of different parameters for suitable excitation. Compared with large objects, small and compact objects usually have higher resonance frequencies and require less impact energy. To excite a small structure with as little energy as possible, a short-duration force is needed, which a small or medium hammer can deliver. Large structures require higher-energy impacts, most likely concentrated in a low-frequency band. In that case a large hammer with a soft or medium-stiffness tip is better suited to providing the required force pulse.

Factor 4. Test repeatability

To provide mechanical excitation with the required parameters, a choice has to be made between different force measuring ranges, tips, and hammer weights. In modal testing practice, hammer impacts performed by an operator vary from person to person in impact energy, excited bandwidth, and impact angle. For this reason the usual practice is to average several results. The goal is to obtain high-quality, repeatable, and consistent data for a given measurement.

9. Supplementary Notes

1. The frequency ranges stated in this guide are practical engineering values. They are affected by the material and surface flatness of the test object, impact force, and other factors, and may be fine-tuned in use based on measured data.
2. If a special test application needs a custom configuration, please contact LNS Dynamics about custom tips and hammers.
3. The manufacturer reserves the right of final interpretation of this guide. If the product is updated, the latest version of this guide applies.



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