

**Traceably Calibrating
the "Grindosonic" for
Impact Excitation
Modulus Measurement**

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August 1996

NPL REPORT CMMT (A) 36

NATIONAL PHYSICAL LABORATORY

Centre for Materials Measurement and Technology

TRACEABLY CALIBRATING THE "GRINDOSONIC" FOR IMPACT EXCITATION MODULUS MEASUREMENT

by

R Morrell

Summary

The "Grindosonic"* is a commercial instrument designed for determining the fundamental natural frequency of a struck object. It is intended principally for quality assurance of products such as vitreous-bonded grinding wheels, but it can also be used for determining the elastic moduli of uniform geometry test-pieces of ceramics and other elastic materials. The instrument detects the fundamental natural frequency of a decaying signal after higher modes have been damped out. A means of providing traceable calibration for the instrument under such detection conditions has been devised. The frequency of a sinusoidal source is measured using a traceably calibrated frequency counter. This frequency is used to energise a hi-fi loudspeaker, and a manual volume control is used to provide a signal of the characteristics required to trigger the "Grindosonic" detection system, using either a microphone or a piezoelectric detector. A comparison of the frequencies recorded on both instruments provides a check on the accuracy of the "Grindosonic".

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Approved on behalf of Managing Director, NPL, by Dr M K Hossain, Director, Centre for Materials Measurement and Technology

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Date.....*30th August '96*.....

Date.....*27 August 1996*.....

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1. INTRODUCTION

The "Grindosonic" is a specialist device originally designed to test the integrity of vitreous bonded grinding wheels by detecting their frequency of vibration when struck, akin to a "wheel-tapper" test. The instrument detects the fundamental vibration frequency of a struck object using a piezoelectric probe or a microphone. The electronic circuitry of the "Grindosonic" analyses the mix of frequencies emitted by a struck object, and waits until higher frequencies have decayed leaving the fundamental for the mode in which the object is struck. It then determines the time for two complete sinusoidal cycles of vibration. The display shows this time (or alternatively, on the model available at NPL, the frequency). It is simple to set a pass/fail criterion for quality assurance purposes.

The instrument also has considerable value as a quick and effective method of measuring the elastic properties of materials of well defined geometry. For this application, there is a need to ensure that the instrument is correctly calibrated. The manufacturer has stated that the instrument employs an accurate crystal quartz oscillator, and thus has no need for calibration. However, it is important to make an independent check that the indicated values are traceable to the National Measurement System. This report describes a simple method for doing this.

2. CALIBRATING FREQUENCIES

Discussion with other Centres within NPL suggested that the most appropriate method of obtaining certified frequencies is to employ a stable sinusoidal frequency generator and a calibrated frequency counter. The former are difficult to calibrate and may drift, whereas the latter can be calibrated to high accuracy. For this work, the assistance of the Acoustics branch of NPL was enlisted. The frequency counter employed was a Racal-Dana Universal Counter Type 1991, serial number 9004, with a NAMAS accredited calibration certificate from Marconi, no. 17049, issued October 1995 (five months prior to this evaluation).

3. CALIBRATION OF THE "GRINDOSONIC"

Since the "Grindosonic" is designed to evaluate a signal of decaying amplitude, inputting a known frequency of constant amplitude from an acoustic source will not activate the counter electronics. A decaying signal is required. Simply using a hi-fi loudspeaker connected to a frequency generator did not trigger the "Grindosonic" display. Moving the "Grindosonic" microphone away from the loudspeaker to produce a decaying signal was unsatisfactory since this induced a detectable Doppler shift. After some experimentation, it was found that the loudspeaker could be used as an effective source for detection by the "Grindosonic" microphone provided that a manual volume control was also employed. When the volume was increased rapidly and then decreased more slowly, this was akin to the intensity profile emitted by a struck object, and was found to be sufficient to trigger the "Grindosonic" electronics. It was thus a simple matter to select a range of frequencies and to detect the corresponding "Grindosonic" response. Other sound sources in the vicinity had to be minimised.

In order to perform similar checks when using the piezoelectric probe rather than the microphone, a metal plate was mounted in an upright position in front of the loudspeaker to act as a mechanical diaphragm. The plate was clamped at the lower edge only. The

piezoelectric probe was held against the plate to detect the vibrations transmitted from the loudspeaker.

4. RESULTS AND DISCUSSION

Table 1 shows a series of evaluations using the microphone at three frequencies typical of the range over which the instrument is normally used for elastic modulus measurement, and Table 2 shows a similar set for the piezoelectric probe. In both cases, the time period displayed, τ , has been converted to a frequency, f , using:

$$f = \frac{2}{\tau}$$

where the factor 2 corresponds to two complete cycles detected.

It can be seen that there is very good agreement between the supplied frequency as measured by the calibrated source and the detected frequency, with the maximum difference between the calibrated value and the indicated value of less than 0.05% being found with one exception where the error was a little less than 0.5%.

It can be concluded that the "Grindosonic" instrument at NPL is reading frequencies to an acceptable degree of accuracy compared with the NAMAS certified source, such that errors in modulus value resulting from the use of uncorrected display output are likely to be somewhat less than 1%.

Acknowledgement

This work has been supported by the Department of Trade and Industry's EAM Division programme on Advanced Materials, Project AM8, Ceramics and Cermets: Mechanical Characterisation .

Table 1 - Calibration using the microphone

Source frequency, counter, Hz	Grindosonic time period, μ s	Grindosonic frequency, Hz	Difference, %
500.014	4000.9	499.89	-0.050
	4002.4	499.70	-0.088
	4000.8	499.90	-0.048
	4000.3	499.96	-0.036
	4000.9	499.89	-0.050
	4000.7	499.91	-0.046
	4000.5	499.94	-0.040
	Mean 4000.9	Mean 499.88	Mean -0.051
2000.014	1000.0	2000.0	-0.001
	1000.0	2000.0	-0.001
	1000.1	1999.8	-0.011
	1000.1	1999.8	-0.011
	1000.1	1999.8	-0.011
	1000.0	2000.0	-0.001
	Mean 1000.05	Mean 1999.9	Mean -0.006
10060.0	198.02	10100	+0.400
	197.98	10102	+0.417
	198.05	10098	+0.378
	198.01	10101	+0.408
	197.99	10102	+0.417
	198.00	10101	+0.408
	Mean 198.01	Mean 10101	Mean +0.405

Table 2 - Calibration using the piezoelectric probe

Source frequency, counter, Hz	Grindosonic time period, μ s	Grindosonic frequency, Hz	Difference, %
499.96	3999.7	500.04	+0.016
499.96	4001.4	499.83	-0.027
499.96	4000.2	499.98	+0.004
500.08	4000.0	500.00	-0.016
500.075	3999.5	500.06	-0.003
500.075	3999.9	500.01	-0.013
500.075	4000.5	499.94	-0.027
	Mean 4000.2	Mean 499.98	Mean -0.009
2000.14	1000.5	1999.0	-0.057
"	1000.0	2000.0	-0.007
"	999.9	2000.2	+0.003
"	1000.0	2000.0	-0.007
"	1000.0	2000.0	-0.007
"	1000.1	1999.8	-0.017
	Mean 1000.1	Mean 1999.8	Mean -0.015
9999.75	200.01	9999.5	-0.003
9999.78	200.01	9999.5	-0.003
9999.79	200.01	9999.5	-0.003
9999.79	200.01	9999.5	-0.003
9999.78	200.01	9999.5	-0.003
9999.79	200.00	10000.0	+0.002
	Mean 200.01	Mean 9999.6	Mean -0.002