Thursday, August 26, 2021

Portable Vibration Calibrator
Model 9100D

Prepared for

Tobias Sparmann
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PCB PIEZOTRONICS
AN MTS COMPANY

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THE MODAL SHOP
AN MTS COMPANY

+1 513 351 9919 (Phone)
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calibration@modalshop.com

Dear Tobias,

Thank you for the opportunity to serve your calibration needs. The Modal Shop and PCB Piezotronics have a long history of serving the test and measurement community. We do so with a commitment to excellence, innovation and Total Customer Satisfaction.

Portable Vibration Calibrators from The Modal Shop offer precision vibration instrumentation calibration in a rugged and portable package. These devices are ideal for confirming critical vibration alarms, system troubleshooting and the creation of test reports. Users achieve improved safety, reduced downtime and peace of mind that their vibration protection systems are working properly. The Modal Shop and PCB offer an unwavering commitment to deliver our mission of Total Customer Satisfaction. This same service is delivered to all: from the largest corporations to the one-man consultancies. It follows our products to you, your facility and your test staff as well.

Only through the verification process of global market leadership in calibration systems are we committed to provide you with the quality, performance, reliability and value to meet this promise. Our family of businesses is dedicated to serving the metrology community, supplying both immediate 24 hour worldwide support, and long term investment in innovation and standards. Thank you for considering our proposal. We look forward to serving you.

Sincerely,

Richard Bono
President
The Modal Shop, Inc.

Expertise at Your Service

The Modal Shop is unique within the portable calibrator market as not only do we provide turn-key solutions designed for end users, we are also a vibration calibration system and service provider with ISO 16063-21 back-to-back accelerometer calibration systems and ISO 16063-11 laser primary systems. Additionally, The Modal Shop is part of PCB Piezotronics, the global leader in design and manufacture of precision accelerometers. Vibration instrumentation calibration is the focus of our business and as such we offer an impressive staff of experts dedicated to ongoing innovation as well as for technical support:

Mike Scott
Industrial Product Manager, The Modal Shop, Inc., an MTS Company, Ohio

- Vibration Institute Certified Category II Vibration Analyst
- 15+ years' experience in the field of industrial vibration & instrumentation
- Presented on the topic of industrial vibration sensor calibration at:
  - ISA Process Safety & Control Symposium
  - Vibration Institute
  - National Conference of Standards Laboratories (NCSL)
  - Canadian Machinery Vibration Association (CMVA)
  - Machinery Failure Prevention Technology (MFPT)
- Published "Field Calibration & Testing of Industrial Vibration Protection Systems"
  - ISA Process Safety & Control Symposium 2015
- Conducted public & on-site calibration seminars featuring industrial vibration technologies
- Bachelor of Science, Electrical Engineering – State University of New York at Buffalo

Patrick Timmons
Senior Scientist, The Modal Shop, Inc. an MTS Company, Ohio

- Senior Scientist facilitating the development, improvement, and support of dynamic calibration systems
- 10+ year focus on dynamic sensors, metrology, and mechanical excitation systems
- Expertise in the design of low frequency vibration calibration exciters utilizing linear motor technology
- Participates on ISO Vibration Calibration Standards Committees
- Authors and presents papers and technical presentations on calibration and calibration system development at vibration and metrology conferences
- Thousands of hours of on-site instruction on theory and operation of calibration systems and laboratory practices at aerospace, defense, automotive, industrial, and metrology facilities around the world
- Bachelor of Science, Mechanical Engineering - Michigan Technological University

Jeff Dosch Ph.D.
Technical Director, PCB Piezotronics, an MTS Company, New York

- Sensor Design Engineer and Calibration System Specialist at PCB's Technology Center
- 20+ years expertise in piezoelectric and capacitive sensor design and calibration
- Doctor of Science in Vibration Control bringing an in-depth knowledge of sensor and system function
- Published multiple technical papers including:
  - "Hopkinson Bar Acceptance Testing for Shock Accelerometers"
  - "Automated Testing of Accelerometer Transverse Sensitivity"
  - "A Heterodyne Laser Interferometer for Primary Calibration of Accelerometers"
  - "Primary Calibration of Accelerometer Complex Sensitivity by Laser Interferometry"
  - "Low Frequency Accelerometer Calibration Using Earth's Gravity"
  - "Air Bearing Shaker for Precision Calibration of Accelerometers"
- PhD in Mechanical Engineering - University at Buffalo

Mike Dillon

Calibration Systems Team Leader, The Modal Shop, Inc. an MTS Company, Ohio

- Calibration Team Leader responsible for leading the development and support of TMS Dynamic Calibration Systems around the globe
- 25+ year focus on dynamic sensors and metrology
- Served as an accelerometer and electronics design engineer for PCB Piezotronics
- Engaged in support of dynamic metrology applications and projects, from definition of technical requirements to procedure writing to uncertainty analysis and interlaboratory comparison programs
- Travels domestically and internationally to present on the topics of Accelerometer Theory, Vibration Applications and Calibration Techniques
- Bachelor of Science, Mechanical Engineering – University of Cincinnati
- Master of Business Administration, Project Management Professional – Xavier University

Marco Peres

Product Manager, The Modal Shop, Inc., an MTS Company, Ohio

- 20+ years' experience in the fields of sound & vibration, product development
- Conducted numerous seminars on the topics of sensors, calibration, shakers, and excitation
- Assisted customers in a wide range of disciplines and markets:
    - Aerospace and Defense
    - Automotive
    - Consumer Products
    - Universities & Research Institutes
- Bachelor of Science, Mechanical Engineering – University of São Paulo, Brazil
- Master of Science, Industrial Engineering – Purdue University

Jesse Coy

Application Engineer, The Modal Shop, Inc., an MTS Company, Ohio

- 6+ years of field and lab experience in the discipline of vibration and pressure instrumentation, with ability to rapidly deploy engineered solutions to challenging platforms and field issues
- Conducted years of customer vibration training and on-site calibration of systems in a variety of fields including:
    - Aerospace and Defense
    - Automotive and Crash Testing
    - Nuclear Power
    - R & D Laboratories and Institutes
    - Petroleum Industry
- Bachelors of Science, Leadership – Wright State University of Ohio
- Bachelors of Science, Psychology – Wright State University of Ohio

The Modal Shop employs a team solely focused on calibration. Staffing consists of Software Engineers, Senior Application Software Developer, System Installation and Design Engineers, Customer Account Coordinators and Product Group Managers. The extensive experience of the team forms the foundation for world class customer service and product support not available from any other calibration company.

Field Application Engineers

In the United States, The Modal Shop offers a network of Field Application Engineers available for on-site customer support. Experts in troubleshooting and applications, these engineers are direct employees of PCB Piezotronics.

International Representatives

The Modal Shop employs a global network of representatives to service international customers. For more information visit www.modalshop.com/sales

Commitment to Quality

Portable Vibration Calibrator Calibration Certificate

Portable vibration calibrators from The Modal Shop are tested for accuracy using a calibration process that is accredited to the ISO 17025 standard governing calibration quality by the American Association of Laboratory Accreditation (A2LA). Our Scope of Accreditation with published uncertainties can be found on www.modalshop.com or www.a2la.org.

Calibration Process & Uncertainty

Our calibration facility in Cincinnati, OH houses a laser primary accelerometer calibration station, the most accurate piezoelectric sensor calibration method currently devised. The reference accelerometer used to calibrate our portable vibration calibrators is calibrated on this laser primary system. As such The Modal Shop has the lowest uncertainties possible for the calibration of portable vibration calibrators. Our uncertainty budget is available upon request and is a critical element to our A2LA accreditation.

Compliance to Globally Recognized Calibration Standard

ISO 16063-21 “Methods for the calibration of vibration and shock transducers – vibration calibration by comparison to reference transducer” is a globally recognized standard that accelerometer calibration labs adhere to in order to ensure quality testing. While it is not critical for the majority of portable calibrator users to meet this standard, The Modal Shop’s portable vibration calibrators are compliant. This compliance is stated on the calibration certificates produced in Microsoft Excel® by the portable vibration calibrators.

Meeting the Requirements of API 670

Field testing requirements for machinery vibration protection systems are outlined in the globally recognized American Petroleum Institute standard 670 (API 670). Portable vibration calibrators from The Modal Shop meet all requirements of the “variable frequency shaker with calibration reference accelerometer” noted in Table F-1. Our shakers generate amplitudes and frequencies as required per Tables 3A and 3B. In addition, the proximity probe adaptor kit can be used to create a DC Probe Curve per section 7.6.2.1. A “proximity probe calibration test kit” is also required per table F-1 and the portable vibration calibrator with proximity probe mounting adaptor fulfills this requirement.

NIST Traceability

The Modal Shop’s portable vibration calibrators are NIST-traceable (National Institute of Standards and Technology). Evidence of traceability is on file at Modal Shop and available upon request.

Warranty

The Modal Shop, Inc. portable vibration calibrators are warranted against defective materials and workmanship for **two years** from the date of shipment, unless otherwise specified.

Total Customer Satisfaction Guarantee

The Modal Shop guarantees Total Customer Satisfaction. If, at any time, for any reason, you are not completely satisfied with any TMS product, TMS will repair, replace, or exchange it at no charge. Anytime within the first year of the warranty, you may also choose to have your purchase price refunded.

Training

Calibration & Testing Training

Many of The Modal Shop's customers need a little help getting started. As such we offer training both on-site and via webinar. Our office is equipped with demo sensors from various manufacturers so we can walk you through your first tests step-by-step using the exact transducers in your facility. For webinars we have the latest video and sound technology to make it seem as if our support engineers are in the room with you. Our webinar training is offered at all hours so that we can assist customers around the world.

A typical industrial calibration training seminar with The Modal Shop includes some or all of the following depending upon the customer's needs:

- Proximity probe calibration and the effect of incorrect cabling
- Accelerometer & velocity sensor calibration
- 4-20 mA loop vibration sensor calibration
- How to test vibration alarms, system testing
- Programming a test using CALROUTE functionality

The Modal Shop provides training certificates if requested:

Sample Training Certificate

Portable Vibration Calibrators

Ideal for the confirmation of critical vibration alarms that protect industrial rotating machinery – and the people who work in and around that machinery – The Modal Shop's portable vibration calibrators have become the industry standard for field testing:

- Accelerometers & velocity vibration sensors
- Proximity probes
- 4-20 mA loop vibration transmitters
- High-temperature on-turbine vibration sensors
- Online vibration monitoring systems, PLC's, and SCADA systems
- Portable vibration analyzers
- Moving coil vibration transducers
- Electronic vibration switches

Benefits

- New instrumentation & calibration service **cost savings**
- Confirmation of critcal vibration alarms promotes **safety & reduces downtime**
- Programming repetitive tests **saves time**, allowing techs to complete calibration work during turnarounds
- Reduction of perceived plant **insurance risk**
- **Elimination of nuisance vibration alarms** by system troubleshooting
- **Peace of Mind,** simulation of vibration alarms at running speed promotes confidence
- Calibration certificates provide **proof** that the vibration instrumentation has been tested during an audit
- I&C and PdM teams earn the **trust** and **confidence** of operations by proving vibration system functionality

Features of shakers for loop checks & vibration calibrators – Models 9100D, 9110D, C9110D, and 9110F

- Rugged portability and re-enforced carbon fiber shaker flexures
- All-day usage, up to 18 hour battery life
- Superior precision, stability and accuracy with automatic payload control, no user entry of mass required
- Frequency response: 5 Hz to 10 kHz (300 CPM to 600,000 CPM)
- Vibration amplitude in English and metric scales, acceleration, velocity and displacement
- High-powered shaker generates up to 20 g's vibration and drives heavy sensors to alarm state
- Connection to reference accelerometer confirms accuracy quickly and easily without returning to the factory
- CALROUTE: programmable test points to quicken repetitive tests
- A full array of supplied mounting accessories including metric threads and plates for multi-hole sensors
- Unique array of proximity probe mounting accessories built to handle 5, 8, 11 and 16 mm series probes as well as reverse mount proximity probes installed inside a probe housing or "stinger"

Features of vibration calibrators – Models 9110D, C9110D, and 9110F

- Sensitivity display for sensor under test in mV, µA, mA or pC
- Creation of calibration certificates for both linearity and frequency response via Microsoft Excel®
- NIST-traceable vibration analyzer calibration report generation, linearity, amplitude, and frequency accuracy
- On-board ICP® sensor power, optional power supplies for piezo-resistive & other technologies
- Memory stores up to 500 calibration records, 30 test points per record
- Modulated Current: calibrate sensors and charge amplifiers with AC current output
- Charge Mode: calibrate vibration sensors with charge output in pC/g
- Instant pass/fail notification after every test point, programmable for all sensor types and tolerances

Industrial Customer List

Our extensive customer list includes Fortune 500 companies, major global refiners, power generation facilities and numerous globally recognizable companies. However as a company that is often consulted on proper vibration testing and procedures we are committed to keeping our relationships confidential unless given specific permission. Hence we cannot publish our customer list.

However, with nearly 3,000 units in service around the globe, The Modal Shop's Portable Vibration Calibrators are the market leader for field testing of vibration instrumentation…

Power Generation

- The Modal Shop's Portable Vibration Calibrators are commonly used inside natural gas, coal, nuclear, and hydro power plants
- Among the top 10 largest energy companies in the world (source: Power Technology, October 2020), nine are using The Modal Shop's Portable Vibration Calibrators. Nearly all of the top 20 largest energy companies in the United States utilize The Modal Shop.
- The Modal Shop's Portable Vibration Calibrators are used to test and troubleshoot proximity probes installed upon critical gas and steam turbines, identifying cable installation errors that go undetected by gap voltage

Refineries

- The Modal Shop's Portable Vibration Calibrators are used to confirm vibration alarms by 8 of the top 10 largest refining companies in the world (source: Offshore Technology, November 2020).
- Our devices are also important for testing Safety Instrumented Systems that include vibration monitoring
- By testing the voting logic on the emergency shutdown system, refineries ensure the safety of their personnel.

Chemical Producers

- Eight of the top 10 world's largest chemical producing companies have implemented The Modal Shop's Calibrators in at least one facility (source: Chemicals Technology, December 2020)

Natural Gas & Liquids Pipelines

- Nearly all of the largest pipeline operators in North America utilize The Modal Shop's Portable Vibration Shaker Tables to test 4-20 mA vibration transmitters installed on their critical pumps and compressors

Mining

- The Modal Shop supplies portable calibrators to 10 different mining companies located in 7 countries

Automotive

- Automobile manufacturers often have such a high volume of accelerometers to calibrate that they can often justify the purchase of The Modal Shop's Automated Calibration Workstation. In addition, the need for portability of the calibration device is not critical.
    - Nonetheless 30 different automotive companies are utilizing The Modal Shop's portable vibration calibrators. In some cases our calibrators are brought to the proving grounds for before and after vibration system testing on critical tests. Other applications include cold test cells.

Other Major Customer Categories

- Pharmaceutical
- Vibration Consultants
- Industrial Original Equipment Manufacturers (OEM's)
- Food Producers
- Steel & Paper Mills
- Wastewater & Water Treatment
- Aviation

THE MODAL SHOP
AN AMPHENOL COMPANY

Quote #: Q-122778

10310 Aerohub Boulevard | Cincinnati, OH | 45215 | USA | www.modalshop.com

Date: 8/26/2021
Expires On: 11/24/2021

To:
Tobias Sparmann
Purdue University
610 Purdue Mall
West Lafayette, IN 47907
US
(765) 496-0201
tsparman@purdue.edu

Local Technical Support:
Michael Orr
Phone: (888) 412-7101
Email: morr@pcb.com

To place an order, contact the factory directly at:
Phone: 800-860-4867
Fax: 513-458-2172
Email: sales@modalshop.com

The Modal Shop, Inc., is pleased to provide the following quote for your consideration. Prices quoted are for purchase.

Qty	Model	Delivery	Unit Price	Extended Net
1	9100D	3-4 WKS	USD 9,990.00	USD 9,990.00
	Portable Vibration Shaker Table: Frequency range 5 Hz to 10 kHz – max amplitude 20 g, 20 ips, 150 mils – English & metric scales – A2LA accredited +/- 3% accuracy (10 Hz to 10 kHz) – stepped sine programmable – 800 grams max payload			
			TOTAL:	USD 9,990.00

INCO terms: FCA Cincinnati, Ohio
Payment terms: Net 30
Final Destination Country: United States

Additional Notes:

- The parties expressly agree that the purchase and use of Goods and/or Services from The Modal Shop are subject to The Modal Shop, Inc. Terms and Conditions of Sale ("The Modal Shop Terms"), in effect as of the date of this Quote, which are located at: http://modalshop.com/terms, and are incorporated by reference into this Quote and any ensuing contract. A printed copy of The Modal Shop Terms will be provided upon request by emailing: Sales@modalshop.com. The Modal Shop limits acceptance of any order or contract to the Modal Shop Terms and objects to any other additional or different terms in the purchaser's purchase order or acceptance.
- Delivery dates are estimated and actual delivery will be determined upon receipt of order. Contact factory to expedite delivery.
- This Quote is valid until the expiration date set forth at the top of this Quote and is quoted in U.S. Dollars.
- These items are controlled by the U.S. Government and authorized for export only to the country of ultimate destination for use by the ultimate consignee or end-user(s) herein identified. They may not be resold, transferred, or otherwise disposed of, to any other country or to any person other than the authorized ultimate consignee or end-user(s), either in their original form or after being incorporated into other items, without first obtaining approval from the U.S. government or as otherwise authorized by U.S. law and regulations.

Sample Calibration Certificates

Accelerometer Frequency Response

~ Calibration Certificate ~

Sensor Information:

Model Number	353B04
Serial Number	123
Manufacturer	
ID Number	
Description	

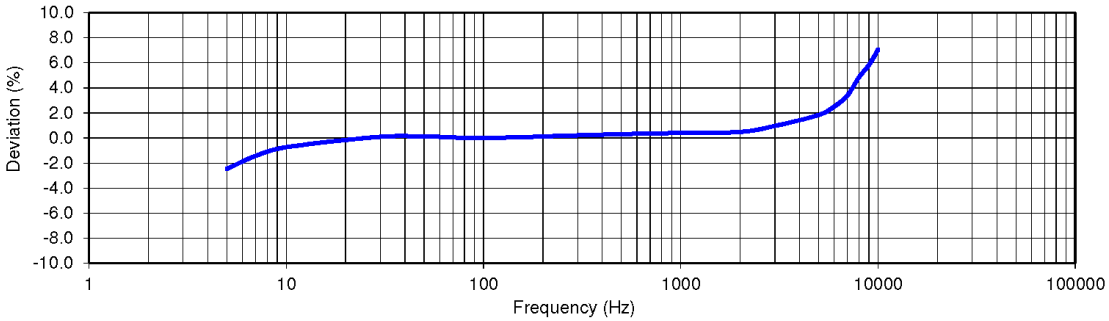
Calibration Data

Sensitivity @ 100 Hz:	9.99	mV/g
Test Level:	1.00	g pk

Transducer Specifications

Amp. Range:	g
Resolution:	g
Resonant Freq:	Hz
Temp. Range:	°C
Axis:	Z

Deviation Plot



Data Table

Frequency (Hz)	Deviation (%)
5	-2.5
7	-1.4
10	-0.7
29	0.1
50	0.1
100	0.0
500	0.3
1000	0.4
2000	0.5
3000	1.0
5000	1.8
6000	2.5
7000	3.4
8000	4.8
9000	5.8
10000	7.0

Notes

Results relate only to the items calibrated.
This certificate may not be reproduced except in full, without written permision.
Traceable to NIST (Project Number 822/271196) and PTB (Project Number 5399).
This calibration was performed with TMS 9110D Portable Vibration Calibrator: S/N: 109, Firmware version 4.1.2.
Back-to-Back Comparison per ISO 16063-21

User Notes

Customer:

Unit Condition

As Found:
As Left:

Lab Conditions

Temperature: °C
Humidity: %

Approval Information

Technician:
Approval:

Calibration Date: 4-May-15
Calibration Time: 16:46
Due Date:

Sample Calibration Certificates

Proximity Probe Dynamic Output Linearity

~ Linearity Certificate ~

Sensor Information

Model Number: 330171-00-20-05-02-00
Serial Number: JUNY449154
Manufacturer: Bently Nevada
ID Number:

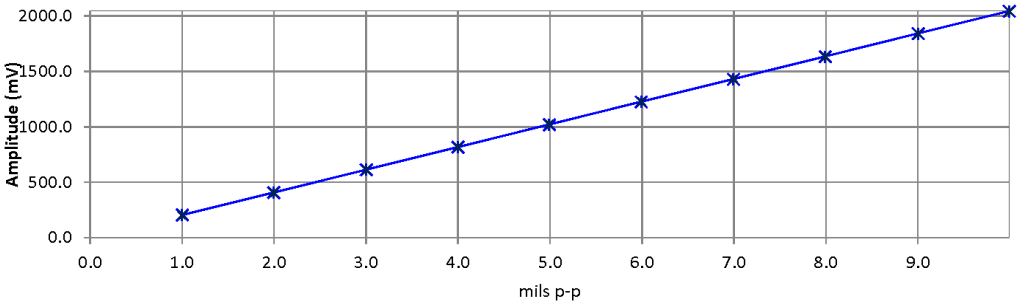
Calibration Data

Sensitivity @ Test Freq.: 204.747 mV/mil
Test Frequency 80 Hz
Linearity: 0.03 %

Transducer Specifications

Amp. Range: g
Resolution: g
Resonant Freq: Hz
Temp. Range: °C

Amplitude Linearity



Data Table

Input (mils p-p)	Output (mV)	Linearity (%)
0.9999	205.15	0.007
1.9933	408.23	-0.008
3.0003	614.36	-0.011
3.9964	818.49	-0.002
4.9902	1022.67	0.032
5.9912	1226.64	-0.016
6.9925	1431.97	0.000
7.9896	1635.98	-0.007
9.0021	1843.55	0.006
9.9922	2046.12	-0.002

Notes

Results relate only to the items calibrated.
This certificate may not be reproduced except in full, without written permision.
Traceable to NIST (Project Number 822/271196) and PTB (Project Number 5399).
This calibration was performed with TMS 9110D Portable Vibration Calibrator:
S/N: 10339, Firmware version 4.2.0.

Customer

User Notes

Calibrated with 330130-045-00-00 extension cable and 330180-50-05 proximitor.

Unit Condition

As Found: In tolerance
As Left: In tolerance

Lab Conditions

Temperature: °C
Humidity: %

Approval Information

Technician: Mike Scott
Approval: Mike Scott

Calibration Date: 16-Jul-15
Calibration Time: 10:19
Due Date:

Sample Calibration Certificates

4-20 mA Loop Vibration Transmitter Linearity

~ Linearity Certificate ~

Sensor Information

Model Number:	641B01
Serial Number:	3349
Manufacturer:	IMI
ID Number:	

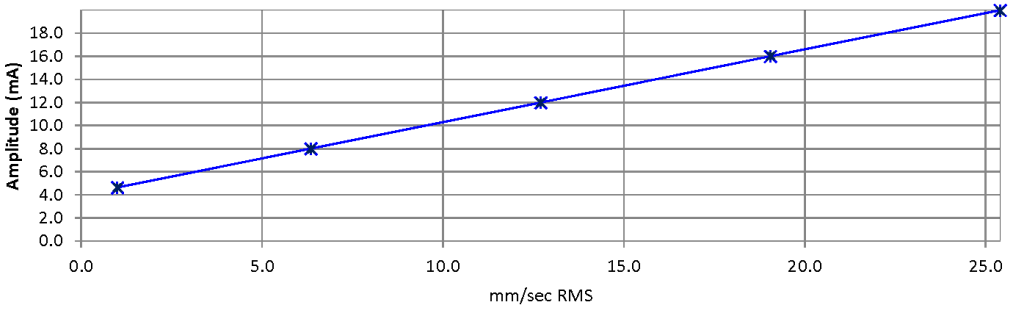
Calibration Data

Sensitivity @ Test Freq.:	0.629	mA/mm/sec
Test Frequency	3000	CPM
Linearity:	0.27	%

Transducer Specifications

Amp. Range:	g
Resolution:	g
Resonant Freq:	Hz
Temp. Range:	°C

Amplitude Linearity



Data Table

Input (mm/sec RMS)	Output (mA)	Linearity (%)
1	4.63	-0.030
6.35	7.98	-0.117
12.7	12.02	0.099
19.05	16.05	0.266
25.4	19.95	-0.219

Notes

Results relate only to the items calibrated.

This certificate may not be reproduced except in full, without written permision.

Traceable to NIST (Project Number 822/271196) and PTB (Project Number 5399).

This calibration was performed with TMS 9110D Portable Vibration Calibrator:
S/N: 10313, Firmware version 2.8.3B.

Customer

User Notes

Unit Condition

As Found: in tolerance
As Left: in tolerance

Lab Conditions

Temperature: °C

Humidity: %

Approval Information

Technician: Mike Scott
Approval: Mike Scott

Calibration Date: 11-Nov-14
Calibration Time: 12:20
Due Date:

Sample Calibration Certificates

Portable Vibration Analyzer Linearity

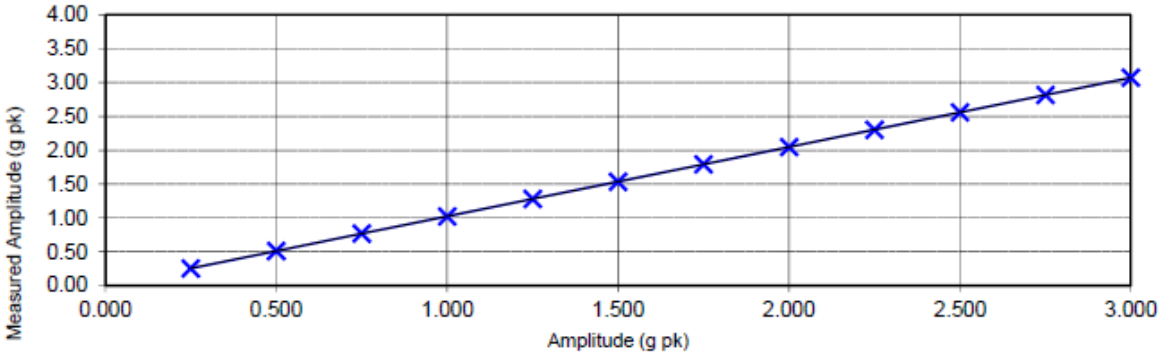
~ Vibration Analyzer Certification ~

Analyzer/Meter Information		Analyzer Settings		Linearity Test	
Manufacturer:	ABC	Analyzer mode:	Spectra	Test Frequency:	100
MN:	Vib Analyzer	Frequency Max:	1000	Frequency Unit:	Hz
SN:	1111	Min:	0	Amplitude Unit:	g pk
Cal Tech:	TMS	Unit:	Hz	Abs. Max Deviation (%):	2.53
Cal date:	5/23/2018	# of Line:	1600		
Cal due:		Averaging Points:	4		
		Window Type:	Hanning		
		Analyzer Sensor Input Sensitivity:	100 mV/EU		

Test Equipment

Description	MN	SN	Cal. Date	Sensitivity @ 100 Hz		% Tolerance	% Deviation
PVC	9110D	11051	3/5/2018	10.42	mV/g	3.00%	-0.10%
Sensor	EX603C01	LW271747	2/12/2018	98.68	mV/g	5.00%	0.32%
DMM							

Amplitude Linearity



Data Table

Input (g pk)	Measured (g pk)	% Deviation
0.250	0.256	2.40
0.500	0.512	2.40
0.750	0.769	2.53
1.000	1.024	2.40
1.250	1.281	2.48
1.500	1.536	2.40
1.750	1.790	2.29
2.000	2.047	2.35
2.250	2.304	2.40
2.500	2.557	2.28
2.750	2.813	2.29
3.000	3.070	2.33

Customer:

Note:
Traceable to NIST (Project Number 822/271196) and PTB (Project Number 5399). Piezoelectric sensor sensitivity tested by back-to-back comparison per ISO 16063-21. This certificate may not be reproduced except in full, without written permission.