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QINETIQ LTD

MOD UK NOISE AND VIBRATION SURVEYS

SHOEBURYNESS RANGE

JUNE 2016

VOLUME 2: TECHNICAL APPENDICES – DETAILED METHODOLOGY

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QINETIQ LTD
MOD UK NOISE AND VIBRATION SURVEYS
SHOEBURYNESS RANGE
VOLUME 2: TECHNICAL APPENDICES – DETAILED METHODOLOGY

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AMENDMENT HISTORY

Issue	**Status**	**Description**	**Date**
01	Final Draft	Draft Report issued to QinetiQ for comment	15/02/2016
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03	Final	Final Report	02/06/2016
04	Final	Final Report	22/06/2016

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This is Volume 2 of 3 of the MOD Shoeburyness Range Final Report. This volume should be read in conjunction with Volumes 1 and 3.

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CHAPTER 1: SITE SELECTION PROCESS

1 SITE SELECTION PROCESS

1.1 Introduction

1.1.1. Figure 1.1 below sets out a simplified depiction of the site selection process to highlight the various stages involved in finalising the preferred monitoring locations. Each stage is described in the following subsections in more detail.

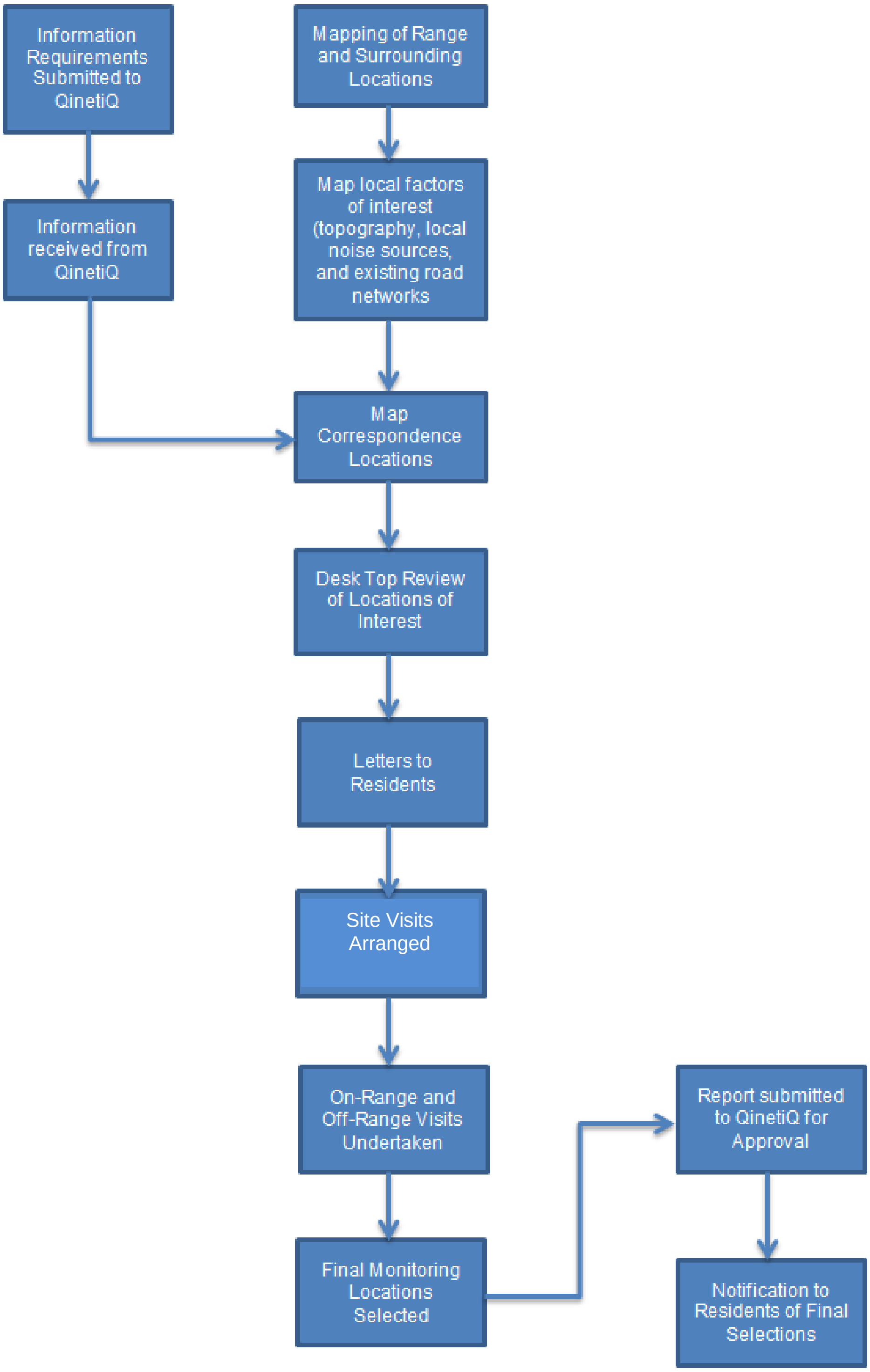


FIGURE 1.1: SITE SELECTION PROCESS

1.2 Acoustic Considerations

1.2.1. The key acoustic considerations when selecting appropriate monitoring locations are summarised below:

- land topography and type (including the effects of ground absorption, reflections, and presence of major intervening landforms);
- prevailing wind direction;
- unobstructed line of sight to Range;
- existence of other extraneous local noise sources;
- distance to Range; and
- other physical obstructions (e.g. buildings, dense vegetation / foliage, etc).

1.2.2. The preferences applied to provide a consistent approach to the siting of monitoring equipment included, where practicable:

- free-field positioning of the microphone (e.g. > 3.5m from any reflecting structure other than the ground) on the elevation of the structure nearest, and facing, the Range;
- use of enhanced windshields to reduce wind effects over the microphone;
- avoidance of shielding of microphone by nearby buildings; and
- vibration transducer sensor placement (e.g. geophone / seismometer / accelerometer array) required on the side of the building nearest to, and facing, the Range.

1.3 Non-Acoustic Considerations

1.3.1. Non-acoustic factors considered when selecting a suitable monitoring location include:

- the availability of continuous, uninterrupted 240v AC mains power supply;
- the availability of a stable internet connection, with suitable minimum bandwidth, and suitable upload and download speeds;
- the siting of equipment to avoid electrical interference from other electrical equipment;
- minimum space available for the installation of the equipment housing and microphone mounting poles;
- obtaining permission from the property owners to install associated equipment mounting accessories;
- provision of safe cable runs between the sound pressure and vibration monitoring equipment, the mains power and internet connection point;
- ensuring the sound pressure and vibration monitoring equipment can be located in a secure location to avoid tampering;

- specific preferences of the occupants of the buildings;
- any potential access restriction a site may have; and
- health and safety hazard which may affect installing and accessing the equipment for maintenance purposes.

1.3.2. Having regard for the considerations set out above, a detailed site selection process was undertaken, to identify suitable monitoring locations for the study. The process included the following stages:

- Review of received information from QinetiQ;
- Desktop study;
- Letters to residents;
- Site suitability walkovers; and
- Selection of monitoring locations.

1.4 Information from Range Operators

1.4.1. Potential locations of interest were presented in ‘Shoeburyness Noise and Vibration Monitoring Study (NVMS) - System Requirements Document (SRD) [1] produced on behalf of the MOD by QinetiQ. Identified as Category A locations, these provided an early indication of the candidate properties in the vicinity of the Range.

1.5 Desktop Study

1.5.1. An initial detailed desktop study was undertaken to identify potential locations of interest. The area was mapped electronically using a series of relevant overlays which enabled an accurate overview of the Range and surrounding areas. The mapping allowed for consideration of important information including topographical features, community areas, building density and major and minor road networks.

1.5.2. The Category A locations of interest were then overlaid, along with the specific properties taken from the correspondence register.

1.5.3. A map showing the physical topography of the Shoeburyness area, along with the community areas and other locations of interest is presented in Figure 1.2 below.

1.5.4. The mapping, in conjunction with satellite photography available from internet resources, was used to consider each location of interest and identify, where possible, the following information:

- property type;
- existence of garage/outbuildings;
- indication of likely building construction;
- proximity to the Range;
- description of the immediate area; and
- initial identification of likely local ambient noise sources.

1.5.5. Figure 1.3 presents mapping showing the local road network and other likely local ambient noise sources.

1.5.6. The desktop study was used to generate an initial sifted list of residential properties for further consideration.

1.6 Letter to Residents

1.6.1. Following the desk top study, personalised letters were sent to residents whose properties represented potential monitoring locations of interest. The letter included a registration form to enable residents to register their interest in participating in the study ahead of a planned site walkover visit.

1.6.2. A list of Frequently Asked Questions (FAQ's) was compiled and was included with the letters to provide residents with further information on the study and the terms of their potential involvement.

1.6.3. A copy of the letter template, the registration form and the FAQ sheet are presented in Figures 1.4, 1.5 and 1.6 respectively.

1.6.4. Twenty-seven letters were submitted, with nineteen responses received, two of which declined an offer of a site visit and four responses arrived after the site walkover had been completed. These responses were collated and contact was made with residents to arrange suitable times to visit during the site walkover.

1.6.5. A map highlighting the locations of the residents who responded to the letters is presented in Figure 1.7.

1.7 Site Suitability Walkovers – Shoeburyness Range (On-Range)

1.7.1. A full on-Range walkover of the Shoeburyness Range was undertaken on Monday 31st March 2014. Following a site induction and introduction to the main staff areas, including Range control, visits were made to individual test sites set out across the Range.

1.7.2. The purpose of the Range walkover was to determine suitable locations for the on-Range monitoring equipment. Monitoring equipment installed on-Range was to be configured to operate as control monitors, to be used both to confirm on-Range activity and send triggering commands to the off-Range monitors to ensure Range activities were captured off-Range, in the far-field. Three, on-Range 'master' control monitor locations were identified:

- DAT control building located north of the Range on Foulness Island;
- Rugwood control building also located on Foulness Island; and
- Q Battery (BTY) control building located towards the south of the Range.

1.8 Site Suitability Walkovers – Off-Range Surveys

1.8.1. A total of 13 off-Range properties were visited by Southdowns on 31st March, 1st and 2nd of April 2014. The locations are presented in Figure 1.8 and summarised in Table 1.2 overleaf.

Southdowns Mapping ID	Property Area	Property Type
CRS1	Bradwell-on-Sea, Essex	Residential detached house
CRS5	Mersea, Island, Essex	Residential detached bungalow
CRS6_CC	St Osyth, Essex	Residential detached bungalow
CRS7	Alresford, Essex	Residential detached cottage
CRS8	Lee-over-Sands, Essex	Residential detached bungalow
CR11_CC	Holland-on-Sea, Essex	Residential detached house
CR13_CC	, Minster-on-Sea, Kent	Residential detached house
CR24_H	Herne Bay, Kent	Residential semi-detached house
CR18_CC	Jaywick, Essex	Residential maisonette
CR21	Jaywick, Essex	Residential detached bungalow
CR22_H	Seasalter,Kent	Residential detached house
CR23_H	Whitstable	Residential detached house
CR25_H	Island Wall, Kent	Residential terraced townhouse

TABLE 1.1: OFF-RANGE PROPERTIES VISITED BY SOUTHDOWNS

1.8.2. For each location, a detailed site suitability survey sheet was completed. The survey sheets were used to collate both the acoustic and non-acoustic information. This information was entered into a site suitability selection matrix and used to make the final location selections.

1.9 Selected Monitoring Locations

1.9.1. The final monitoring locations are presented in Table 1.2 and presented in Figure 1.9.

Mapping Ref. (Southdowns)	Monitoring Station ID	Area /Region
DAT	SHB_R1_DAT	On-Range, DAT Control Building
RUG	SHB_R2_RUG	On-Range, Rugwood Control Building
Q BTY	SHB_R3_BAT	On-Range, Q Battery Control Building
CR11	SHB_OS1	Holland-On-Sea
CR18	SHB_OS2	Jaywick
ADD_SHB01	SHB_OS3	Southminster
CR8	SHB_OS4	Lee-over-Sands
CR5	SHB_OS5	Mersea Island
RANGE CONTROL	SHB_OS6	On-Range, Range Control Building (nr Great Wakering)
CR13	SHB_OS7	Isle of Sheppey
CR22	SHB_OS8	Seasalter
CR16	SHB_OS9	Herne Bay
CR24	SHB_OS10	Birchington

TABLE 1.2: MONITORING LOCATIONS

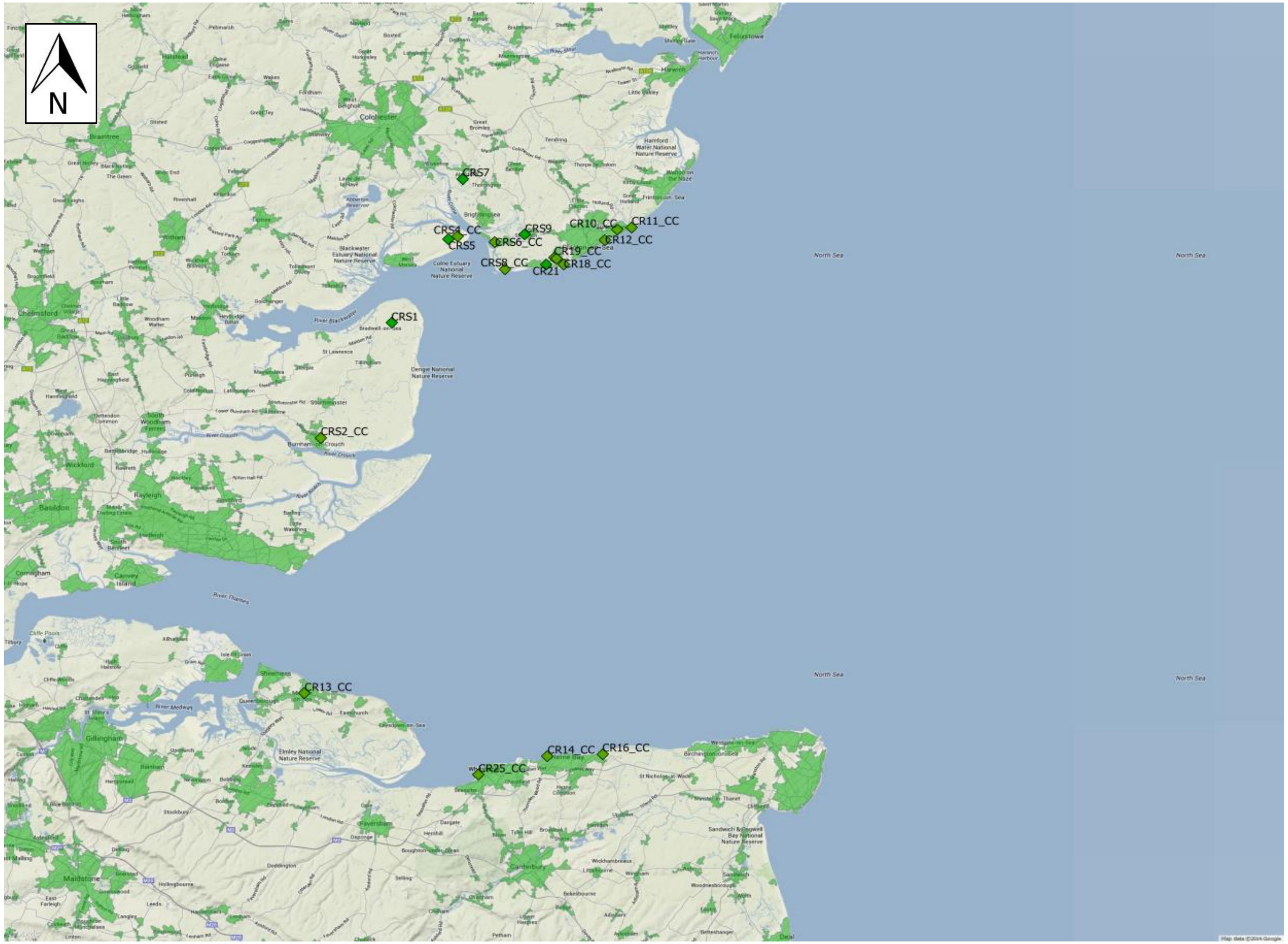


FIGURE 1.2: MAPPING SHOWING TOPOGRAPHY, LOCATIONS OF INTEREST AND COMMUNITY AREAS IN THE VICINITY OF SHOEBURYNESS RANGE

By Letter

PRIVATE AND CONFIDENTIAL

Mr/Mrs xxx
Address Line 1
Address Line 2
Postcode

Date XXXX 2014 Our Reference: 1897m-SEC-00027-0x

Dear xxx

Subject: Noise and Vibration Monitoring Study
MOD Shoeburyness Range

Southdowns Environmental Consultants Ltd (Southdowns) has been appointed to undertake a noise and vibration monitoring study around the Ministry of Defence (MOD) Range at Shoeburyness.

QinetiQ Ltd, which operates the Range at Shoeburyness on behalf of the UK Ministry of Defence (MOD), has commissioned an independent study to determine the noise and vibration effects of Test, Evaluation, Demilitarisation and Training Support activities which are carried out on the Range.

Southdowns is an independent noise and vibration consultancy, established in January 1996. As a corporate member of the Association of Noise Consultants, our experts are affiliated with professional bodies including the Institute of Acoustics and the Chartered Institute of Environmental Health. For further information about our company, please visit our website www.southdowns.eu.com.

The Noise and Vibration study will require continuous monitoring of noise and vibration at multiple locations of interest in the vicinity of the Range. Following the completion of a desktop study, we have identified your property as a potential location of interest for the study and would like to discuss with you the possibility of installing a monitoring system at your property.

Typically, such a system would be installed externally. The monitoring duration would be between six and nine months, commencing in early 2015. You would not be required to operate or maintain the equipment, although access to an electricity supply and internet connection would be required, for which you would receive financial compensation to cover usage costs.

Should you wish to assist with the study and are willing to allow a monitoring system to be installed at your property, please complete the enclosed form and return it in the pre-paid reply envelope by Friday 21st March 2014. The preferred sites will then be shortlisted and we will contact you to discuss further. We enclose a Frequently Asked Questions (FAQ) sheet which I hope you will find useful.

I look forward to hearing from you.

Yours sincerely

For Southdowns Environmental Consultants Ltd

Richard Fenton BSc (Hons), MSc, MCIEH, MIOA
Senior Consultant
Telephone: 01273 488186/ Email: rjf@southdowns.eu.com

FIGURE 1.4: SAMPLE LETTER TO RESIDENTS

Noise and Vibration Monitoring Study – Shoeburyness

Registration Form for Participants

Name:		Contact telephone number:	
Address:			

Contact email address:		Tenancy status (e.g. owner, rented):	
Alternative contact name & details:		Landlord contact details (if applicable):	

Property type (bungalow, terraced, detached):		No. of floors:	
Garage/Outbuildings with power supply:	Yes / No	Secure garden area:	Yes / No

Internet provider (if known):		Type: (if known)	Fibre / ADSL
Router type (if known):		Location of router in property:	

FIGURE 1.5: SAMPLE REGISTRATION FORM

MOD Shoeburyness Noise & Vibration Study

Frequently Asked Questions

1. **Why is this Study being carried out?**

   There is a public perception that some activities at the Ministry of Defence (MOD) Shoeburyness (the Range) produce noise and vibration that may be damaging to property. The Study is being carried out to address concerns raised by communities surrounding the Range.

2. **Why has the Study taken so long to get underway?**

   As a Defence contractor, QinetiQ has to abide by Government contracting policies that ensure value for money for the taxpayer when inviting bids and placing a contract.

3. **Who has arranged this Study and who is paying for it?**

   QinetiQ, as operator and manager of the site, has contracted Southdowns Environmental Consultants Ltd (Southdowns) but the Study itself is being paid for by the MOD.

4. **If I have a noise and / or vibration complaint during the study, whom should I contact?**

   Any concerns or complaints regarding range activity should continue to be directed to QinetiQ who operate the range on behalf of the MOD on the Freephone Careline 0800 092 1345 or by email at QQSHBEnquiries@qinetiq.com.

5. **What is the Study measuring?**

   The Study will measure what, if any, effect noise and vibration emanating from the Range has on property and whether this has the potential to cause damage.

6. **When will the Study start?**

   The Study is scheduled to start early 2015.

7. **How long will the Study last?**

   The Study will last for approximately six months, to cover a representative selection of the work undertaken on the Range, across a representative selection of meteorological (and therefore acoustic) conditions.

8. **Will the monitors be switched on all the time?**

   Yes. The monitors require a continuous 240v power supply and will remain switched on at all times during the Study.

Ctd.

Ctd.

9. Will the monitors record my conversations?

The monitors will be configured to continuously collect numerical noise level and vibration data. However, in the event of a central trigger signal being generated by activity on the Range, the monitors will also capture the measured sound and vibration waveforms for a short duration (up to approximately 10 seconds). This information is needed to allow further technical analysis after the Range event has finished. If the waveforms contain any extraneous contribution as a result of domestic activity in the vicinity of the microphone they will automatically be discarded from further consideration in any case.

10. Why have you chosen my property?

Following a desktop study of data supplied by QinetiQ and examination of local conditions, your property has been identified as a potential monitoring location.

11. Will I get paid for my help?

Access to an electricity supply and internet connection will be required, for which Southdowns will make a small payment to cover the direct costs as a goodwill gesture.

12. When will the findings of the Study be made available to the Public?

Following the Study, there will be a period of data analysis. It is too early to say how long this will take, but the findings will be made available as soon as practicably possible after the end of the Study.

13. What will happen if the Study proves that the noise and vibration is damaging property?

The MOD, as owner of the site, will be responsible for any subsequent action if the Study concludes that damage is being caused to property as a result of Range activity.

14. If I agree to help, what is the next step?

If you are agreeable to a monitor being placed on your property, please contact Southdowns on 01273 488186 or by email at rjf@southdowns.eu.com to discuss further. Preferred candidate locations will then be shortlisted and contact will be made to arrange a suitable date to visit those properties and undertake a more detailed survey. Only after completion of this exercise can a decision on final monitoring locations be made. This site visit will also provide an opportunity to discuss in more detail any other queries or concerns which may arise.

- END –

FIGURE 1.6: FREQUENTLY ASKED QUESTIONS

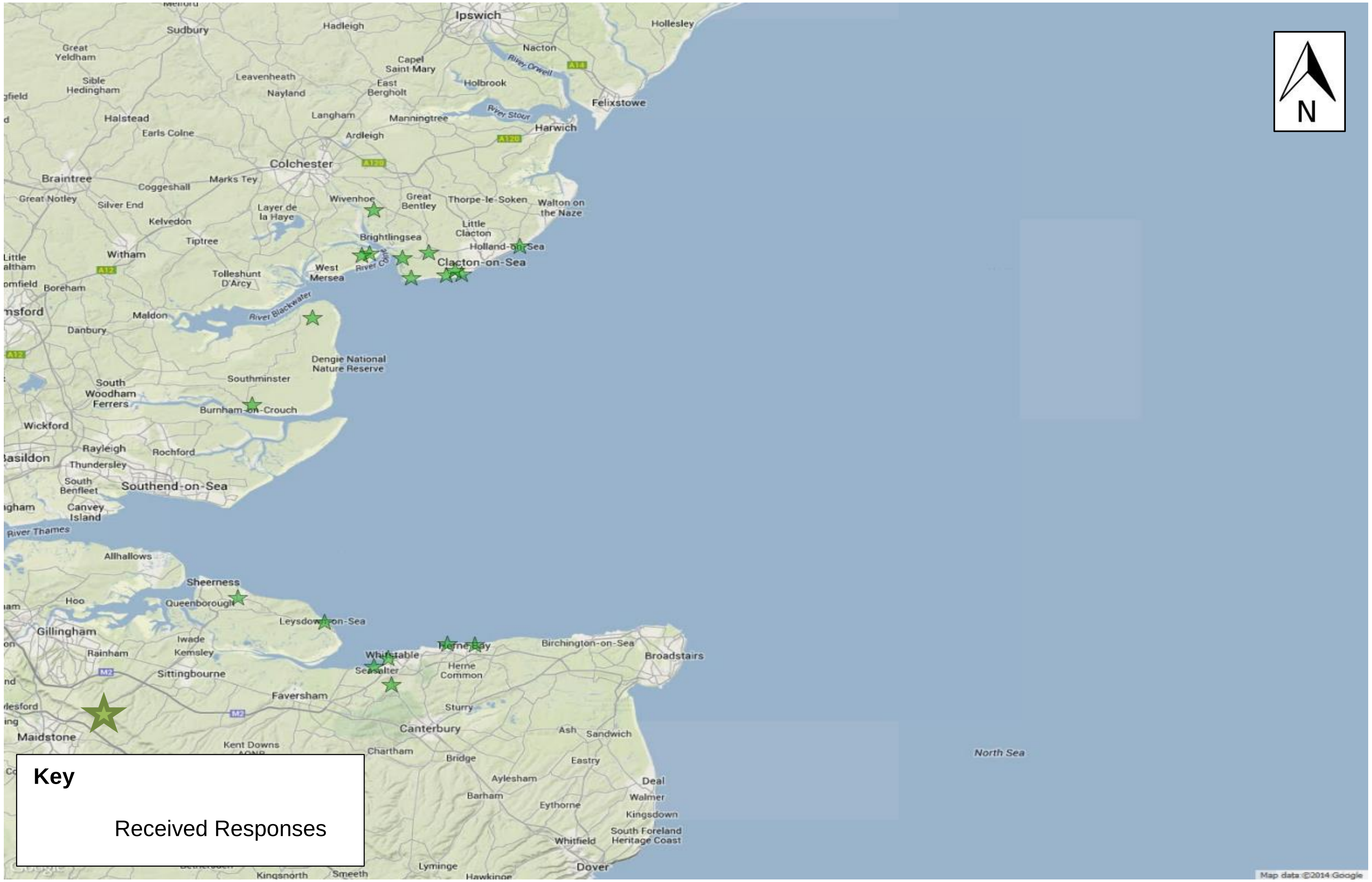


FIGURE 1.7: LOCATIONS OF RESIDENT RESPONSES

FIGURE 1.8: VISITED PROPERTIES

FIGURE 1.9: MONITORING LOCATIONS

VOLUME 2: TECHNICAL APPENDICES – DETAILED METHODOLOGY
CHAPTER 2: MONITORING METHODOLOGY

2 MONITORING METHODOLOGY

2.1 Samurai Noise and Vibration Monitoring System

2.1.1. Each monitoring station included:

- SINUS Swing 4-channel noise and vibration monitoring station; and
- Uninterruptible Power Supply (UPS) system (up to 48 hours of power backup).

2.1.2. Instrumentation connected to the SINUS noise and vibration monitoring station include:

- G.R.A.S. 41CN Outdoor Microphone System;
- SINUS tri-axial geophone;
- Garmin Global Positioning System (GPS) receiver; and
- Thies Clima Sensor (selected monitoring locations).

2.1.3. Services requirements for each monitoring station comprised of a 220 – 240 AC continuous power supply and hardwired broadband internet connection, including Fixed Internet Protocol (Fixed I.P.).

2.1.4. Dedicated third party desktop control software was installed on each monitoring station which allowed remote connection to each of the monitoring stations to change system settings and monitoring parameters as required.

2.2 Measurement Parameters - Sound / Air Overpressure

2.2.1. The monitoring systems were configured to measure:

- uncompressed instantaneous time and frequency weighted levels, at 125 msec sampling intervals, in the frequency range 0.5 Hz to 20 kHz;
- maximum microphone input sound pressure level of 156 dB re. 20 µPa (on-Range monitors);
- simultaneous measurement of A, C and Z frequency weighted levels;
- simultaneous measurement of Fast, Slow and Impulse time weighted levels;
- simultaneous L_{max}, L_{eq}, L_{peak} measurements for all frequency weightings;
- user defined measurement intervals;
- third-octave band measurements (in accordance with IEC 61260 Class 0);
- third-octave band middle frequencies from 0.04 Hz to 20 kHz;
- uncompressed raw waveform capture (event triggered or continuous) for subsequent analysis of stored signals. Sample rate 51200 Hz, 32bit and effective 21kHz bandwidth.

2.2.2. Field calibration checks of each sound / air overpressure measurement system installed (including extension cables and adaptors) were undertaken at the start (during installation), at 3 months, and at the end (during decommissioning) of the monitoring study. Field calibration checks were undertaken using a Rion NC-74, Class 1 (IEC 60942) Acoustic Calibrator fitted with a G.R.A.S RA0041 Sound Calibrator adaptor to generate a calibration level of 92.6 dB at 1 kHz.

2.2.3. In addition, the G.R.A.S 41CN outdoor microphone system is equipped with a built-in electrostatic actuator and test oscillator to enable precise in-situ calibration checks at 1000 Hz.

2.2.4. Each monitoring station was configured to perform in-situ electrostatic calibration checks via the built-in electrostatic actuator at 12 hour intervals throughout the monitoring study.

2.3 Measurement Parameters - Vibration

2.3.1. The monitoring systems were configured to measure:

- continuous maximum component Peak Particle Velocity (PPV);
- frequency range 0.5 Hz to 315 Hz (PPV), and 0.2 Hz to 700 Hz (acceleration);
- third-octave band measurements; and
- uncompressed raw waveform capture (event triggered or continuous) for subsequent analysis of stored signals). Sample rate 6400 Hz, 32bit.

2.4 Meteorological Stations

2.4.1. Wind strength and direction can have a dramatic effect on sound pressure levels received at receptors over longer distances. Temperature inversions also need consideration as sound can travel over greater distances when ground temperatures cool relative to atmospheric temperatures leading to the refraction of sound waves back towards the ground.

2.4.2. Meteorological data were acquired using Thies Clima Sensor US (Ultrasonic) sensors. Monitoring stations with meteorological sensors attached are shown on Figure 2.1. Where installed, the meteorological stations were configured to measure the following parameters:

- wind velocity;
- wind direction;
- air temperature;
- relative air humidity;
- barometric pressure;
- precipitation; and
- precipitation intensity.

2.4.3. Monitoring locations were grouped into five zones allowing a single meteorological station to provide representative data for the zone.

2.4.4. The zones are presented in Figure 2.1 below, and further details presented in Table 2.1

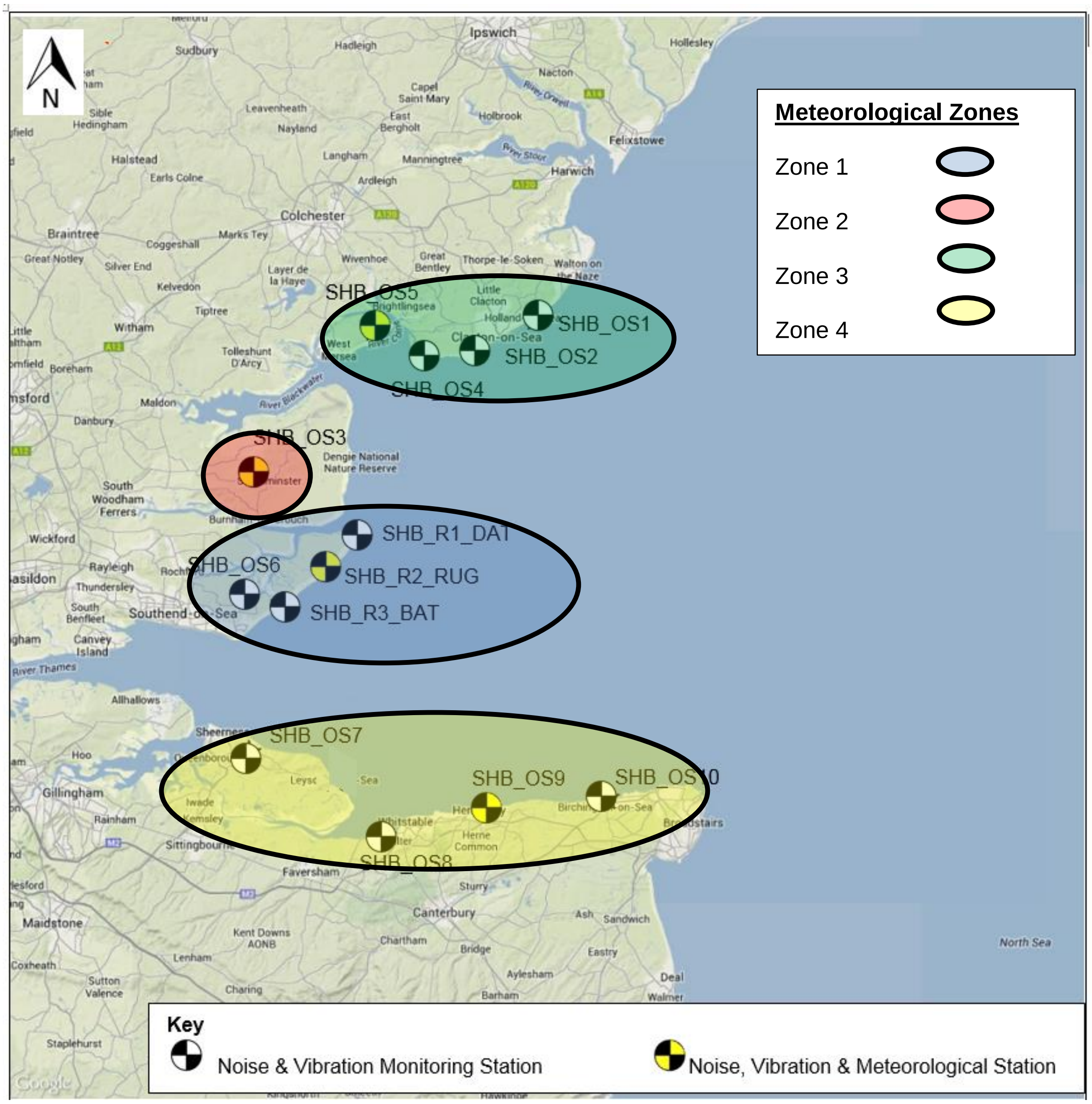


FIGURE 2.1: ZONES DEFINED FOR METEOROLOGICAL STATIONS

Monitoring Location I.D.	Zone	Expected Worse Case Wind Direction [1]	Approx. Distance to Range (km)	Representative Meteorological Station
SHB_OS1	Zone 3	SW	32	SHB_OS5
SHB_OS2	Zone 3	SW	26	SHB_OS5
SHB_OS3	Zone 2	SE	10	SHB_OS3
SHB_OS4	Zone 3	SW	23	SHB_OS5
SHB_OS5	Zone 3	SW	24	SHB_OS5
SHB_OS6	Zone 1	E	7	SHB_R2_RUG
SHB_OS7	Zone 4	NE	19	SHB_OS9
SHB_OS8	Zone 4	N	27	SHB_OS9
SHB_OS9	Zone 4	NW	29	SHB_OS9
SHB_OS10	Zone 4	NW	35	SHB_OS9

TABLE 2.1: OFF-RANGE MONITORING LOCATION ZONING CATEGORIES

Note:

[1] Represents wind direction which would result in positive wind vector at each off-Range monitoring location.

2.5 Equipment Installations

2.5.1. Prior to the equipment installations, successful commissioning of each monitoring station was undertaken.

2.5.2. During the installations, on-site acceptance testing of various system component functions were tested, including:

- acoustic calibration check of measurement system;
- built in electrostatic check of measurement system;
- UPS operation and mains failure notification;
- triggering functions; and
- sensor failure.

2.5.3. For each equipment installation location, an Equipment Installation Record (EIR) was completed, detailing:

- equipment serial numbers;
- installation date;
- monitoring start date;
- location of equipment (including co-ordinates);
- estimated straight-line distance to Pendine Range;
- field calibration check details (performed at the start, during and end of monitoring period);
- on-site acceptance testing results; and
- photographic evidence of installation.

2.5.4. Full copies of the installation records are presented in section 2.6.

2.5.5. Before any equipment installation works started, detailed Risk Assessment Method Statements (RAMS) were prepared by Southdowns and submitted to the QinetiQ project team for approval.

2.5.6. Throughout the monitoring study, daily checks for each monitoring station and central data management systems were performed, including:

- ensuring station(s) were on-line;
- ensuring off-Range monitors were receiving trigger commands from the Range monitors;
- successful built-in electrostatic calibration checks complete;
- successful data transfer from monitoring station(s) to central data server; and
- successful back up of central data server (physical and cloud backups).

2.6 Installation Records

2.6.1. Installation records are presented in full in Tables 2.2 – 2.14.

SHB-R1-DAT Shoeburyness Range, DAT Control Building

SWING Serial No:	#0010025	**Microphone Type & Serial No:**	G.R.A.S 41CN 214166	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 0504082
Installation Date:	24/04/2015	**Last Microphone Field Calibration:**	24/04/2015	**Monitoring Start Date:**	28/06/2015
Unit Powered:	240v domestic	**Fitted With UPS backup:**	Yes	**Weather Station:**	None
Location of Equipment Cabinet:	On desk of spare control room building on 1st floor.	**Location of Microphone:**	Fixed to steel handrail surrounding roof of 1st floor of control building.	**Location of Transducer:**	Fixed to slab of buildings concrete foundations (externally)
Estimated Distance from Range (Central) [km]		n/a	**Co-ordinates**	51°37'4.43"N 0°56'53.64"E	
Master / Slave Monitor	Master	**Trigger Threshold:**	75.0 dB(A)	**Installation Undertaken by:**	IJA & ASW

Field Calibration Details			
Time : Date:	10:38:00 24/04/2015	**Calibrator Make:**	Rion NC-74 s/n 34546634 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.00537007 V/Pa	0.00537064 V/Pa	0.00536879 V/Pa
Used Sensitivity:	0.00485355 V/Pa	0.00537007 V/Pa	0.00537064 V/Pa
New Calibration Level:	93.48 dB	92.60 dB	92.60 dB

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:	Field Calibration Check 'passed' but system did not create / update calibration logs with details.		
Notes	None		

Field Calibration Check Details – 3 Month Interval			
Time : Date:	2015.09.28 16:10:14	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0587136 V/Pa	0.00475607 V/Pa	0.00476513 V/Pa
Used Sensitivity:	0.057515 V/Pa	0.00595645 V/Pa	0.00475607 V/Pa
New Calibration Level:	92.78 dB	90.65 dB	92.62 dB

Field Calibration Check Details – Study End				
Time : Date:		**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60	0.0050456	0.00503597	92.62

TABLE 2.2: SHB-R1-DAT SHOEBURYNESS RANGE, DAT CONTROL BUILDING

SHB-R2-RUG: Shoeburyness Range, Rugwood Control Building

SWING Serial No:	#0010024	**Microphone Type & Serial No:**	G.R.A.S 41CN 177434	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 0503949
Installation Date:	18/05/2015	**Last Microphone Field Calibration:**	18/05/2015	**Monitoring Start Date:**	28/06/2015
Unit Powered:	240v domestic	**Fitted With UPS backup:**	Yes	**Weather Station:**	Clima Sensor US s/n 8140258
Location of Equipment Cabinet:	On desk of spare control room building on 1st floor.	**Location of Microphone:**	Fixed to external handrail with scaffold clamps.	**Location of Transducer:**	Fixed to Plaster of Paris Patch using Epoxy Resin. Free-field monitoring location. X-axis perpendicular with northern façade.
Estimated Distance from Range (Central) [km]		n/a	**Co-ordinates**	51°35'2.10"N 0°54'30.86"E	
Master / Slave Monitor	Master	**Trigger Threshold:**	75.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:					

Field Calibration Details				
Time : Date:	2015.05.18 17:28:47	**Calibrator Make:**	Rion NC-74 s/n 34546634 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**		**Cal #3**
Reference Value:	92.60 dB	92.60		92.60
New Sensitivity:	0.00530567	0.00509939		0.00510432
Used Sensitivity:	0.00510385	0.00510385		0.00509939
New Calibration Level:	92.26	92.59		92.61

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval				
Time : Date:	2015.09.29 11:40:58	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**		**Cal #3**
Reference Value:	92.60 dB	92.60 dB		92.60 dB
New Sensitivity:	0.00493205V/Pa	0.00493033V/Pa		0.00492082V/Pa
Used Sensitivity:	0.00493033V/Pa	0.00492082V/Pa		0.00510432V/Pa
New Calibration Level:	92.60 dB	92.62 dB		92.28 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.01.25	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.00502652V/Pa	0.00502577V/Pa	92.60 dB

TABLE 2.3: SHB-R2-RUG SHOEBURYNESS RANGE, RUGWOOD CONTROL BUILDING

SHB-R3-BAT: Shoeburyness Range, Q Battery Control Building

SWING Serial No:	#0010030	**Microphone Type & Serial No:**	G.R.A.S 41CN 177432	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504071
Installation Date:	24/04/2015	**Last Microphone Field Calibration:**	24/04/2015	**Monitoring Start Date:**	28/06/2015
Unit Powered:	240v domestic	**Fitted With UPS backup:**	Yes	**Weather Station:**	None
Location of Equipment Cabinet:	Internal within Q Battery Control Building	**Location of Microphone:**	Fixed to external brickwork of Q Battery Control Building. Microphone elevated c. 4.5m above local ground, Free-Field.	**Location of Transducer:**	Fixed to concrete foundation slab of Q Battery Control Building (southern façade) using Epoxy Resin
Estimated Distance from Range (Central) [km]		**n/a**	**Co-ordinates**	51°33'14.52"N 0°50'53.91"E	
Master / Slave Monitor	Master	**Trigger Threshold:**	75.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:					

Field Calibration Details			
Time : Date:	09:55:00 24/04/2015	**Calibrator Make:**	Rion NC-74 s/n 34546634 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60	92.60	92.60
New Sensitivity:	0.00503597	0.0050456	0.00504877
Used Sensitivity:	0.00536209	0.00503597	0.0050456
New Calibration Level:	92.05	92.62	92.61

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval			
Time : Date:	2015.09.29 10:36:24	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.00504502 V/Pa	0.00504632 V/Pa	0.00503763 V/Pa
Used Sensitivity:	0.00504877 V/Pa	0.00504502 V/Pa	0.00504632 V/Pa
New Calibration Level:	92.59 dB	92.60 dB	92.59 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.02.10 16:33:38	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0053756 V/Pa	0.00503891 V/Pa	93.16 dB

TABLE 2.4: SHB-R3-BAT SHOEBURYNESS RANGE, Q BATTERY CONTROL BUILDING

SHB_OS1: Holland-On-Sea, CO15

SWING Serial No:	#0010027	**Microphone Type & Serial No:**	G.R.A.S 41CN 218137	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504083
Installation Date:	20/05/2015	**Last Microphone Field Calibration:**	20/05/2015	**Monitoring Start Date:**	28/06/2015
Unit Powered:	240v domestic (garage)	**Fitted With UPS backup:**	Yes	**Weather Station:**	N/A
Location of Equipment Cabinet:	Located on external balcony on Southern façade of property.	**Location of Microphone:**	Fixed to external balcony on Southern façade of property with scaffold clamps.	**Location of Transducer:**	Located on West of property on paving slab. No safe or appropriate alternative was available.
Estimated Distance from Range (Central) [km]		32			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:	No alternative location for the transducer could be established.				

Field Calibration Details

Time : Date:	Tue 20/05/2015	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0537687V/Pa	0.0495027V/Pa	0.0495027 V/Pa
Used Sensitivity:	0.0537687V/Pa	0.0537687V/Pa	0.0495027V/Pa
New Calibration Level:	91.91 dB	92.57 dB	92.60 dB

On-Site Acceptance Testing

Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:	None		

Field Calibration Check Details – 3 Month Interval

Time : Date:	2015.09.22 12:37:34	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0492262 V/Pa	0.0492649 V/Pa	0.0493499 V/Pa
Used Sensitivity:	0.0495251 V/Pa	0.0492262 V/Pa	0.0492649 V/Pa
New Calibration Level:	92.55 dB	92.61 dB	92.61 dB

Field Calibration Check Details – Study End

Time : Date:	2016.01.26 11:32:25	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0510099 V/Pa	0.0493499 V/Pa	92.89 dB

TABLE 2.5: SHB_OS1: HOLLAND-ON-SEA, C015

SHB_OS2: Jaywick, CO16

SWING Serial No:	#0010026	**Microphone Type & Serial No:**	G.R.A.S 41CN 214167	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504078
Installation Date:	19/05/2015	**Last Microphone Field Calibration:**	19/05/2015	**Monitoring Start Date:**	28/06/2015
Unit Powered:	240v domestic (outdoor socket)	**Fitted With UPS backup:**	Yes	**Weather Station:**	None
Location of Equipment Cabinet:	Located in shed on southern façade of property.	**Location of Microphone:**	Rear Garden (Southern façade) free-field location. Microphone elevated c. 2.5m above local ground.	**Location of Transducer:**	Fixed to concrete foundation slab of property (southern façade) using Epoxy Resin.
Estimated Distance from Range (Central) [km]		26			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:					

Field Calibration Details				
Time : Date:	Tue 19/05/2015 17:22	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**		**Cal #3**
Reference Value:	92.60 dB	92.60 dB		92.60 dB
New Sensitivity:	0.0536327 V/Pa	0.0501098 V/Pa		0.0501068 V/Pa
Used Sensitivity:	0.053629 V/Pa	0.0536327 V/Pa		0.0501098 V/Pa
New Calibration Level:	92.60	92.01 dB		92.60dB

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval				
Time : Date:	2015.09.29 17:29:42	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**		**Cal #3**
Reference Value:	92.60 dB	92.60 dB		92.60 dB
New Sensitivity:	0.0494749 V/Pa	0.0495437 V/Pa		0.0495923 V/Pa
Used Sensitivity:	0.0501068 V/Pa	0.0494749 V/Pa		0.0495437 V/Pa
New Calibration Level:	92.49 dB	92.61 dB		92.61 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.01.26 15:27:18	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.051438 V/Pa	0.0495923 V/Pa	92.92 dB

TABLE 2.6: SHB_OS2: JAYWICK, C016

SHB_OS3: Southminster, Essex, CM0

SWING Serial No:	#0010037	**Microphone Type & Serial No:**	G.R.A.S 41CN 214165	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504079
Installation Date:	08/07/2015	**Last Microphone Field Calibration:**	08/07/2015	**Monitoring Start Date:**	08/07/2015
Unit Powered:	240v domestic	**Fitted With UPS backup:**	Yes	**Weather Station:**	None.
Location of Equipment Cabinet:	Inside office	**Location of Microphone:**	Fixed to external gate post off northern façade of property.	**Location of Transducer:**	Glued to foundation slab of property on South facing façade
Estimated Distance from Range (Central) [km]		10			
Master / Slave Monitor	Slave	**Trigger Threshold:**	75.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:					

Field Calibration Details			
Time : Date:	08/07/2015	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0502458 V/Pa	0.0502256 V/Pa	0.0502290 V/Pa
Used Sensitivity:	0.0500400 V/Pa	0.0502458 V/Pa	0.0502256 V/Pa
New Calibration Level:	92.64 dB	92.60 dB	92.60 dB

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:	Install date relates to commissioning date. Hardware installed prior to commissioning of unit.		

Field Calibration Check Details – 3 Month Interval			
Time : Date:	2015.09.29 15:40:17	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0510852 V/Pa	0.0510875 V/Pa	0.0511356 V/Pa
Used Sensitivity:	0.050229 V/Pa	0.0510852 V/Pa	0.0510875 V/Pa
New Calibration Level:	92.75 dB	92.60 dB	92.61 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.01.25 14:22:00	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0520652 V/Pa	0.0511356 V/Pa	92.76 dB

TABLE 2.7: SHB_OS3: SOUTHMINSTER, CM0

SHB_0S4: Lee-over-Sands, CO16

SWING Serial No:	#0010023	**Microphone Type & Serial No:**	G.R.A.S 41CN 218142	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor #0504077
Installation Date:	10/07/2015	**Last Microphone Field Calibration:**	10/07/2015	**Monitoring Start Date:**	28/06/2015
Unit Powered:	240v domestic	**Fitted With UPS backup:**	Yes	**Weather Station:**	Clima Sensor US [s/n to be confirmed]
Location of Equipment Cabinet:	Outside south facing façade of property	**Location of Microphone:**	Free field position on approx. 3 m from south façade of property.	**Location of Transducer:**	Glued to foundation slab of property on South facing façade.
Estimated Distance from Range (Central) [km]		24			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:					

Field Calibration Details			
Time : Date:		**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60dB	92.60dB	92.60dB
New Sensitivity:	0.0488529 V/Pa	0.0493081 V/Pa	0.0492747 V/Pa
Used Sensitivity:	0.0424075 V/Pa	0.0488529 V/Pa	0.0493081 V/Pa
New Calibration Level:	93.83dB	92.68dB	92.59dB

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval			
Time : Date:	2015.10.13 12:25:03	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0493051 V/Pa	0.049346 V/Pa	0.0493651 V/Pa
Used Sensitivity:	0.0492747 V/Pa	0.0493051 V/Pa	0.049346 V/Pa
New Calibration Level:	92.61 dB	92.61 dB	92.60 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.01.26 13:25:11	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0513691 V/Pa	0.0493651 V/Pa	92.95 dB

TABLE 2.8: SHB_OS4: LEE-OVER-SANDS, C016:

SHB_OS5 :Mersea Island, CO5

SWING Serial No:	#0010033	**Microphone Type & Serial No:**	G.R.A.S 41CN 218135	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504081
Installation Date:	19/05/2015	**Last Microphone Field Calibration:**	09/0/2015	**Monitoring Start Date:**	28/06/15
Unit Powered:	240v domestic (garage)	**Fitted With UPS backup:**	Yes	**Weather Station:**	Clima Sensor US s/n
Location of Equipment Cabinet:	Inside shed on west of property	**Location of Microphone:**	Fixed to external hand rail off western façade of property.	**Location of Transducer:**	Glued to foundation slab of property on north facing façade
Estimated Distance from Range (Central) [km]		24			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:					

Field Calibration Details				
Time : Date:	Tue 19/05/2015 11:04	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**	
Reference Value:	92.60 dB	92.60 dB	92.60 dB	
New Sensitivity:	0.0459157 V/Pa	0.0459106 V/Pa	0.0458971 V/Pa	
Used Sensitivity:	0.0514400 V/Pa	0.0459157 V/Pa	0.0459106 V/Pa	
New Calibration Level:	91.61 dB	92.60 dB	92.60 dB	

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval				
Time : Date:	2015.10.13 08:56:31	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**	
Reference Value:	92.60 dB	92.60 dB	92.60 dB	
New Sensitivity:	0.0461046 V/Pa	0.046124 V/Pa	0.046117 V/Pa	
Used Sensitivity:	0.045897 V/Pa	0.0461046 V/Pa	0.046124 V/Pa	
New Calibration Level:	92.64 dB	92.60 dB	92.60 dB	

Field Calibration Check Details – Study End				
Time : Date:	2016.02.11 08:41:20	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0467796 V/Pa	0.046117 V/Pa	92.72 dB

TABLE 2.9: SHB_OS5: MERSEA ISLAND, C05:

SHB_OS6 :Range Boundary Location (Great Wakering)

SWING Serial No:	#0010029	**Microphone Type & Serial No:**	G.R.A.S 41CN 218140	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504076
Installation Date:	19/06/2015	**Last Microphone Field Calibration:**	19/06/2015	**Monitoring Start Date:**	28/06/15
Unit Powered:	240v domestic (garage)	**Fitted With UPS backup:**	Yes	**Weather Station:**	None
Location of Equipment Cabinet:	On floor of building on 1st floor.	**Location of Microphone:**	Fixed to external handrail with scaffold clamps.	**Location of Transducer:**	Glued to foundation slab of property on South facing façade
Estimated Distance from Range (Central) [km]		**5**			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:					

Field Calibration Details				
Time / Date:	10:14:59 19/06/2015	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**	
Reference Value:	92.60 dB	92.60 dB	92.60 dB	
New Sensitivity:	0.0501319 V/Pa	0.0500587 V/Pa	0.0500927 V/Pa	
Used Sensitivity:	0.0531065 V/Pa	0.0501319 V/Pa	0.0500587 V/Pa	
New Calibration Level:	92.10 dB	92.59 dB	92.61 dB	

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval			
Time : Date:	2015.09.29 09:21:48	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.053282 V/Pa	0.0532127 V/Pa	0.0532557 V/Pa
Used Sensitivity:	0.0500927 V/Pa	0.053282 V/Pa	0.0532127 V/Pa
New Calibration Level:	92.14 dB	92.59 dB	92.61 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.01.25 10:04:31	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0528073 V/Pa	0.0532557 V/Pa	92.53 dB

TABLE 2.10: SHB_OS6: GREAT WAKERING

SHB_OS7 Minster-On-Sea, Sheppey, ME12

SWING Serial No:	#0010035	**Microphone Type & Serial No:**	G.R.A.S 41CN 218141	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504072
Installation Date:	22/05/2015	**Last Microphone Field Calibration:**	22/05/2015	**Monitoring Start Date:**	29/06/15
Unit Powered:	240v domestic (garage)	**Fitted With UPS backup:**	Yes	**Weather Station:**	None
Location of Equipment Cabinet:	Rear Garden location.	**Location of Microphone:**	Rear Gardenfree-field location. Microphone elevated c. 3m above local ground.	**Location of Transducer:**	Glued to foundation slab of property.
Estimated Distance from Range (Central) [km]		19			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:					

Field Calibration Details				
Time : Date:	11:42:00 22/05/2015	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**		**Cal #3**
Reference Value:	92.60 dB	92.60 dB		92.60 dB
New Sensitivity:	0.0490482 V/Pa	0.0492246 V/Pa		0.0493264 V/Pa
Used Sensitivity:	0.0528944 V/Pa	0.0490482 V/Pa		0.0492246 V/Pa
New Calibration Level:	91.94 dB	92.63 dB		92.62 dB

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval				
Time : Date:	2015.09.30 14:23:20	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**		**Cal #3**
Reference Value:	92.60 dB	92.60 dB		92.60 dB
New Sensitivity:	0.0502767 V/Pa	0.0505064 V/Pa		0.0505706 V/Pa
Used Sensitivity:	0.0493264 V/Pa	0.0502767 V/Pa		0.0505064 V/Pa
New Calibration Level:	92.77 dB	92.64 dB		92.61 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.02.10 16:54:42	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0488245 V/Pa	0.0504882 V/Pa	92.31 dB

TABLE 2.11: SHB_OS7: SHEPPEY, ME12

SHB_OS8: Seasalter, CT5

SWING Serial No:	#0010032	**Microphone Type & Serial No:**	G.R.A.S 41CN 218139	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504075
Installation Date:	21/05/2015	**Last Microphone Field Calibration:**	21/05/2015	**Monitoring Start Date:**	29/06/15
Unit Powered:	240V Domestic	**Fitted With UPS backup:**	Yes	**Weather Station:**	None
Location of Equipment Cabinet:	On property bacony. Southern façade.	**Location of Microphone:**	Fixed to external handrail on southern façade of building.	**Location of Transducer:**	Glued to foundation slab of property on South facing façade
Estimated Distance from Range (Central) [km]		27			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken by:**	ASW
Notes:	Weather Station (as shown in Photo) removed				

Field Calibration Details

Time : Date:	2015.05.21 14:58:32	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0496497 V/Pa	0.0496400 V/Pa	0.0496561 V/Pa
Used Sensitivity:	0.0496561 V/Pa	0.0496497 V/Pa	0.0496400 V/Pa
New Calibration Level:	92.06 dB	92.60 dB	92.60 dB

On-Site Acceptance Testing

Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval

Time : Date:	2015.09.30 11:54:35	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0500579 V/Pa	0.0500587 V/Pa	0.0500557 V/Pa
Used Sensitivity:	0.0496561 V/Pa	0.0500579 V/Pa	0.0500587 V/Pa
New Calibration Level:	92.67 dB	92.60 dB	92.60 dB

Field Calibration Check Details – Study End

Time : Date:	2016.01.27 11:31:47	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0625246 V/Pa	0.0594501 V/Pa	93.04 dB

TABLE 2.12: SHB_OS8: SEASALTER, CT5

SHB_OS9: Herne Bay, CT6

SWING Serial No:	#0010031	**Microphone Type & Serial No:**	G.R.A.S 41CN 218138	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504070
Installation Date:	21/05/2015	**Last Microphone Field Calibration:**	21/05/2015	**Monitoring Start Date:**	29/06/15
Unit Powered:	240v domestic	**Fitted With UPS backup:**	Yes	**Weather Station:**	Clima Sensor US [s/n TBC]
Location of Equipment Cabinet:	Inside resident shed.	**Location of Microphone:**	Fixed to external handrail on Eastern façade of building.	**Location of Transducer:**	Glued to foundation slab of property on Eastern façade
Estimated Distance from Range (Central) [km]		31			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken By:**	ASW
Notes:					

Field Calibration Details				
Time : Date:	11:28:39 21/05/2015	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**		**Cal #3**
Reference Value:	92.60 dB	92.60 dB		92.60 dB
New Sensitivity:	0.0517447V/Pa	0.0517452V/Pa		0.0517526V/Pa
Used Sensitivity:	0.0517497V/Pa	0.0517447V/Pa		0.0517452V/Pa
New Calibration Level:	92.60 dB	92.60 dB		92.60 dB

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval				
Time : Date:	2015.09.30 09:59:41	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal no.	**Cal #1**	**Cal #2**		**Cal #3**
Reference Value:	92.60 dB	92.60 dB		92.60 dB
New Sensitivity:	0.047886 V/Pa	0.0478662 V/Pa		0.0478971 V/Pa
Used Sensitivity:	0.0487943 V/Pa	0.047886 V/Pa		0.0478662 V/Pa
New Calibration Level:	92.44 dB	92.60 dB		92.61 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.01.27 13:38:21	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0503421 V/Pa	0.0478971 V/Pa	93.03 dB

TABLE 2.13: SHB_OS9: HERNE BAY, CT6

SHB_OS10: Birchington, CT7 9EY

SWING Serial No:	#0010036	**Microphone Type & Serial No:**	G.R.A.S 41CN 218136	**Transducer Type & Serial No:**	SINUS tri-axial velocity sensor 504073
Installation Date:	09/07/2015	**Last Microphone Field Calibration:**	09/07/2015	**Monitoring Start Date:**	29/06/15
Unit Powered:	240v domestic	**Fitted With UPS backup:**	Yes	**Weather Station:**	None
Location of Equipment Cabinet:	Outdoor location in north of property garden	**Location of Microphone:**	Rear Gardenfree-field location. Microphone elevated c. 3m above local ground.	**Location of Transducer:**	Fixed to Plaster of Paris Patch using Epoxy Resin. Free-field monitoring location. X-axis perpendicular with southern façade.
Estimated Distance from Range (Central) [km]		36			
Master / Slave Monitor	Slave	**Trigger Threshold:**	85.0 dB(A)	**Installation Undertaken By:**	ASW

Field Calibration Details			
Time : Date:	11:56 09/07/2015	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60dB	92.60dB	92.60dB
New Sensitivity:	0.0516231 V/Pa	0.0516354 V/Pa	0.0516782 V/Pa
Used Sensitivity:	0.0499000 V/Pa	0.0516231 V/Pa	0.0516354 V/Pa
New Calibration Level:	92.89 dB	92.60 dB	92.61 dB

On-Site Acceptance Testing			
Acoustic Calibration:	PASS	**Triggering From Master(s):**	PASS
Electrostatic Calibration:	PASS	**Sensor Failure Notification:**	PASS
Main Failure Notification:	PASS	**UPS:**	PASS
GPS Sync:	PASS	**Local Trigger:**	PASS
Notes:			

Field Calibration Check Details – 3 Month Interval			
Time : Date:	2015.09.30 08:38:51	**Calibrator Make:**	Rion NC-74 s/n 00830791 (fitted with G.R.A.S. RA0041 Adaptor)
Cal no.	**Cal #1**	**Cal #2**	**Cal #3**
Reference Value:	92.60 dB	92.60 dB	92.60 dB
New Sensitivity:	0.0525674 V/Pa	0.0528142 V/Pa	0.0527253 V/Pa
Used Sensitivity:	0.0516782 V/Pa	0.0525674 V/Pa	0.0528142 V/Pa
New Calibration Level:	92.75 dB	92.64 dB	92.59 dB

Field Calibration Check Details – Study End				
Time : Date:	2016.01.27 15:14:37	**Calibrator Make:**	Rion NC-74 s/n 34625621 (fitted with G.R.A.S. RA0041 Adaptor)	
Cal #1	**Reference Value:**	**New Sensitivity:**	**Used Sensitivity:**	**New Calibration Level:**
	92.60 dB	0.0531872 V/Pa	0.0527253 V/Pa	92.68 dB

TABLE 2.14: SHB_OS10: BIRCHINGTON, CT7

2.7 Calibration Certification

2.7.1 The calibration certificates for each of the monitoring stations are presented in the subsequent pages.

SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10025

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 214166

G.R.A.S.
Sound & Vibration

System Sensitivity:	49.99 mV/Pa
	-26.02 dB re. 1V/Pa
Actuator output:	31.74 mV
Preamplifier type:	26AX
Preamplifier serial no:	210482
Microphone type:	40AS
Microphone Serial No:	178510
Operator:	FBL
Date:	17. jul 2014

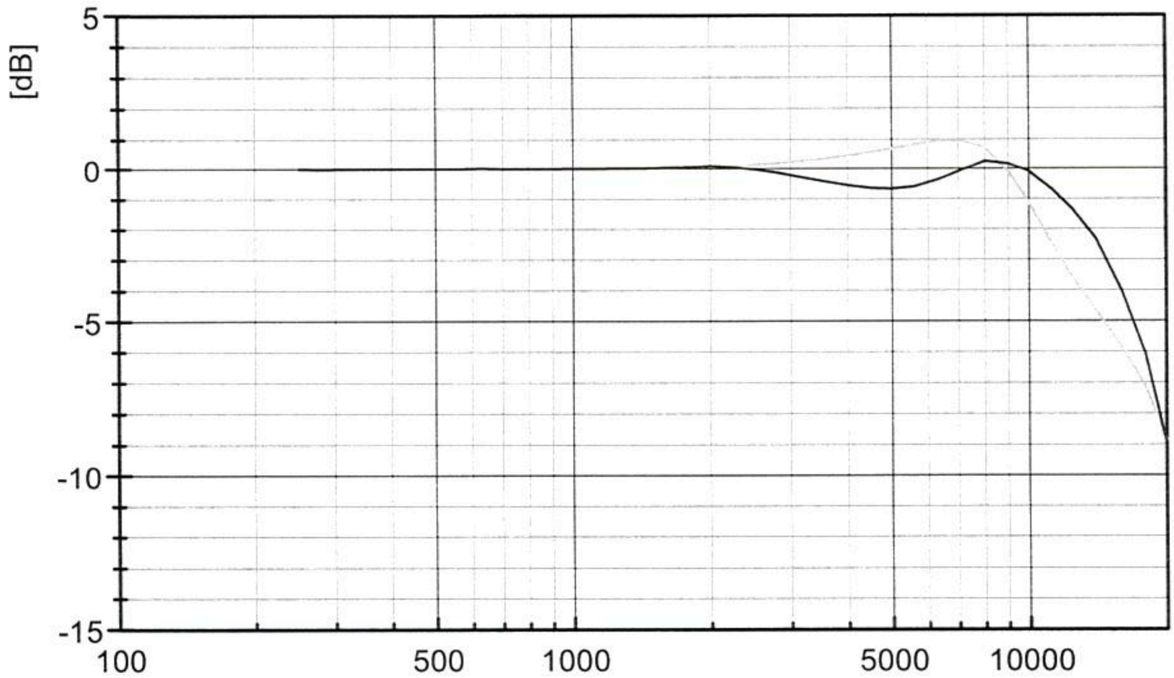
The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa

Frequency response re. 250 Hz



G.R.A.S. Sound & Vibration A/S
Skovlytoften 33
DK-2840 Holte, Denmark

Tel.: +45 45 66 40 46
Fax : +45 45 66 40 47
e-mail : gras@gras.dk

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierschein
Calibration Certificate

Kalibrierzeichen / *Calibration mark*: 1976 | D-K-15183-01-00 | 2014-09

Gegenstand *Object*	**Velocity transducer**	
Hersteller *Manufacturer*	**SINUS Messtechnik**	
Typ *Type*	**902219.7**	
Fabrikat/Serien-Nr. *Serial number*	**#0504082**	
Auftraggeber *Customer*	**SINUS Messtechnik GmbH** **DE-04347 Leipzig**	
Auftragsnummer *Order No.*		**141335**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*		**6**
Datum der Kalibrierung *Date of calibration*		**24/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Leiter des Kalibrierlaboratoriums *Head of the calibration laboratory*	Bearbeiter *Person in charge*
24/09/2014	Philipp Begoff	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504082**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(22.5 ± 1) °C**
Relative humidity:	**(40 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity:	**horizontal (x- and y-axis)** **vertical (z-axis)**	
Temperature of test object:	**(22.5 ± 2) °C**	
Attachment of test object to vibration exciter:		
z-axis:	**screwed SAM-018**	
x- and y-axis:	**screwed SAM-025**	
Technical data of the connecting cable (cable of the laboratory)		
Manufacturer:	**SINUS Messtechnik GmbH**	
Type:	**902246**	
Length:	**2 m**	
Specification of excitation for determination of the transfer coefficient		
Frequency:	**16 Hz**	
Velocity (peak)	**10 mm/s**	
for determination of the amplitude-frequency response		
Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:

- for determination of the transfer coefficient at 16 Hz		1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range		
0.5 Hz bis	< 1 Hz	2.0% / 2.0°
1 Hz bis	80 Hz	1.5% / 1.5°
> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.249 mV/(mm/s)**	**0.009 %**	**0.0026 mV/(mm/s)**
y-axis:	**30.326 mV/(mm/s)**	**0.004 %**	**0.0012 mV/(mm/s)**
z-axis:	**29.858 mV/(mm/s)**	**0.003 %**	**0.0009 mV/(mm/s)**

(acceleration due to gravity 1 g_n = 9.80665 m/s²)

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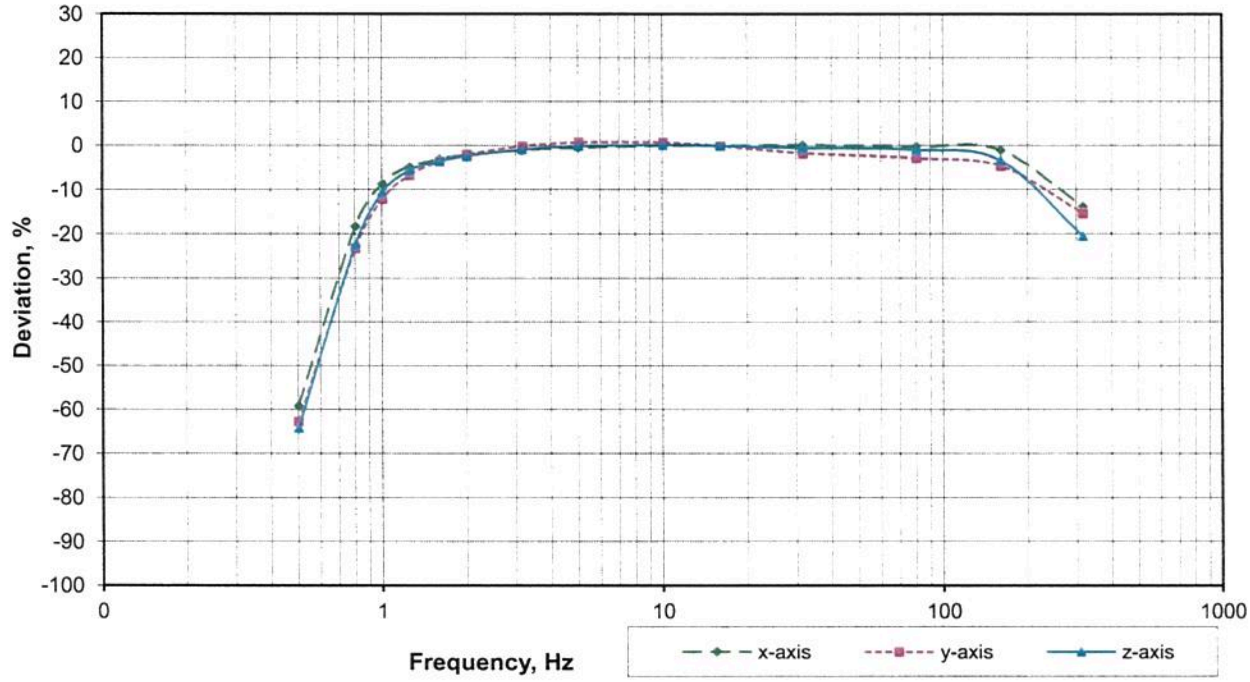
7.2 Amplitude frequency response (relative to 16 Hz)

Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.95	-59.15	137.7	11.30	-62.74	139.7	10.70	-64.15	142.8
0.8	23.92	-18.22	90.9	23.30	-23.16	95.0	23.19	-22.35	97.5
1	26.75	-8.56	70.1	26.73	-11.86	74.2	26.74	-10.44	75.4
1.25	27.86	-4.76	54.3	28.38	-6.43	57.9	28.20	-5.55	58.3
1.6	28.35	-3.06	41.5	29.27	-3.48	44.5	28.84	-3.40	44.5
2	28.61	-2.19	32.8	29.76	-1.88	35.2	29.17	-2.30	35.2
3.15	28.94	-1.07	20.4	30.34	0.04	21.7	29.61	-0.85	21.8
5	29.11	-0.49	12.1	30.59	0.88	12.6	29.85	-0.04	12.9
10	29.26	0.03	4.1	30.59	0.87	3.6	29.92	0.21	4.3
16	**29.25**	**0.0**	**0.1**	**30.33**	**0.0**	**-0.8**	**29.86**	**0.0**	**-0.1**
31.5	29.27	0.08	-6.0	29.86	-1.53	-6.9	29.71	-0.49	-6.2
80	29.21	-0.15	-20.1	29.54	-2.60	-20.6	29.60	-0.85	-19.8
160	28.96	-0.99	-42.0	29.00	-4.37	-42.0	28.88	-3.28	-42.5
315	25.24	-13.71	-87.7	25.73	-15.15	-87.4	23.77	-20.39	-82.0

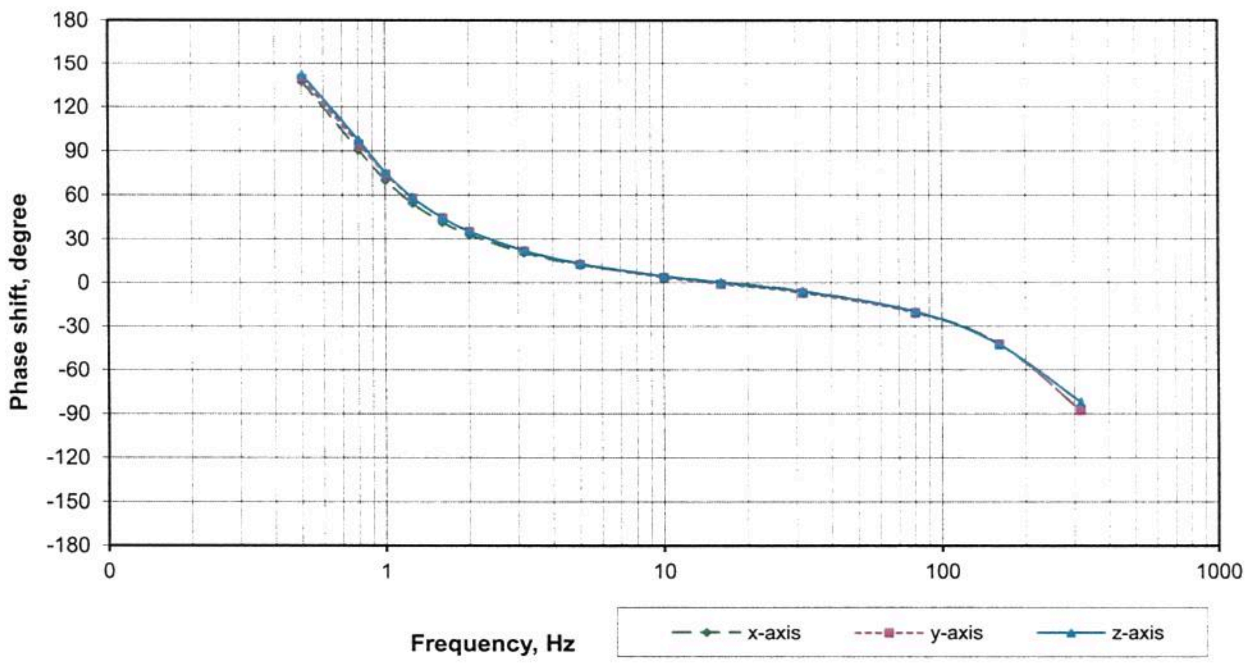
Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

1976
D-K-15183-01-00
2014-09

Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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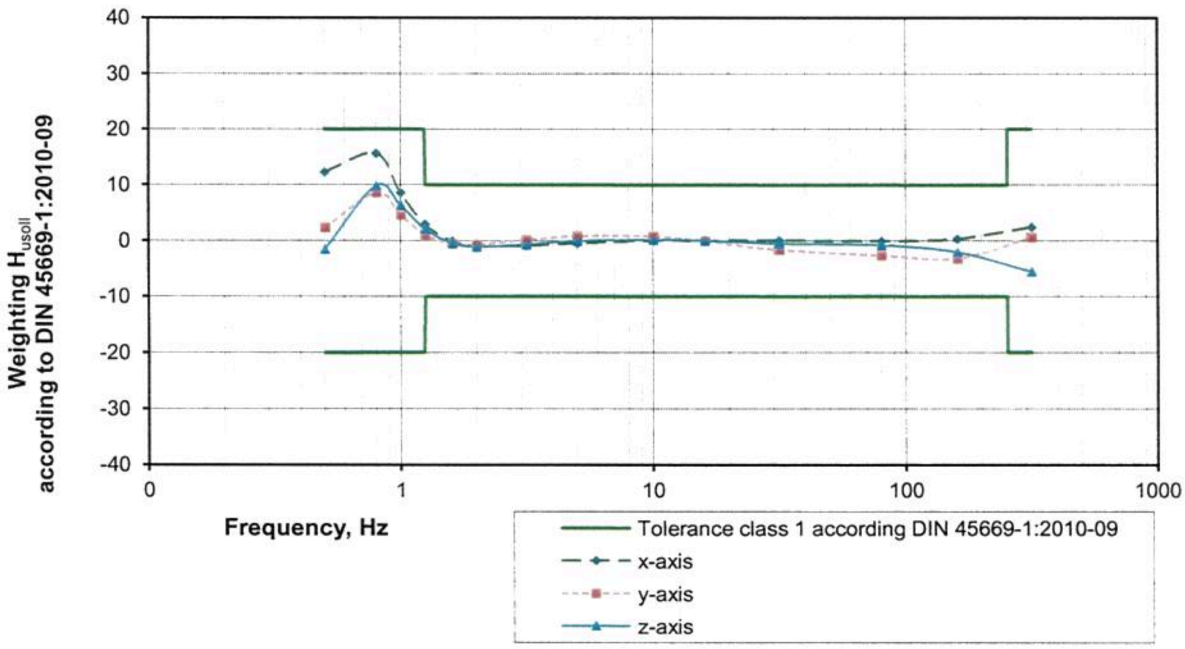
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis			y-axis			z-axis		
	Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}
0.5	0.364	0.408	12.3	0.364	0.373	2.4	0.364	0.358	-1.5
0.8	0.707	0.818	15.7	0.707	0.768	8.7	0.707	0.777	9.8
1	0.842	0.914	8.6	0.842	0.881	4.6	0.842	0.896	6.3
1.25	0.925	0.952	2.9	0.925	0.936	1.1	0.925	0.945	2.1
1.6	0.970	0.969	-0.1	0.970	0.965	-0.5	0.970	0.966	-0.4
2	0.987	0.978	-0.9	0.987	0.981	-0.6	0.987	0.977	-1.1
3.15	0.998	0.989	-0.9	0.998	1.000	0.2	0.998	0.992	-0.6
5	1.000	0.995	-0.5	1.000	1.009	0.9	1.000	1.000	0.0
10	1.000	1.000	0.0	1.000	1.009	0.9	1.000	1.002	0.2
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	1.001	0.1	1.000	0.985	-1.5	1.000	0.995	-0.5
80	0.999	0.999	-0.1	0.999	0.974	-2.5	0.999	0.991	-0.8
160	0.987	0.990	0.3	0.987	0.956	-3.1	0.987	0.967	-2.0
315	0.842	0.863	2.4	0.842	0.848	0.7	0.842	0.796	-5.5



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

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Tel: +49-341-244290
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Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10024

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 177434

G.R.A.S.
Sound & Vibration

System Sensitivity:	50.02 mV/Pa -26.02 dB re. 1V/Pa
Actuator output:	31.65 mV
Preamplifier type:	26AX
Preamplifier serial no:	192401
Microphone type:	40AS
Microphone Serial No:	138460
Operator:	DN
Date:	28. jan 2014

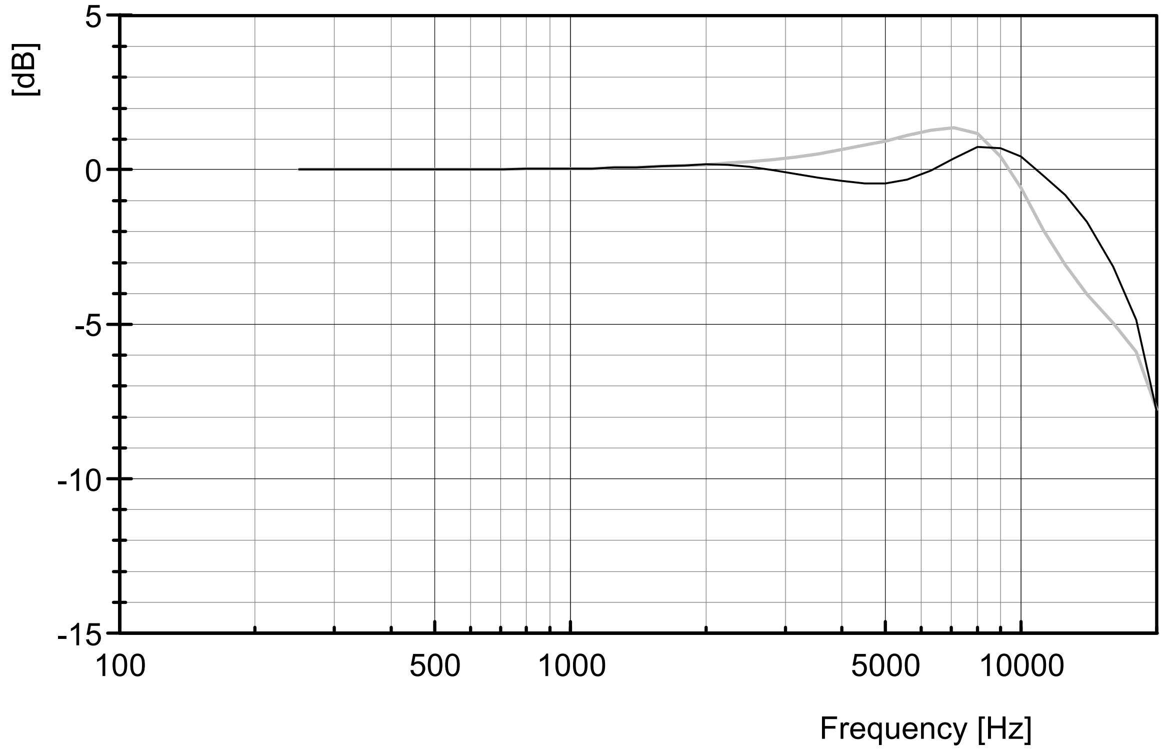
The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa

Frequency response re. 250 Hz



G.R.A.S. Sound & Vibration A/S
Skovlytoften 33
DK-2840 Holte, Denmark

Tel.: +45 45 66 40 46
Fax : +45 45 66 40 47
e-mail : gras@gras.dk

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

1912
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0503949**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH** **DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**16/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
17/09/2014	Mario Chares	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0503949**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(23.8 ± 1) °C**
Relative humidity:	**(55 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity: **horizontal (x- and y-axis)**
vertical (z-axis)

Temperature of test object: **(23.8 ± 2) °C**

Attachment of test object to vibration exciter:
- z-axis: **screwed SAM-018**
- x- and y-axis: **screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)
- Manufacturer: **SINUS Messtechnik GmbH**
- Type: **902246**
- Length: **2 m**

Specification of excitation
for determination of the transfer coefficient
- Frequency: **16 Hz**
- Velocity (peak) **10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:
- for determination of the transfer coefficient at 16 Hz 1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range

0.5 Hz bis	< 1 Hz	2.0% / 2.0°
1 Hz bis	80 Hz	1.5% / 1.5°
> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**28.986 mV/(mm/s)**	**0.004 %**	**0.0012 mV/(mm/s)**
y-axis:	**29.162 mV/(mm/s)**	**0.003 %**	**0.0009 mV/(mm/s)**
z-axis:	**30.024 mV/(mm/s)**	**0.025 %**	**0.0075 mV/(mm/s)**

(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.68	-59.69	137.8	10.68	-63.38	141.2	10.72	-64.29	140.6
0.8	23.56	-18.74	91.2	22.14	-24.07	94.7	23.16	-22.88	95.5
1	26.39	-8.96	70.3	25.05	-14.09	73.7	26.65	-11.25	74.1
1.25	27.49	-5.16	54.4	26.39	-9.52	57.9	28.13	-6.29	57.4
1.6	27.97	-3.51	41.6	27.21	-6.70	44.9	28.83	-3.97	44.0
2	28.20	-2.70	32.9	27.76	-4.80	36.0	29.21	-2.73	34.8
3.15	28.52	-1.60	20.5	28.59	-1.98	22.7	29.70	-1.09	21.6
5	28.67	-1.10	12.3	28.88	-0.98	13.6	29.97	-0.17	12.8
10	28.89	-0.32	4.5	29.25	0.29	4.7	30.08	0.18	4.2
16	**28.99**	**0.0**	**0.6**	**29.16**	**0.0**	**0.4**	**30.02**	**0.0**	**-0.1**
31.5	29.13	0.49	-5.5	29.12	-0.16	-5.8	29.97	-0.18	-6.3
80	29.39	1.38	-19.4	29.24	0.27	-19.6	29.77	-0.83	-20.1
160	28.15	-2.88	-40.9	28.22	-3.22	-41.9	28.86	-3.89	-43.3
315	25.09	-13.44	-86.8	25.15	-13.75	-87.0	21.64	-27.92	-100.2

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

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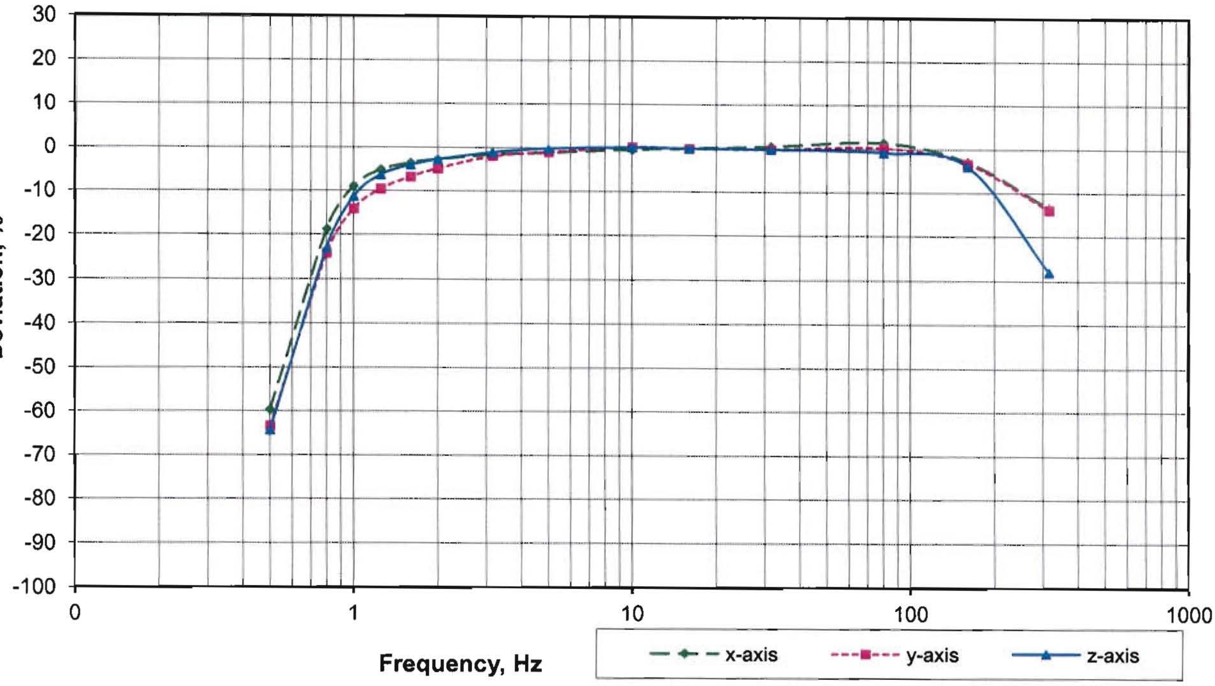
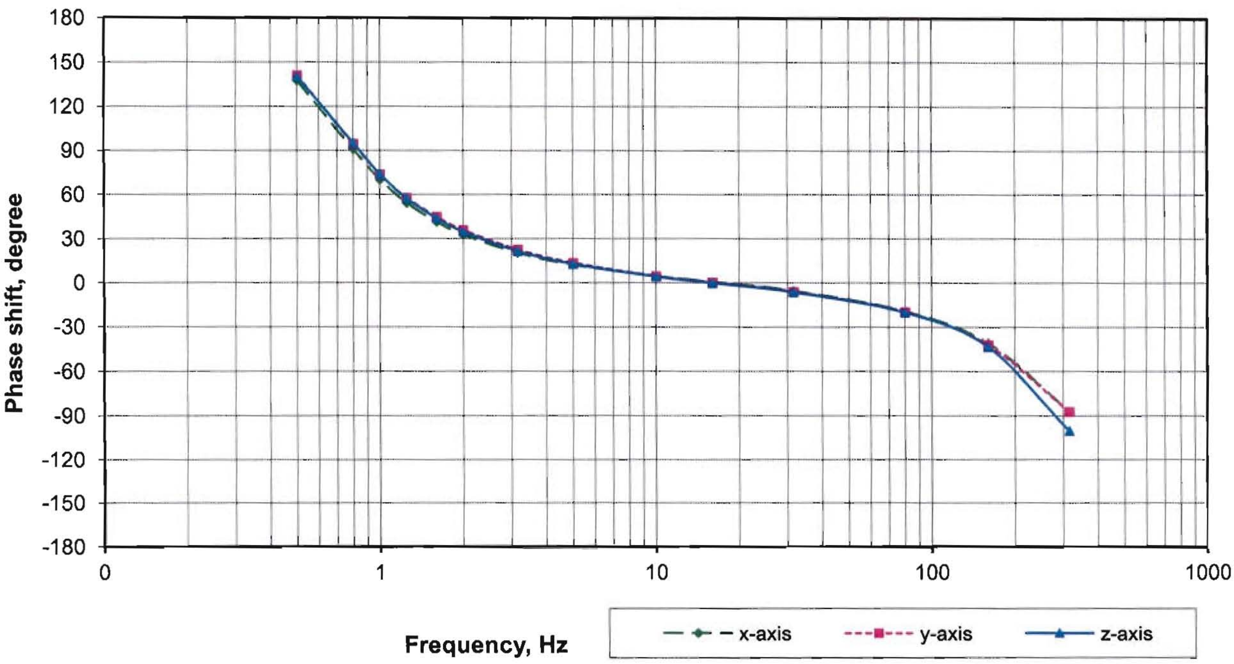
Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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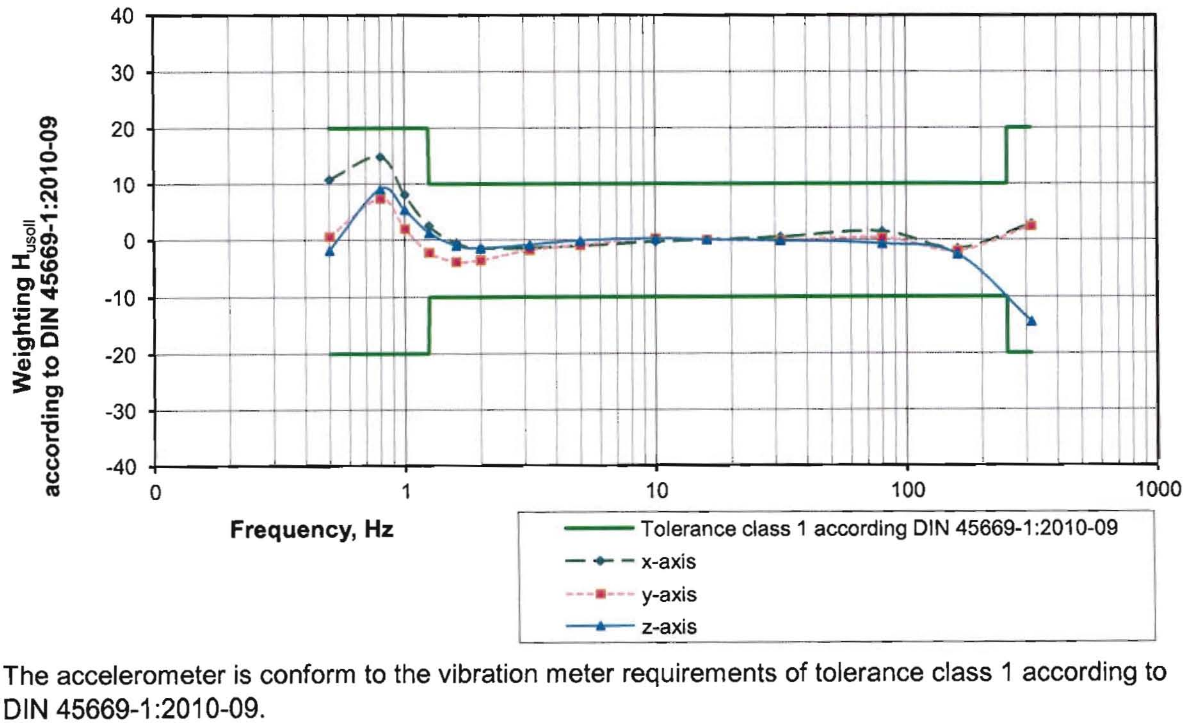
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis			y-axis			z-axis		
	Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}
0.5	0.364	0.403	10.8	0.364	0.366	0.6	0.364	0.357	-1.9
0.8	0.707	0.813	14.9	0.707	0.759	7.4	0.707	0.771	9.1
1	0.842	0.910	8.1	0.842	0.859	2.0	0.842	0.887	5.4
1.25	0.925	0.948	2.5	0.925	0.905	-2.2	0.925	0.937	1.3
1.6	0.970	0.965	-0.5	0.970	0.933	-3.8	0.970	0.960	-1.0
2	0.987	0.973	-1.5	0.987	0.952	-3.6	0.987	0.973	-1.5
3.15	0.998	0.984	-1.4	0.998	0.980	-1.8	0.998	0.989	-0.9
5	1.000	0.989	-1.1	1.000	0.990	-1.0	1.000	0.998	-0.1
10	1.000	0.997	-0.3	1.000	1.003	0.3	1.000	1.002	0.2
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	1.005	0.5	1.000	0.998	-0.2	1.000	0.998	-0.2
80	0.999	1.014	1.5	0.999	1.003	0.4	0.999	0.992	-0.7
160	0.987	0.971	-1.6	0.987	0.968	-1.9	0.987	0.961	-2.6
315	0.842	0.866	2.8	0.842	0.863	2.4	0.842	0.721	-14.4



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10030

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 177432

G.R.A.S.
Sound & Vibration

System Sensitivity:	50.00 mV/Pa
	-26.02 dB re. 1V/Pa
Actuator output:	31.65 mV
Preamplifier type:	26AX
Preamplifier serial no:	163450
Microphone type:	40AS
Microphone Serial No:	138453
Operator:	DN
Date:	28. jan 2014

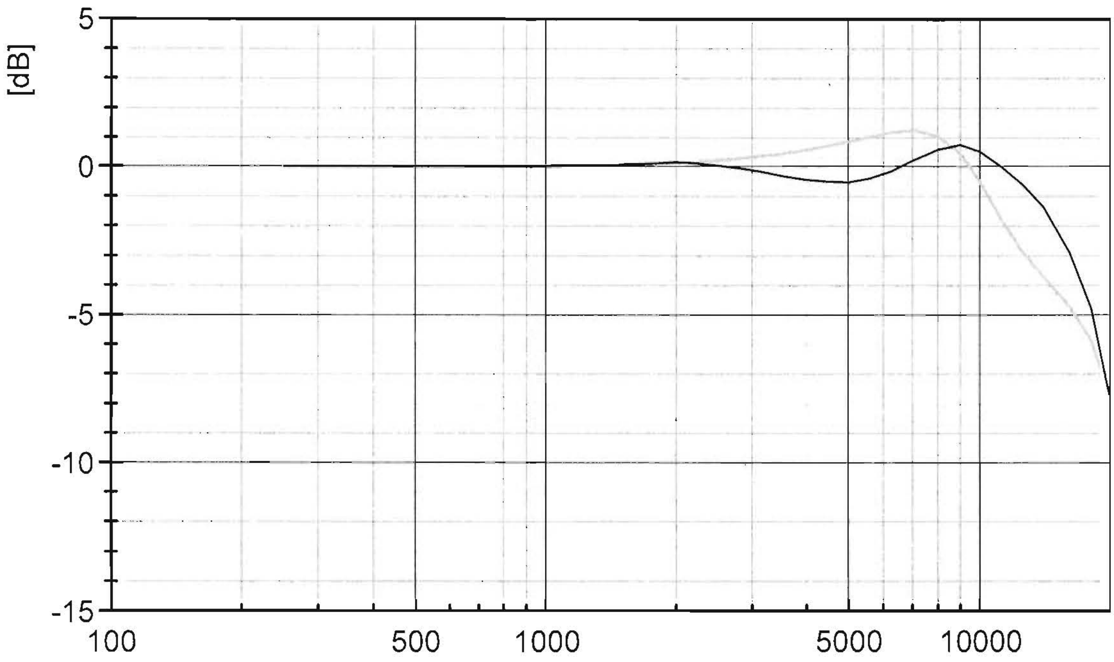
The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa

Frequency response re. 250 Hz



G.R.A.S. Sound & Vibration A/S
Skovlytoften 33
DK-2840 Holte, Denmark

Tel.: +45 45 66 40 46
Fax : +45 45 66 40 47
e-mail : gras@gras.dk

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

1915
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504071**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH** **DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**17/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
18/09/2014	Heiko Deierlein	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504071**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(23.4 ± 1) °C**
Relative humidity:	**(54 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity: **horizontal (x- and y-axis)**
vertical (z-axis)

Temperature of test object: **(23.4 ± 2) °C**

Attachment of test object to vibration exciter:
- z-axis: **screwed SAM-018**
- x- and y-axis: **screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)
- Manufacturer: **SINUS Messtechnik GmbH**
- Type: **902246**
- Length: **2 m**

Specification of excitation
for determination of the transfer coefficient
- Frequency: **16 Hz**
- Velocity (peak) **10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:

- for determination of the transfer coefficient at 16 Hz 1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range

0.5 Hz bis	< 1 Hz	2.0% / 2.0°
1 Hz bis	80 Hz	1.5% / 1.5°
> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.733 mV/(mm/s)**	**0.005 %**	**0.0015 mV/(mm/s)**
y-axis:	**30.004 mV/(mm/s)**	**0.008 %**	**0.0024 mV/(mm/s)**
z-axis:	**29.401 mV/(mm/s)**	**0.004 %**	**0.0012 mV/(mm/s)**

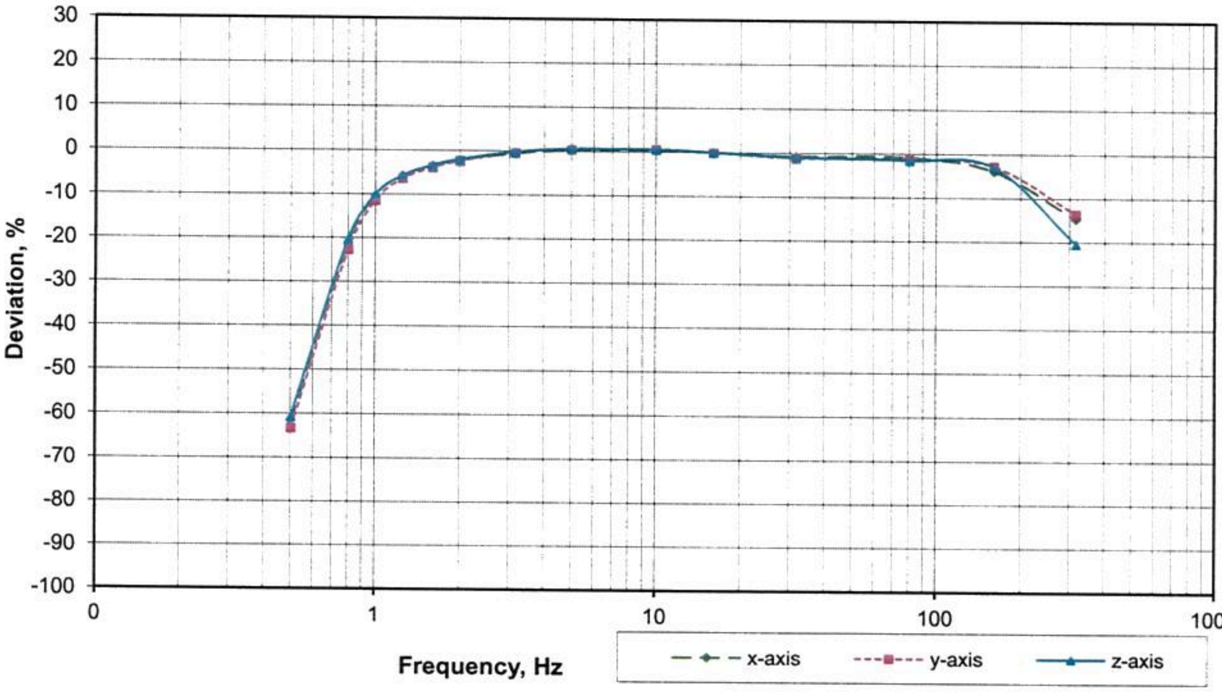
(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

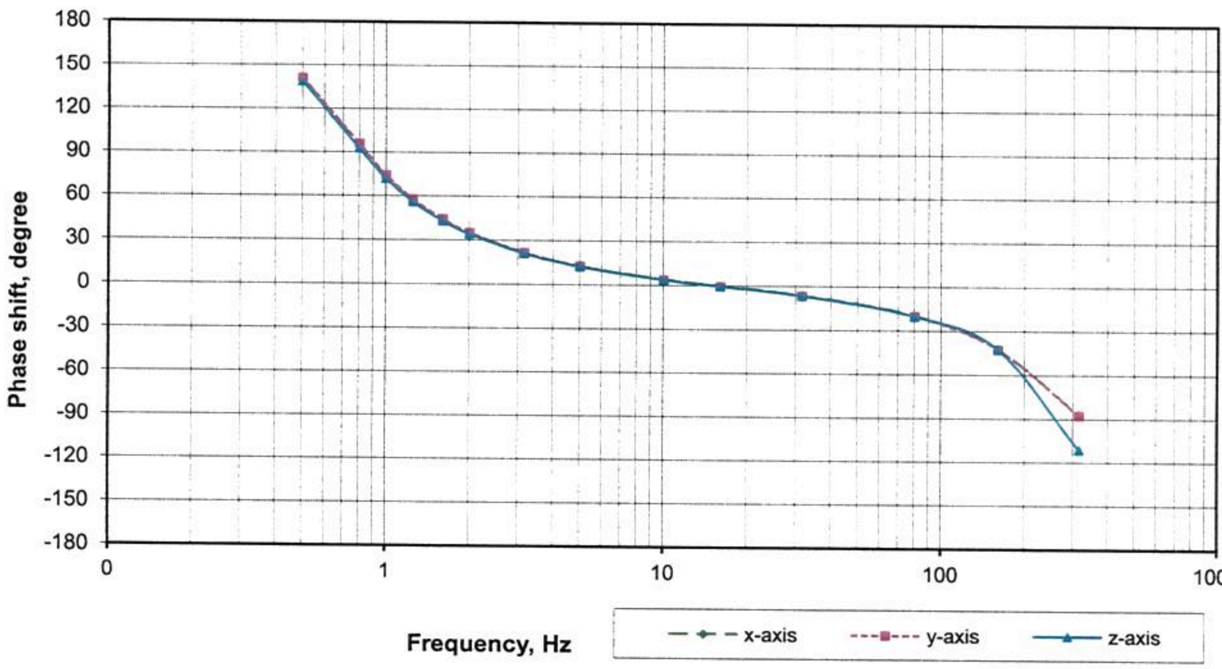
Frequency, Hz	x-axis Transfer coefficient, mV/(mm/s)	x-axis Deviation, %	x-axis Phase shift, degree	y-axis Transfer coefficient, mV/(mm/s)	y-axis Deviation, %	y-axis Phase shift, degree	z-axis Transfer coefficient, mV/(mm/s)	z-axis Deviation, %	z-axis Phase shift, degree
0.5	11.15	-62.50	140.7	11.02	-63.27	141.3	11.55	-60.71	139.1
0.8	23.38	-21.36	95.0	23.21	-22.66	95.9	23.47	-20.19	92.7
1	26.68	-10.26	73.6	26.61	-11.30	74.6	26.47	-9.98	71.9
1.25	28.09	-5.54	57.1	28.14	-6.23	58.0	27.77	-5.56	56.0
1.6	28.76	-3.28	43.7	28.92	-3.62	44.5	28.45	-3.24	43.0
2	29.12	-2.07	34.6	29.35	-2.19	35.2	28.84	-1.91	34.1
3.15	29.58	-0.53	21.4	29.89	-0.37	21.8	29.34	-0.20	21.1
5	29.80	0.22	12.6	30.14	0.47	12.8	29.58	0.62	12.3
10	29.87	0.45	4.0	30.21	0.67	3.9	29.58	0.59	3.7
16	**29.73**	**0.0**	**-0.3**	**30.00**	**0.0**	**-0.5**	**29.40**	**0.0**	**-0.7**
31.5	29.51	-0.75	-6.3	29.70	-1.03	-6.6	29.13	-0.91	-6.7
80	29.49	-0.83	-19.7	29.65	-1.17	-19.9	28.99	-1.39	-20.1
160	28.61	-3.79	-42.0	29.22	-2.62	-42.2	28.56	-2.86	-42.3
315	25.37	-14.68	-86.7	25.98	-13.41	-87.0	23.40	-20.41	-111.1

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

Amplitude frequency response (relative to 16 Hz)

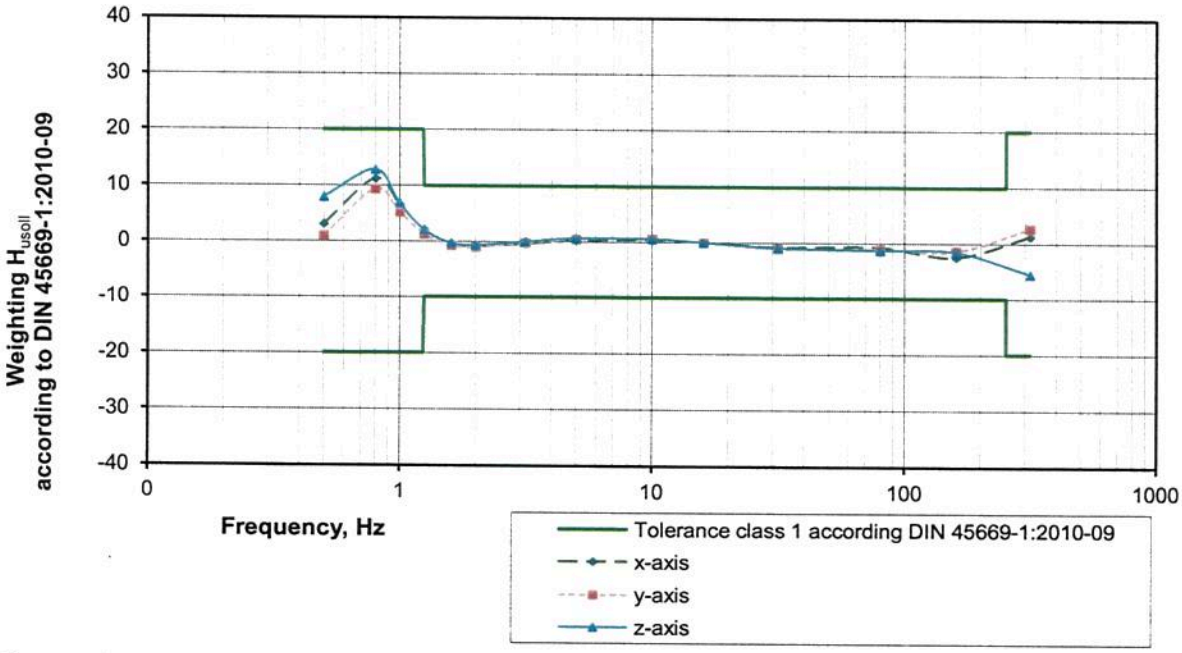


Phase frequency response



7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis: Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	x-axis: Weighting factor, (measured value)	x-axis: Deviation to H_{uSOLL}	y-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	y-axis: Weighting factor, (measured value)	y-axis: Deviation to H_{uSOLL}	z-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	z-axis: Weighting factor, (measured value)	z-axis: Deviation to H_{uSOLL}
0.5	0.364	0.375	3.1	0.364	0.367	1.0	0.364	0.393	8.0
0.8	0.707	0.786	11.2	0.707	0.773	9.4	0.707	0.798	12.9
1	0.842	0.897	6.5	0.842	0.887	5.3	0.842	0.900	6.9
1.25	0.925	0.945	2.1	0.925	0.938	1.3	0.925	0.944	2.1
1.6	0.970	0.967	-0.3	0.970	0.964	-0.7	0.970	0.968	-0.3
2	0.987	0.979	-0.8	0.987	0.978	-0.9	0.987	0.981	-0.7
3.15	0.998	0.995	-0.3	0.998	0.996	-0.2	0.998	0.998	0.0
5	1.000	1.002	0.2	1.000	1.005	0.5	1.000	1.006	0.6
10	1.000	1.004	0.4	1.000	1.007	0.7	1.000	1.006	0.6
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	0.992	-0.7	1.000	0.990	-1.0	1.000	0.991	-0.9
80	0.999	0.992	-0.7	0.999	0.988	-1.1	0.999	0.986	-1.3
160	0.987	0.962	-2.5	0.987	0.974	-1.3	0.987	0.971	-1.5
315	0.842	0.853	1.3	0.842	0.866	2.8	0.842	0.796	-5.5



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10027

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 218137

G.R.A.S.
Sound & Vibration

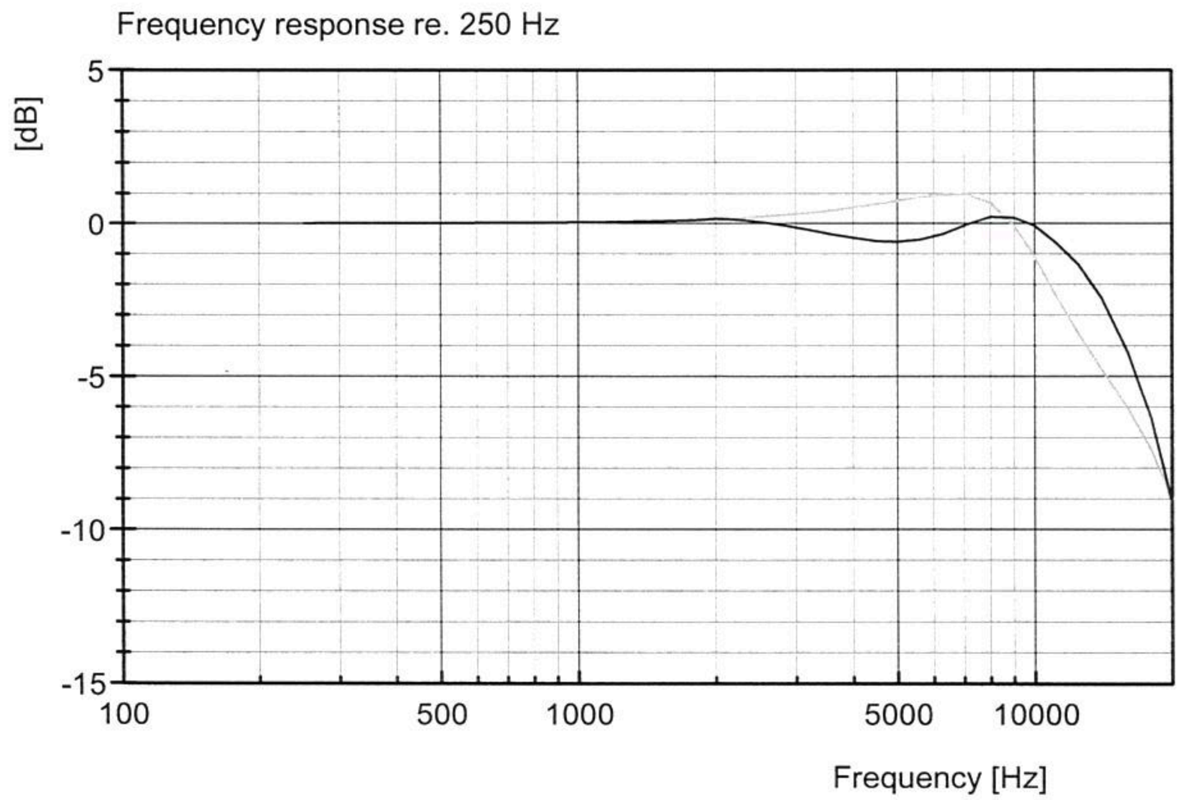
System Sensitivity:	50.06 mV/Pa
	-26.01 dB re. 1V/Pa
Actuator output:	31.68 mV
Preamplifier type:	26AX
Preamplifier serial no:	214112
Microphone type:	40AS
Microphone Serial No:	178531
Operator:	FBL
Date:	21. aug 2014

The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa



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akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

ilac-MRA | DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

1977
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504083**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141335**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**24/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Leiter des Kalibrierlaboratoriums *Head of the calibration laboratory*	Bearbeiter *Person in charge*
24/09/2014	Philipp Begoff	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504083**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(22.8 ± 1) °C**
Relative humidity:	**(38 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity: **horizontal (x- and y-axis)**
vertical (z-axis)

Temperature of test object: **(22.8 ± 2) °C**

Attachment of test object to vibration exciter:
- z-axis: **screwed SAM-018**
- x- and y-axis: **screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)
- Manufacturer: **SINUS Messtechnik GmbH**
- Type: **902246**
- Length: **2 m**

Specification of excitation
for determination of the transfer coefficient
- Frequency: **16 Hz**
- Velocity (peak) **10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

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5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:

- for determination of the transfer coefficient at 16 Hz — 1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range

0.5 Hz bis	< 1 Hz	2.0% / 2.0°
1 Hz bis	80 Hz	1.5% / 1.5°
> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.815 mV/(mm/s)**	**0.005 %**	**0.0015 mV/(mm/s)**
y-axis:	**29.517 mV/(mm/s)**	**0.008 %**	**0.0024 mV/(mm/s)**
z-axis:	**30.128 mV/(mm/s)**	**0.002 %**	**0.0006 mV/(mm/s)**

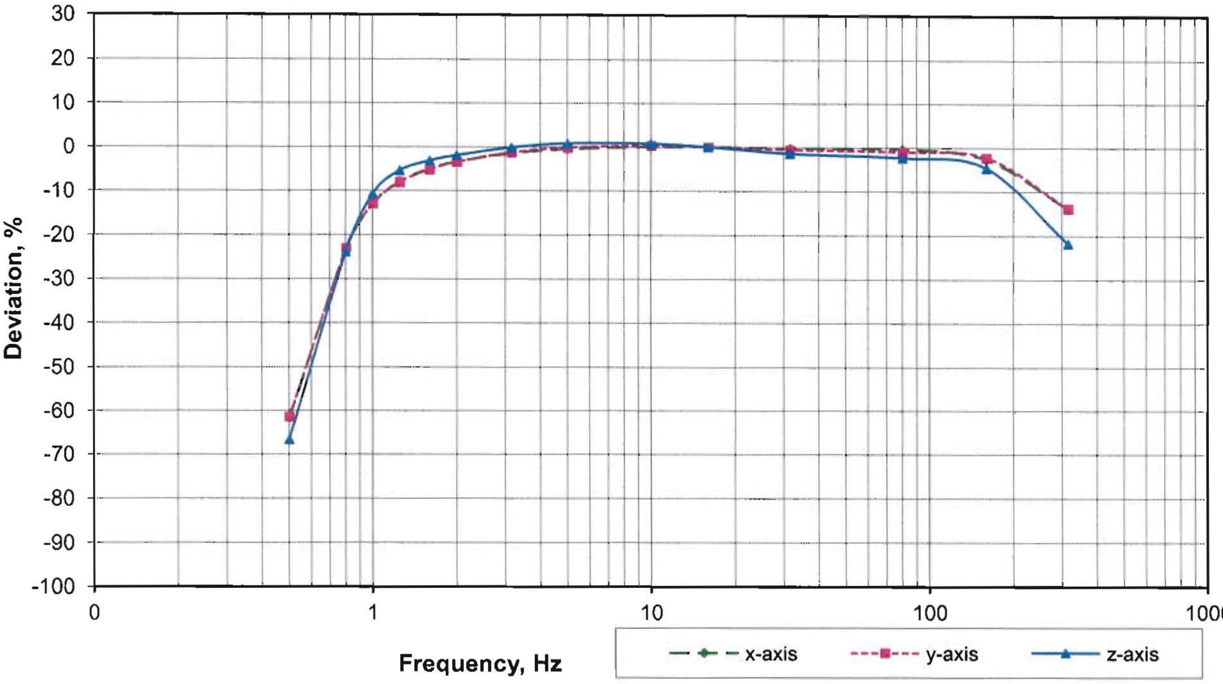
(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

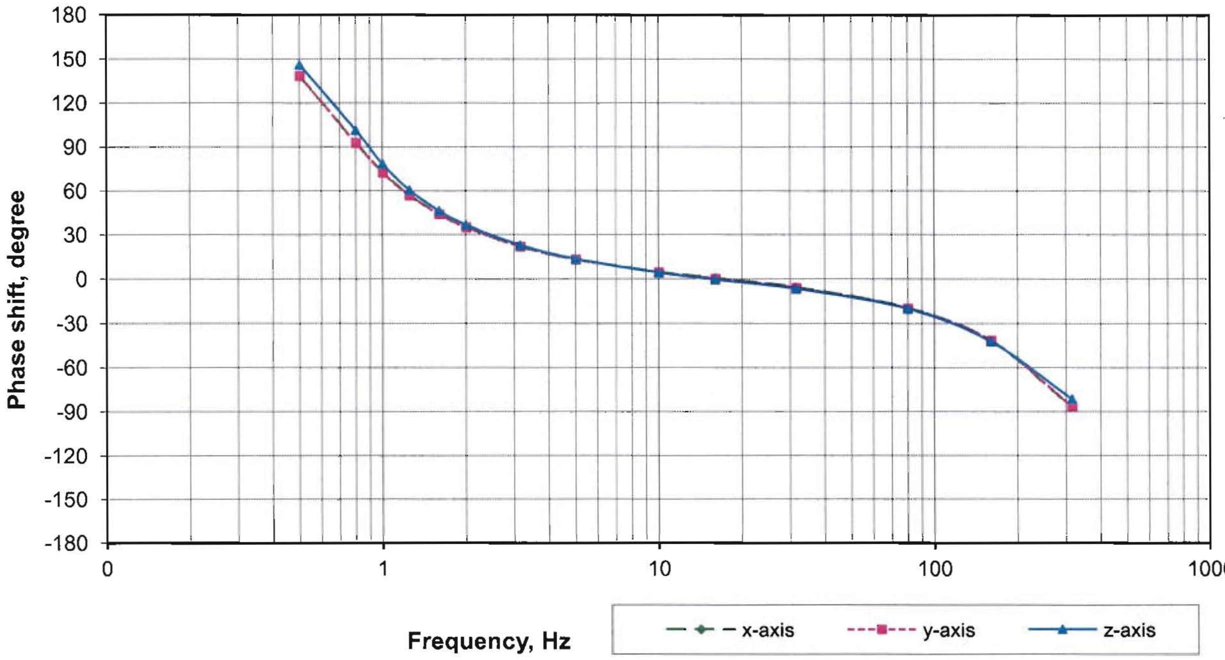
Frequency, Hz	x-axis Transfer coefficient, mV/(mm/s)	x-axis Deviation, %	x-axis Phase shift, degree	y-axis Transfer coefficient, mV/(mm/s)	y-axis Deviation, %	y-axis Phase shift, degree	z-axis Transfer coefficient, mV/(mm/s)	z-axis Deviation, %	z-axis Phase shift, degree
0.5	11.40	-61.75	138.2	11.39	-61.42	138.2	10.04	-66.68	146.0
0.8	22.83	-23.43	93.0	22.73	-23.00	92.5	22.93	-23.91	101.2
1	25.92	-13.06	72.7	25.68	-12.99	72.3	26.88	-10.78	78.2
1.25	27.43	-8.00	57.0	27.12	-8.14	56.7	28.47	-5.50	60.3
1.6	28.29	-5.11	43.9	27.97	-5.23	43.8	29.15	-3.24	46.0
2	28.78	-3.47	34.9	28.47	-3.53	34.9	29.52	-2.01	36.4
3.15	29.38	-1.47	21.7	29.12	-1.33	21.8	30.06	-0.22	22.6
5	29.66	-0.51	12.9	29.45	-0.22	12.9	30.35	0.75	13.2
10	29.83	0.04	4.5	29.60	0.28	4.3	30.34	0.72	4.0
16	**29.82**	**0.0**	**0.3**	**29.52**	**0.0**	**0.0**	**30.13**	**0.0**	**-0.7**
31.5	29.74	-0.24	-5.8	29.35	-0.58	-6.1	29.68	-1.49	-6.9
80	29.68	-0.45	-19.9	29.21	-1.03	-20.0	29.39	-2.45	-20.4
160	29.01	-2.71	-41.7	28.85	-2.27	-41.5	28.70	-4.73	-42.5
315	25.69	-13.85	-86.8	25.46	-13.73	-86.3	23.57	-21.78	-81.5

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

Amplitude frequency response (relative to 16 Hz)

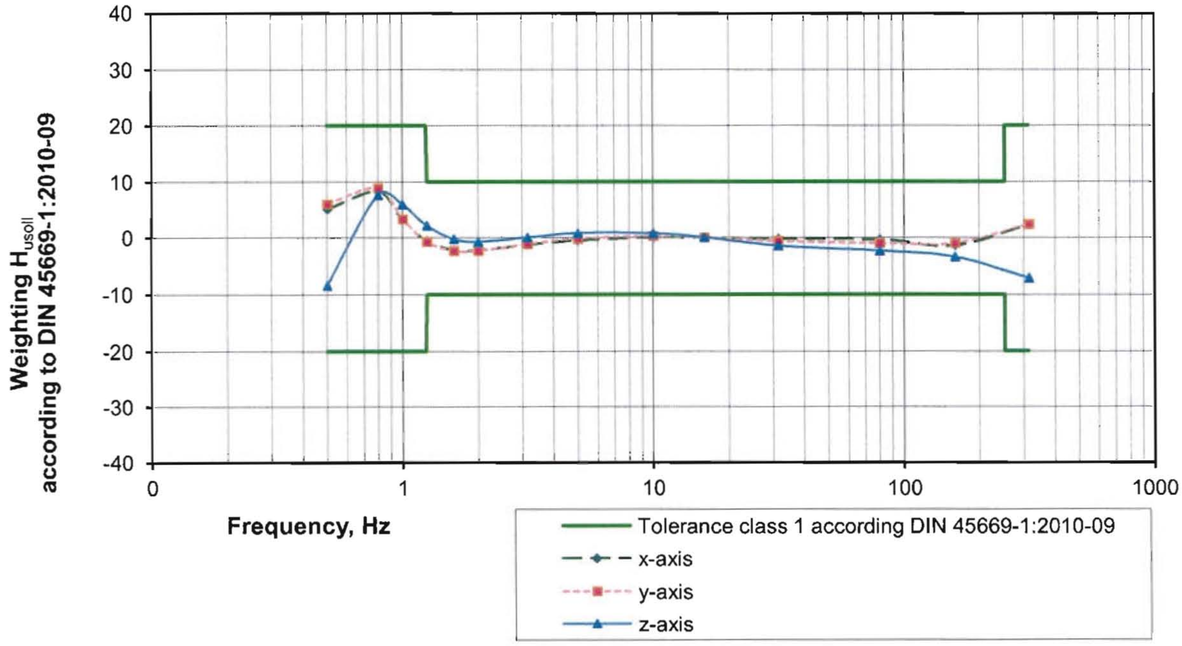


Phase frequency response



7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis			y-axis			z-axis		
	Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}
0.5	0.364	0.382	5.1	0.364	0.386	6.0	0.364	0.333	-8.4
0.8	0.707	0.766	8.3	0.707	0.770	8.9	0.707	0.761	7.6
1	0.842	0.869	3.2	0.842	0.870	3.3	0.842	0.892	5.9
1.25	0.925	0.920	-0.6	0.925	0.919	-0.7	0.925	0.945	2.1
1.6	0.970	0.949	-2.2	0.970	0.948	-2.3	0.970	0.968	-0.3
2	0.987	0.965	-2.2	0.987	0.965	-2.3	0.987	0.980	-0.8
3.15	0.998	0.985	-1.3	0.998	0.987	-1.1	0.998	0.998	0.0
5	1.000	0.995	-0.5	1.000	0.998	-0.2	1.000	1.007	0.8
10	1.000	1.000	0.0	1.000	1.003	0.3	1.000	1.007	0.7
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	0.998	-0.2	1.000	0.994	-0.6	1.000	0.985	-1.5
80	0.999	0.996	-0.4	0.999	0.990	-0.9	0.999	0.976	-2.4
160	0.987	0.973	-1.4	0.987	0.977	-0.9	0.987	0.953	-3.4
315	0.842	0.862	2.3	0.842	0.863	2.4	0.842	0.782	-7.1



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10026

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 214167

G.R.A.S.
Sound & Vibration

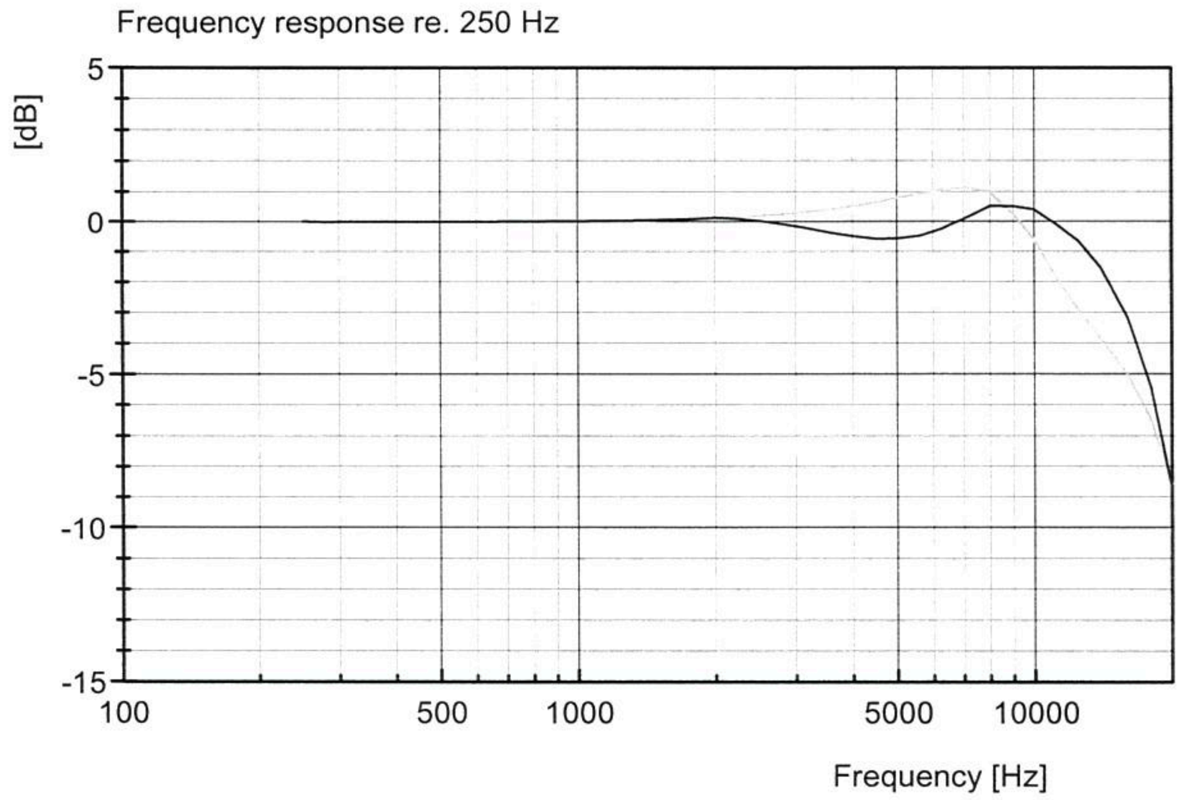
System Sensitivity:	50.01 mV/Pa
	-26.02 dB re. 1V/Pa
Actuator output:	31.85 mV
Preamplifier type:	26AX
Preamplifier serial no:	210483
Microphone type:	40AS
Microphone Serial No:	178519
Operator:	FBL
Date:	17. jul 2014

The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa



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akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierschein
Calibration Certificate

Kalibrierzeichen *Calibration mark*

1922
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504078**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**15/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
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The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
15/09/2014	Mario Chares	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504078**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(24.1 ± 1) °C**
Relative humidity:	**(57 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity:	**horizontal (x- and y-axis)** **vertical (z-axis)**
Temperature of test object:	**(24.1 ± 2) °C**

Attachment of test object to vibration exciter:

z-axis:	**screwed SAM-018**
x- and y-axis:	**screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)

Manufacturer:	**SINUS Messtechnik GmbH**
Type:	**902246**
Length:	**2 m**

Specification of excitation
for determination of the transfer coefficient

Frequency:	**16 Hz**
Velocity (peak)	**10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:

- for determination of the transfer coefficient at 16 Hz			1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range			
	0.5 Hz bis	< 1 Hz	2.0% / 2.0°
	1 Hz bis	80 Hz	1.5% / 1.5°
	> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.647 mV/(mm/s)**	**0.004 %**	**0.0012 mV/(mm/s)**
y-axis:	**30.733 mV/(mm/s)**	**0.005 %**	**0.0015 mV/(mm/s)**
z-axis:	**30.125 mV/(mm/s)**	**0.003 %**	**0.0009 mV/(mm/s)**

(acceleration due to gravity 1 g_n = 9.80665 m/s²)

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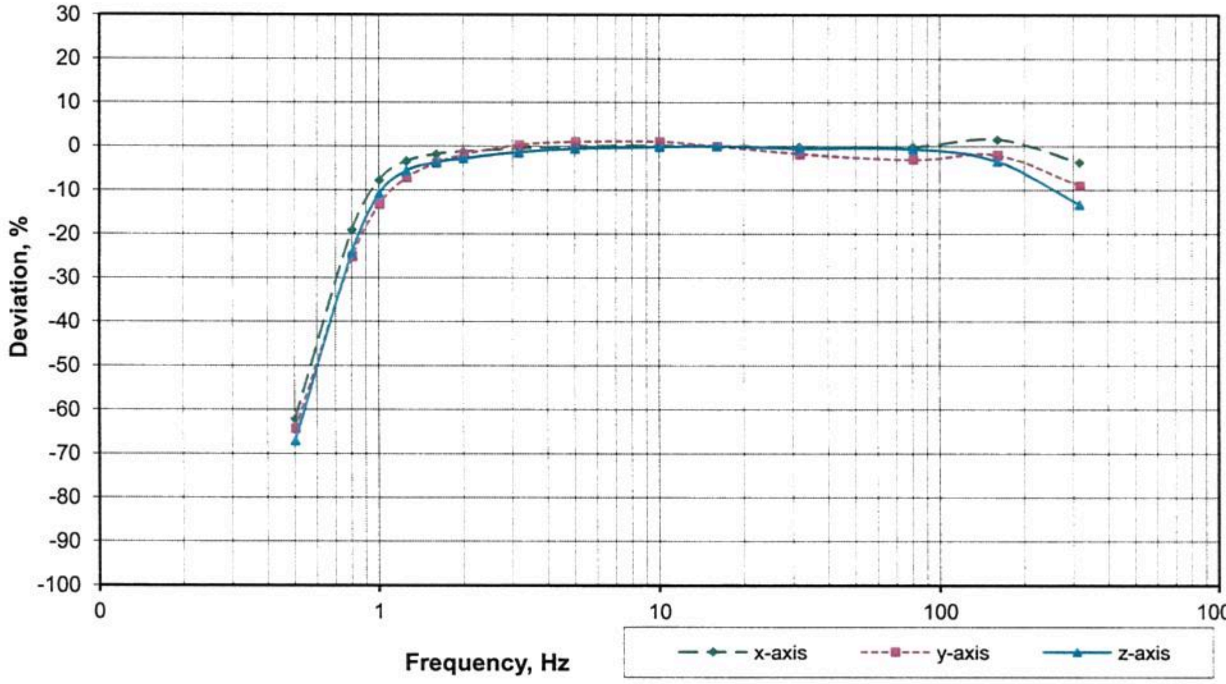
7.2 Amplitude frequency response (relative to 16 Hz)

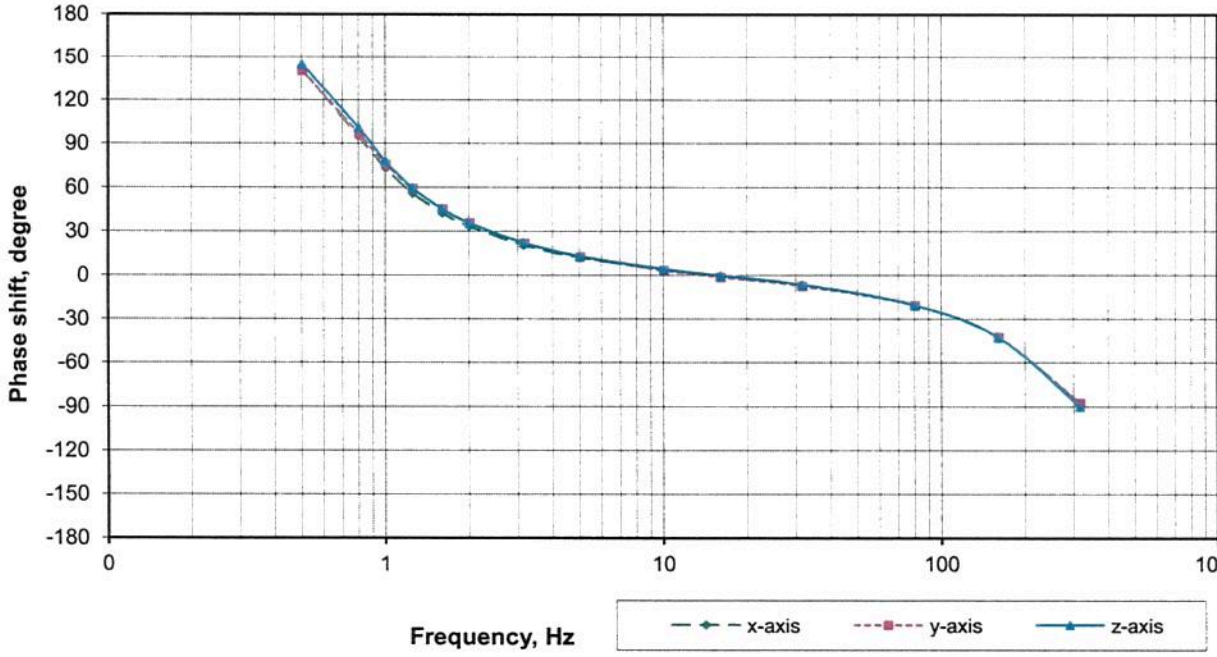
Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.27	-62.00	140.8	11.01	-64.17	140.1	10.00	-66.80	145.2
0.8	24.00	-19.06	95.0	23.02	-25.09	96.4	22.88	-24.06	101.0
1	27.37	-7.67	73.1	26.70	-13.11	75.7	26.90	-10.72	77.9
1.25	28.64	-3.40	56.1	28.56	-7.07	59.2	28.47	-5.51	59.8
1.6	29.09	-1.87	42.6	29.60	-3.70	45.5	29.05	-3.58	45.5
2	29.26	-1.29	33.5	30.16	-1.86	36.0	29.31	-2.69	35.9
3.15	29.48	-0.56	20.6	30.83	0.32	22.2	29.70	-1.40	22.3
5	29.62	-0.10	12.2	31.05	1.02	12.8	29.95	-0.58	13.3
10	29.70	0.19	4.0	31.06	1.08	3.6	30.08	-0.14	4.7
16	**29.65**	**0.0**	**0.0**	**30.73**	**0.0**	**-0.9**	**30.13**	**0.0**	**0.3**
31.5	29.59	-0.19	-6.1	30.22	-1.68	-7.0	29.97	-0.51	-5.9
80	29.60	-0.17	-19.9	29.83	-2.93	-20.2	29.93	-0.63	-19.9
160	30.11	1.55	-42.4	30.14	-1.94	-42.0	29.11	-3.36	-42.1
315	28.57	-3.63	-88.0	28.00	-8.89	-87.5	26.16	-13.18	-89.6

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

Amplitude frequency response (relative to 16 Hz)

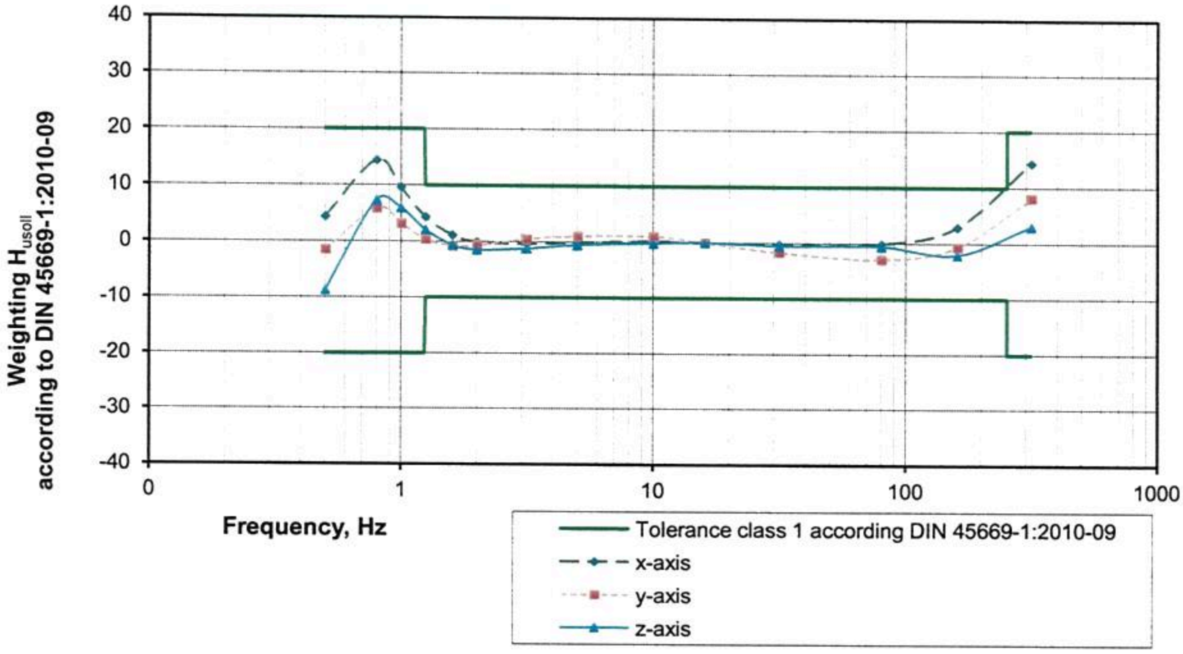


Phase frequency response



7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis			y-axis			z-axis		
	Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}
0.5	0.364	0.380	4.4	0.364	0.358	-1.5	0.364	0.332	-8.7
0.8	0.707	0.809	14.5	0.707	0.749	5.9	0.707	0.759	7.4
1	0.842	0.923	9.6	0.842	0.869	3.2	0.842	0.893	6.0
1.25	0.925	0.966	4.4	0.925	0.929	0.4	0.925	0.945	2.1
1.6	0.970	0.981	1.2	0.970	0.963	-0.7	0.970	0.964	-0.6
2	0.987	0.987	0.0	0.987	0.981	-0.6	0.987	0.973	-1.5
3.15	0.998	0.994	-0.4	0.998	1.003	0.5	0.998	0.986	-1.2
5	1.000	0.999	-0.1	1.000	1.010	1.1	1.000	0.994	-0.5
10	1.000	1.002	0.2	1.000	1.011	1.1	1.000	0.999	-0.1
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	0.998	-0.2	1.000	0.983	-1.7	1.000	0.995	-0.5
80	0.999	0.998	-0.1	0.999	0.971	-2.9	0.999	0.994	-0.5
160	0.987	1.015	2.9	0.987	0.981	-0.6	0.987	0.966	-2.0
315	0.842	0.964	14.4	0.842	0.911	8.2	0.842	0.868	3.1



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10037

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 214165

G.R.A.S.
Sound & Vibration

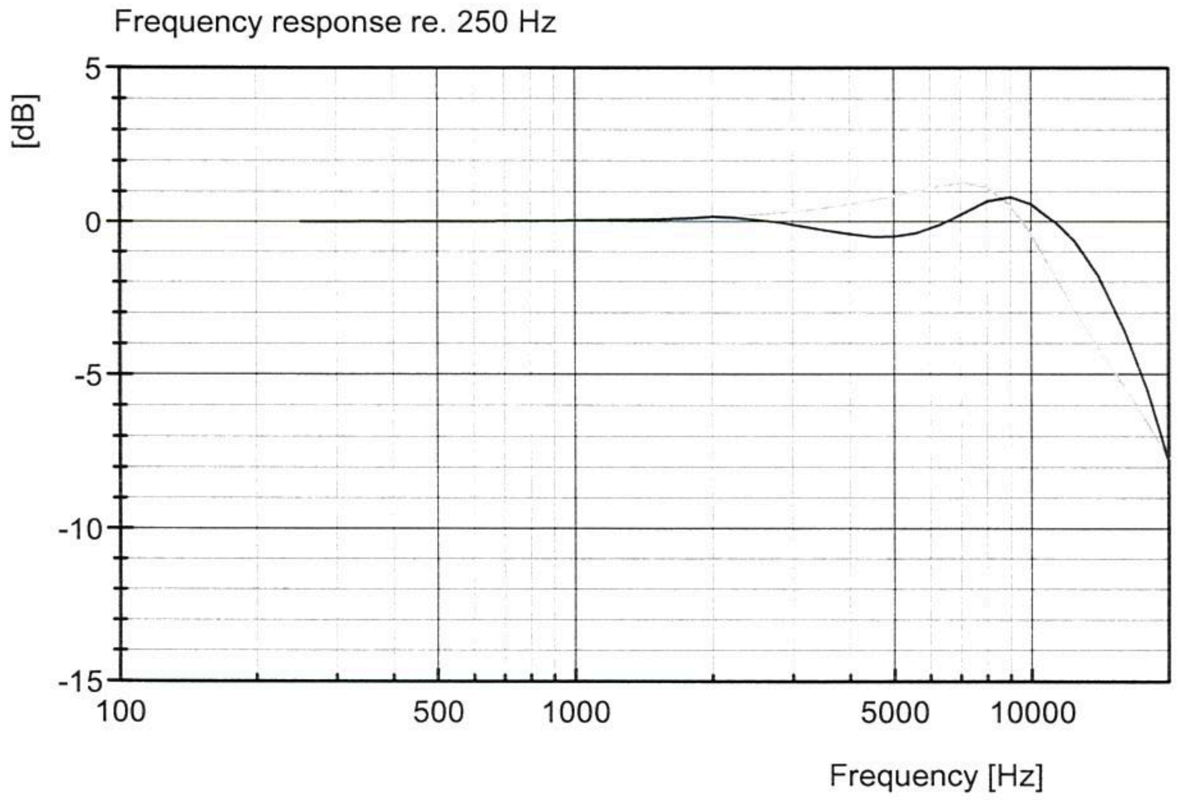
System Sensitivity:	50.04 mV/Pa
	-26.01 dB re. 1V/Pa
Actuator output:	31.72 mV
Preamplifier type:	26AX
Preamplifier serial no:	210477
Microphone type:	40AS
Microphone Serial No:	138457
Operator:	FBL
Date:	16. jul 2014

The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa



G.R.A.S. Sound & Vibration A/S
Skovlytoften 33
DK-2840 Holte, Denmark

Tel.: +45 45 66 40 46
Fax : +45 45 66 40 47
e-mail : gras@gras.dk

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierzeichen *Calibration mark*
1923
D-K-15183-01-00
2014-09

Kalibrierschein
Calibration Certificate

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504079**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**15/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
15/09/2014	Mario Chares	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504079**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(24.4 ± 1) °C**
Relative humidity:	**(57 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity: **horizontal (x- and y-axis)**
vertical (z-axis)

Temperature of test object: **(24.4 ± 2) °C**

Attachment of test object to vibration exciter:

z-axis:	**screwed SAM-018**
x- and y-axis:	**screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)

Manufacturer:	**SINUS Messtechnik GmbH**
Type:	**902246**
Length:	**2 m**

Specification of excitation
for determination of the transfer coefficient

Frequency:	**16 Hz**
Velocity (peak)	**10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:
- for determination of the transfer coefficient at 16 Hz 1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range

0.5 Hz bis	< 1 Hz	2.0% / 2.0°
1 Hz bis	80 Hz	1.5% / 1.5°
> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**30.006 mV/(mm/s)**	**0.004 %**	**0.0012 mV/(mm/s)**
y-axis:	**30.249 mV/(mm/s)**	**0.002 %**	**0.0006 mV/(mm/s)**
z-axis:	**29.968 mV/(mm/s)**	**0.003 %**	**0.0009 mV/(mm/s)**

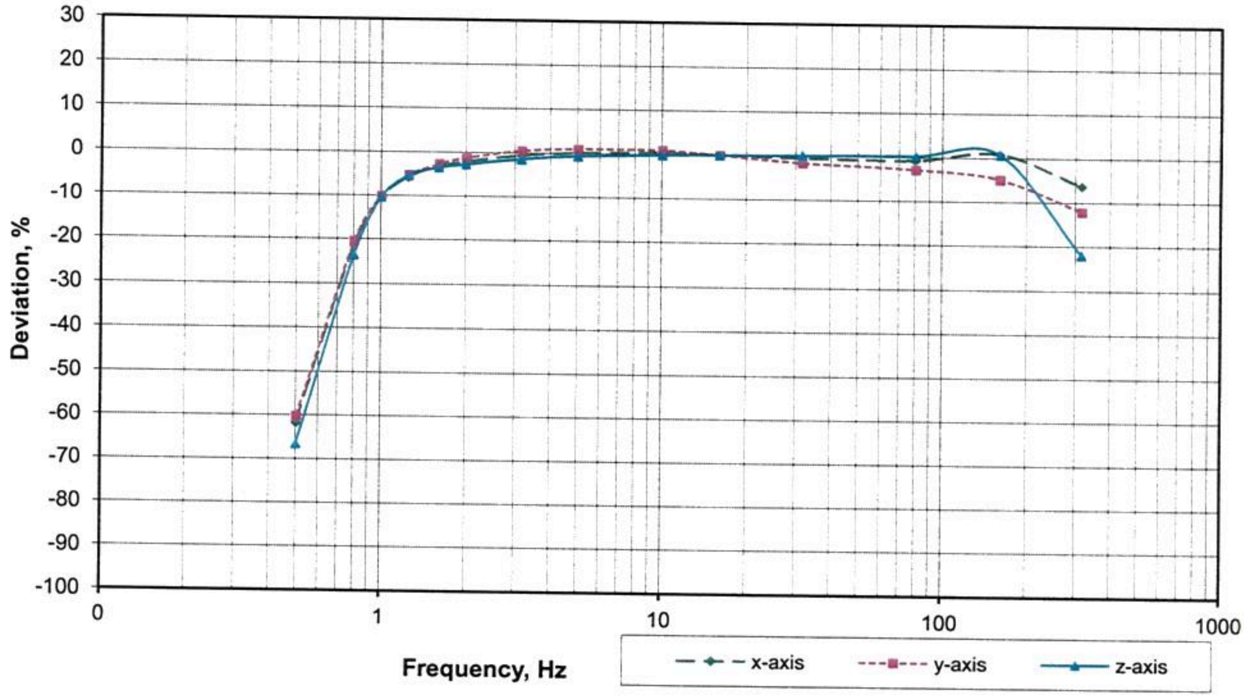
(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

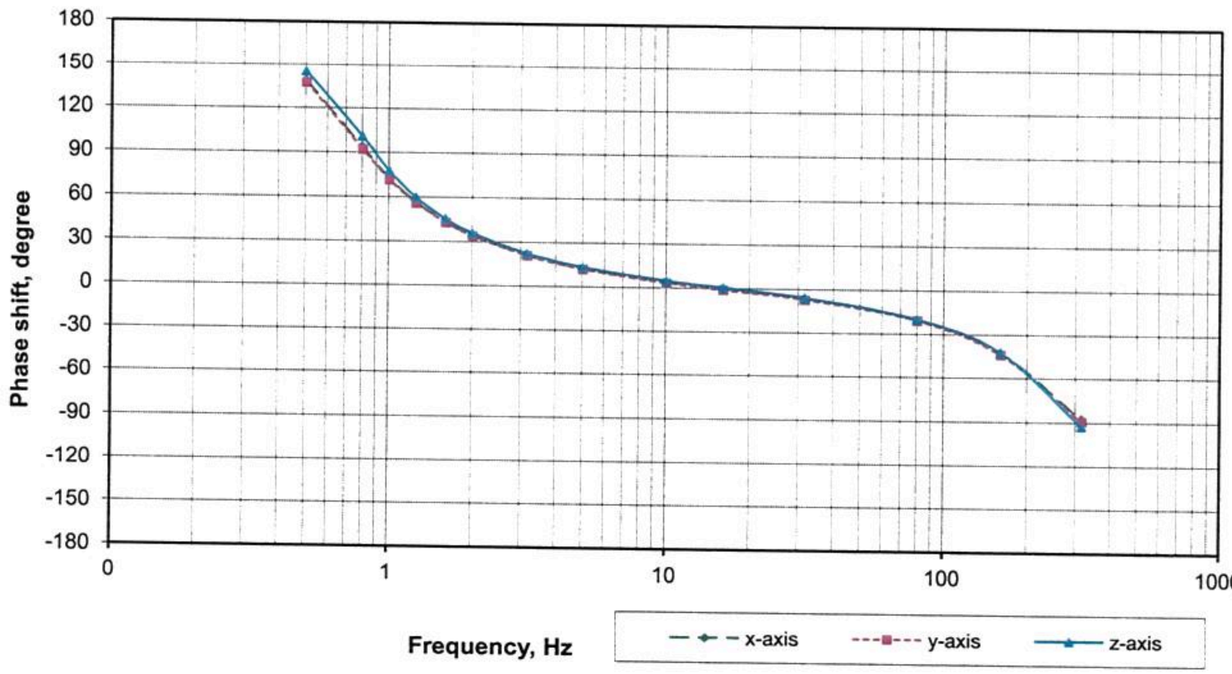
Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.48	-61.74	139.0	12.03	-60.23	137.5	10.03	-66.52	145.6
0.8	23.57	-21.45	93.7	24.06	-20.46	92.0	22.91	-23.57	100.9
1	26.84	-10.56	72.8	27.21	-10.06	71.6	26.86	-10.38	77.8
1.25	28.29	-5.71	56.6	28.67	-5.23	55.8	28.37	-5.34	59.7
1.6	29.00	-3.35	43.3	29.45	-2.65	42.8	28.92	-3.51	45.4
2	29.37	-2.13	34.2	29.87	-1.24	33.9	29.17	-2.67	35.8
3.15	29.80	-0.68	21.2	30.39	0.47	20.8	29.54	-1.44	22.3
5	30.02	0.04	12.5	30.56	1.02	12.0	29.78	-0.63	13.4
10	30.11	0.35	4.0	30.54	0.97	3.2	29.93	-0.14	4.8
16	**30.01**	**0.0**	**-0.2**	**30.25**	**0.0**	**-1.1**	**29.97**	**0.0**	**0.5**
31.5	29.85	-0.51	-6.2	29.80	-1.48	-7.2	30.01	0.13	-5.8
80	29.77	-0.77	-20.0	29.43	-2.70	-20.8	30.06	0.32	-19.7
160	30.24	0.78	-42.3	28.81	-4.76	-43.7	30.19	0.72	-41.9
315	28.14	-6.22	-87.6	26.61	-12.02	-89.3	23.40	-21.92	-92.4

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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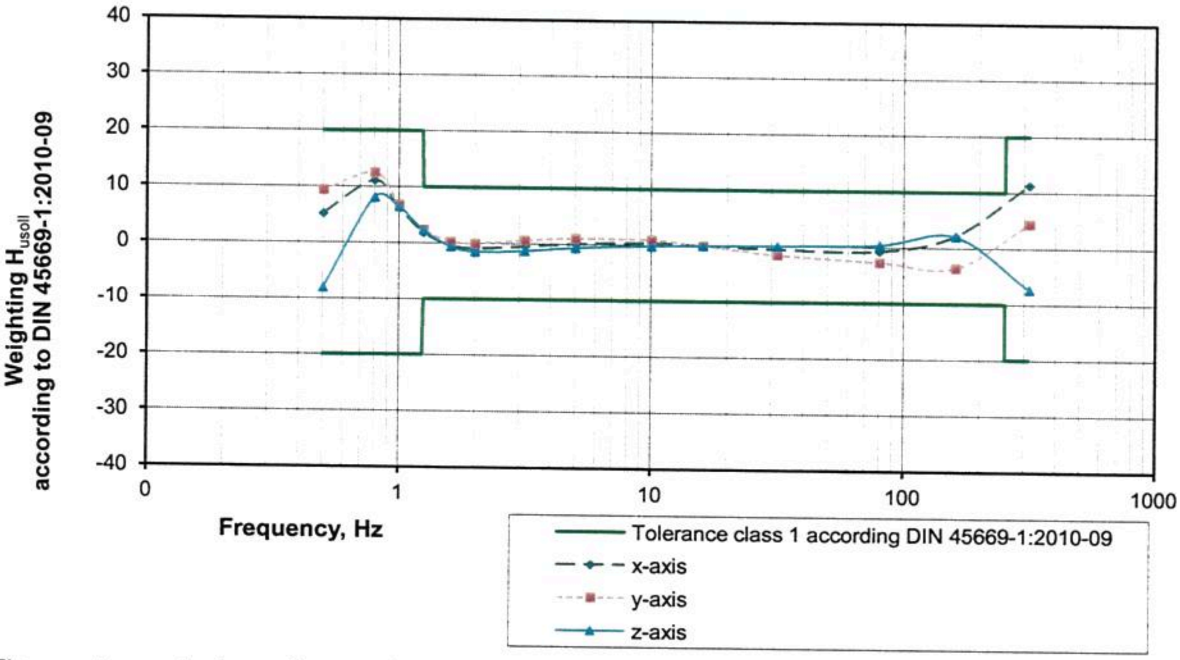
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis: Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	x-axis: Weighting factor, (measured value)	x-axis: Deviation to H_{uSOLL}	y-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	y-axis: Weighting factor, (measured value)	y-axis: Deviation to H_{uSOLL}	z-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	z-axis: Weighting factor, (measured value)	z-axis: Deviation to H_{uSOLL}
0.5	0.364	0.383	5.2	0.364	0.398	9.3	0.364	0.335	-8.0
0.8	0.707	0.786	11.1	0.707	0.795	12.5	0.707	0.764	8.1
1	0.842	0.894	6.2	0.842	0.899	6.8	0.842	0.896	6.4
1.25	0.925	0.943	1.9	0.925	0.948	2.4	0.925	0.947	2.3
1.6	0.970	0.967	-0.4	0.970	0.973	0.3	0.970	0.965	-0.5
2	0.987	0.979	-0.9	0.987	0.988	0.0	0.987	0.973	-1.4
3.15	0.998	0.993	-0.5	0.998	1.005	0.7	0.998	0.986	-1.2
5	1.000	1.000	0.1	1.000	1.010	1.1	1.000	0.994	-0.6
10	1.000	1.003	0.3	1.000	1.010	1.0	1.000	0.999	-0.1
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	0.995	-0.5	1.000	0.985	-1.5	1.000	1.001	0.1
80	0.999	0.992	-0.7	0.999	0.973	-2.6	0.999	1.003	0.4
160	0.987	1.008	2.1	0.987	0.952	-3.5	0.987	1.007	2.1
315	0.842	0.938	11.3	0.842	0.880	4.5	0.842	0.781	-7.3



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10023

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 218137

G.R.A.S.
Sound & Vibration

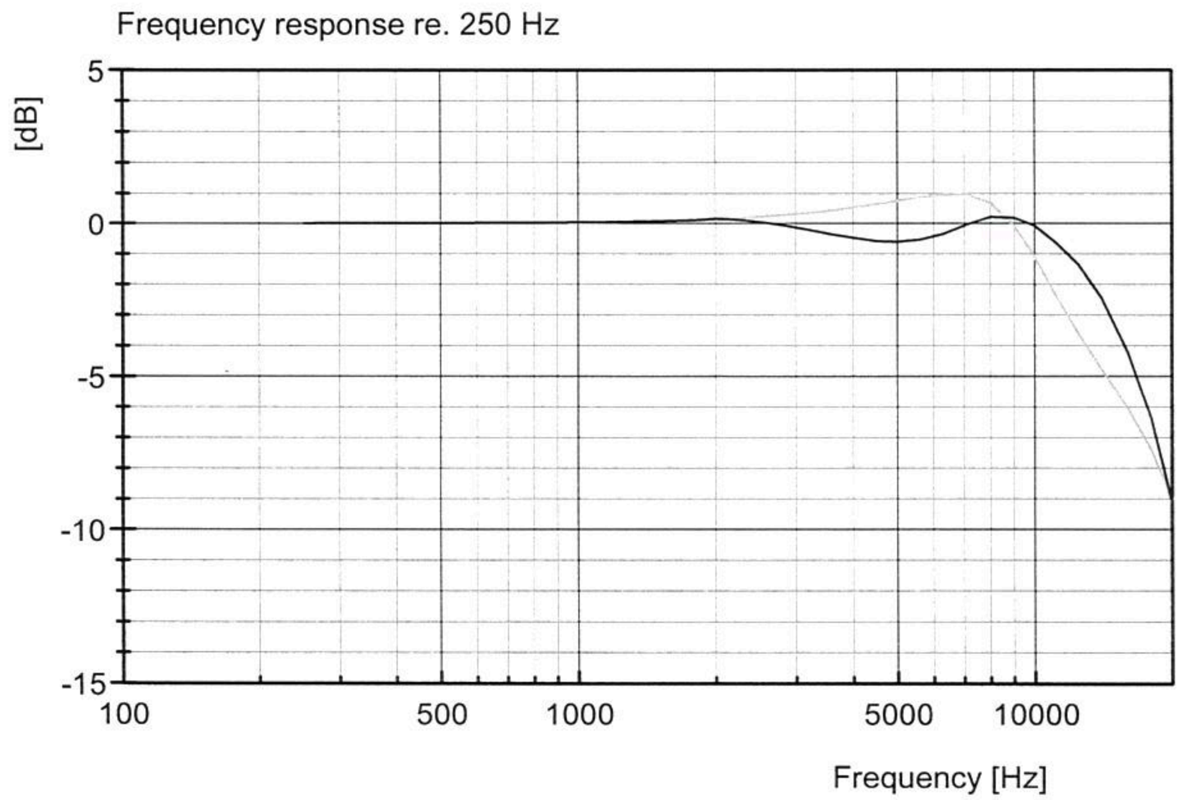
System Sensitivity:	50.06 mV/Pa
	-26.01 dB re. 1V/Pa
Actuator output:	31.68 mV
Preamplifier type:	26AX
Preamplifier serial no:	214112
Microphone type:	40AS
Microphone Serial No:	178531
Operator:	FBL
Date:	21. aug 2014

The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa



G.R.A.S. Sound & Vibration A/S
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e-mail : gras@gras.dk

SPEKTRA Vibration and Acoustics Systems Engineering

Calibration Systems · Special Equipment · DAkkS Laboratory · Environmental Simulation

SPEKTRA

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

1921
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504077**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH** **DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**12/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
15/09/2014	Mario Chares	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504077**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(24.2 ± 1) °C**
Relative humidity:	**(50 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity:	**horizontal (x- and y-axis)** **vertical (z-axis)**
Temperature of test object:	**(24.2 ± 2) °C**

Attachment of test object to vibration exciter:

z-axis:	**screwed SAM-018**
x- and y-axis:	**screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)

Manufacturer:	**SINUS Messtechnik GmbH**
Type:	**902246**
Length:	**2 m**

Specification of excitation
for determination of the transfer coefficient

Frequency:	**16 Hz**
Velocity (peak)	**10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:
- for determination of the transfer coefficient at 16 Hz — 1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range

0.5 Hz bis	< 1 Hz	2.0% / 2.0°
1 Hz bis	80 Hz	1.5% / 1.5°
> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**28.912 mV/(mm/s)**	**0.007 %**	**0.0020 mV/(mm/s)**
y-axis:	**29.380 mV/(mm/s)**	**0.005 %**	**0.0015 mV/(mm/s)**
z-axis:	**29.623 mV/(mm/s)**	**0.003 %**	**0.0009 mV/(mm/s)**

(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	10.92	-62.22	140.8	11.63	-60.42	139.9	11.90	-59.82	137.7
0.8	22.72	-21.41	93.7	24.37	-17.06	93.4	23.85	-19.48	91.4
1	25.58	-11.53	72.3	27.55	-6.24	71.5	26.79	-9.57	70.7
1.25	26.70	-7.65	56.2	28.64	-2.52	54.8	28.02	-5.40	55.0
1.6	27.24	-5.78	43.2	28.96	-1.43	41.5	28.62	-3.37	42.1
2	27.58	-4.62	34.5	29.06	-1.08	32.6	28.94	-2.30	33.3
3.15	28.07	-2.91	21.7	29.20	-0.63	20.1	29.34	-0.96	20.6
5	28.39	-1.81	13.3	29.29	-0.31	11.9	29.55	-0.26	12.2
10	28.72	-0.66	5.3	29.39	0.04	4.0	29.63	0.04	4.0
16	**28.91**	**0.0**	**1.2**	**29.38**	**0.0**	**0.1**	**29.62**	**0.0**	**-0.1**
31.5	29.20	0.99	-5.0	29.40	0.05	-6.0	29.49	-0.44	-6.2
80	29.49	2.00	-19.1	29.44	0.20	-19.7	29.55	-0.24	-19.9
160	29.43	1.80	-41.1	29.25	-0.46	-42.2	29.27	-1.21	-42.1
315	27.53	-4.79	-87.2	26.87	-8.55	-87.3	25.81	-12.86	-87.5

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

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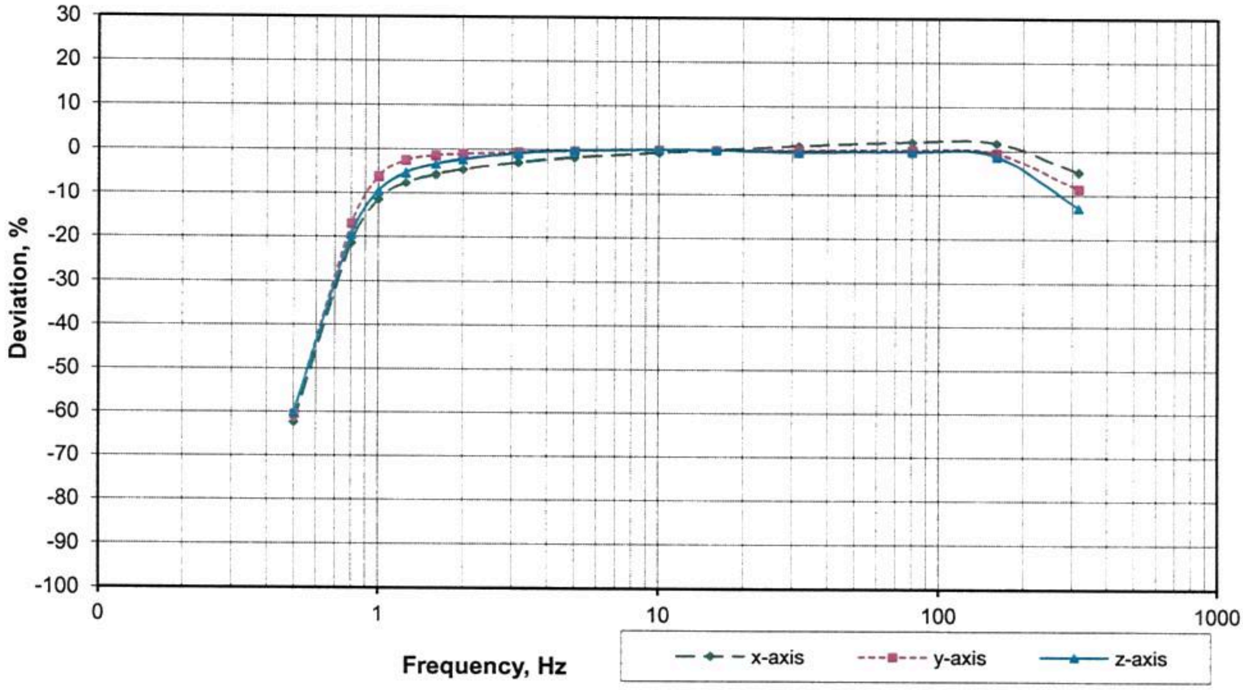
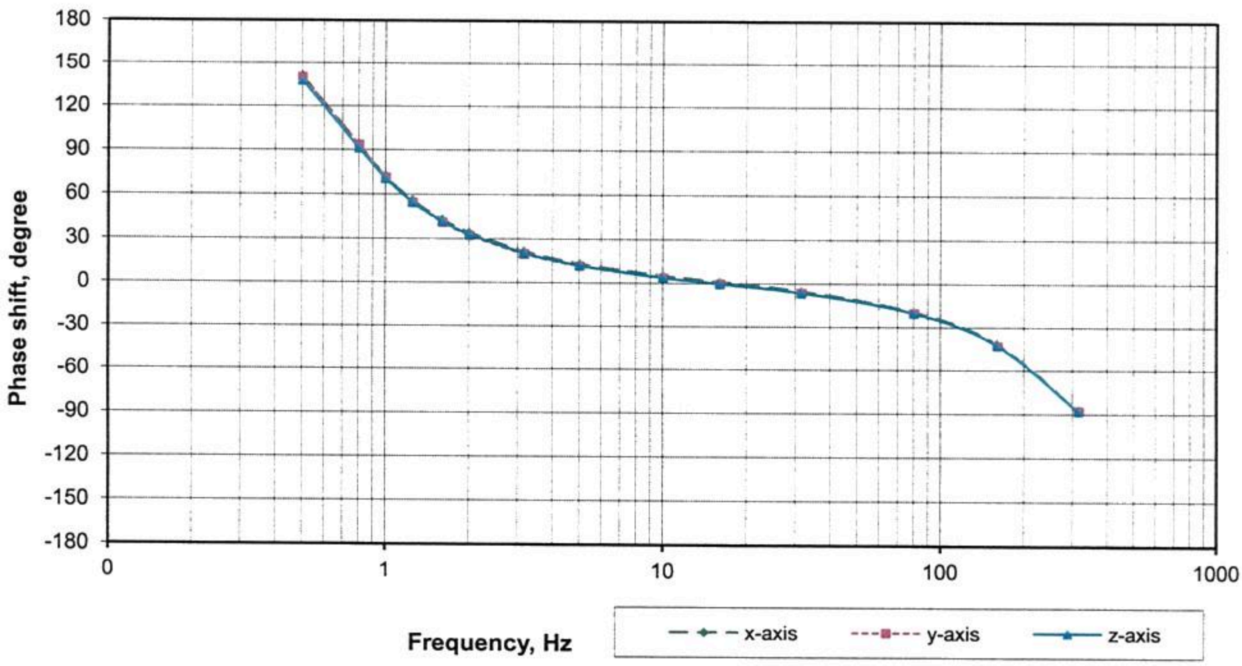
2014-09

Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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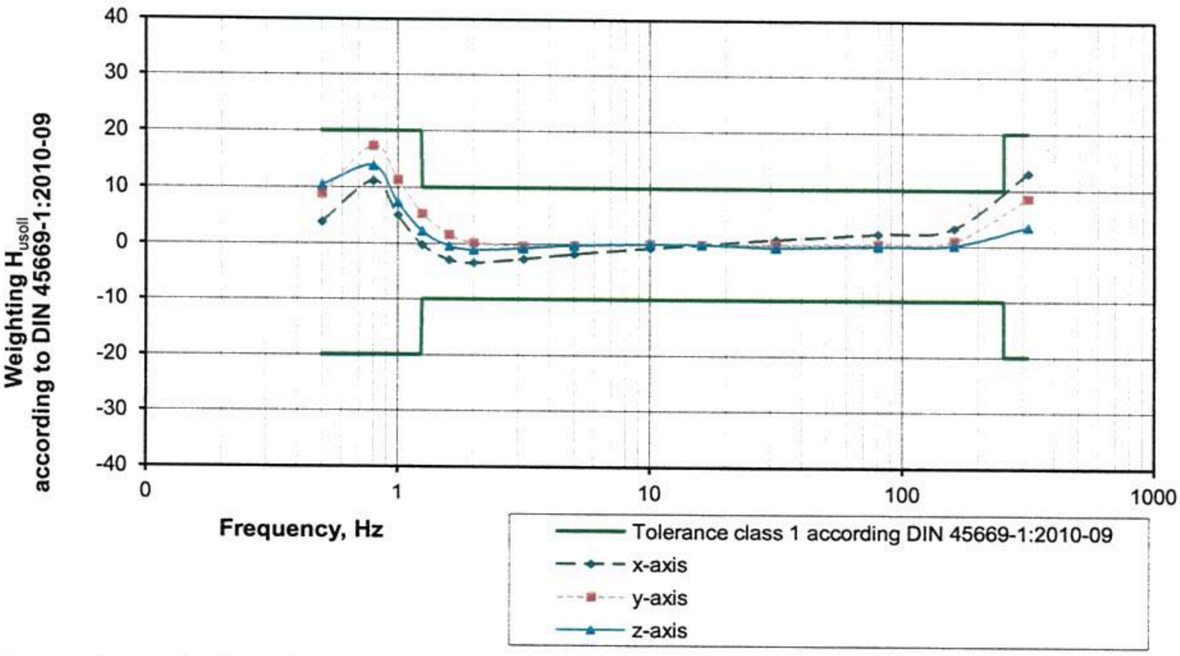
7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis			y-axis			z-axis		
	Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}
0.5	0.364	0.378	3.8	0.364	0.396	8.8	0.364	0.402	10.4
0.8	0.707	0.786	11.1	0.707	0.829	17.3	0.707	0.805	13.9
1	0.842	0.885	5.0	0.842	0.938	11.3	0.842	0.904	7.4
1.25	0.925	0.923	-0.2	0.925	0.975	5.3	0.925	0.946	2.2
1.6	0.970	0.942	-2.9	0.970	0.986	1.6	0.970	0.966	-0.4
2	0.987	0.954	-3.4	0.987	0.989	0.2	0.987	0.977	-1.1
3.15	0.998	0.971	-2.7	0.998	0.994	-0.4	0.998	0.990	-0.8
5	1.000	0.982	-1.8	1.000	0.997	-0.3	1.000	0.997	-0.2
10	1.000	0.993	-0.7	1.000	1.000	0.0	1.000	1.000	0.0
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	1.010	1.0	1.000	1.001	0.1	1.000	0.996	-0.4
80	0.999	1.020	2.1	0.999	1.002	0.3	0.999	0.998	-0.2
160	0.987	1.018	3.2	0.987	0.995	0.9	0.987	0.988	0.1
315	0.842	0.952	13.0	0.842	0.914	8.6	0.842	0.871	3.5



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

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SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10033

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 218135

G.R.A.S.
Sound & Vibration

System Sensitivity:	50.00 mV/Pa
	-26.02 dB re. 1V/Pa
Actuator output:	31.71 mV
Preamplifier type:	26AX
Preamplifier serial no:	214103
Microphone type:	40AS
Microphone Serial No:	138462
Operator:	FBL
Date:	18. aug 2014

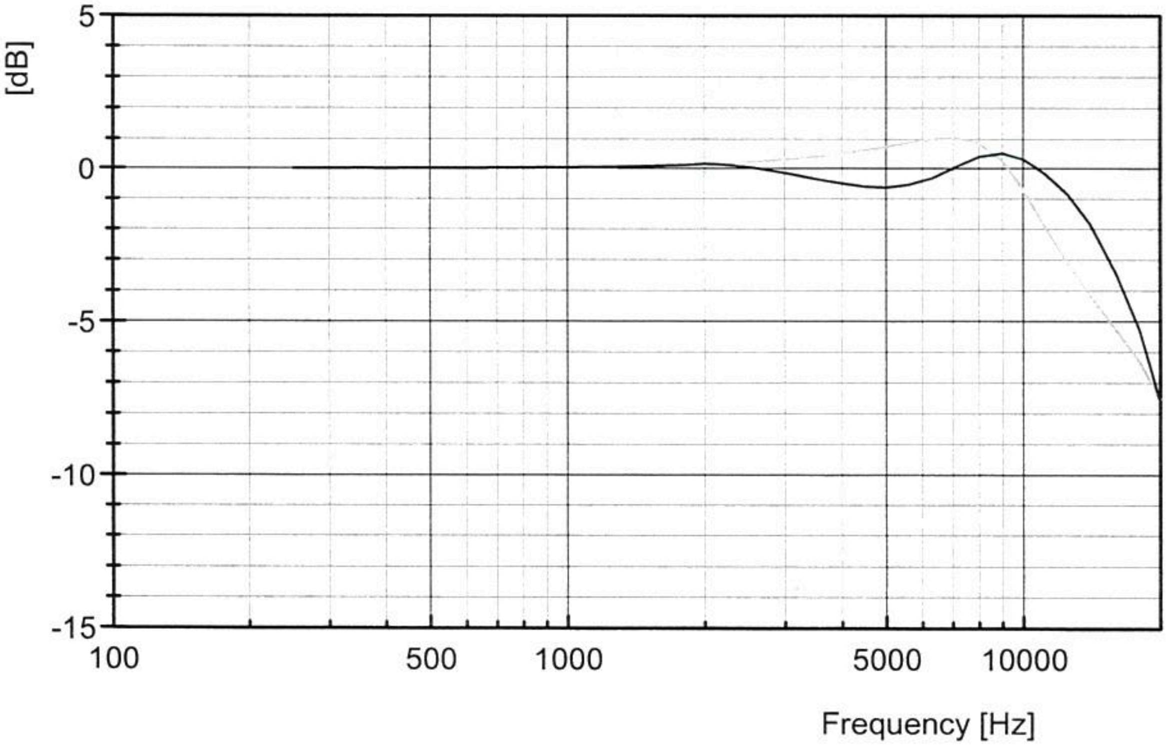
The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa

Frequency response re. 250 Hz



G.R.A.S. Sound & Vibration A/S
Skovlytoften 33
DK-2840 Holte, Denmark

Tel.: +45 45 66 40 46
Fax : +45 45 66 40 47
e-mail : gras@gras.dk

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst **DKD**

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

1925
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504081**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH** **DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**17/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
17/09/2014	Mario Chares	René Zimmermann

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1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504081**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(23.1 ± 1) °C**
Relative humidity:	**(55 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity:	**horizontal (x- and y-axis)** **vertical (z-axis)**
Temperature of test object:	**(23.1 ± 2) °C**

Attachment of test object to vibration exciter:

z-axis:	**screwed SAM-018**
x- and y-axis:	**screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)

Manufacturer:	**SINUS Messtechnik GmbH**
Type:	**902246**
Length:	**2 m**

Specification of excitation
for determination of the transfer coefficient

Frequency:	**16 Hz**
Velocity (peak)	**10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

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5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:
- for determination of the transfer coefficient at 16 Hz 1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range

0.5 Hz bis	< 1 Hz	2.0% / 2.0°
1 Hz bis	80 Hz	1.5% / 1.5°
> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.734 mV/(mm/s)**	**0.003 %**	**0.0009 mV/(mm/s)**
y-axis:	**30.034 mV/(mm/s)**	**0.002 %**	**0.0006 mV/(mm/s)**
z-axis:	**29.650 mV/(mm/s)**	**0.002 %**	**0.0006 mV/(mm/s)**

(acceleration due to gravity 1 g_n = 9.80665 m/s²)

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7.2 Amplitude frequency response (relative to 16 Hz)

Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.37	-61.76	140.0	11.48	-61.78	138.9	9.96	-66.40	145.9
0.8	23.48	-21.03	94.3	23.44	-21.95	93.7	22.86	-22.89	100.7
1	26.74	-10.08	73.2	26.72	-11.05	73.1	26.68	-10.03	77.3
1.25	28.17	-5.26	56.9	28.24	-5.99	57.0	28.03	-5.47	59.2
1.6	28.90	-2.80	43.6	29.04	-3.31	43.7	28.47	-3.99	45.0
2	29.30	-1.48	34.5	29.48	-1.84	34.6	28.67	-3.30	35.6
3.15	29.78	0.15	21.3	30.04	0.02	21.4	29.02	-2.12	22.3
5	29.99	0.84	12.3	30.14	0.36	12.4	29.28	-1.26	13.5
10	29.98	0.82	3.6	30.30	0.89	3.6	29.51	-0.47	5.2
16	**29.73**	**0.0**	**-0.8**	**30.03**	**0.0**	**-0.6**	**29.65**	**0.0**	**1.0**
31.5	29.36	-1.26	-6.8	29.72	-1.06	-6.6	29.95	1.02	-5.2
80	29.29	-1.50	-19.9	29.65	-1.27	-19.9	30.01	1.20	-19.1
160	28.74	-3.34	-41.8	29.11	-3.07	-41.7	29.47	-0.59	-41.6
315	25.19	-15.28	-86.9	25.67	-14.54	-86.6	21.99	-25.84	-92.3

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

1925
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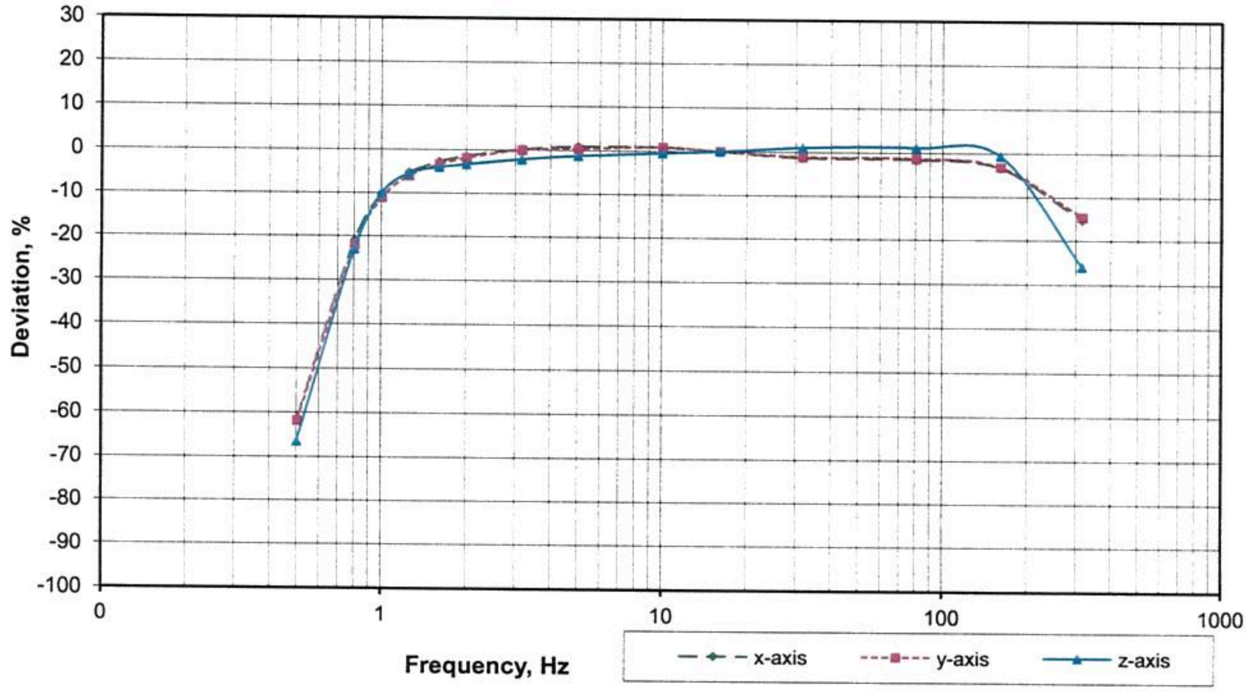
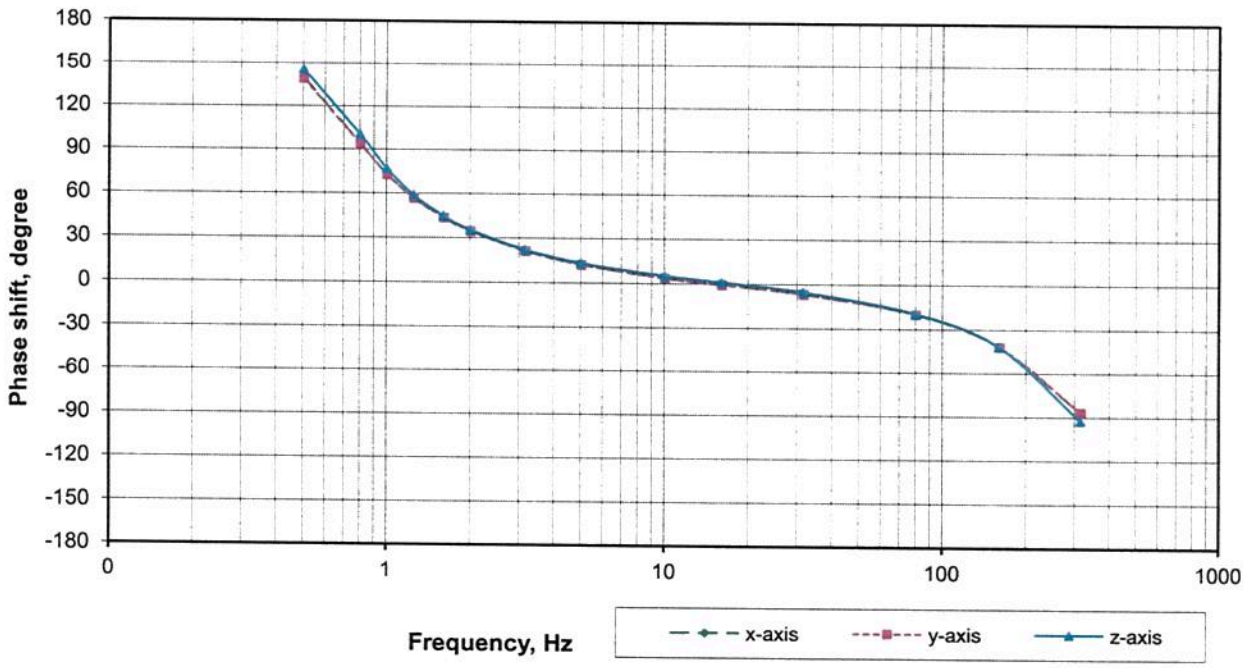
Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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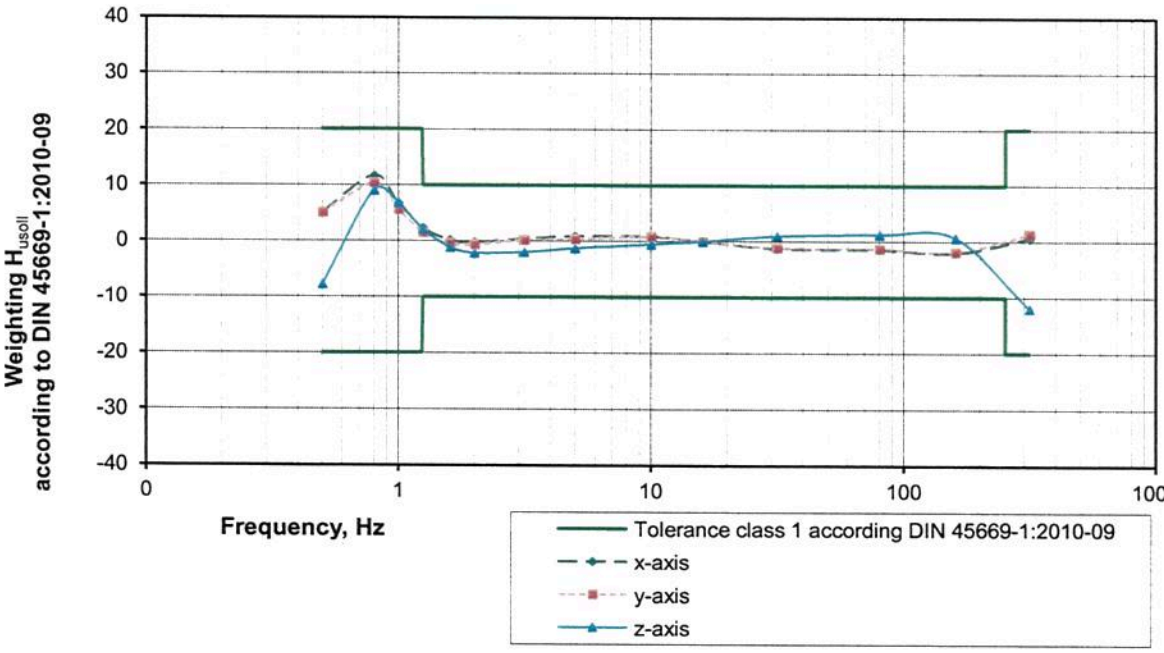
7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis: Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	x-axis: Weighting factor, (measured value)	x-axis: Deviation to H_{uSOLL}	y-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	y-axis: Weighting factor, (measured value)	y-axis: Deviation to H_{uSOLL}	z-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	z-axis: Weighting factor, (measured value)	z-axis: Deviation to H_{uSOLL}
0.5	0.364	0.382	5.1	0.364	0.382	5.1	0.364	0.336	-7.6
0.8	0.707	0.790	11.7	0.707	0.780	10.4	0.707	0.771	9.0
1	0.842	0.899	6.8	0.842	0.890	5.6	0.842	0.900	6.8
1.25	0.925	0.947	2.4	0.925	0.940	1.6	0.925	0.945	2.2
1.6	0.970	0.972	0.2	0.970	0.967	-0.3	0.970	0.960	-1.0
2	0.987	0.985	-0.2	0.987	0.982	-0.6	0.987	0.967	-2.1
3.15	0.998	1.002	0.4	0.998	1.000	0.2	0.998	0.979	-1.9
5	1.000	1.008	0.9	1.000	1.004	0.4	1.000	0.987	-1.2
10	1.000	1.008	0.8	1.000	1.009	0.9	1.000	0.995	-0.5
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	0.987	-1.3	1.000	0.989	-1.1	1.000	1.010	1.0
80	0.999	0.985	-1.4	0.999	0.987	-1.2	0.999	1.012	1.3
160	0.987	0.967	-2.0	0.987	0.969	-1.8	0.987	0.994	0.8
315	0.842	0.847	0.6	0.842	0.855	1.5	0.842	0.742	-12.0



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

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SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10029

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 218140

G.R.A.S.
Sound & Vibration

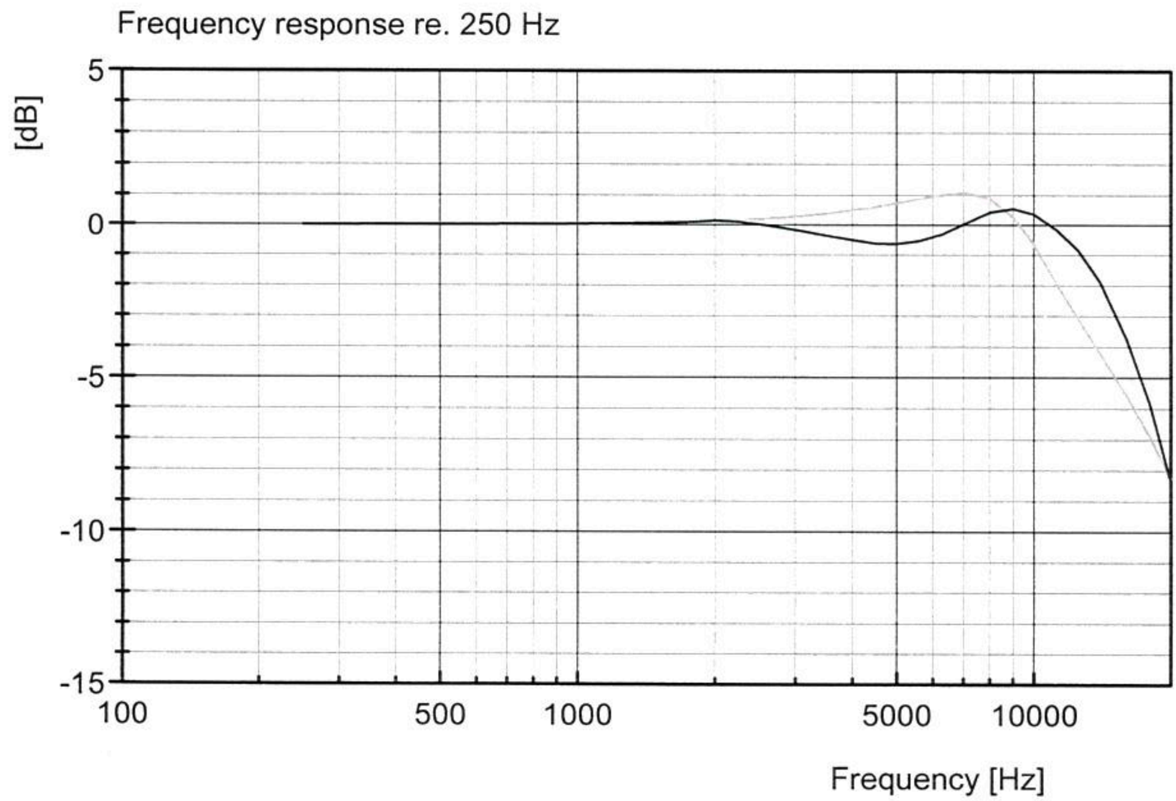
System Sensitivity:	50.05 mV/Pa
	-26.01 dB re. 1V/Pa
Actuator output:	31.70 mV
Preamplifier type:	26AX
Preamplifier serial no:	214110
Microphone type:	40AS
Microphone Serial No:	178540
Operator:	FBL
Date:	21. aug 2014

The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa



G.R.A.S. Sound & Vibration A/S
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DK-2840 Holte, Denmark

Tel.: +45 45 66 40 46
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e-mail : gras@gras.dk

SPEKTRA Vibration and Acoustics Systems Engineering

Calibration Systems · Special Equipment · DAkkS Laboratory · Environmental Simulation

SPEKTRA

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst **DKD**

Kalibrierschein
Calibration Certificate

Kalibrierzeichen *Calibration mark*

1920
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504076**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH** **DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**18/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
18/09/2014	Heiko Deierlein	René Zimmermann

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Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1 9 2 0
D-K- 15183-01-00
2014-09

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504076**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(22.4 ± 1) °C**
Relative humidity:	**(52 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity: **horizontal (x- and y-axis)**
vertical (z-axis)

Temperature of test object: **(22.4 ± 2) °C**

Attachment of test object to vibration exciter:

z-axis:	**screwed SAM-018**
x- and y-axis:	**screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)

Manufacturer:	**SINUS Messtechnik GmbH**
Type:	**902246**
Length:	**2 m**

Specification of excitation
for determination of the transfer coefficient

Frequency:	**16 Hz**
Velocity (peak)	**10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

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5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:

- for determination of the transfer coefficient at 16 Hz			1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range			
	0.5 Hz bis	< 1 Hz	2.0% / 2.0°
	1 Hz bis	80 Hz	1.5% / 1.5°
	> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.836 mV/(mm/s)**	**0.005 %**	**0.0015 mV/(mm/s)**
y-axis:	**30.114 mV/(mm/s)**	**0.005 %**	**0.0015 mV/(mm/s)**
z-axis:	**29.843 mV/(mm/s)**	**0.004 %**	**0.0012 mV/(mm/s)**

(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.43	-61.69	137.3	11.33	-62.37	139.4	9.89	-66.87	145.5
0.8	22.76	-23.73	92.5	23.57	-21.74	94.6	22.67	-24.04	101.0
1	25.86	-13.33	72.6	27.01	-10.32	73.6	26.60	-10.88	77.8
1.25	27.44	-8.03	57.1	28.55	-5.19	57.1	28.08	-5.90	59.7
1.6	28.40	-4.81	44.1	29.31	-2.67	43.7	28.62	-4.10	45.4
2	28.97	-2.91	35.0	29.70	-1.38	34.5	28.87	-3.26	35.9
3.15	29.67	-0.57	21.7	30.15	0.13	21.2	29.26	-1.96	22.4
5	29.95	0.40	12.7	30.34	0.74	12.3	29.52	-1.08	13.5
10	30.04	0.67	3.9	30.35	0.77	3.6	29.73	-0.39	5.1
16	**29.84**	**0.0**	**-0.5**	**30.11**	**0.0**	**-0.7**	**29.84**	**0.0**	**0.8**
31.5	29.50	-1.12	-6.6	29.74	-1.23	-6.8	29.92	0.25	-5.5
80	29.48	-1.21	-19.9	29.68	-1.46	-20.0	29.99	0.49	-19.7
160	28.84	-3.33	-42.1	29.28	-2.77	-42.2	29.21	-2.13	-42.2
315	25.50	-14.53	-87.6	26.10	-13.33	-87.5	26.02	-12.80	-92.9

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

1920
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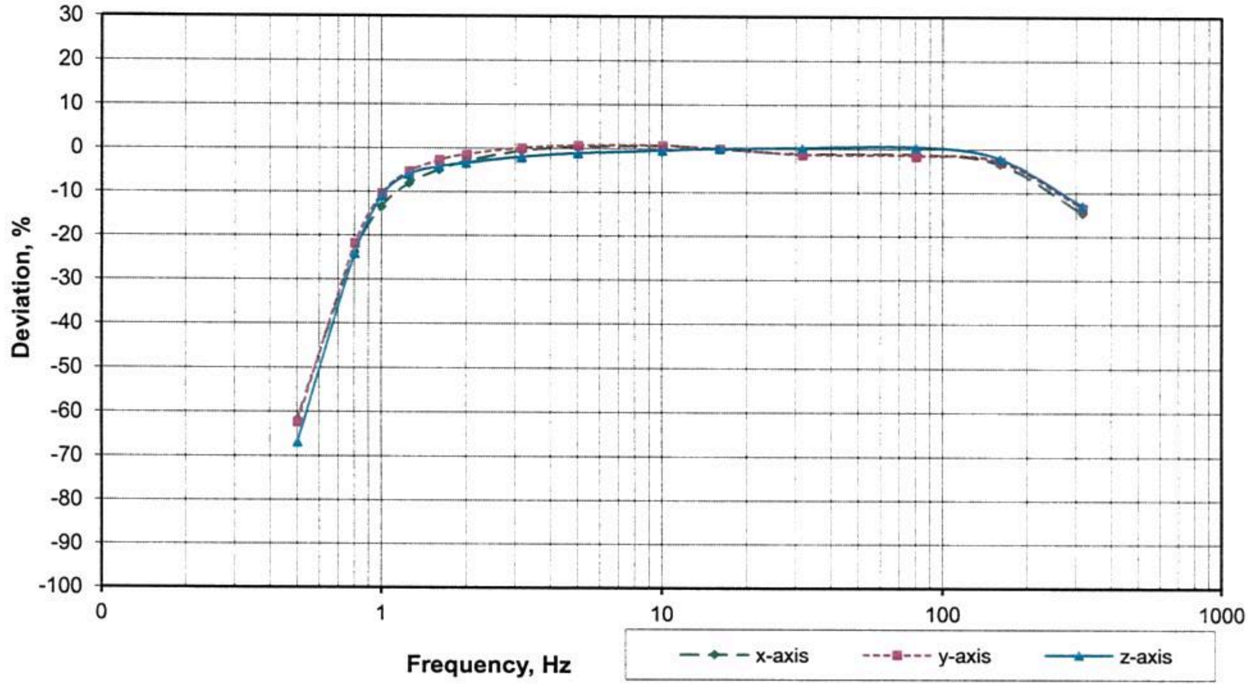
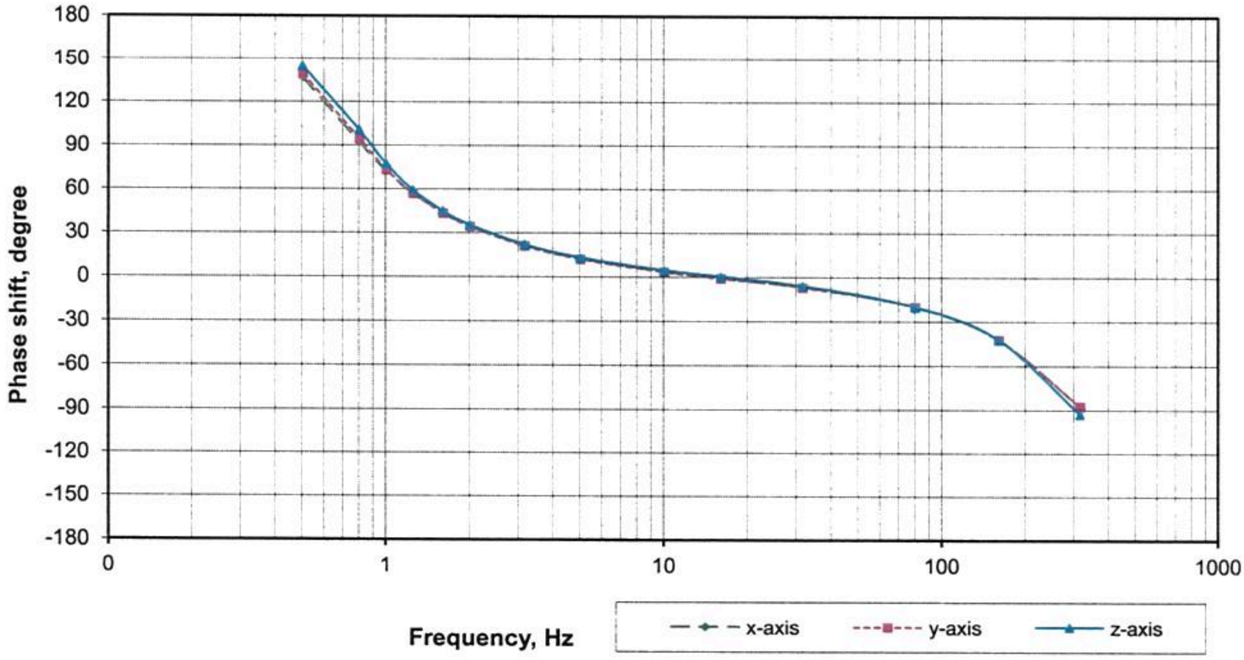
2014-09

Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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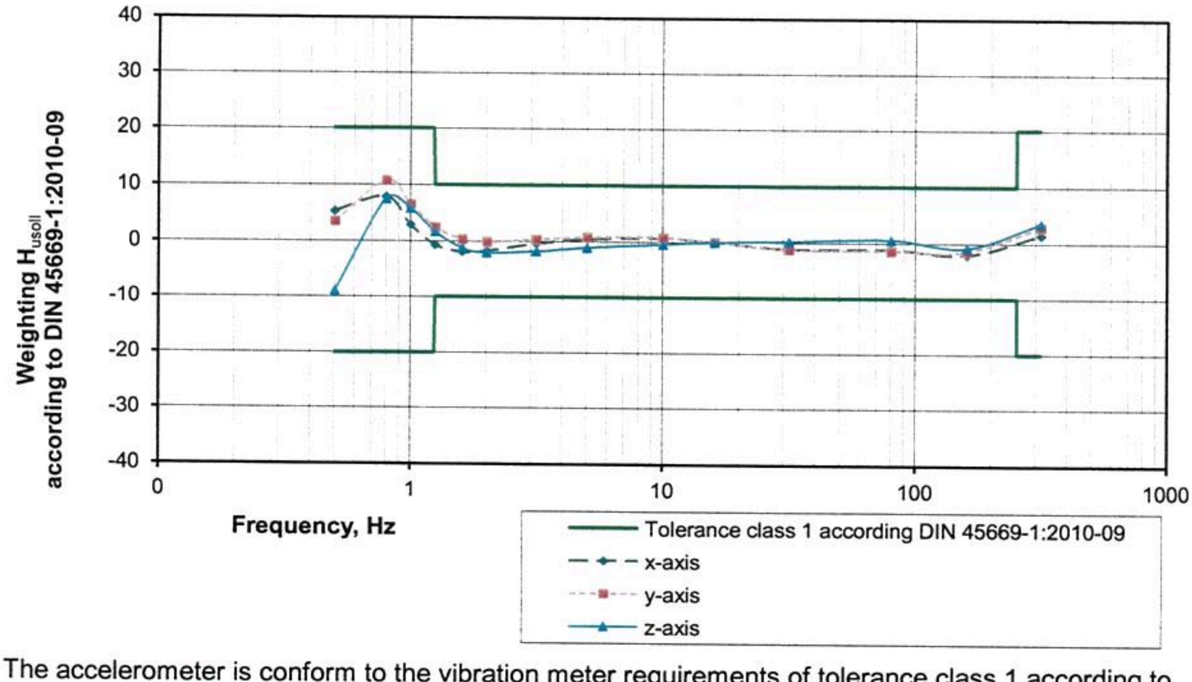
7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis			y-axis			z-axis		
	Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}
0.5	0.364	0.383	5.3	0.364	0.376	3.4	0.364	0.331	-8.9
0.8	0.707	0.763	7.9	0.707	0.783	10.7	0.707	0.760	7.4
1	0.842	0.867	2.9	0.842	0.897	6.5	0.842	0.891	5.8
1.25	0.925	0.920	-0.6	0.925	0.948	2.5	0.925	0.941	1.7
1.6	0.970	0.952	-1.9	0.970	0.973	0.3	0.970	0.959	-1.2
2	0.987	0.971	-1.7	0.987	0.986	-0.1	0.987	0.967	-2.0
3.15	0.998	0.994	-0.4	0.998	1.001	0.3	0.998	0.980	-1.8
5	1.000	1.004	0.4	1.000	1.007	0.8	1.000	0.989	-1.0
10	1.000	1.007	0.7	1.000	1.008	0.8	1.000	0.996	-0.4
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	0.989	-1.1	1.000	0.988	-1.2	1.000	1.003	0.3
80	0.999	0.988	-1.1	0.999	0.985	-1.4	0.999	1.005	0.6
160	0.987	0.967	-2.0	0.987	0.972	-1.4	0.987	0.979	-0.8
315	0.842	0.855	1.5	0.842	0.867	2.9	0.842	0.872	3.5



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

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SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10035

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 218139

G.R.A.S.
Sound & Vibration

System Sensitivity:	49.99 mV/Pa
	-26.02 dB re. 1V/Pa
Actuator output:	31.72 mV
Preamplifier type:	26AX
Preamplifier serial no:	214109
Microphone type:	40AS
Microphone Serial No:	178539
Operator:	FBL
Date:	21. aug 2014

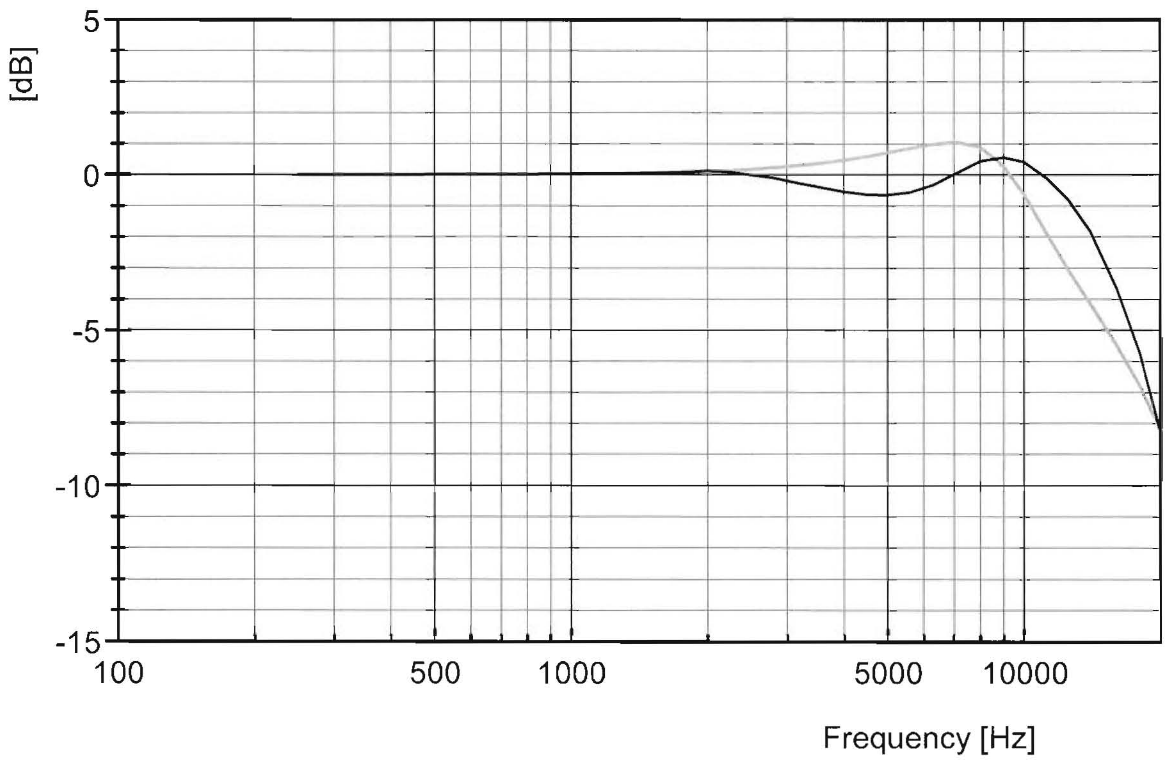
The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa

Frequency response re. 250 Hz



G.R.A.S. Sound & Vibration A/S
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SPEKTRA Vibration and Acoustics Systems Engineering

Calibration Systems · Special Equipment · DAkkS Laboratory · Environmental Simulation

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst **DKD**

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

Kalibrierschein
Calibration Certificate

Kalibrierzeichen / *Calibration mark*: 1916 · D-K-15183-01-00 · 2014-09

Gegenstand / *Object*	**Velocity transducer**
Hersteller / *Manufacturer*	**SINUS Messtechnik**
Typ / *Type*	**902219.7**
Fabrikat/Serien-Nr. / *Serial number*	**#0504072**
Auftraggeber / *Customer*	**SINUS Messtechnik GmbH DE-04347 Leipzig**
Auftragsnummer / *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines / *Number of pages of the certificate*	**6**
Datum der Kalibrierung / *Date of calibration*	**15/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum / *Date*	Stellv. Leiter des Kalibrierlaboratoriums / *Deputy head of the calibration laboratory*	Bearbeiter / *Person in charge*
15/09/2014	Mario Chares	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504072**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(24.1 ± 1) °C**
Relative humidity:	**(56 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity: **horizontal (x- and y-axis)**
vertical (z-axis)

Temperature of test object: **(24.1 ± 2) °C**

Attachment of test object to vibration exciter:

z-axis:	**screwed SAM-018**
x- and y-axis:	**screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)

Manufacturer:	**SINUS Messtechnik GmbH**
Type:	**902246**
Length:	**2 m**

Specification of excitation
for determination of the transfer coefficient

Frequency:	**16 Hz**
Velocity (peak)	**10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

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5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:

- for determination of the transfer coefficient at 16 Hz			1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range			
	0.5 Hz bis	< 1 Hz	2.0% / 2.0°
	1 Hz bis	80 Hz	1.5% / 1.5°
	> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**28.819 mV/(mm/s)**	**0.005 %**	**0.0014 mV/(mm/s)**
y-axis:	**29.607 mV/(mm/s)**	**0.010 %**	**0.0030 mV/(mm/s)**
z-axis:	**29.466 mV/(mm/s)**	**0.003 %**	**0.0009 mV/(mm/s)**

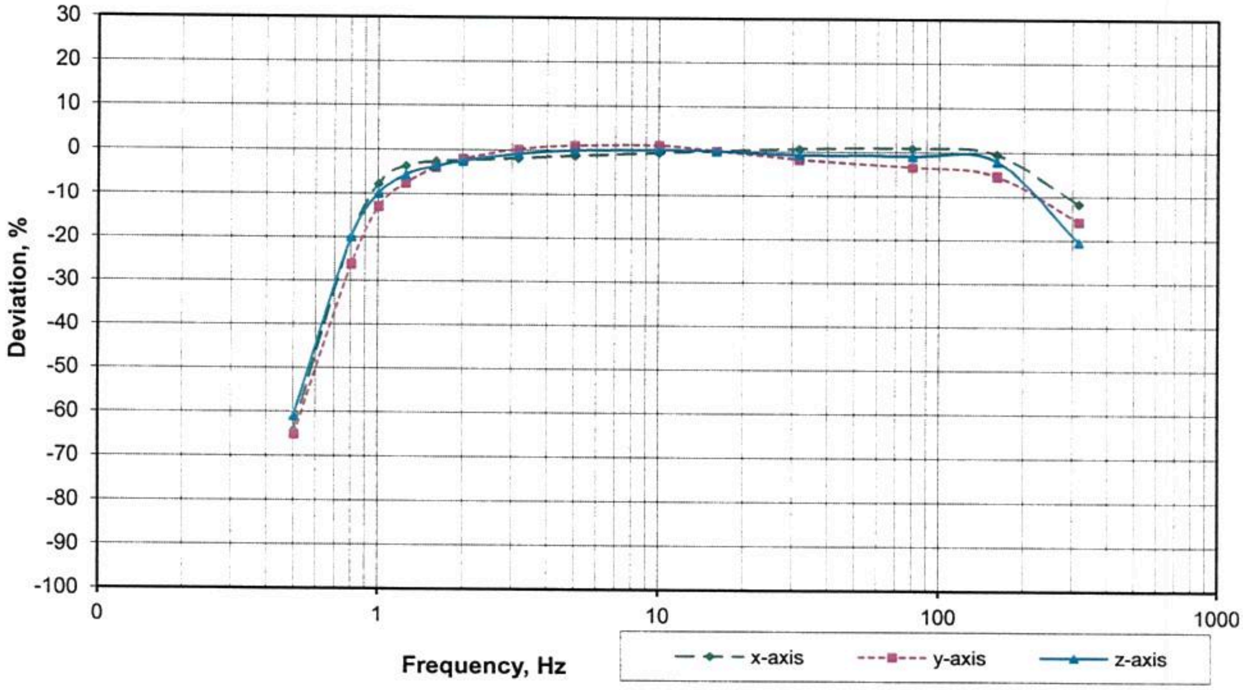
(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

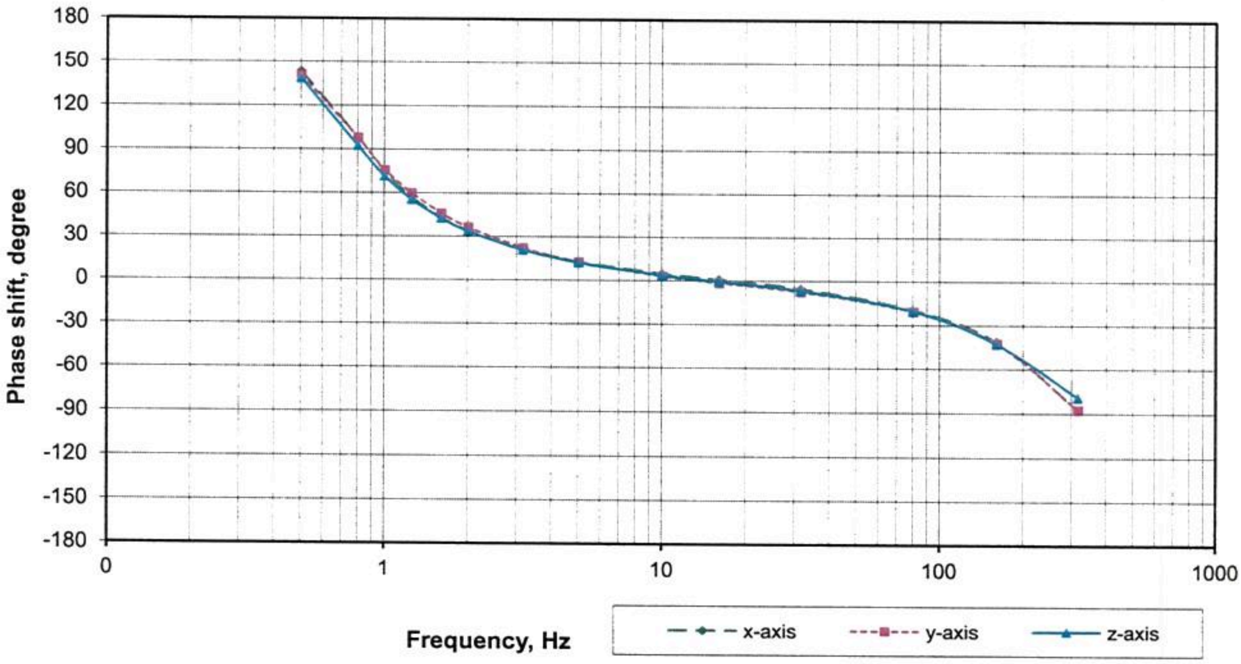
Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	10.31	-64.23	143.5	10.37	-64.99	140.6	11.57	-60.73	138.7
0.8	23.03	-20.09	98.2	21.83	-26.27	97.6	23.59	-19.96	92.3
1	26.59	-7.75	75.2	25.78	-12.94	75.7	26.55	-9.89	71.4
1.25	27.78	-3.62	57.4	27.37	-7.57	60.0	27.79	-5.70	55.5
1.6	28.06	-2.62	43.4	28.42	-4.01	46.1	28.40	-3.62	42.6
2	28.14	-2.35	34.1	28.99	-2.10	36.4	28.74	-2.45	33.7
3.15	28.29	-1.82	21.2	29.65	0.14	22.4	29.21	-0.88	20.9
5	28.46	-1.26	12.8	29.91	1.04	12.8	29.45	-0.06	12.3
10	28.68	-0.47	4.9	29.96	1.18	3.5	29.52	0.18	4.0
16	**28.82**	**0.0**	**1.0**	**29.61**	**0.0**	**-1.0**	**29.47**	**0.0**	**-0.3**
31.5	29.00	0.64	-5.2	29.10	-1.70	-7.0	29.25	-0.72	-6.4
80	29.07	0.87	-19.4	28.61	-3.36	-20.2	29.21	-0.87	-19.9
160	28.69	-0.44	-40.8	28.03	-5.33	-41.7	28.89	-1.96	-42.0
315	25.45	-11.68	-87.4	24.94	-15.75	-86.9	23.44	-20.44	-78.8

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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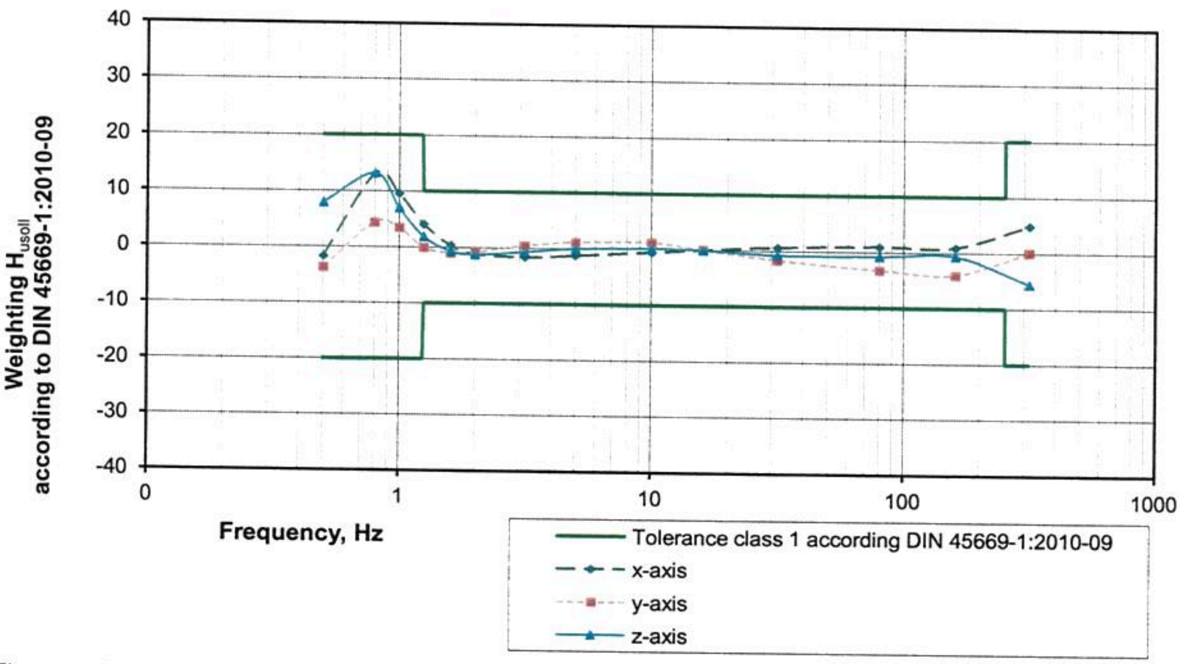
7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis: Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	x-axis: Weighting factor, (measured value)	x-axis: Deviation to H_{uSOLL}	y-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	y-axis: Weighting factor, (measured value)	y-axis: Deviation to H_{uSOLL}	z-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	z-axis: Weighting factor, (measured value)	z-axis: Deviation to H_{uSOLL}
0.5	0.364	0.358	-1.7	0.364	0.350	-3.8	0.364	0.393	7.9
0.8	0.707	0.799	13.0	0.707	0.737	4.3	0.707	0.800	13.2
1	0.842	0.922	9.5	0.842	0.871	3.4	0.842	0.901	7.0
1.25	0.925	0.964	4.2	0.925	0.924	-0.1	0.925	0.943	1.9
1.6	0.970	0.974	0.4	0.970	0.960	-1.1	0.970	0.964	-0.7
2	0.987	0.976	-1.1	0.987	0.979	-0.9	0.987	0.975	-1.2
3.15	0.998	0.982	-1.6	0.998	1.001	0.3	0.998	0.991	-0.7
5	1.000	0.987	-1.2	1.000	1.010	1.1	1.000	0.999	0.0
10	1.000	0.995	-0.5	1.000	1.012	1.2	1.000	1.002	0.2
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	1.006	0.6	1.000	0.983	-1.7	1.000	0.993	-0.7
80	0.999	1.009	1.0	0.999	0.966	-3.3	0.999	0.991	-0.8
160	0.987	0.996	0.9	0.987	0.947	-4.0	0.987	0.980	-0.6
315	0.842	0.883	4.9	0.842	0.842	0.0	0.842	0.796	-5.5



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
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SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
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Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10032

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 218139

G.R.A.S.
Sound & Vibration

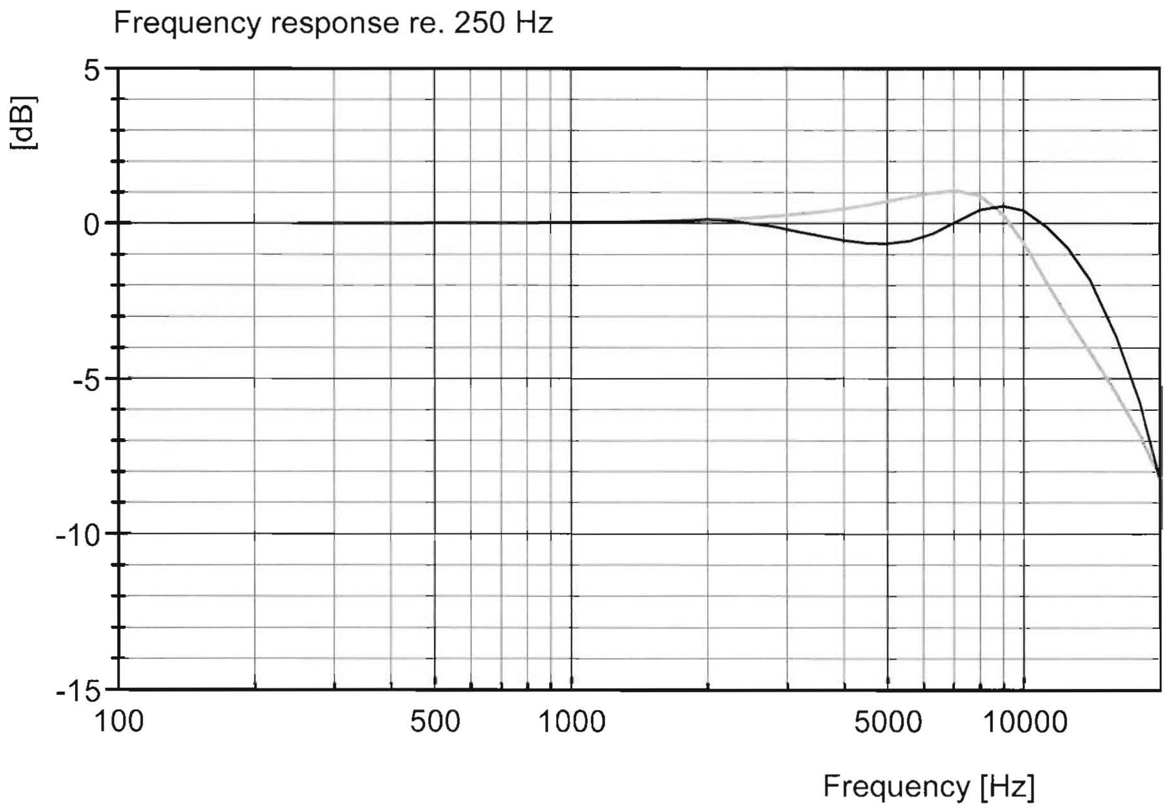
System Sensitivity:	49.99 mV/Pa
	-26.02 dB re. 1V/Pa
Actuator output:	31.72 mV
Preamplifier type:	26AX
Preamplifier serial no:	214109
Microphone type:	40AS
Microphone Serial No:	178539
Operator:	FBL
Date:	21. aug 2014

The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa



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e-mail : gras@gras.dk

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst **DKD**

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

1919
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504075**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH** **DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**16/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

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This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
16/09/2014	Mario Chares	René Zimmermann

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504075**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(23.3 ± 1) °C**
Relative humidity:	**(58 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity: **horizontal (x- and y-axis)**
vertical (z-axis)

Temperature of test object: **(23.3 ± 2) °C**

Attachment of test object to vibration exciter:
- z-axis: **screwed SAM-018**
- x- and y-axis: **screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)
- Manufacturer: **SINUS Messtechnik GmbH**
- Type: **902246**
- Length: **2 m**

Specification of excitation
for determination of the transfer coefficient
- Frequency: **16 Hz**
- Velocity (peak) **10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

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5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:

- for determination of the transfer coefficient at 16 Hz			1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range			
	0.5 Hz bis	< 1 Hz	2.0% / 2.0°
	1 Hz bis	80 Hz	1.5% / 1.5°
	> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.623 mV/(mm/s)**	**0.004 %**	**0.0012 mV/(mm/s)**
y-axis:	**29.199 mV/(mm/s)**	**0.003 %**	**0.0009 mV/(mm/s)**
z-axis:	**29.083 mV/(mm/s)**	**0.002 %**	**0.0006 mV/(mm/s)**

(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.32	-61.79	138.9	12.09	-58.58	136.8	11.48	-60.54	139.3
0.8	22.88	-22.76	93.0	23.81	-18.45	90.1	23.41	-19.50	92.4
1	25.90	-12.58	72.5	26.57	-9.01	69.7	26.28	-9.64	71.3
1.25	27.31	-7.83	56.8	27.72	-5.07	54.2	27.43	-5.68	55.4
1.6	28.10	-5.13	43.8	28.29	-3.12	41.6	27.99	-3.78	42.5
2	28.59	-3.50	34.8	28.60	-2.07	32.9	28.30	-2.70	33.7
3.15	29.20	-1.42	21.7	29.00	-0.67	20.4	28.74	-1.19	21.0
5	29.52	-0.34	12.9	29.10	-0.33	12.0	28.98	-0.36	12.5
10	29.68	0.20	4.3	29.30	0.33	3.8	29.10	0.04	4.2
16	**29.62**	**0.0**	**0.1**	**29.20**	**0.0**	**-0.1**	**29.08**	**0.0**	**0.0**
31.5	29.53	-0.31	-6.1	29.13	-0.23	-6.1	29.09	0.02	-6.2
80	29.78	0.51	-19.9	29.33	0.45	-19.9	29.03	-0.19	-20.0
160	29.64	0.06	-41.9	29.10	-0.35	-42.0	28.53	-1.92	-42.8
315	27.44	-7.37	-87.8	26.27	-10.02	-87.0	23.62	-18.77	-98.3

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

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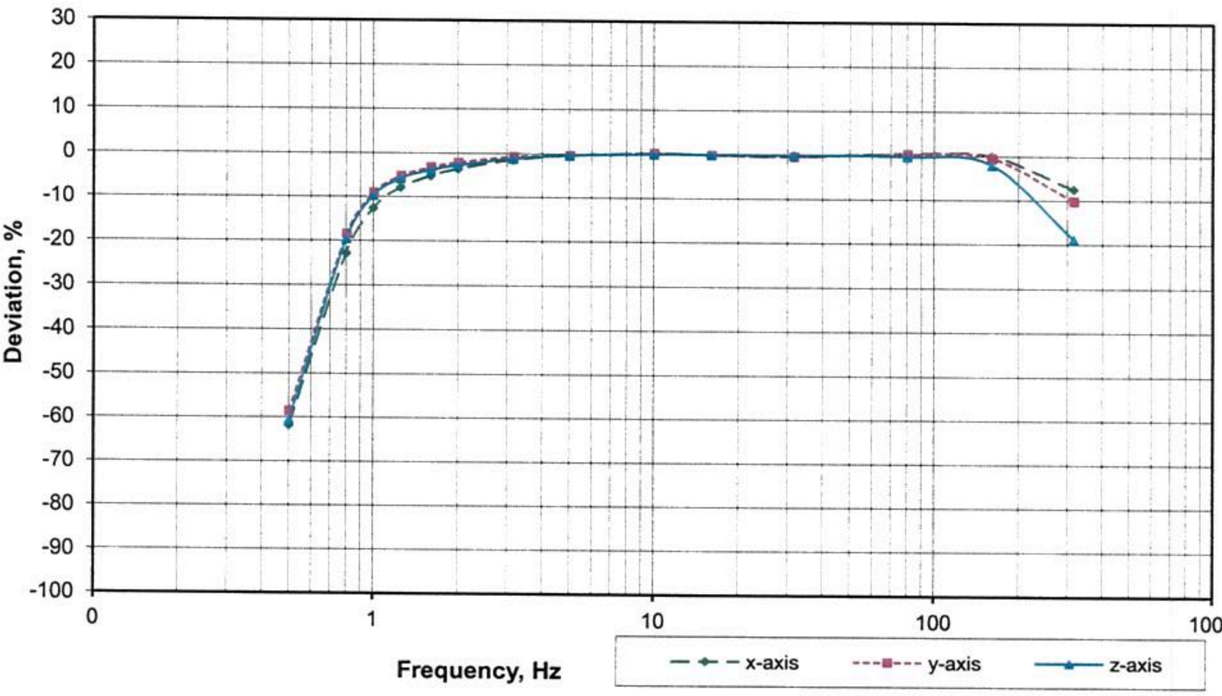
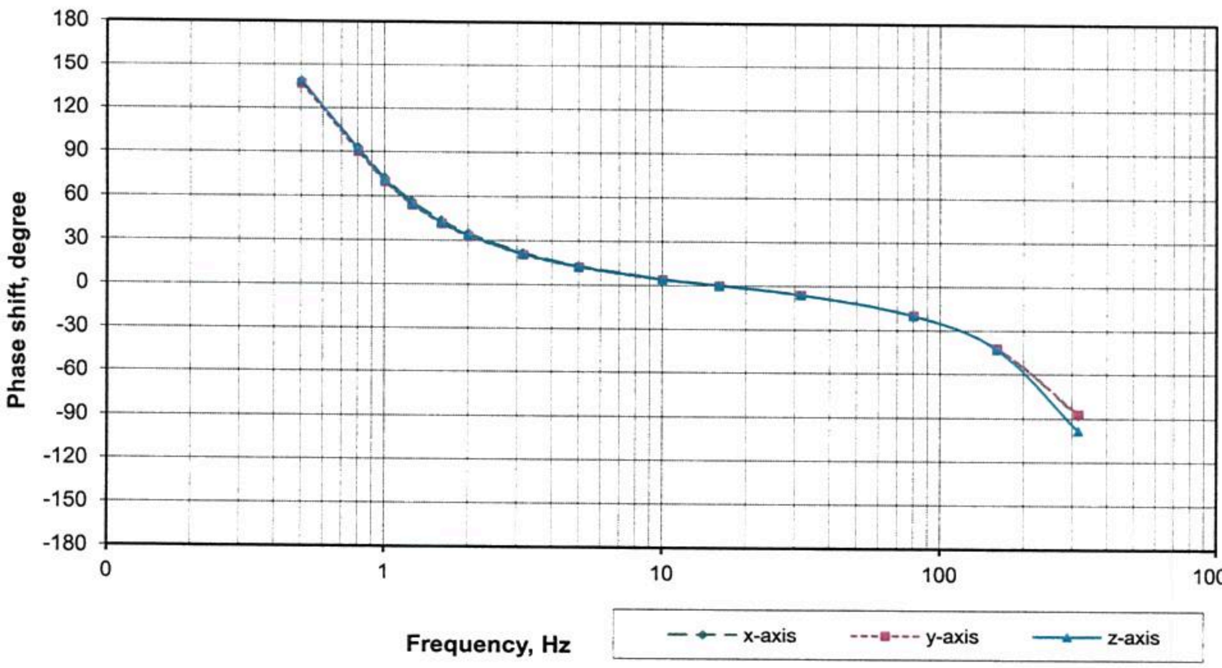
Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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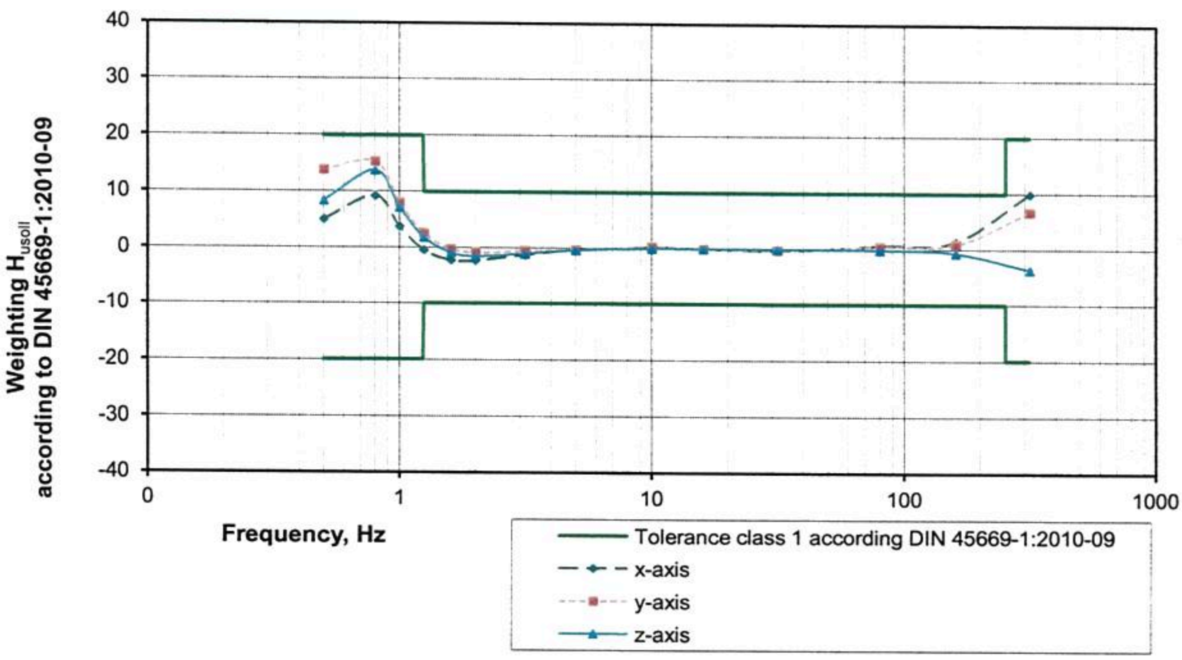
7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis			y-axis			z-axis		
	Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}	Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	Weighting factor, (measured value)	Deviation to H_{uSOLL}
0.5	0.364	0.382	5.0	0.364	0.414	13.8	0.364	0.395	8.4
0.8	0.707	0.772	9.2	0.707	0.815	15.3	0.707	0.805	13.8
1	0.842	0.874	3.8	0.842	0.910	8.0	0.842	0.904	7.3
1.25	0.925	0.922	-0.4	0.925	0.949	2.6	0.925	0.943	1.9
1.6	0.970	0.949	-2.2	0.970	0.969	-0.1	0.970	0.962	-0.8
2	0.987	0.965	-2.3	0.987	0.979	-0.8	0.987	0.973	-1.5
3.15	0.998	0.986	-1.2	0.998	0.993	-0.5	0.998	0.988	-1.0
5	1.000	0.997	-0.3	1.000	0.997	-0.3	1.000	0.996	-0.3
10	1.000	1.002	0.2	1.000	1.003	0.3	1.000	1.000	0.0
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	0.997	-0.3	1.000	0.998	-0.2	1.000	1.000	0.0
80	0.999	1.005	0.6	0.999	1.004	0.5	0.999	0.998	-0.1
160	0.987	1.001	1.4	0.987	0.996	1.0	0.987	0.981	-0.6
315	0.842	0.926	10.0	0.842	0.900	6.8	0.842	0.812	-3.6



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

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Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

SINUS Messtechnik GmbH
Foepplstrasse 13
D-04347 Leipzig
Tel: +49-341-244290
Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10031

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 218138

G.R.A.S.
Sound & Vibration

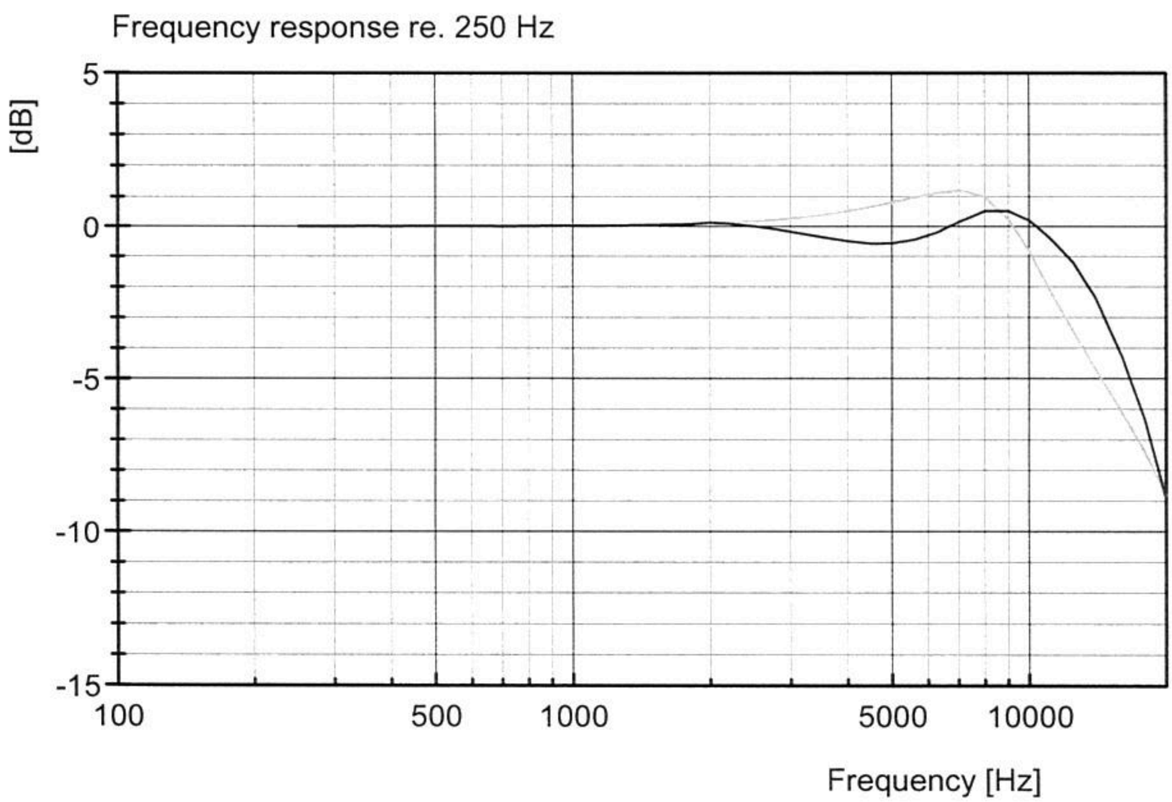
System Sensitivity:	49.98 mV/Pa
	-26.02 dB re. 1V/Pa
Actuator output:	31.71 mV
Preamplifier type:	26AX
Preamplifier serial no:	214106
Microphone type:	40AS
Microphone Serial No:	178538
Operator:	FBL
Date:	20. aug 2014

The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa



G.R.A.S. Sound & Vibration A/S
Skovlytoften 33
DK-2840 Holte, Denmark

Tel.: +45 45 66 40 46
Fax : +45 45 66 40 47
e-mail : gras@gras.dk

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

1914
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504070**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH** **DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141290**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**17/09/2014**

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Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
18/09/2014	Heiko Deierlein	René Zimmermann

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504070**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(23.6 ± 1) °C**
Relative humidity:	**(46 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity:	**horizontal (x- and y-axis)** **vertical (z-axis)**
Temperature of test object:	**(23.6 ± 2) °C**

Attachment of test object to vibration exciter:

z-axis:	**screwed SAM-018**
x- and y-axis:	**screwed SAM-025**

Technical data of the connecting cable (cable of the laboratory)

Manufacturer:	**SINUS Messtechnik GmbH**
Type:	**902246**
Length:	**2 m**

Specification of excitation
for determination of the transfer coefficient

Frequency:	**16 Hz**
Velocity (peak)	**10 mm/s**

for determination of the amplitude-frequency response

Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**14**	

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5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:

- for determination of the transfer coefficient at 16 Hz			1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range			
	0.5 Hz bis	< 1 Hz	2.0% / 2.0°
	1 Hz bis	80 Hz	1.5% / 1.5°
	> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.569 mV/(mm/s)**	**0.004 %**	**0.0012 mV/(mm/s)**
y-axis:	**31.294 mV/(mm/s)**	**0.006 %**	**0.0019 mV/(mm/s)**
z-axis:	**29.448 mV/(mm/s)**	**0.002 %**	**0.0006 mV/(mm/s)**

(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.31	-61.77	139.7	11.19	-64.25	141.1	10.16	-65.48	145.1
0.8	23.01	-22.17	93.5	23.68	-24.32	97.9	22.95	-22.06	99.4
1	26.02	-12.00	72.7	27.73	-11.40	77.0	26.58	-9.74	76.3
1.25	27.38	-7.39	56.8	29.83	-4.67	60.2	27.87	-5.38	58.6
1.6	28.15	-4.80	43.8	30.99	-0.96	46.1	28.31	-3.86	44.6
2	28.60	-3.27	34.8	31.61	1.01	36.2	28.53	-3.11	35.3
3.15	29.21	-1.21	21.7	32.28	3.16	21.9	28.90	-1.85	22.1
5	29.50	-0.25	12.9	32.48	3.79	12.0	29.16	-0.99	13.3
10	29.65	0.28	4.3	32.09	2.55	2.0	29.36	-0.31	4.9
16	**29.57**	**0.0**	**0.0**	**31.29**	**0.0**	**-3.0**	**29.45**	**0.0**	**0.7**
31.5	29.42	-0.49	-6.1	30.03	-4.05	-8.9	29.60	0.50	-5.7
80	29.54	-0.09	-19.6	29.36	-6.19	-21.0	29.67	0.77	-19.9
160	29.13	-1.47	-41.8	28.81	-7.92	-42.3	29.20	-0.85	-42.4
315	25.71	-13.05	-87.4	26.05	-16.76	-87.1	23.52	-20.14	-98.4

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

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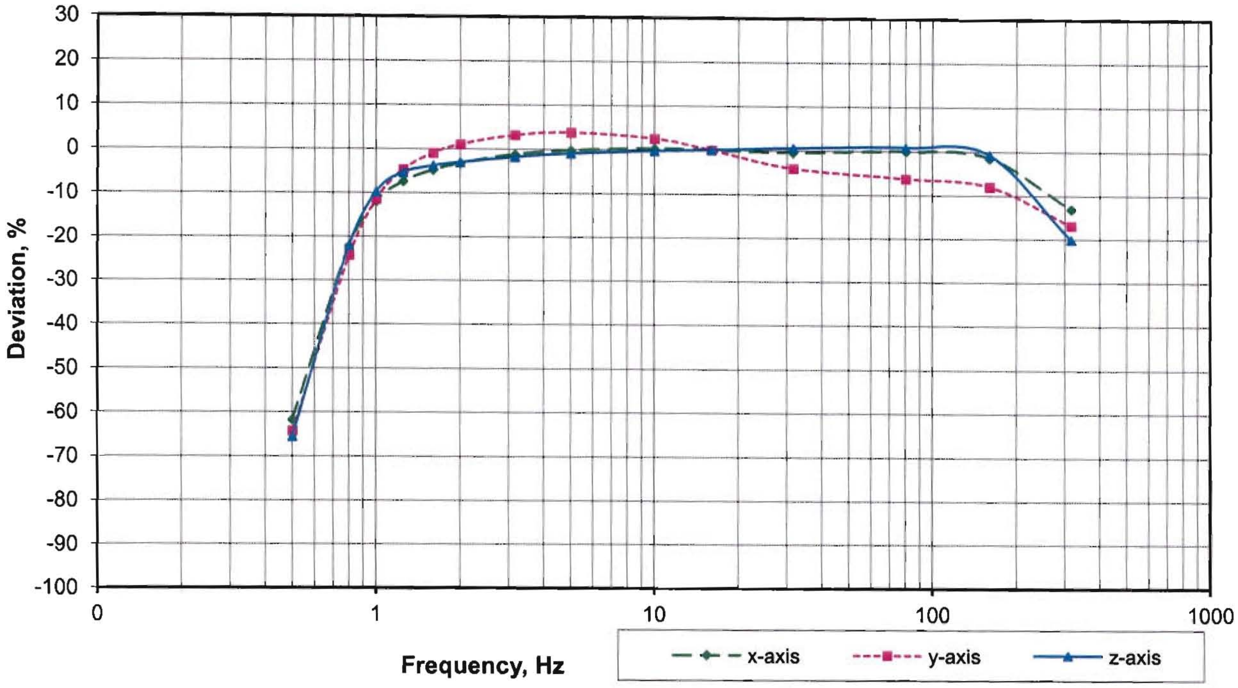
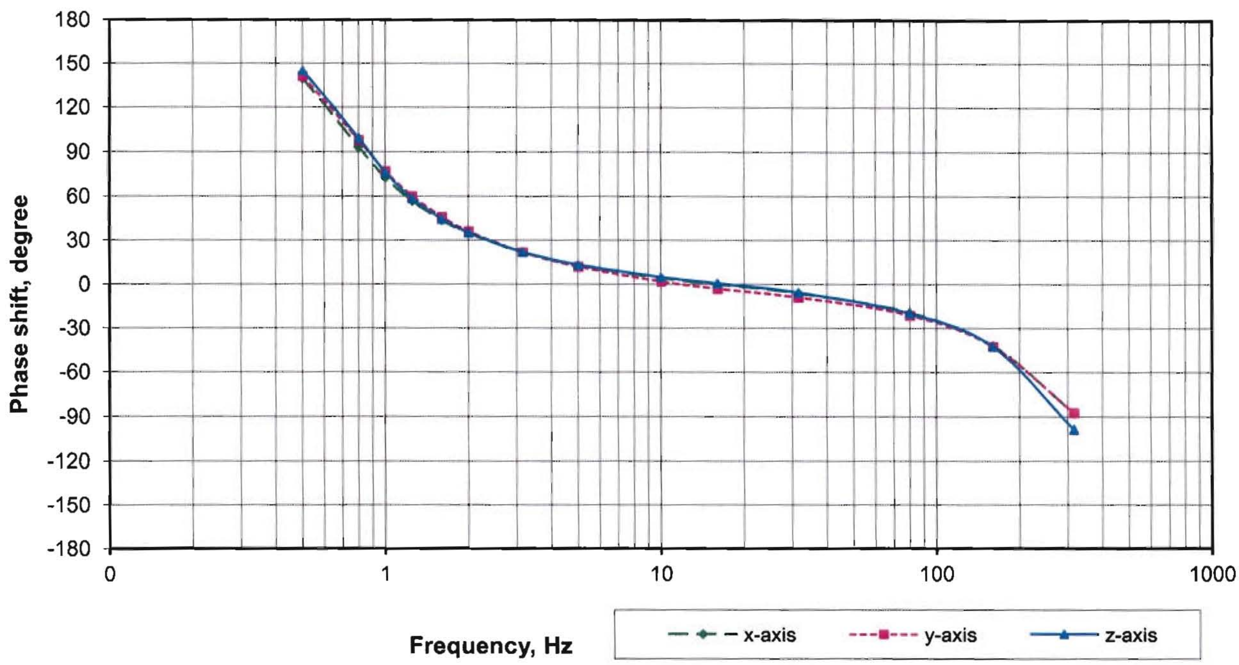
Amplitude frequency response (relative to 16 Hz)

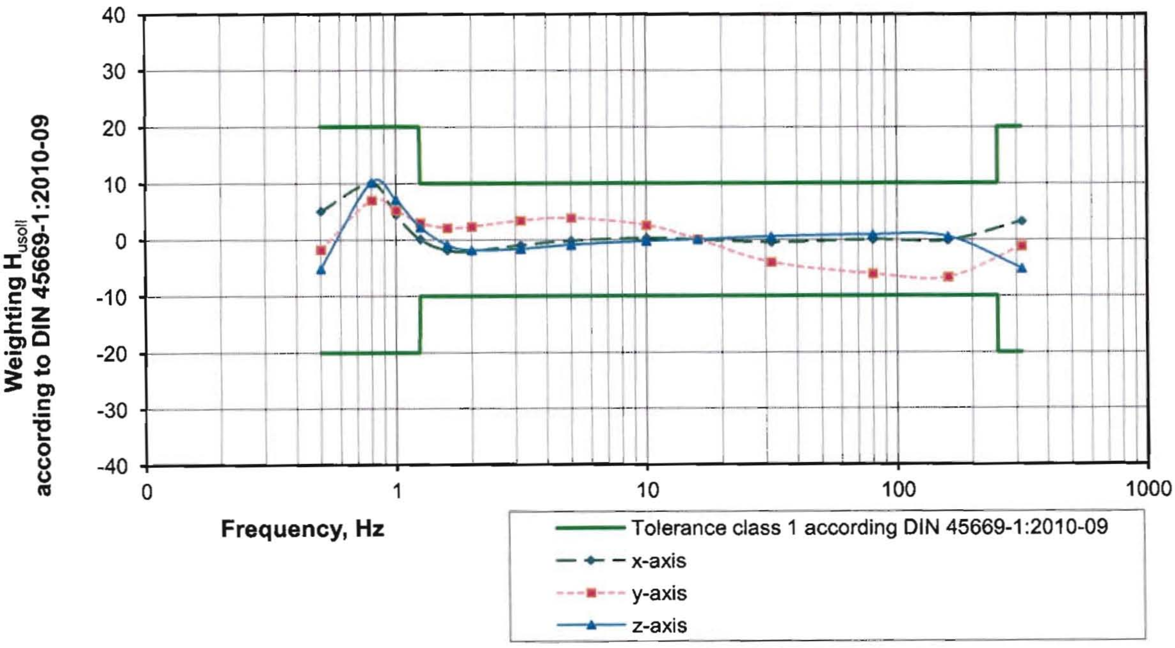


Phase frequency response



7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis: Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	x-axis: Weighting factor, (measured value)	x-axis: Deviation to H_{uSOLL}	y-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	y-axis: Weighting factor, (measured value)	y-axis: Deviation to H_{uSOLL}	z-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	z-axis: Weighting factor, (measured value)	z-axis: Deviation to H_{uSOLL}
0.5	0.364	0.382	5.1	0.364	0.357	-1.8	0.364	0.345	-5.1
0.8	0.707	0.778	10.1	0.707	0.757	7.0	0.707	0.779	10.2
1	0.842	0.880	4.5	0.842	0.886	5.2	0.842	0.903	7.2
1.25	0.925	0.926	0.1	0.925	0.953	3.0	0.925	0.946	2.3
1.6	0.970	0.952	-1.9	0.970	0.990	2.1	0.970	0.961	-0.9
2	0.987	0.967	-2.0	0.987	1.010	2.3	0.987	0.969	-1.9
3.15	0.998	0.988	-1.0	0.998	1.032	3.4	0.998	0.981	-1.7
5	1.000	0.997	-0.2	1.000	1.038	3.8	1.000	0.990	-1.0
10	1.000	1.003	0.3	1.000	1.026	2.6	1.000	0.997	-0.3
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	0.995	-0.5	1.000	0.959	-4.0	1.000	1.005	0.5
80	0.999	0.999	0.0	0.999	0.938	-6.1	0.999	1.008	0.9
160	0.987	0.985	-0.1	0.987	0.921	-6.7	0.987	0.992	0.5
315	0.842	0.869	3.2	0.842	0.832	-1.2	0.842	0.799	-5.2



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

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Fax: +49-341-2442999

Declaration of Conformity

We, SINUS Messtechnik GmbH, Foepplstrasse 13, 04347 Leipzig, GERMANY, declare under our sole responsibility that our product

SWING_4ch Monitor Station

SN: #10036

to which this declaration relates, is in conformity with the following standards or other normative documents:

Performance compliant with:	IEC 61672 type 1 IEC 60651/60804 IEC 60260 type 1
EMC:	EN 50081-1 EN 50082-1

The measuring system is for use with outdoor measuring microphones GRAS 41CN.

This product has been manufactured in compliance with the provisions of the relevant internal SINUS Messtechnik GmbH documentation for production including quality management documentation.

Test documentation:	- SINUS QS-Handbuch ISO 9001	
	- Prüfvorschrift FBG DT-Apollo	908351.2/12
	- Prüfvorschrift FBG AT-Apollo	908357.8/12
	- Prüfvorschrift Apollo_PCIe	908035.8/12
	- Prüfvorschrift SWING	901301.8/12
	- FAT SWING	901301.8/12

This product has been tested individually and found to fulfill all specifications.

Leipzig, September 2014

Gunther Papsdorf
General Manager

Calibration Chart for
41CN Outdoor Microphone
Serial No. 218136

G.R.A.S.
Sound & Vibration

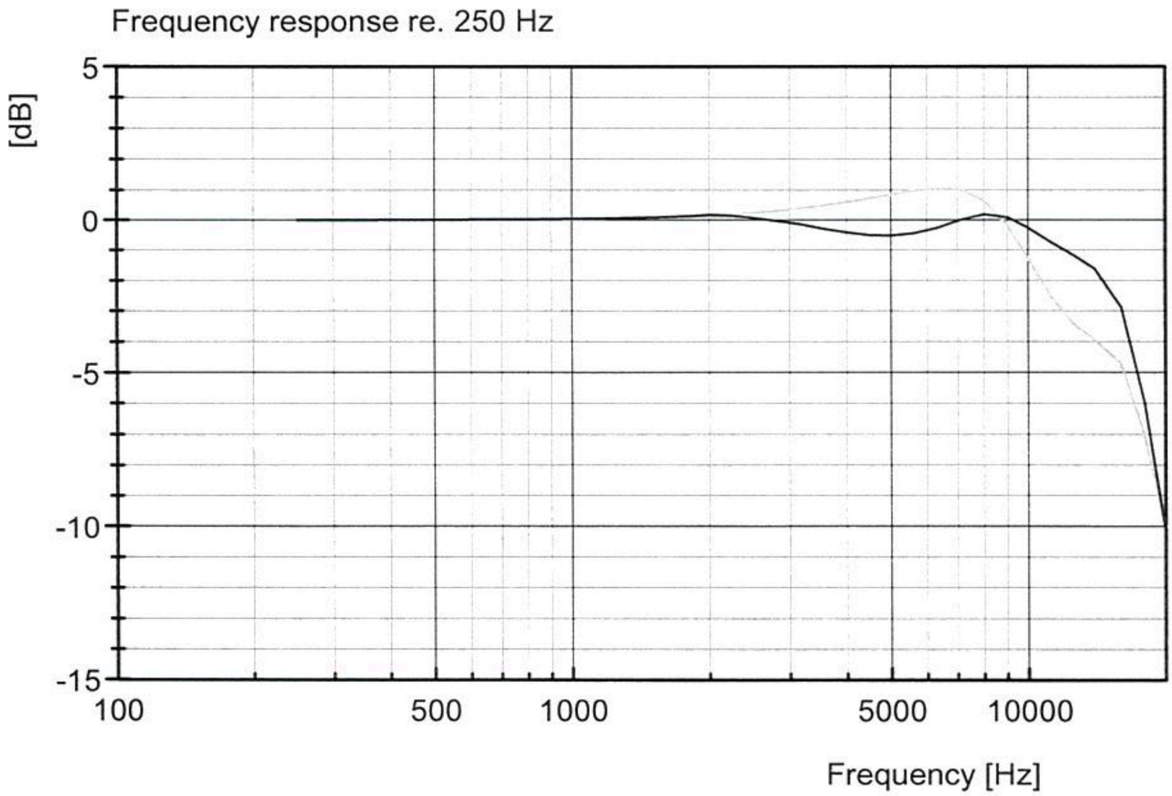
System Sensitivity:	49.99 mV/Pa
	-26.02 dB re. 1V/Pa
Actuator output:	31.70 mV
Preamplifier type:	26AX
Preamplifier serial no:	214104
Microphone type:	40AS
Microphone Serial No:	138456
Operator:	FBL
Date:	19. aug 2014

The stated sensitivity is the sensitivity for the complete microphone unit including preamplifier for 0 dB Gain setting and without A-weighting filter, with an uncertainty of ± 0.1 dB. The calibration is performed with a 42AA Pistonphone and is traceable to National Physical Laboratory, UK. The stated actuator calibration output is for 1kHz and with an uncertainty of ± 0.4 dB.

The frequency response is recorded with electrostatic actuator. The grey curve is the pressure response and the black curve is the free field response for 90 deg. incidence with the raincap and windscreen mounted on the microphone.

Environmental Calibration Conditions:

Temperature:	23 ± 3 C°
Relative humidity:	60 ± 20 %
Barometric pressure:	101.3 ± 3 kPa



G.R.A.S. Sound & Vibration A/S
Skovlytoften 33
DK-2840 Holte, Denmark

Tel.: +45 45 66 40 46
Fax : +45 45 66 40 47
e-mail : gras@gras.dk

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

1974
D-K-15183-01-00
2014-09

Gegenstand *Object*	**Velocity transducer**
Hersteller *Manufacturer*	**SINUS Messtechnik**
Typ *Type*	**902219.7**
Fabrikat/Serien-Nr. *Serial number*	**#0504073**
Auftraggeber *Customer*	**SINUS Messtechnik GmbH DE-04347 Leipzig**
Auftragsnummer *Order No.*	**141335**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**6**
Datum der Kalibrierung *Date of calibration*	**23/09/2014**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Leiter des Kalibrierlaboratoriums *Head of the calibration laboratory*	Bearbeiter *Person in charge*
24/09/2014	Philipp Begoff	René Zimmermann

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Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

1. Object of Calibration

Object:	**Velocity transducer**
Manufacturer:	**SINUS Messtechnik**
Type:	**902219.7**
Serial number:	**#0504073**

2. Calibration Method

Calibration was performed by using the method of primary calibration according to the Directive ISO 16063-11. The transducer was exposed to sinusoidal acceleration which was applied by means of an electrodynamic vibration exciter. The transducer was calibrated by comparing the display of the transducer under test with the measured velocity.

3. Environmental Conditions

Environmental temperature of the test object:	**(22.3 ± 1) °C**
Relative humidity:	**(41 ± 5) %**

4. Test Conditions

Position of exciting axis (axes) relative to the earth gravity:	**horizontal (x- and y-axis)** **vertical (z-axis)**	
Temperature of test object:	**(22.3 ± 2) °C**	
Attachment of test object to vibration exciter:		
z-axis:	**screwed SAM-018**	
x- and y-axis:	**screwed SAM-025**	
Technical data of the connecting cable (cable of the laboratory)		
Manufacturer:	**SINUS Messtechnik GmbH**	
Type:	**902246**	
Length:	**2 m**	
Specification of excitation for determination of the transfer coefficient		
Frequency:	**16 Hz**	
Velocity (peak)	**10 mm/s**	
for determination of the amplitude-frequency response		
Frequency range:	**0.5 Hz to 16 Hz**	**>16 Hz to 315 Hz**
Velocity (peak):	**10 mm/s**	
Acceleration (peak)		**1 m/s²**
Number of frequency points on log scale:	**15**	

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5. Measurement Uncertainty

These are the total relative measurement uncertainties at selected values:
- for determination of the transfer coefficient at 16 Hz — 1.5% / 1.5°
- for determination of the amplitude-frequency response in the frequency range

0.5 Hz bis	< 1 Hz	2.0% / 2.0°
1 Hz bis	80 Hz	1.5% / 1.5°
> 80 Hz bis	315 Hz	2.0% / 2.0°

The specified values are the extended measurement uncertainties obtained by multiplying the standard measurement uncertainties by extension factor k = 2. They were ascertained in line with DAkkS-DKD-3. The values of the measuring quantity fall into the assigned intervals with a probability of 95 %.

6. Components of the Reference Measuring Equipment

	Manufacturer	Type	Serial number
Vibration exciter	APS DYNAMICS INC.	113AB	836
Vibration exciter	APS DYNAMICS INC.	129	165
Laservibrometer	Polytec	CLV-1000	1 00 0633 0005
Calibration system	SPEKTRA	CS18 STF HF	200112

7. Results

7.1 Determination of the Transfer Coefficient

Frequency: **16 Hz**
Velocity (peak) **10 mm/s**

Axis	Mean value	Standard deviation	
x-axis:	**29.183 mV/(mm/s)**	**0.005 %**	**0.0015 mV/(mm/s)**
y-axis:	**29.183 mV/(mm/s)**	**0.005 %**	**0.0015 mV/(mm/s)**
z-axis:	**29.710 mV/(mm/s)**	**0.001 %**	**0.0003 mV/(mm/s)**

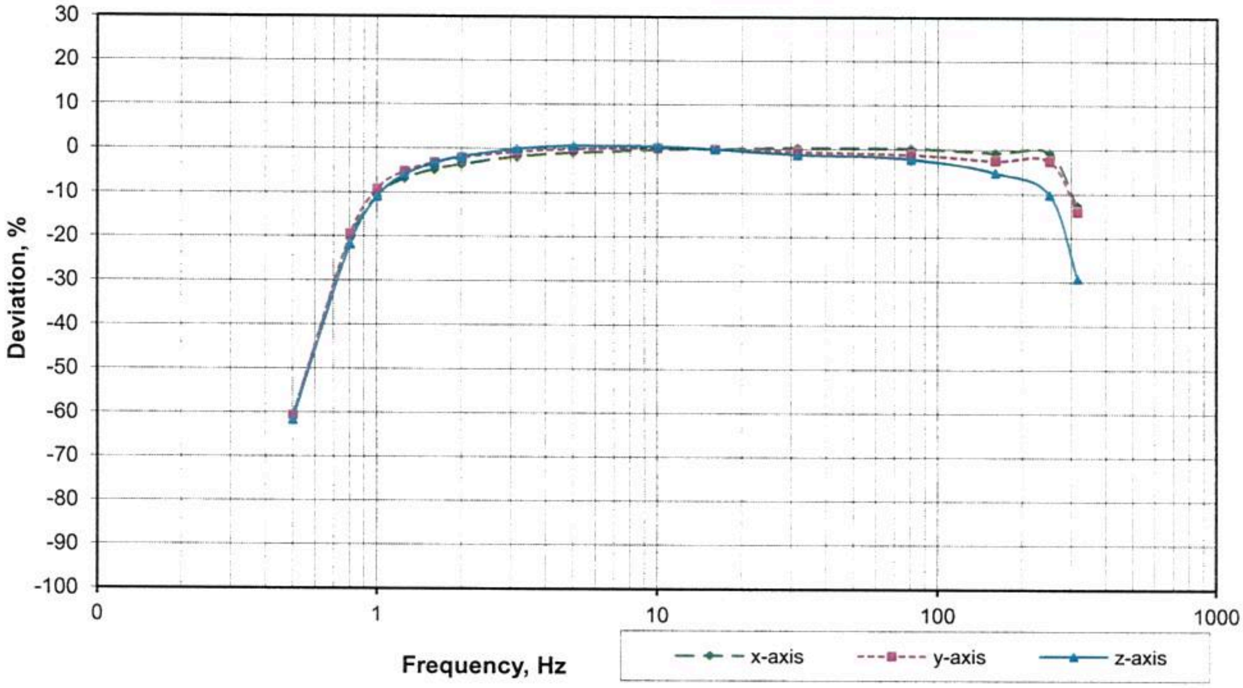
(acceleration due to gravity 1 g_n = 9.80665 m/s²)

7.2 Amplitude frequency response (relative to 16 Hz)

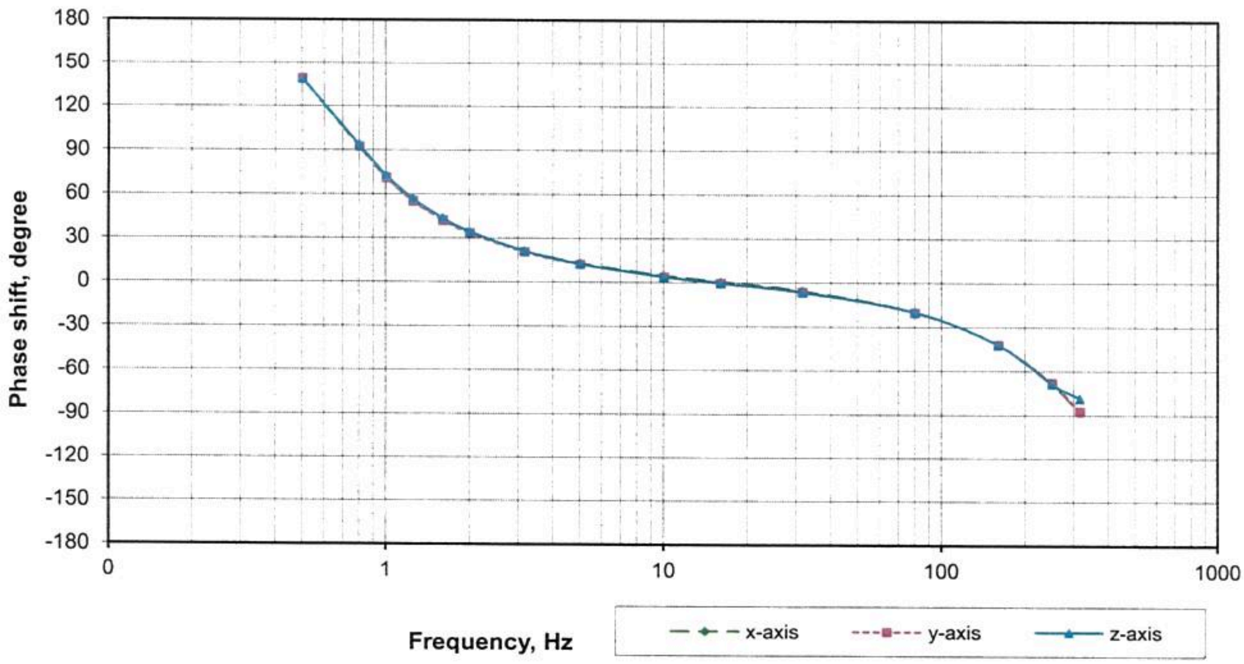
Frequency, Hz	x-axis			y-axis			z-axis		
	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree	Transfer coefficient, mV/(mm/s)	Deviation, %	Phase shift, degree
0.5	11.42	-60.85	139.1	11.48	-60.66	139.4	11.39	-61.68	139.1
0.8	23.19	-20.53	92.3	23.55	-19.31	92.8	23.27	-21.68	93.7
1	26.03	-10.80	71.4	26.53	-9.08	71.6	26.48	-10.86	73.0
1.25	27.21	-6.76	55.6	27.73	-4.97	55.5	27.96	-5.88	56.9
1.6	27.81	-4.71	42.7	28.29	-3.06	42.5	28.74	-3.25	43.6
2	28.16	-3.51	34.0	28.59	-2.04	33.6	29.17	-1.82	34.5
3.15	28.64	-1.85	21.2	28.98	-0.71	20.8	29.69	-0.08	21.3
5	28.91	-0.94	12.8	29.18	-0.02	12.3	29.92	0.69	12.4
10	29.14	-0.16	4.6	29.27	0.28	4.0	29.90	0.63	3.7
16	**29.18**	**0.0**	**0.5**	**29.18**	**0.0**	**-0.2**	**29.71**	**0.0**	**-0.7**
31.5	29.28	0.34	-5.7	29.04	-0.51	-6.2	29.36	-1.16	-6.7
80	29.26	0.26	-20.0	28.87	-1.08	-20.1	29.11	-2.03	-20.0
160	28.99	-0.67	-41.9	28.52	-2.27	-41.7	28.20	-5.10	-42.0
250	29.01	-0.61	-68.7	28.49	-2.37	-67.9	26.73	-10.03	-68.6
315	25.51	-12.60	-87.8	25.14	-13.87	-86.9	21.05	-29.16	-78.5

Factory calibration:
Values higher than 80 Hz (color marked) are outside of the accredited range of the calibration laboratory. Those result have the state of a factory calibration.

Amplitude frequency response (relative to 16 Hz)



Phase frequency response



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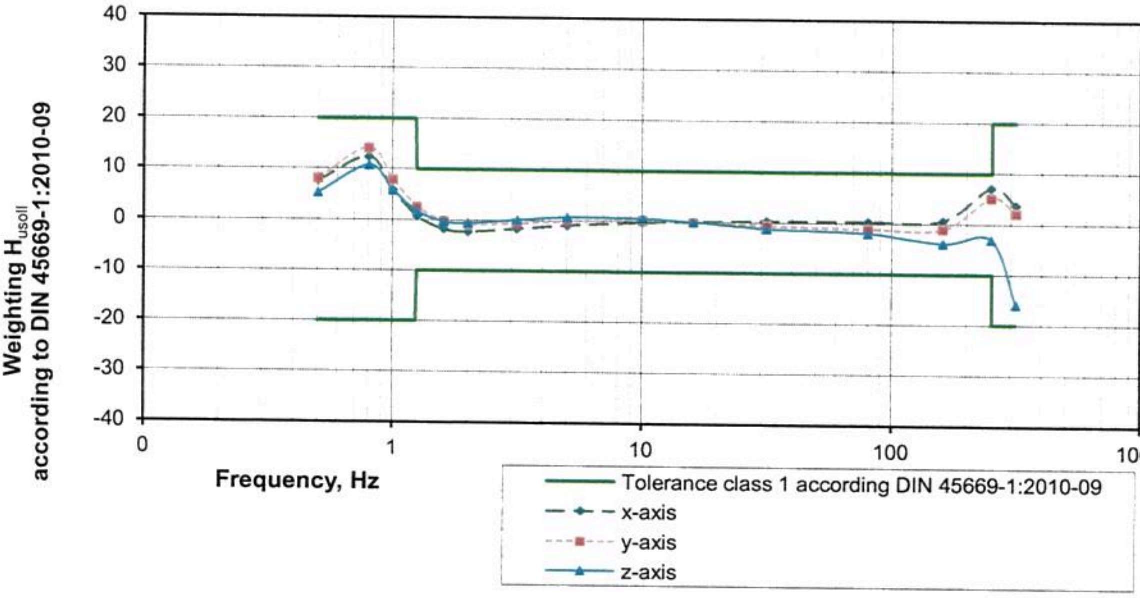
7.3 According to DIN 45669-1:2010-09

Frequency, Hz	x-axis: Weighting factor H_{uSOLL} according DIN 45669-1:2010-09 (nominal value)	x-axis: Weighting factor, (measured value)	x-axis: Deviation to H_{uSOLL}	y-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	y-axis: Weighting factor, (measured value)	y-axis: Deviation to H_{uSOLL}	z-axis: Weighting factor HuSOLL according DIN 45669-1:2010-09 (nominal value)	z-axis: Weighting factor, (measured value)	z-axis: Deviation to H_{uSOLL}
0.5	0.364	0.391	7.6	0.364	0.393	8.1	0.364	0.383	5.3
0.8	0.707	0.795	12.4	0.707	0.807	14.1	0.707	0.783	10.8
1	0.842	0.892	5.9	0.842	0.909	7.9	0.842	0.891	5.8
1.25	0.925	0.932	0.8	0.925	0.950	2.7	0.925	0.941	1.7
1.6	0.970	0.953	-1.8	0.970	0.969	-0.1	0.970	0.967	-0.3
2	0.987	0.965	-2.3	0.987	0.980	-0.8	0.987	0.982	-0.6
3.15	0.998	0.981	-1.6	0.998	0.993	-0.5	0.998	0.999	0.1
5	1.000	0.991	-0.9	1.000	1.000	0.0	1.000	1.007	0.7
10	1.000	0.998	-0.2	1.000	1.003	0.3	1.000	1.006	0.6
16	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.0**	**1.0**	**0.0**
31.5	1.000	1.003	0.3	1.000	0.995	-0.5	1.000	0.988	-1.2
80	0.999	1.003	0.3	0.999	0.989	-1.0	0.999	0.980	-1.9
160	0.987	0.993	0.7	0.987	0.977	-0.9	0.987	0.949	-3.8
250	0.927	0.994	7.2	0.927	0.976	5.3	0.927	0.900	-3.0
315	0.842	0.874	3.8	0.842	0.861	2.3	0.842	0.708	-15.9



The accelerometer is conform to the vibration meter requirements of tolerance class 1 according to DIN 45669-1:2010-09.

VOLUME 2 – TECHNICAL APPENDICES – DETAILED METHODOLOGY

CHAPTER 3: EQUIPMENT OUTAGES AND SCHEDULED MAINTENANCE

SCHEDULED EQUIPMENT / TELECOMS / DATA MANAGEMENT MAINTENANCE						
Date	**Time**	**Maintenance Description**	**Affected Stations (Monitoring Locations)**	**On-Site Trigger During Outage**	**Trigger Captured**	**Notes**
08/2015 – 22/09/2015	-	Ongoing investigations into poor network speeds at SHB_OS1.	SHB_OS1	N/A	-	Remote router restarts, intrusive line testing/resets carried out by telecoms provider. Site attendance deemed necessary.
03/09/2015	08:00 – 18:00	Site visit to investigation network problems at SHB_OS1.	SHB_OS1	N/A	-	Preliminary checks to measurement system, switch of network realm (data centre), replacement of network components. Unit download and data clearance. Data checks for trigger acquisition. BT Openreach instructed to begin further line checks/ mobilise for call out.
03/09/2015	08:00 – 18:00	Site visit to attend to network outages at SHB_OS2.	SHB_OS2	N/A	-	Preliminary checks made to measurements system replacements of network components. No further works required.
15/09/2015	08:00 – 18:00	BT Openreach site visit to SHB_OS1 for investigation into network problems.	SHB_OS1	N/A	-	Re-wiring main socket bypassing ADSL filter. Monitor offline following BT Openreach visit.
22/09/2015	08:00 – 18:00	Site visit to investigate network problems and monitor offline. Following termination of wires and router reset monitor online and network speeds increased. Manual Field Calibration.	SHB_OS1	N/A	-	
29/09/2015	08:00-18:00	Manual Field Calibrations	SHB_OS6 SHB_R3_BAT SHB_R1_DAT SHB_R2_RUG SHB_OS3 SHB_OS2	N/A	-	
30/09/2015	08:00 – 12:00	Manual Field Calibrations	SHB_OS7 SHB_OS8 SHB_OS9 SHB_OS10	N/A	-	
10/09/2015 - 13/10/2015	-	-On-going investigation into high measured vibration values.	SHB_OS2	N/A	-	Equipment supplier remotely tested monitoring station, geophone and connections (including earth) – OK -Equipment supplier advised visit to site to check physical connections. -Southdowns attend site, check physical connections (potential loose termination identified) and install additional independent vibration monitor (with daily data emails) alongside existing monitor to verify dataset. -Comparison of vibration datasets indicates issue with high measured vibration values resolved. – investigation complete
29/10/2015	12:00	Review of router configuration settings at all applicable off-Range monitoring locations following observed issue with SHB_OS9.	All off-Range monitoring locations with the exception of SHB_OS6	N/A	-	
10/2015 – 12/2015	Daily checks	On-going daily system checks revised to include check of all station parameters, including record duration	All Station	N/A	-	On-going daily station checks
10/2015 – 12/2015	Weekend data transfer	On-going weekly data transfers from the station HDD carried out over each weekend to accommodate excessive data capture. Data cross checked and removed from station.	All Stations	N/A	-	On-going weekly data transfer

TABLE 3.1: SUMMARY OF SCHEDULED EQUIPMENT / TELECOMS / DATA MANAGEMENT MAINTENANCE FOR MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

SCHEDULED EQUIPMENT / TELECOMS / DATA MANAGEMENT MAINTENANCE						
Date	**Time**	**Maintenance Description**	**Affected Stations (Monitoring Locations)**	**On-Site Trigger During Outage**	**Trigger Captured**	**Notes**
Wednesday 18/11/2015	08:30 – 18:00 hrs	Change of ADSL network realm/data circuits as advised by Internet Service Provider. Site visit by Southdowns required to install new ADSL routers (see Early Warning Notice ref: 1897m-SECEWN-00176-01 for full details)	SHB_OS2, SHB_OS5, SHB_OS8 and SHB_OS10	N/A	-	Complete
Retrieval of all stations.	Completion of Shoeburyness Study.	Shoeburyness monitoring study complete	All Stations	N/A	-	Shoeburyness monitoring study complete. Retrieval of all monitoring stations and final field calibration checks of monitoring systems.

TABLE 3.1 (CTD): SUMMARY OF SCHEDULED EQUIPMENT / TELECOMS / DATA MANAGEMENT MAINTENANCE FOR MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

RANGE EQUIPMENT / TELECOMS OUTAGES DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
15/07/2015 – 23/07/2015	10:45hrs 15/07 – 10:55hrs 22/07	SHB_R1_DAT disconnected from network following IS audit	9 days	Yes. Open DET Trials on DAT Range 15/07 – 22/07	N	Range monitor off-line. This was found to be because during a QinetiQ IS hardware audit the monitor at DAT was disconnected from the network; it transpired that the configuration info used to the audit had not been updated with details of the monitor installation (though info has been provided to IS centrally)
24/09/2015	15:39	Unable to establish remote connection. Range IT support rebooted station.	118hrs	6	-	Following unsuccessful remote and manual reboot of station, site visit to investigate station crash on 29th October took place and station replaced at 13:30hrs. No further works required.
22/10/2015	08:30 – 10:25hrs	Unable to establish remote connection with SHB_R3_BAT & SHB_R2_RUG	1.55hrs	N	N/A	- Manual restart required. - issue raised with equipment supplier for further investigation; - equipment supplier advised issue due to Teamviewer memory usage. - Southdowns working with equipment supplier to resolve issue. EWN to be issued in due course. - SHB_R2_RUG and SHB_R3_BAT both online at time of Range firing activity.
27/10/2015	08:30 – 11:47	Unable to establish remote connection with SHB_R2_RUG	2.47hrs	Y	-	- Range IS team advised of Range network issue likely to be cause of problem - approx. 11:47 remote connection to station established following resolution of Range network issue. - Remote connection established within the same minute of Range activity occurring. No trigger captured.
Wednesday 18/11/2015	08:30 – 15:35hrs	Unable to establish remote connection with SHB_R1_DAT	7.55hrs	N	N/A	- 08:30 Following daily checks, unable to establish remote connection with SHB_R1_DAT. - 08:32 Southdowns contact on-Range support contact and requests manual restart. - 12:45 Range control informed Southdowns unable to gain access to SHB_R1_DAT due to Range activity. - 15:35 Manual restart of station performed.
Wednesday 18/11/2015 – Thursday 19/11/2015	16:00hrs 18/11/2015 – 09:23hrs 19/11/2015	Unable to establish remote connection with SHB_R3_BAT	17.23hrs	N	N/A	- 16:00 18/11/2015, unable to establish remote connection with SHB_R3_BAT. - 16:00 18/11/2015 Southdowns contact on-Range support contact and requests manual restart. - 09:23 19/11/2015 Manual restart performed.

TABLE 3.2: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB_R1_DAT, SHB_R2_RUG & SHB_R3_BAT DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

RANGE EQUIPMENT / TELECOMS OUTAGES DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
Tuesday 01/12/2015	08:30 – 10:22hrs	Unable to establish remote connection with SHB_R2_RUG	1.7hrs	N	N/A	- 08:30 01/12/2015, Unable to establish remote connection with SHB_R3_RUG. Investigation commenced. - 09:02 01/12/2015 Southdowns contact on-Range support contact and requests manual restart. - 10:22 01/12/2015 Manual restart of station performed and monitoring station back up and running.
Monday 07/12/2015 – Tuesday 08/12/2015	08:30hrs 07/12/15 – 09:00hrs 08/12/15	Power loss to SHB_R1_DAT	24.5hrs	N	N/A	- 08:30 07/12/15 Following daily checks, unable to establish remote connection with SHB_R1_DAT. - 09:38 07/12/15 Southdowns contact on-Range support contact and requests manual restart. - 09:50 07/12/15 Range control informed Southdowns of power loss to monitoring station. - 09:00 08/12/15 Power to monitoring station reinstated.
Wednesday 11/12/2015 – Monday 14/11/2015	14:10hrs 11/12/2015 – 09:00hrs 14/12/2015	Unable to establish remote connection with SHB_R3_BAT	2days 18.5hrs	N	N/A	- 14:10 11/12/2015, Unable to establish remote connection with SHB_R3_BAT. - 14:14 11/12/2015 Southdowns contact on-Range support contact and requests manual restart. - 15:13 11/12/2015 – On Range support notifies Southdowns unable to gain access to monitoring location until 14/12/15. 09:30 14/12/15 – Manual restart performed and monitoring station back up and running.
Monday 21/12/2015	08:30 – 14:14hrs	Unable to establish remote connection with SHB_R2_RUG	5.4hrs	N	N/A	- 08:30 21/12/2015, Unable to establish remote connection with SHB_R2_RUG. Investigation commenced. - 10:08 21/12/2015 Southdowns contact on-Range support contact and requests manual restart. - 14:14 21/12/2015 – Manual restart performed and station back up and running.

TABLE 3.2 (CTD): SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB_R1_DAT, SHB_R2_RUG & SHB_R3_BAT DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB-OS1 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
Jul-15	-	Poor connection speed	N/A	N/A	N/A	Bandwidth (Up/Down) [kbps/kbps]: 35 / 283 First Action: - remote router restart followed by manual restart. Investigate using different data centres. Openreach Call out.
15/09/2015 – 22/09/2015	08:00-18:00	Offline following BT Openreach attendance on 15/09/2015 to investigate slow network speeds.	c.168hrs	25	N	15/09/2015 BTOpenreach attend SHB_OS1 due to on-going slow network speeds, where ADSL filter bypassed. Station offline following visit. Site visit carried out 17/09/2015 to investigate, wiring found incorrect, unable to establish network connection. 22/09/2015 Site visit to replace router, monitor online with increased network speed. Manual field calibration carried out. No further action required.

TABLE 3.3: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS1 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS2 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
29-July-15	8:00 - 18:00	File size too large to send	N/A	R1-568 R1-575 R1-581 R1-584 R1-590 R1-616 R1-618 R1-630 R1-643 R1-664 R1-666 R1-679	Y	Download file upon reconnection.
24/08 – 31/08	08:00 24/08 – 14:00 02/09	Network Outage	7 days (intermittent)	R1-494 R1-498 R1-501 R1-505 R2-187 R2-191 R2-192 R2-199 R2-187 R2-191 R2-192 R2-199	Y	Daily system checks noted intermittent drop outs at SHB_OS2 24/08. Initial investigations into router and station status undertaken. Telecom supplier contacted on 24/08 to begin line tests. Advised that site attendance was necessary. Checks on measurement station carried out on site to identify problem. Micro filter on master socket faulty, potentially weather damaged – site visit at 03/09 to fix issue. Micro filter replaced.
01/10/2015	08:30	SHB_OS2 memory error. Caused by numerous local and Range triggers. File unable to zip and therefore multiple large files creating in 'working folder'. Remote manual file transfer required before station could be restarted.	2.5hrs	R1-4 & R2-3 & R3-10, R1-2 & R2-1 & R3-3, R1-7 & R2-5 & R3-17	N	08:30hrs – Following daily checks SHB_OS2 offline and investigation carried out. 09:00hrs – Data check of SHB_OS2 carried out prior to deletion of data. 10:50hrs – Monitor back up and running. 11:00hrs – Further investigation carried out to prevent reoccurrence.
13/10/2015 – 15/10/2015	09:00 13/10/2015 – 09:30 15/10/2015	Network line down	2 days	R1-124 R1-143 R1-147	N	13/11/2015 occasional network drops 14/11/2015 12:00 hrs SHB_OS2 offline. 12:00 – Investigation commenced, unable to connect to router. 12:30 – Telecoms provider contacted to investigate. 13:30 – Telecoms provider confirm line is down, the cause understood to be Digital Line Multiplexer. Engineers assigned to restore service. 16:30 – Telecoms provider contacted and update required by close of business. 15/10/2015 09:30 – Telecoms provider confirm line is back up and running.
18/11/2015	11:30 – 12:00	ADSL router swap out	0.5hrs	R2-93	N	Router swap out required due to change of ADSL network realm/data circuits.

TABLE 3.4: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS2 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

RANGE EQUIPMENT / TELECOMS OUTAGES DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
07/12/2015	07/12/15 08:30 – 11/12/15 10:00	Manual restart required.	4days	R1-95 & R3-75; R1-94 & R2-25; R2-26 & R3-78; R1-97 & R2-27; R1-98 & R2-28; R1-103 & R2-29; R1-105 & R2-30; R1-105 & R2-30; R2-31; R1-114; R1-118 & R2-34; R1-120; R2-35; R2-36; R1-123; R1-126; R1-134 & R3-82; R1-139; R2-55 & R3-101 R1-160 & R2-56 & R3-103 R2-61	N	Manual restart required.

TABLE 3.4 (CTD): SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS2 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS3 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
No outages during this monitoring period						

TABLE 3.5: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS3 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS4 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
No outages during this monitoring period						

TABLE 3.6: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS4 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS5 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
18/11/2015	10:00 - 11:00	ADSL router swap out	0.5hrs	R2-87 R2-90 R3-217 R3-234 R3-242	N	Router swap out required due to change of ADSL network realm/data circuits.

TABLE 3.7: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS5 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS6 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
29-/07/15	8:00 - 18:00	File size too large to send	N/A	Y - R2-120	Y	Investigate breaking down large file into smaller components. Action with supplier. Potential to download uncompressed file.
21/09/2015	10:30	Station required manual reboot.	23hrs	4 Range Triggers from SHB_R1_DAT	N	Remote reboot carried out. Range IT control carried out manual reboot at 09:30 22/09/2015. No further action required.
16/11/2015	09:00 – 11:30 hrs	Remote connection with station lost. Trigger commands not being received	2.5hrs	R1-249 R2-45 R3-65	N	09:00 – Following daily equipment checks SHB_OS6 offline – investigation commenced. 09:20 – Established cause due to station crash. 10:00 – On-Range support contacted and request for manual restart sent. 11:30 – Manual restart performed and station back up and running.
11/12/2015 - 14/12/2015	11/12/2015 13:50 – 14/12/2015 09:30 hrs	Remote connection with station lost.	2days 20.5hrs	R2-69	N	11/12/15 13:50 – SHB_OS6 offline – investigation commenced. 13:55 – Established cause due to monitoring station in 'hang' state. 13:55 – On-Range support contacted and request for manual restart sent. 15:13 – On Range support unable to attend unit until 14/12/15 09:30 – Manual restart performed and station back up and running.

TABLE 3.8: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS6 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS7 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
No outages during this monitoring period						

TABLE 3.9: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS7 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS8 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
23/11/2015	10:30 – 15:00 hrs	Station not receiving trigger alerts from SHB_R1_DAT following modem swap out.	4.5hrs	R1-456 R1-459 R1-464 R1-469 R1-474 R1-480	N	

TABLE 3.10: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS8 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS9 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
29/10/2015	09:30	Remote connection with station lost. Trigger commands not being received.	2.5hrs	R1-395 & R2-101 & R3-356	N	09:30 – SHB_OS9 offline – investigation commenced. 11:00 – Established cause due to router port settings being re-set. 12:00 – Router re-configured. No further actions required.
16/11/2015	09:00	Remote connection with station lost. Trigger commands not being received	0.5hrs	N	N/A	09:00 – Following daily equipment checks SHB_OS9 offline – investigation commenced. 09:20 – Established cause due to station crash. 09:30 – Station remotely restarted. No further actions required.

TABLE 3.11: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS9 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

EQUIPMENT / TELECOMS OUTAGES AT SHB -OS10 DURING MONITORING STUDY						
Date	**Time**	**Fault Description**	**Downtime**	**Range Trigger Occurred During Outage**	**Range Trigger Captured**	**Notes**
19/11/2015 – 26/11/2015	various	Intermittent network following modem swap out.	Intermittent 7 days	R1-456 R1-459 R1-464 R1-469 R1-474 R1-480 R1-486 R1-515 R2-127 R2-152 R2-157 R2-167 R2-169 R3-334 R3-364 R3-368 R3-379 R3-381	N	18/11/2015 – Following modem swap out monitor intermittently offline. 19/11/2015 – 23/11/2015 – In contact with Telecoms provider concerning line issues, remote line tests carried out. 24/11/2015 - Southdowns and BT engineer attend monitor. Manual line tests carried out, re-wiring and cable swap outs performed. Connectivity improves however occasional drop outs still present. 26/11/2015 - On-going monitoring of network connection.

TABLE 3.12: SUMMARY OF EQUIPMENT / TELECOMS OUTAGES AT SHB-OS10 DURING MONITORING PERIOD 28TH JUNE 2015 TO 31ST DECEMBER 2015

VOLUME 2: TECHNICAL APPENDICES – DETAILED METHODOLOGY

CHAPTER 4: DATA PROCESSING METHODS

4. DATA PROCESSING METHODS

4.1 Introduction

4.1.1 One of the key strengths of this study is the ability to analyse the recorded signals after they have been captured.

4.1.2 Digital signal processing methods have been applied to ensure: a consistent treatment of the large data-set; minimisation of any potential skew to the assessment due to subjective approaches; and to provide a robust scientific approach to the determination of a causal link.

4.1.3 The processing and analysis of the collated dataset has been separated into two stages, namely:

- determining the probability of causal link using signal processing techniques; and
- calculation of sound / air overpressure and vibration magnitudes for activities with a confirmed causal link.

4.1.4 An overview of the methodologies and signal statistical techniques used and subsequent calculation and presentation of sound / air overpressure and vibration magnitudes is presented in the following subsections and includes detailed, annotated examples of a selection of Range Activities captured during the monitoring study along with some locally triggered activities not associated with Range Activity. These were undertaken and documented as part of an assurance study to verify the application of the analytical methods prior to their wider application on the main study data.

4.1.5 The full results of the processing for all Range activities are presented graphically in Volume 03 – Technical Appendices – Results.

4.1.6 An overview of the approach is presented schematically in Figure 4.1.

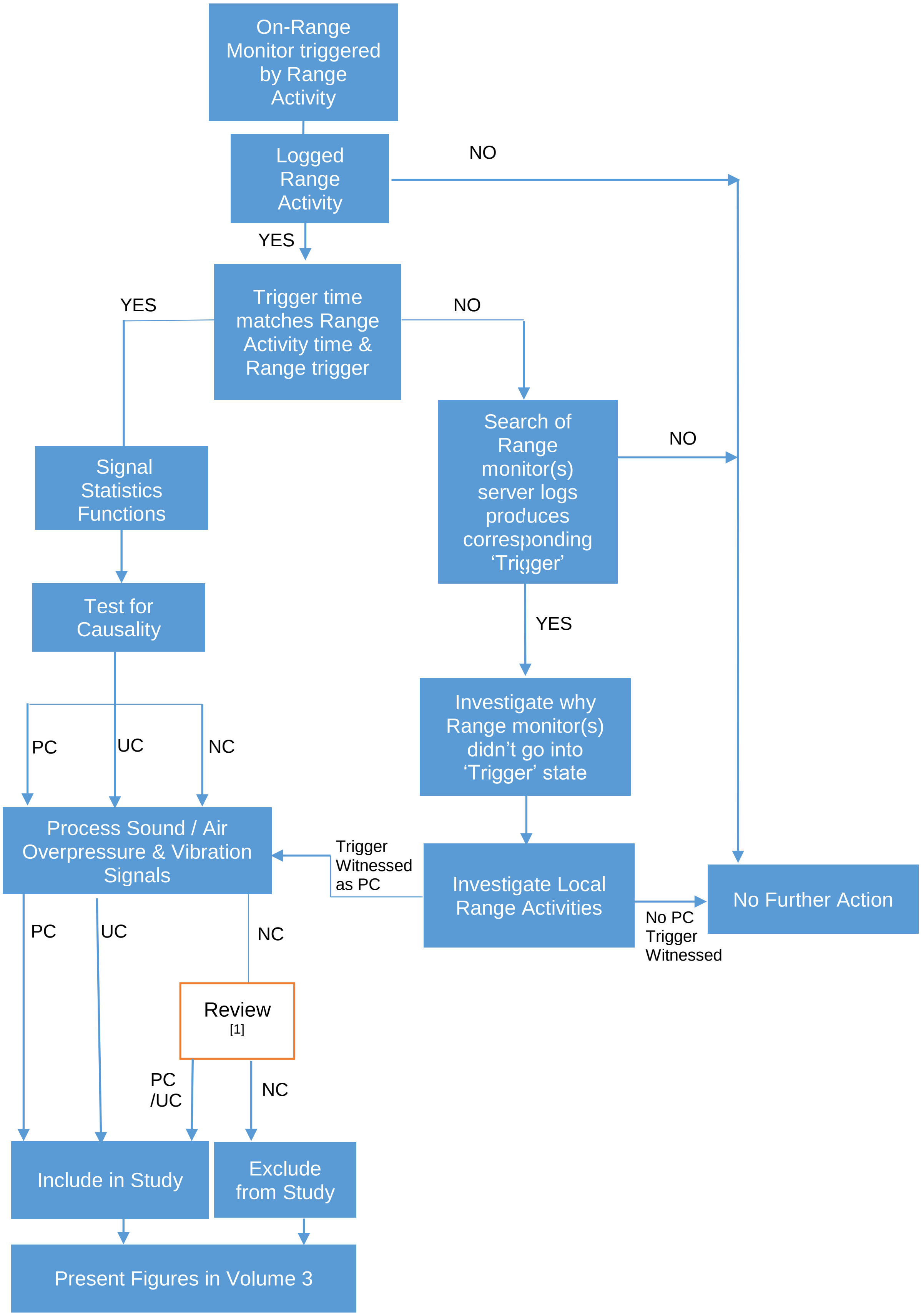


FIGURE 4.1: OVERVIEW OF DATASET PROCESSING

Notes

[1] manual analysis of dataset undertaken and review where levels are likely to have a tangible effect on the outcome of the study

[2] where PC = positive causality; UC = uncertain causality; NC = non-causal

4.2 Test for Causal Link

4.2.1 The Range Activity logs provided by QinetiQ (as presented in Vol 3 – Chapter 1) provided an approximation of when an on- Range triggered activity might be expected to occur at an off-Range monitoring location. With each monitoring station synchronised with a GPS clock, this approach provides a first pass assumption that a confirmed Range Activity would need to exist within a predefined time window following the activity itself.

4.2.2 A test for causal link was developed to assess the likelihood of an off-Range measured event occurring from a Range Activity. A number of individual analytical and statistical functions have been developed using MATLAB, a proprietary software package which allows mathematical calculations, plotting of functions and data, and the implementation of digital signal processing algorithms. Functions have been developed using MATLAB to collectively enable the testing of captured signals. A description of these individual functions is described in more detail below.

4.3 Statistical Function - Signal Cross-Correlation

4.3.1 Cross-correlation is a signal statistic used to assess the similarity between two signals. It is a measure of the similarity as a function of time, specifically the time lag. It is a useful function for the calculation of a time separation or a delay between two signals.

4.3.2 The function shifts one signal in time and compares the summation of the two signals. When two signals are summed, a maximum will occur at the point at which the signals are most similar.

4.3.3 Figure 4.2 shows a simplified example of cross-correlation using two signals 'Range' and 'Off-Range' and the cross-correlation depicted by the function name 'Range * Off-Range'. It can be seen from the graphical representation that Off-Range moves across Range and they are summed at every iteration producing 'Range * Off-Range'.

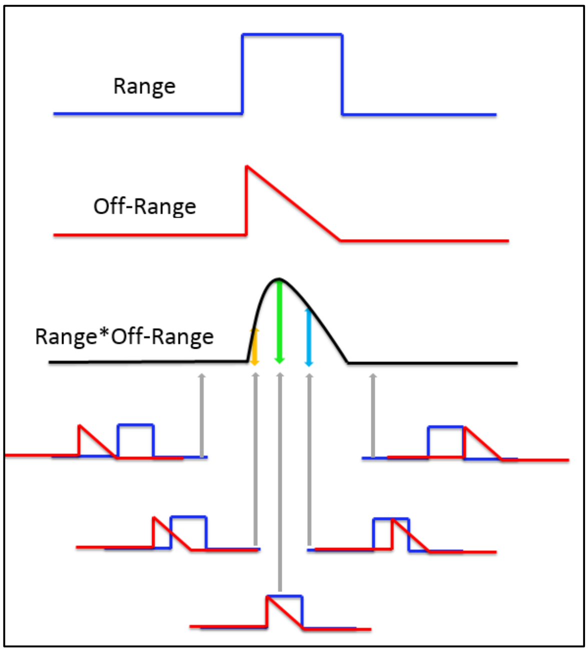


FIGURE 4.2: GRAPHICAL REPRESENTATION OF CROSS-CORRELATION

4.3.4 The peak occurs when the signals are most similar, even though they may not be exactly the same.

4.3.5 An example of a typical cross-correlation plot produced using this technique is presented in Figure 4.3 overleaf.

4.4 Statistical Function – Signal Coherence

4.4.1 The coherence is a statistical quantity that is used to examine relationships between two digital signals and estimate the similarity of the two signals.

4.4.2 The coherence function produces a series of measures between 0 and 1 across the frequency spectrum. If the coherence is zero, this is an indication that the signals are not similar.

4.4.3 If the coherence between two signals is greater than zero but less than one, there is some similarity evident with a greater level of confidence the higher the numerical value.

4.4.4 For the purposes of establishing a causal link from Range activities, the coherence function uses the signal from an identified on-Range Activity and compares it against waveforms captured at off-Range locations.

4.4.5 Owing to the expected low frequency component of Range activities, and the higher degree of sound energy decay due to distance in the mid to high frequencies, the coherence of the signals focussed primarily on the frequency range of 1 to 500Hz.

4.4.6 An example of a typical coherence plot produced is presented in Figure 4.4 overleaf.

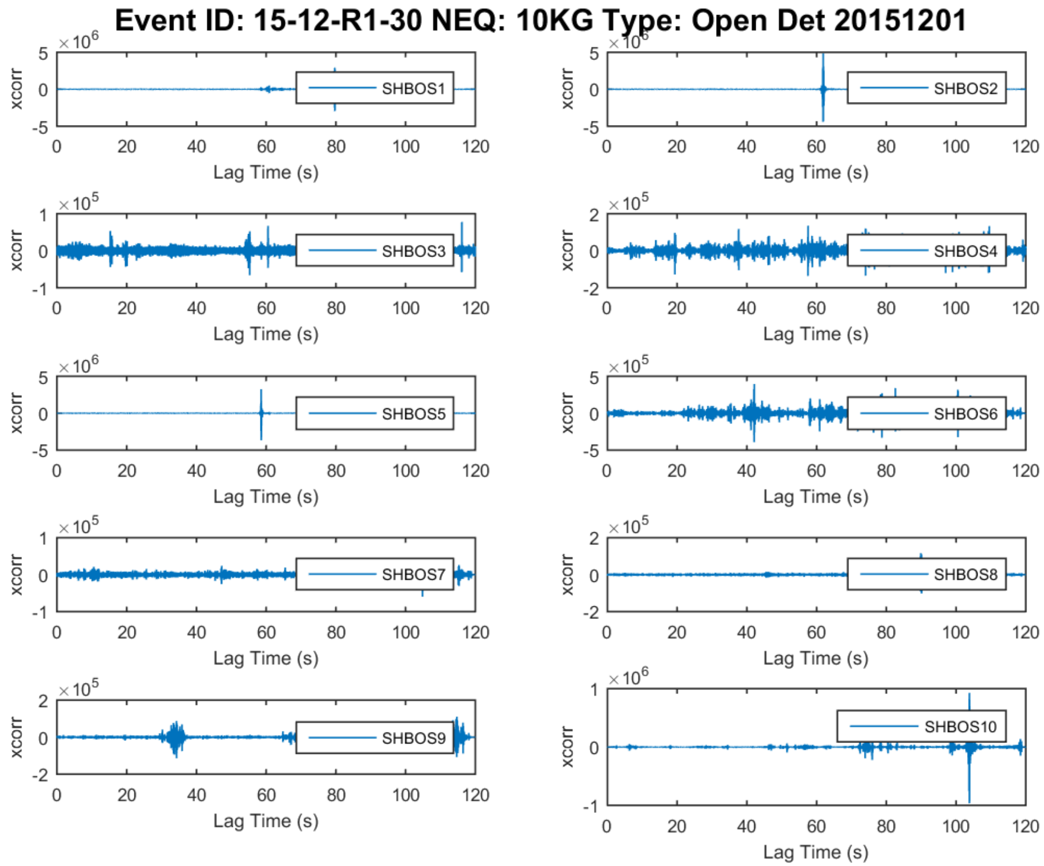


FIGURE 4.3: EXAMPLE OF A TYPICAL CROSS-CORRELATION ACOUSTIC PLOT

Note:

[1] Cross correlation peak presented in plots identifies the time when the off-Range signal is most similar to the on-Range signal. This technique is also useful for determining the time at which the acoustic waveform arrives at the monitor point..

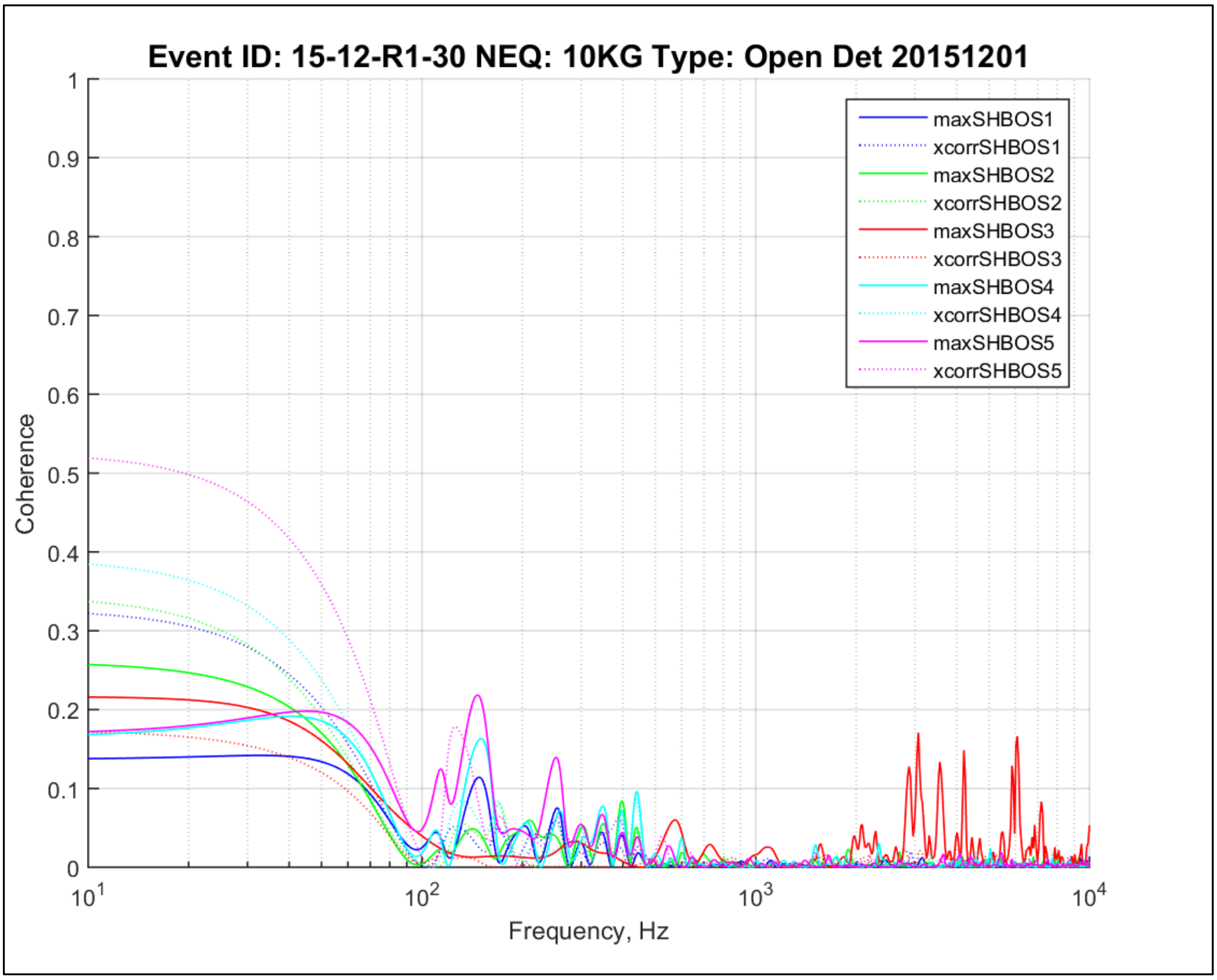


FIGURE 4.4: EXAMPLE OF A TYPICAL COHERENCE CALCULATION

Notes:
[1] 'max' presents the coherence of the maximum value in the audio signal; and
[2] 'xcorr' presents the coherence of activity found by cross correlation.

4.5 Derivation of Threshold Values for Causality Categories

4.5.1 These signal processing techniques have been used to determine causality at all monitoring locations for all captured Range activities. The magnitude of causality has been categorised as follows:

- positive causality (PC) – statistical evidence indicates a reasonable likelihood that an Range Activity has caused an off-Range effect (i.e. probable causality);
- uncertain causality (UC) – insufficient statistical evidence to confirm that the Range Activity caused an off-Range effect (i.e. possible causality);
- non-causal (NC) – little or no statistical evidence to suggest that the Range Activity has caused an off-Range effect (i.e. unlikely causality).

4.5.2 A number of tests were performed on a sample of the collated dataset, to enable a threshold value to be calculated for each causality category.

4.5.3 The sample dataset used to derive the threshold values for causality categories included a sample of measurements that were confirmed as being causal from audio playback and analysis of Range Activity logs. In addition, the sample dataset also included a number of control tests carried out on data known not to be causal (non-causal), which included:

- unrelated Range activities of the same type;
- unrelated Range activities of different types; and
- activities not related to Range activities.

4.5.4 A maximum value of coherence from the selected frequency range, (between 1 and 500Hz due to the low frequency nature of the activities) was chosen for the three causality categories.

Positive Causality (PC)

4.5.5 From the test performed (as presented in Section 4.4) it was observed that Coherence values of above 0.15 provided positive causality across the frequency range of interest.

4.5.6 Results which fall into the Positive Causality category will include off-Range captured activities which exhibit similar characteristics to that of the measured Range activities, such as activity rise time; and that occur at an off-Range monitoring location at or around the time that a Range generated signal could be expected to arrive.

4.5.7 It is very unlikely that a small or significant activity which is not related to the Range signal will fall into this category. Typical activities which fall into this category are Range activities which are not heavily affected by ambient noise contributions at the off-Range monitor.

Uncertain Causality (UC)

4.5.8 From the tests performed (as presented in Section 4.4) it was observed that Coherence values between 0.05 and 0.15 introduced a level of ‘uncertain causality’.

4.5.9 The uncertain causality category may contain events that are similar to the Range Activity in some respects but may differ in others, for example a low level, low frequency event which is not related to Range Activity such as wind noise. Also events which share all of the same features but are low level in comparison to the existing ambient are likely to be rated within this category.

4.5.10 It is unlikely that a significant event which is not related to Range Activity will fall into this category.

Non-causal (NC).

4.5.11 From the tests performed (as presented in Section 4.4) it was observed that Coherence values below 0.05 indicated no causality.

4.5.12 Results which fall into the 'no causality' category will include large events which are not related to Range Activity. It is very unlikely that a Range Activity will fall into this category, unless it has been heavily affected by ambient sound.

4.5.13 Typical events which will fall into this category are events which are unrelated to Range Activity.

4.6 Testing and Effectiveness

4.6.1 Testing was undertaken to validate the causality categories using all triggered activities where 6 or more Off Range stations were classified as non-casual. Details of the sample dataset used for this purpose are presented in Table 4.1 overleaf.

Trigger ID	No. Range Activities in Causal Category			Analyst Comment
	NC	UC	PC	
15-6-R1-46	7	0	0	Alarm Causes Trigger
15-6-R1-61	6	0	1	Alarm Causes Trigger - Some other Range Activity observed in OS traces
15-7-R1-107	6	1	0	Alarm Causes Trigger
15-7-R1-470	10	0	0	Alarm Causes Trigger
15-7-R2-65	8	2	0	Wind Noise Causes Trigger
15-7-R2-84	9	0	0	Wind Noise Causes Trigger
15-7-R2-90	7	2	0	Wind Noise Causes Trigger
15-7-R1-568	10	0	0	Alarm/Wind Noise Causes Trigger
15-7-R1-584	9	1	0	Alarm/Wind Noise Causes Trigger
15-7-R1-618	6	1	0	Alarm Causes Trigger
15-7-R1-664	6	1	1	Range Activity inaudible at NC OR locations (low level Range Activity 114 dB Lzpk)
15-8-R1-137 & R3-360	8	2	0	Range Activity inaudible at NC OR locations (low level Range Activity 102 dB Lzpk)
15-8-R1-229	8	1	0	Alarm Causes Trigger
15-8-R1-402	6	4	0	Alarm Causes Trigger
15-8-R1-498 & R2-192	6	3	0	Extraneous Noise Cause of Trigger
15-9-R1-306 & R3-381	8	1	0	Extraneous Noise Cause of Trigger
15-9-R1-316 & R3-442	9	0	0	Alarm Causes Trigger
15-9-R1-430	7	2	0	Alarm Causes Trigger
15-9-R1-464	6	3	1	Range Activity inaudible at NC OR locations
15-11-R1-502	9	1	0	Noise in input measurement Revisit
15-12-R1-44	9	1	0	Alarm Causes Trigger
15-12-R1-74	6	4	0	Range Activity inaudible at NC OR locations (102 dB Lzpk)

TABLE 4.1: ACTIVITY BY ACTIVITY INVESTIGATION

Notes:
[1] where NC = non-casual
[2] where UC = Uncertain Causality
[3] where PC = Positive Causality

4.6.2 Table 4.1 shows that none of the triggered activities which were not related to Range Activity were classified as having positive causality.

4.6.3 Table 4.1 shows that triggered activities which are adversely affected by wind or other factors are largely classified into Uncertain Causality. In the example of 12-S2-61 a number of activities were not picked up at off-Range locations due to the comparative low level of the activity.

4.7 Manual Identification of Causality

4.7.1 Following the application of the automated digital signal process, activities which fall into the uncertain causality (UC) category have been included in the data set for assessing magnitudes of sound / air overpressure and vibration at off-Range locations, as it is accepted that the measured effect could be due to Range activities.

4.7.2 For activities where the test showed no causality (NC) following the initial application of the signal processing techniques, manual analysis of the data set was applied to determine whether a causal link could be established by other techniques.

4.7.3 This included visual inspection of the spectrograms to identify 'typical' Range Activity signals and review of the audio wave file for Range Activity confirmation.

4.7.4 Where causality could be established, the individual activities were included in the assessment of sound / air overpressure magnitudes from Range activities.

4.8 Calculation of Sound / Air Overpressure and Vibration Magnitudes for Activities

4.8.1 Functions have been developed using MATLAB to collectively enable the calculation of sound / air overpressure and vibration magnitudes of captured signals. A description of these individual functions is described in more detail below.

Time History

4.8.2 The L_{Zpeak}, L_{Cpeak} and $L_{Amax,F}$ levels, along with the time histories of the raw sound pressure signals captured during a Range Activity at all on-Range and off-Range monitoring locations have been produced. Elevated levels or other distinguishing features can be used to assist in the positive recognition and quantification of Range activities.

4.8.3 An example of a typical time history plot produced is presented in Figure 4.5 below.

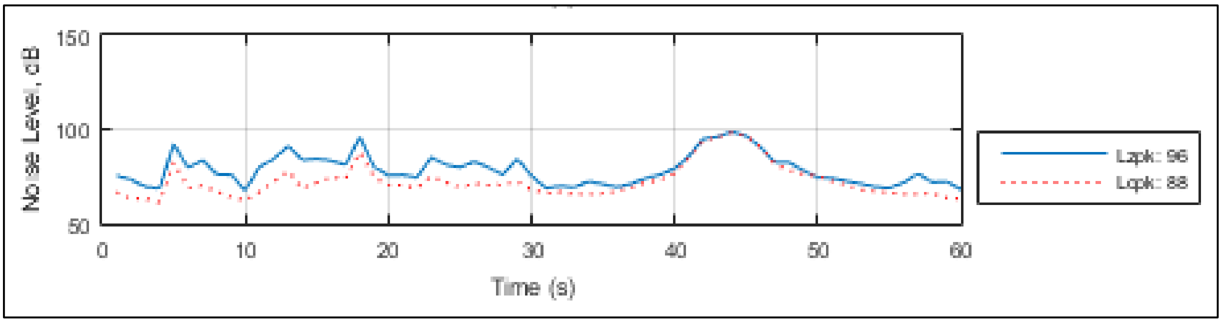


FIGURE 4.5: EXAMPLE OF A TYPICAL TIME HISTORY

4.8.4 The time histories produced using MATLAB coded functions have been verified against those produced in a proprietary software package SINUS SAMURAI 2.6 to ensure correct functionality.

Sound Spectrogram

4.8.5 A sound spectrogram (or sonogram) was used to enable visual analysis of the frequency and amplitude components of a signal in the time domain. Frequency is represented in the vertical axis, time in the horizontal axis, and the amplitude of the signal is represented by a colour scale. Spectrograms have been produced for the raw sound pressure signals collated, enabling analyses and comparison of the acoustic signatures of Range activities captured by on-Range and off-Range monitors.

4.8.6 An example of a sound spectrogram, produced by a typical Range Activity is presented in Figure 4.6.

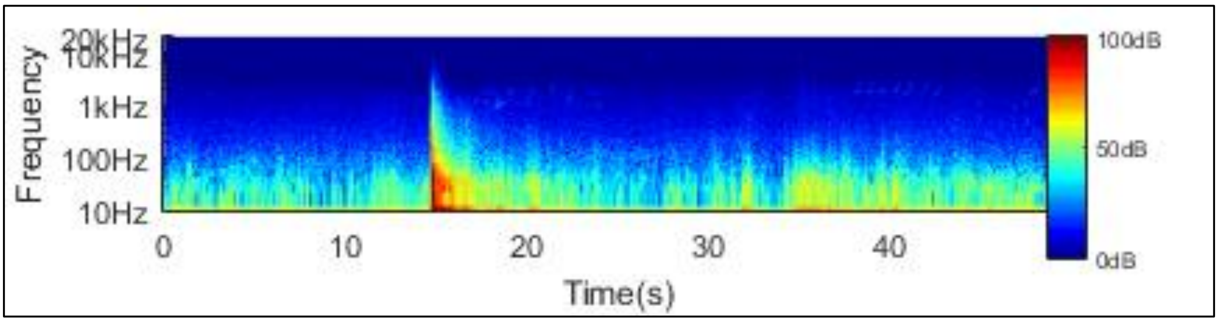


FIGURE 4.6: EXAMPLE OF A TYPICAL SOUND SPECTROGRAM PRODUCED

4.8.7 The time resolution was based on a compromise between peak approximation and dynamic range.

4.8.8 The methodology applied for the spectrogram production using MATLAB coded functions were verified against those produced using the proprietary software SINUS SAMURAI 2.6 and against a computer generated 1kHz sine-wave test signal.

Vibration

Peak Particle Velocity

4.8.9 In addition to sound pressure signals, the raw measured vibration signals have been considered. As discussed in the main body of the report, seismometers have been used to measure ground vibration in this study, with velocity being the physical units measured (expressed as mms^{-1}).

4.8.10 The uncompressed .wav files measured by each monitor will display physical units (mms^{-1}). These units can be directly imported into MATLAB for presentation and results. Cross correlation has been used for Range Activity time identification.

4.8.11 Seismic signals can travel through the earth much faster than the speed of sound through air (in materials such as clay it can be up to 5 times faster). To ensure that the seismic signals, would be captured at off Range locations, the off-Range monitors were configured with a 5 second pre-trigger. This would allow for the delay in the off-Range monitor receiving its trigger command, while still ensuring any seismic signal was captured.

4.8.12 For the assessment against the criteria presented in the Section 2.2 of Volume 1, max component peak particle velocities have been presented.

4.8.13 However, the analysis of the data set indicates that the detectable vibration signals captured during Range Activity arrive at a similar time to the air pressure signal. This would indicate that the vibration captured during the activity is likely to have been caused by a coupling effect with the ground, from the air pressure wave, rather than from direct ground-borne propagation of vibration from the site of the activity.

Displacement

4.8.14 The transient vibration thresholds for the on-set of cosmetic damage as previously presented in Chapter 3 of main report, considers Maximum Displacement for frequency components below 4 Hz. Using integration, displacement values have been derived from the raw velocity signals.

4.9 Effectiveness of Signal Processing Techniques

4.9.1 The information set out in this sub-section provides an example of how the signal processing techniques can be used to identify a Range Activity and determine the causality and measure the magnitude of the sound pressure and vibration magnitudes.

4.9.2 Figure 4.7 presents the spectrogram relating to a 3 kg static Range Activity captured on 23rd November 2015, assigned trigger ID 15-11-R2-152 & R3-364, processed for Range monitor SHB_R2. Figure 4.8 and Figure 4.9 present the spectrogram and time history with the L_{Cpeak} and L_{Zpeak} traces for the same activity, captured at off-Range monitor SHB_OS6.

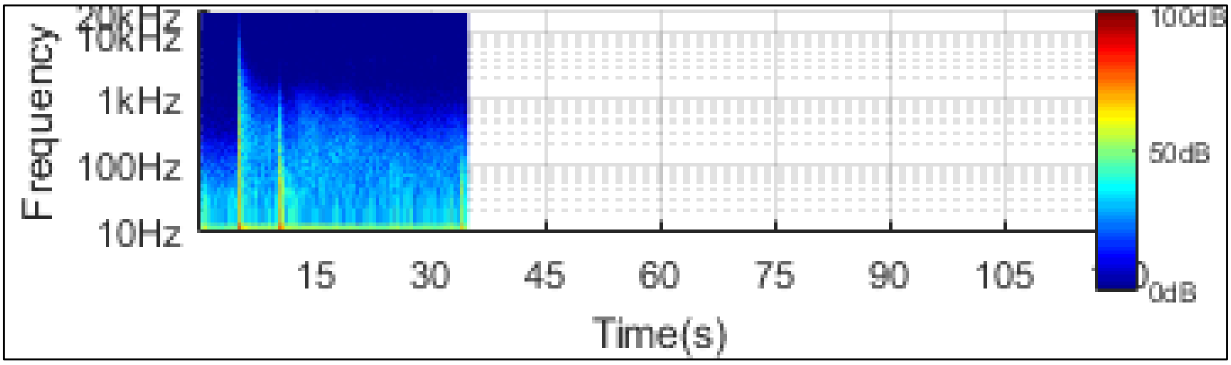


FIGURE 4.7: SPECTROGRAM – 3 KG OPEN DET, 23RD NOVEMBER 2015 – SHB_R2

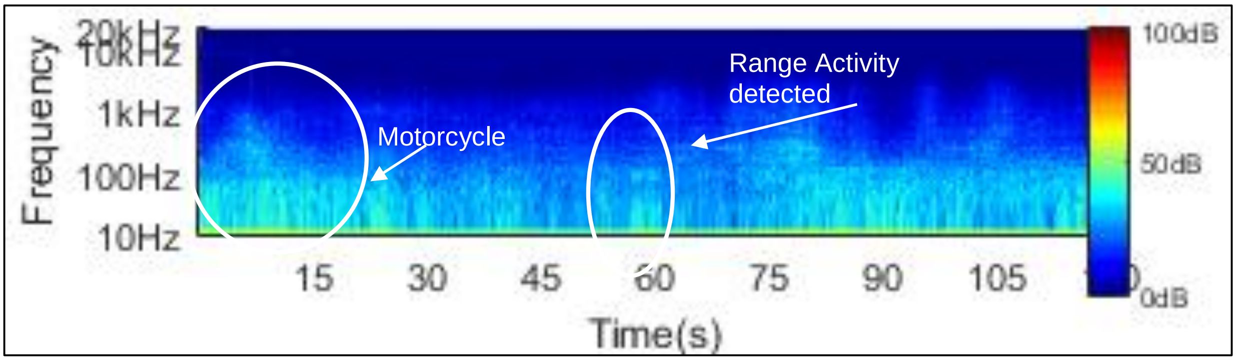


FIGURE 4.8: SPECTROGRAM – 3 KG OPEN DET, 23RD NOVEMBER 2015 – SHB_OS6

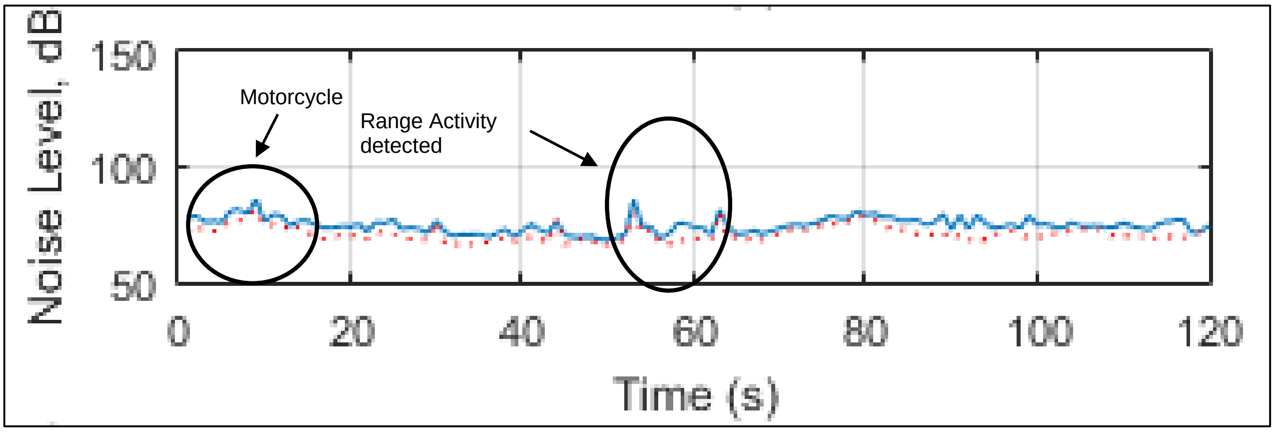


FIGURE 4.9: TIME HISTORIES – 3 KG OPEN DET, 23RD NOVEMBER 2015 – SHB_OS6

4.9.3 Figure 4.7 above clearly shows the open detonation at a point 5 seconds into the captured signal at the on-Range monitor SHB_R2. The unique acoustic signature is evident in the spectrogram produced for off-Range monitor SHB_OS6 at approximately 55 seconds into the signal trace, as presented in Figure 4.8.

4.9.4 Apparent from the time histories presented in Figure 4.9, the graph also shows a local activity (with the characteristics of a motorcycle) occurring at approximately 10 seconds into the signal trace with an apparently greater magnitude of sound than the Range Activity.

4.9.5 Inspection of the cross correlation shown in Figure 4.10 confirms the Range Activity at c. 45 seconds (50 seconds when adjusted for the 5 second pre-trigger) whilst the coherence shown in Figure 4.11 validates the time correction from the cross correlation. This allows for the calculation of the L_{Cpeak} and L_{Zpeak} of the Range Activity, not the louder local motorcycle noise activity captured within the waveform.

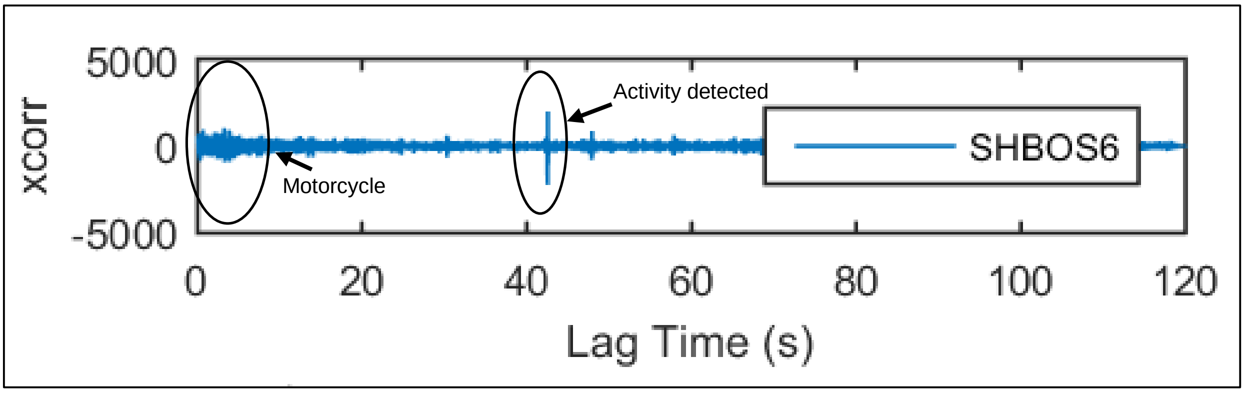


FIGURE 4.10: CROSS CORRELATION – 3 KG OPEN DET, 23RD NOVEMBER 2015 – SHB_OS6

4.9.6 It should be noted that the cross correlation plots do not share a common time zero with the noise and vibration plots. The cross correlation results present a time difference between Range and off Range signals or '*Lag Time'* in this context.

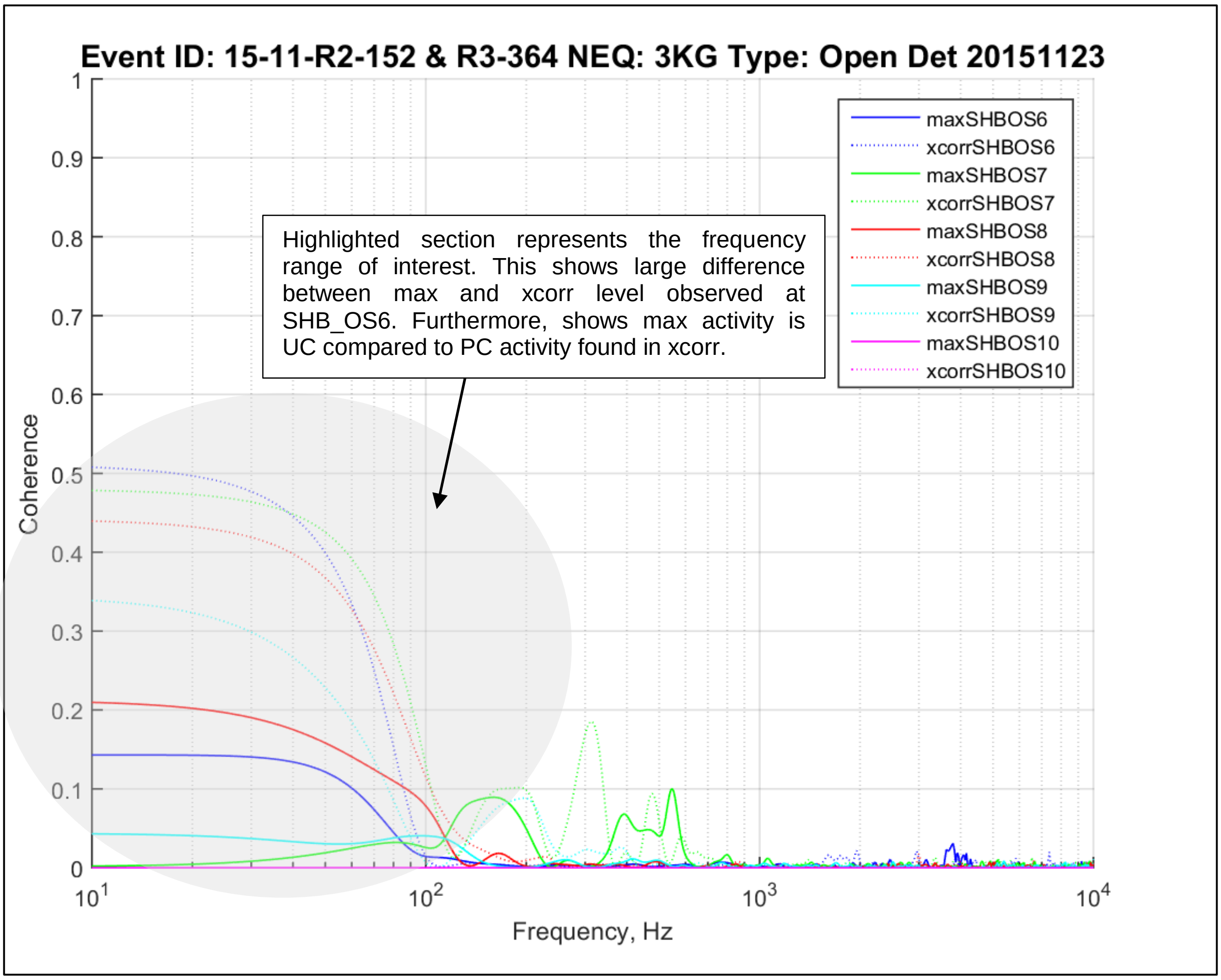


FIGURE 4.11: COHERENCE– 3 KG OPEN DET, 3 KG OPEN DET, 23RD NOVEMBER 2015 – SHB_OS6

Notes:
[1] 'max' presents the coherence of the maximum value in the audio signal; and
[2] 'xcorr' presents the coherence of activity found by cross correlation.

4.9.7 The above coherence plot presented in Figure 4.11, shows two important roles of the techniques applied. Namely, that the localised noise activity is shown to be in the UC category, whereas the actual Range Activity was classified as being in the PC category according to the cross correlation analysis.

4.9.8 Once the Range Activity has been identified as having positive causality, the time history data can be used to identify the L_{Cpeak} and L_{Zpeak} sound pressure levels.

4.10 Detailed Examples

4.10.1 A selection of Range activities captured during the monitoring study between 3rd November 2014 and 3rd May 2015 are presented in the following sub-section to demonstrate the analytical and statistical methods described above, and how they have been applied to the obtained data for determining causal link and assessing the potential effects.

4.10.2 The examples include open detonations from the Shoeburyness Range along with some examples of locally triggered events known not to be associated with Range Activity for comparative purposes.

Detailed Example – 25 kg Single Open Detonation Activity, 10:33 9th November 2015

Sound Pressure

4.10.3 The spectrograms associated with trigger 15-11-R1-48 relating to a 25 kg open detonation at 10:33 on 9th November 2015, are presented in Figures 4.12 – 4.22.

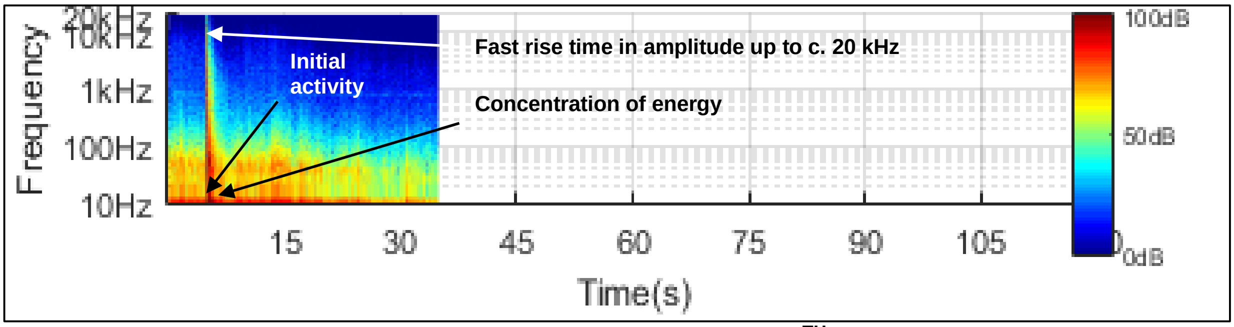


FIGURE 4.12: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – DAT (SHB_R1)

4.10.4 Figure 4.12 above shows the spectrogram processed from the raw data signal captured by the on-Range monitor installed at DAT (SHB_R1). The spectrogram clearly shows the open detonation at approximately 5 seconds (n.b. total signal includes 5 second pre-trigger). The very fast rise time in amplitude across the frequency spectrum up to approximately 10 kHz, along with a concentration of energy of approximately 100 - 140 dB in the 10 – 100 Hz zone is apparent (represented by red, orange and yellow).

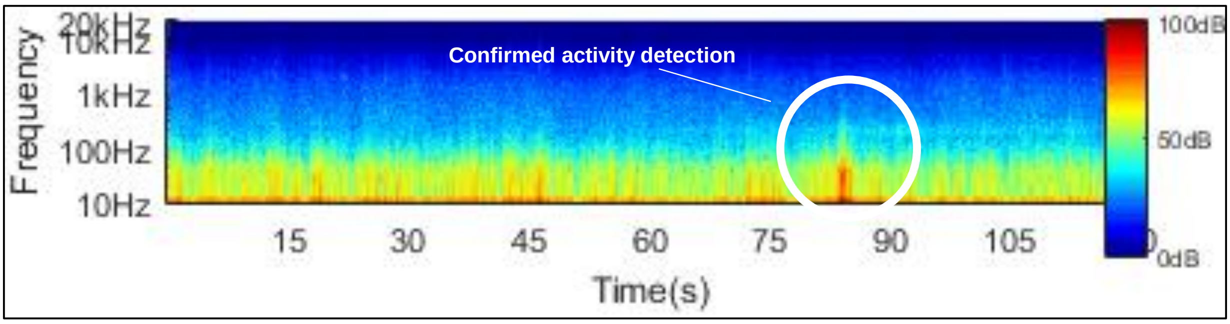


FIGURE 4.13: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS1

4.10.5 Figure 4.13 above shows the spectrogram processed from the raw data signal captured at a distance of approximately 32 km north east of the Range monitor at SHB_OS1 during the same 25 kg open detonation. Detection of the Range Activity is evident at approximately 80 seconds (which includes the 5 second pre-trigger) with the concentration of energy in the 10 – 50 Hz zone also apparent (represented by red and yellow). The staggered arrival times of the

10 – 50 Hz frequencies combined with the attenuation of frequencies above 50 Hz is also noticeable.

4.10.6 The spectrograms processed from the raw signals captured at the remaining off-Range monitoring locations during the same 25 kg open detonation are presented in Figures 4.14 – 4.22 below with detection of the Range Activity evident at all off-Range monitors.

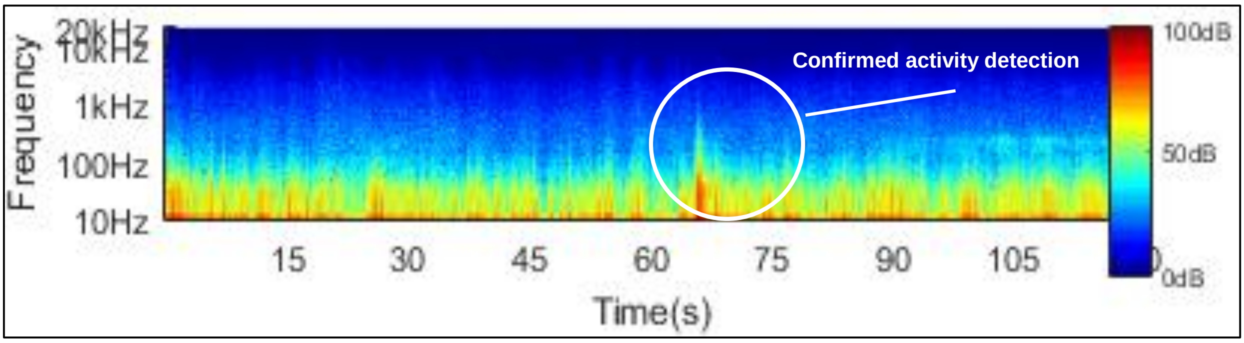


FIGURE 4.14: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS2

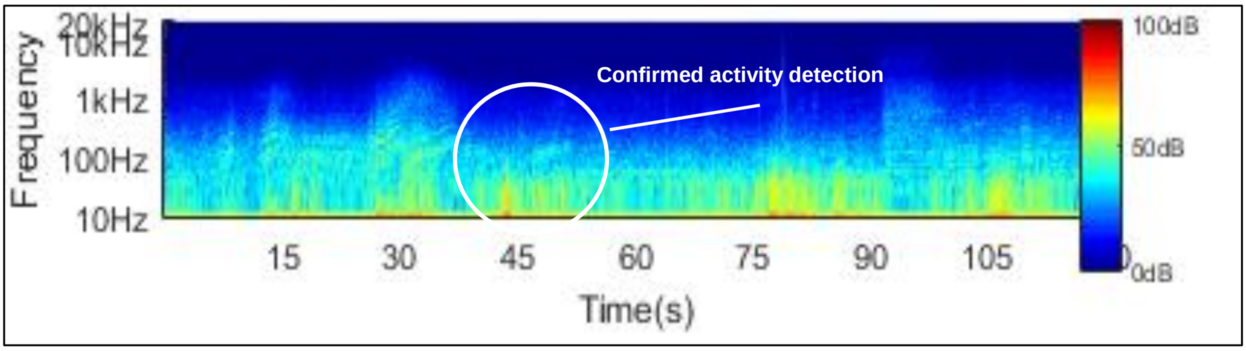


FIGURE 4.15: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS3

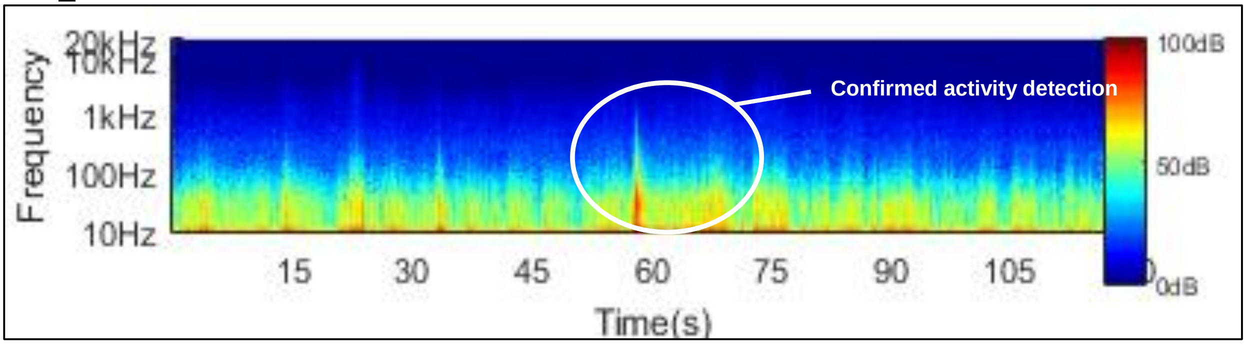


FIGURE 4.16: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS4

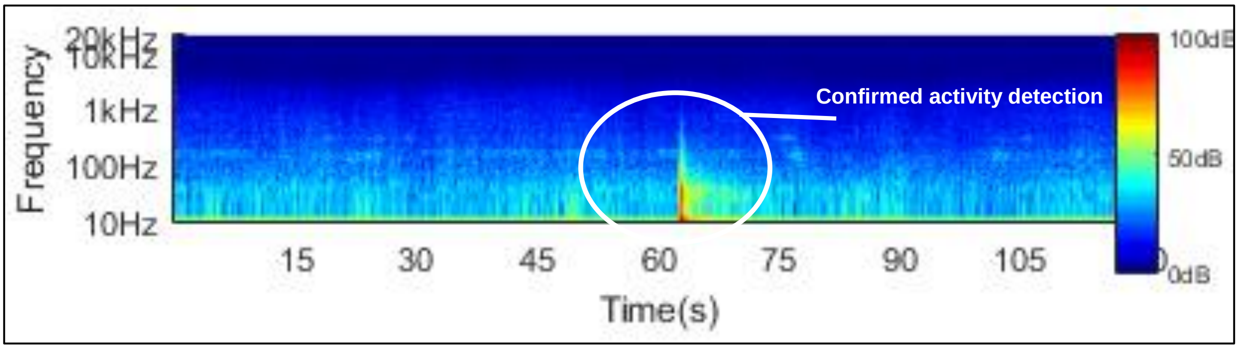


FIGURE 4.17: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS5

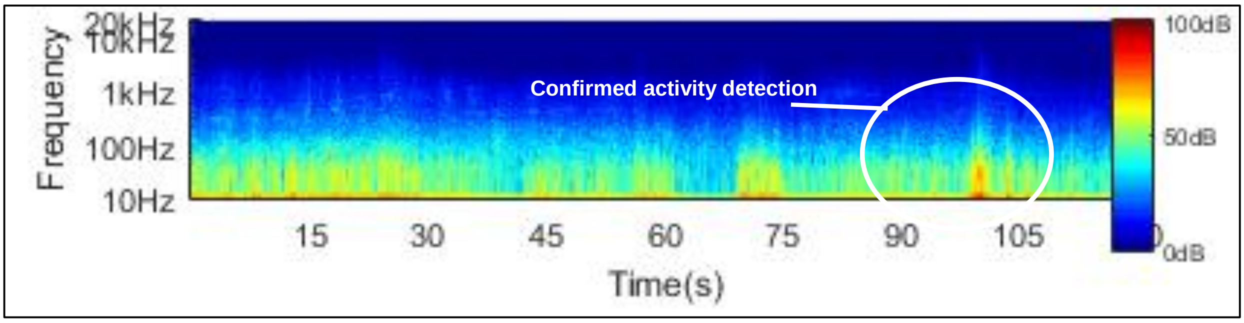


FIGURE 4.18: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS6

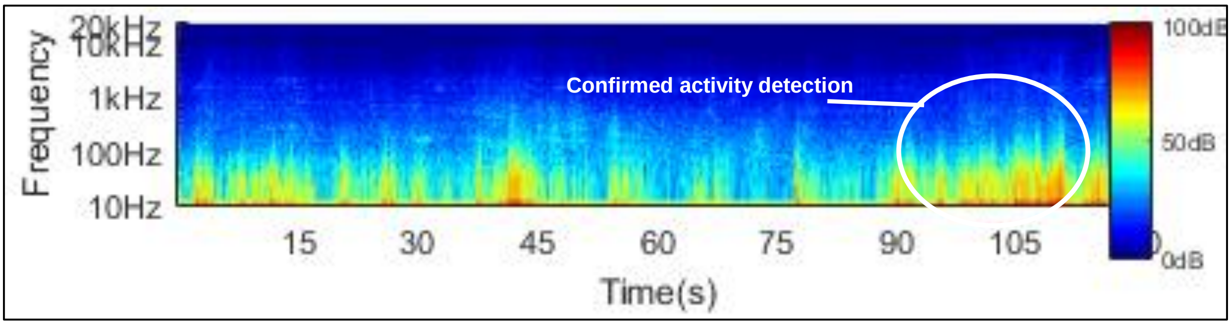


FIGURE 4.19: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS7

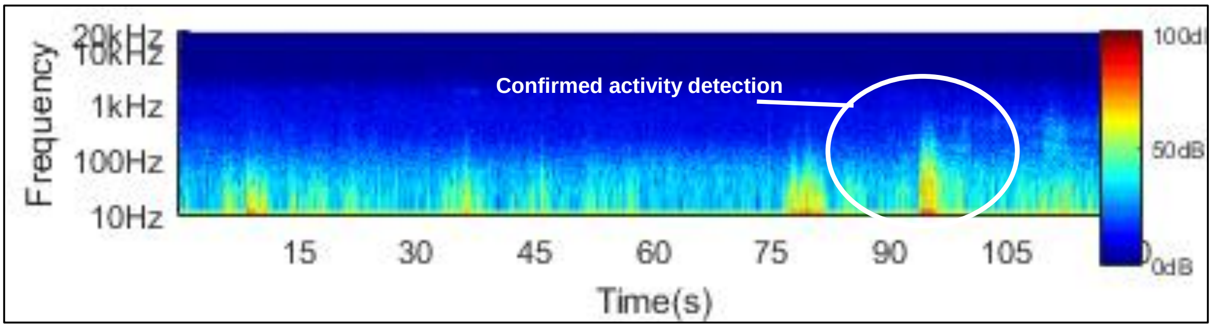


FIGURE 4.20: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS8

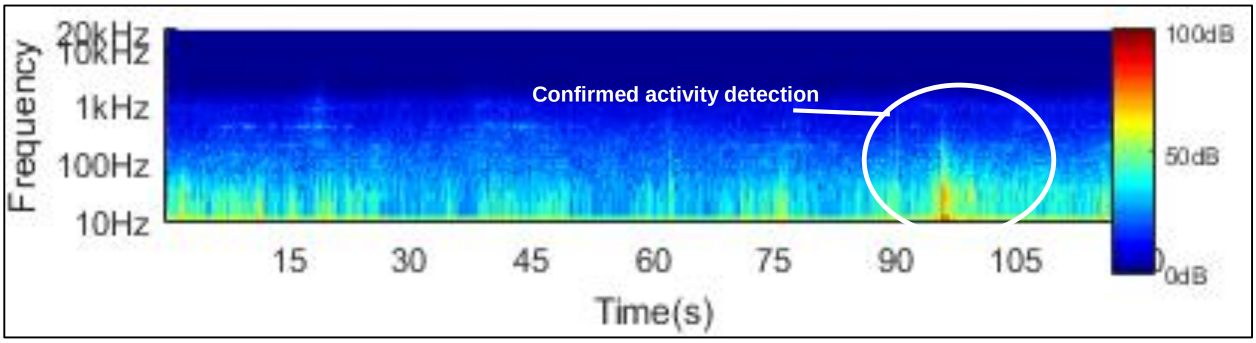


FIGURE 4.21: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS9

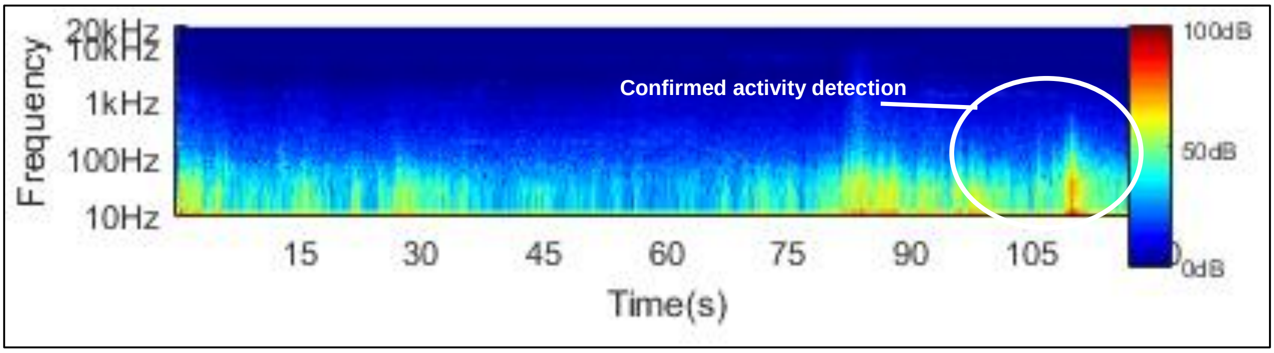


FIGURE 4.22: SPECTROGRAM – 25KG OPEN DET 10:33 9TH NOVEMBER 2015 – SHB_OS10

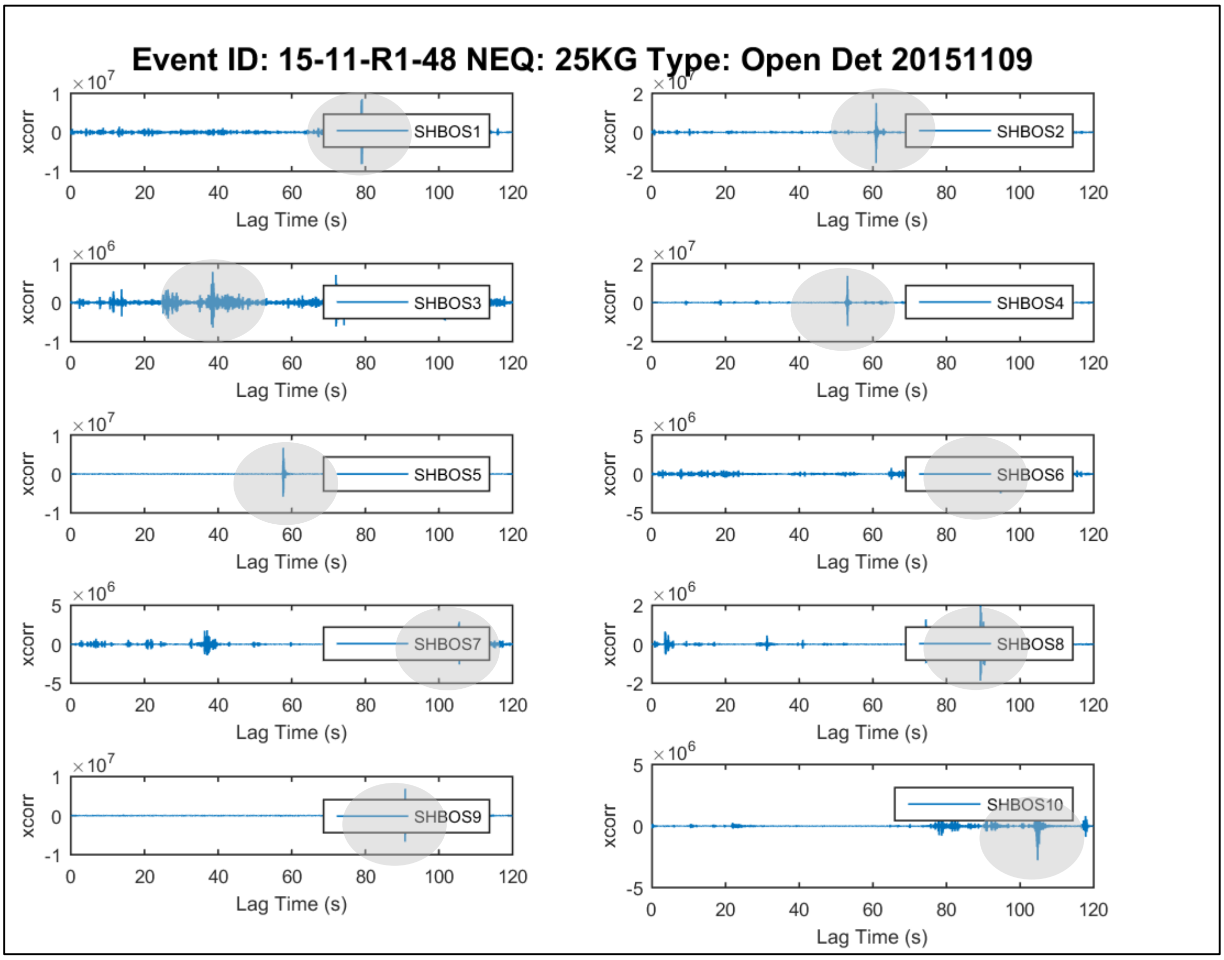


FIGURE 4.21: CROSS-CORRELATION – 25KG OPEN DET 10:33 9TH NOVEMBER 2015

Notes:
[1] highlighted area indicates Range Activity detection; and
[2] where cross-correlation is a measure of the similarity as a function of time, specifically the time lag

4.10.7 The results presented in Figure 4.21 show the time lag between a Range Activity captured at on-Range and off-Range locations.

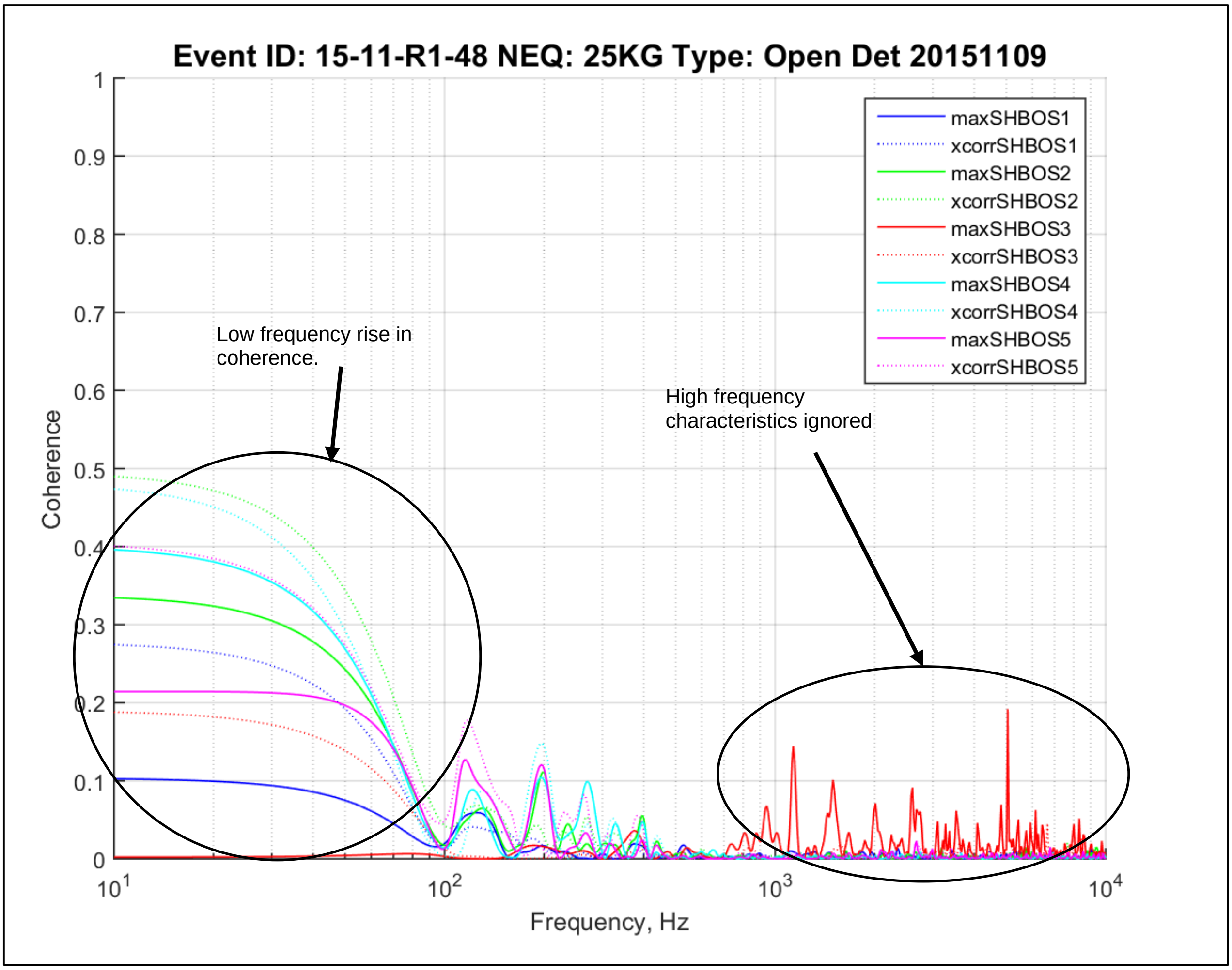


FIGURE 4.22: COHERENCE – 25KG OPEN DET 10:33 9TH NOVEMBER 2015, SHB_OS1 – SHB_OS5

Notes:
[1] 'max' presents the coherence of the maximum value in the audio signal; and
[2] 'xcorr' presents the coherence of activity found by cross correlation.

4.10.8 The coherence traces for SHB_OS1 – SHB_OS5 presented in Figure 4.22 during a 25kg open detonation show decreasing coherence with increasing frequency in the lower frequency range. Evident, is the steady coherence below approximately 60 Hz which is considered a typical signature for activities from the Range.

4.10.9 The maximum activity in the SHB_OS3 measurement is shown to be NC however the value found through cross-correlation is PC. It is evident from Figures 4.12 and 4.13 that this was due to a great amount of ambient activity occurring at the time of the trigger. This is also evident in SHB_OS1.

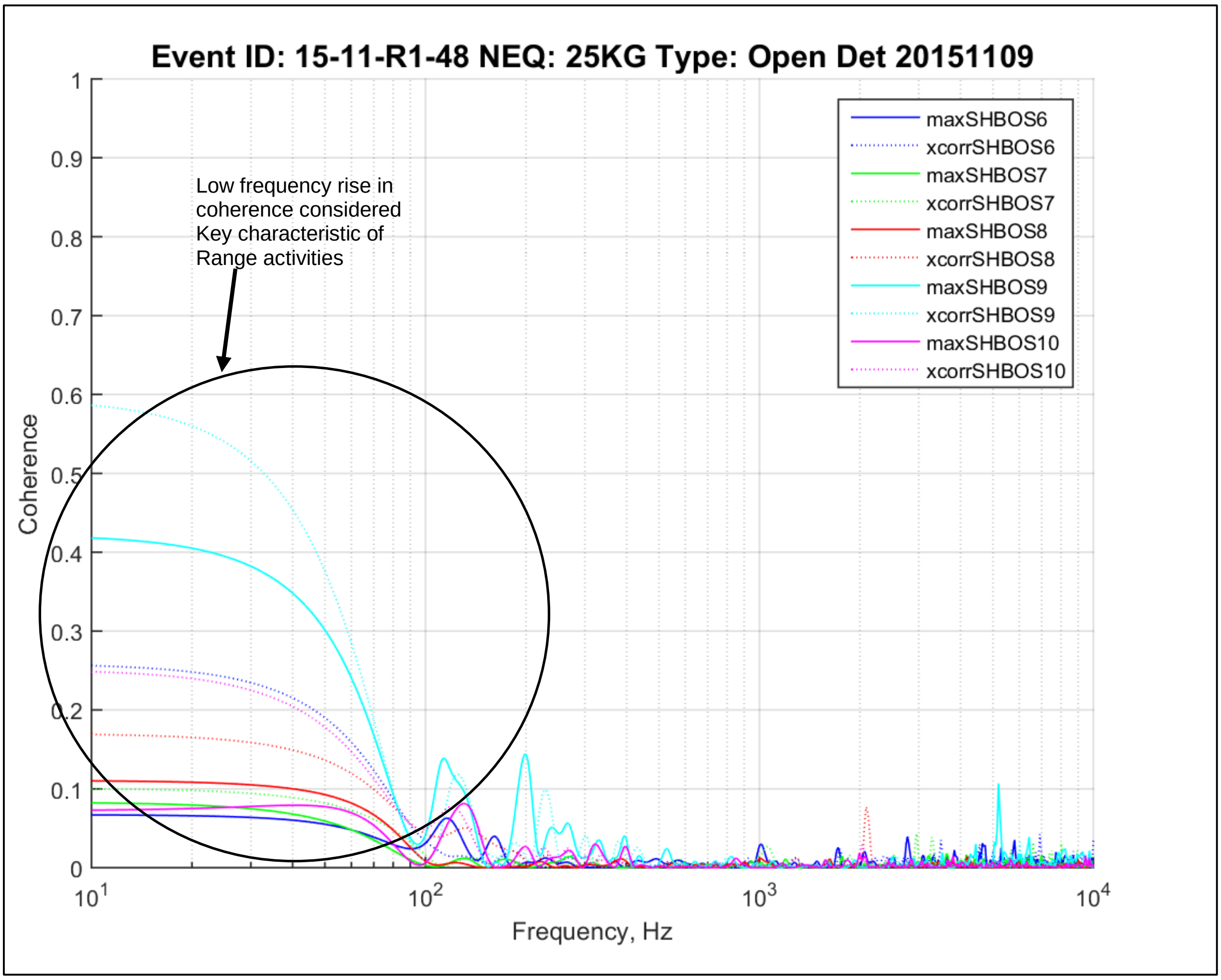


FIGURE 4.23: COHERENCE – 25KG OPEN DET 10:33 9TH NOVEMBER 2015, SHB_OS6 – SHB_OS10

Notes:
[1] 'max' presents the coherence of the maximum value in the audio signal; and
[2] 'xcorr' presents the coherence of activity found by cross correlation.

4.10.10 A similar spectral shape of coherence can be seen for SHB_OS9 between 100 and 400 Hz in Figure 4.23 above. Elevated levels of coherence within this range are considered to be a key characteristic of any Range Activity at these two locations.

Vibration

4.10.11 The velocity traces processed from the raw data signals captured at SHB_OS1 - SHB_OS5 are presented in Figure 4.24, the velocity traces SHB_OS6 - SHB_OS10 in Figure 4.25 and the applied cross-correlation function presented in Figure 4.26.

4.10.12 While vibration is evident at all locations where equipment was installed, Figure 4.24 highlights the very low magnitudes measured at some locations. Having looked in detail at the activity times, and compared them to the sound pressure graphs, there is an indication that the vibration captured during the activity is likely to have been caused by a coupling effect with the ground, from the air pressure wave, rather than from direct ground vibration from the site of the activity.

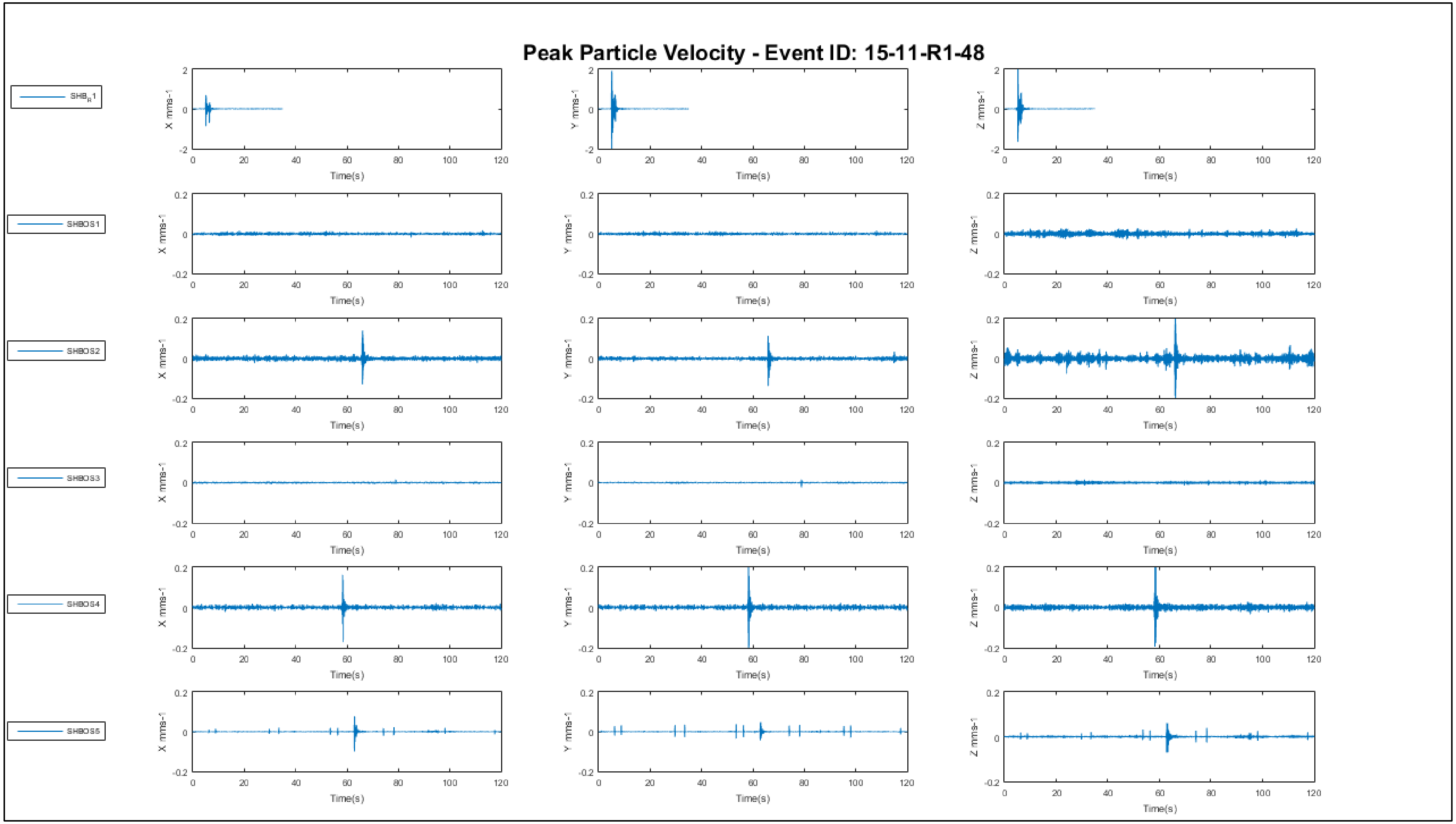


FIGURE 4.24: VELOCITY SIGNALS – 25KG OPEN DET 10:33 9TH NOVEMBER 2015, SHB_OS1 – SHB_OS5

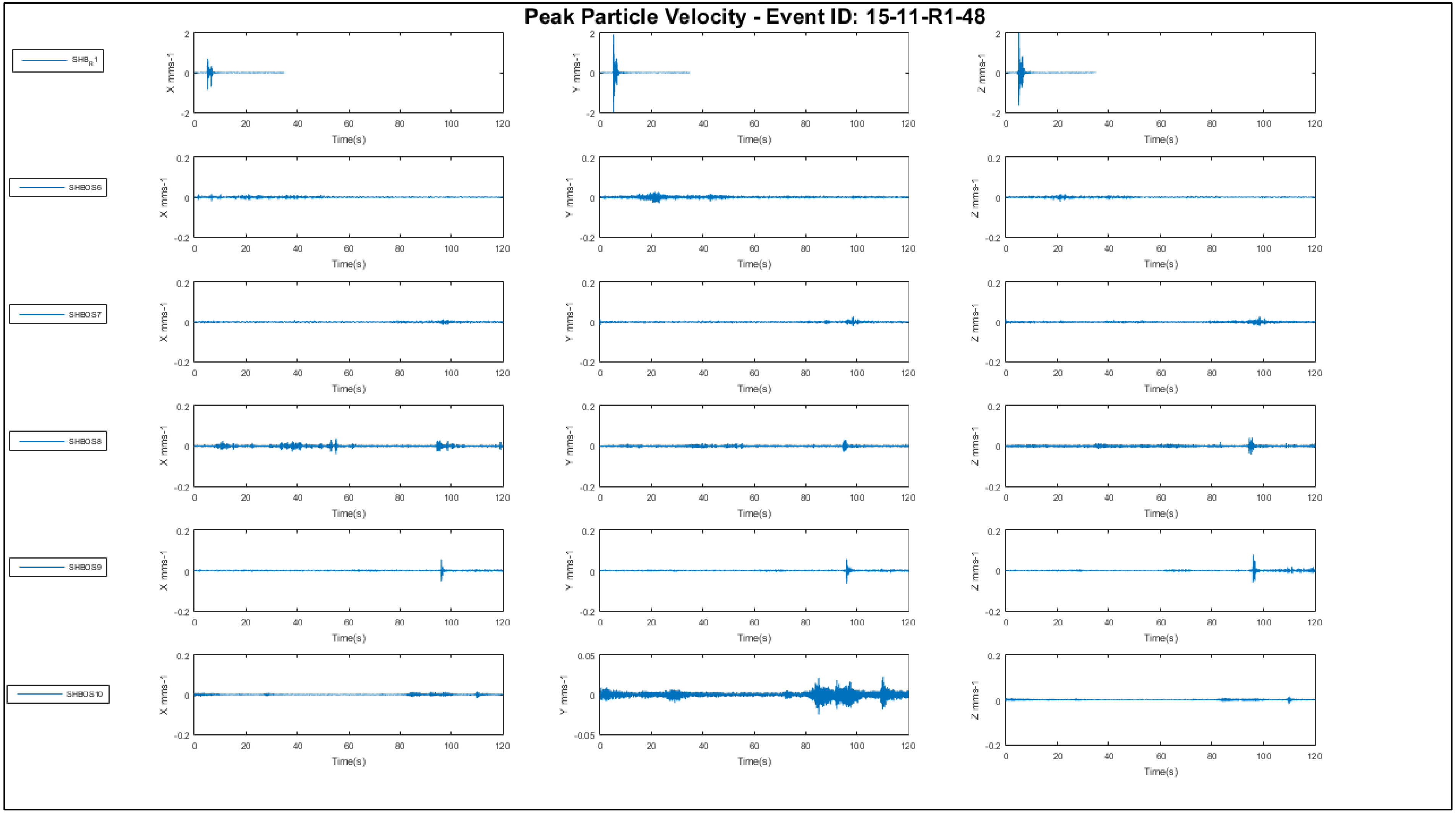


FIGURE 4.25: VELOCITY SIGNALS – 25KG OPEN DET 10:33 9TH NOVEMBER 2015, SHB_OS6 – SHB_OS10

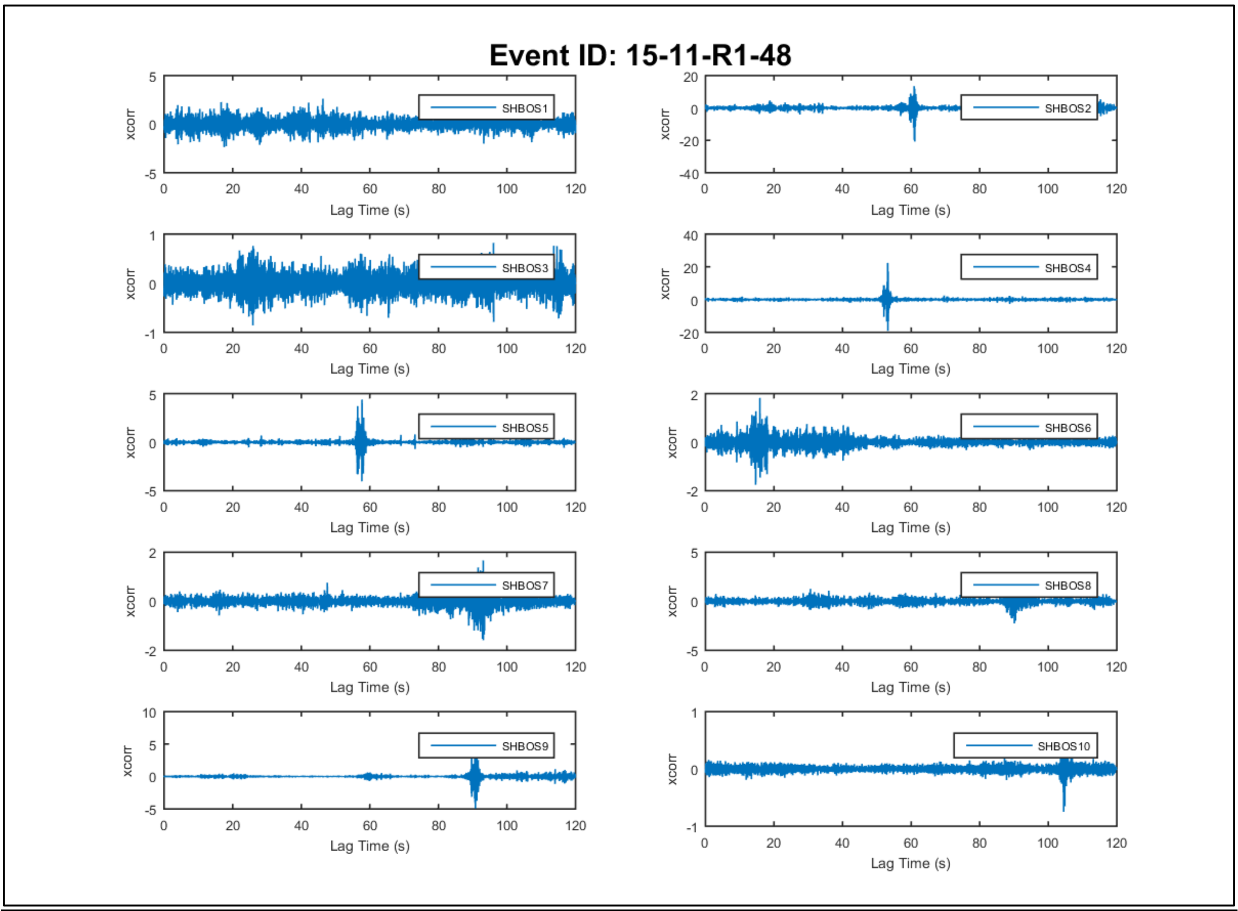


FIGURE 4.26: CROSS CORRELATION – 25KG OPEN DET 10:33 9TH NOVEMBER 2015, SHB_OS1 – SHB_OS10

<u>Detailed Example – 13 kg Multiple Open Detonation, 14:31 on 10th November 2015</u>

4.10.13 Triggered Range Activity 15-11-R1-77 relating to a 13 kg open detonation event consisting of 5 pit explosions at 14:31 on 10th November 2015 is presented in Figures 4.26 – 4.36

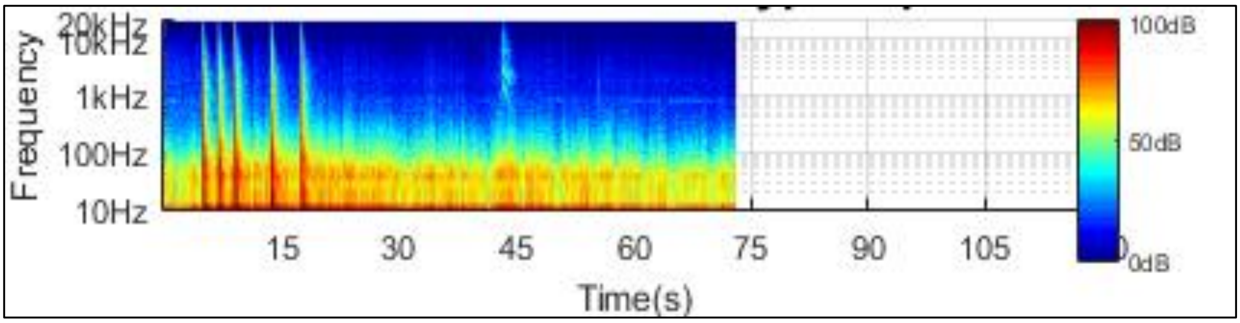


FIGURE 4.27: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – DAT (SHB_R1)

4.10.14 Figure 4.26 above shows the spectrogram processed from the raw data signal captured by the Range monitor installed at DAT (SHB_R1). As with the previous activity presented in 4.12, the series of detonations can be seen from approximately 5 seconds. The fast rise time in amplitude in frequencies up to 5 kHz is evident along with the concentration of energy up to approximately 500 Hz (represented by red and yellow).

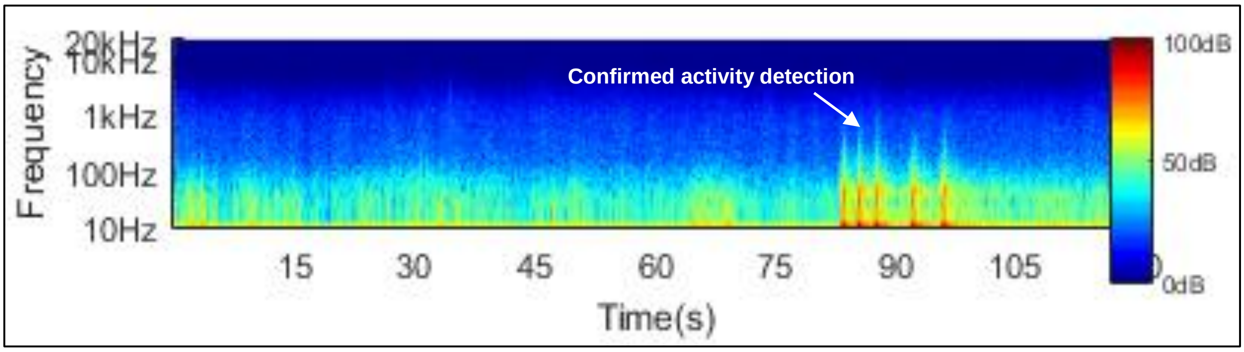


FIGURE 4.27: SPECTROGRAM 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS1

4.10.15 Figure 4.27 above show the spectrogram processed from the raw data signal captured at SHB_OS1 during the same 13kg open detonation. A similar 5 activity sequence is observed. The spectrograms from the raw signals captured at the other off-Range monitoring locations are presented in Figure 4.28 to 4.34.

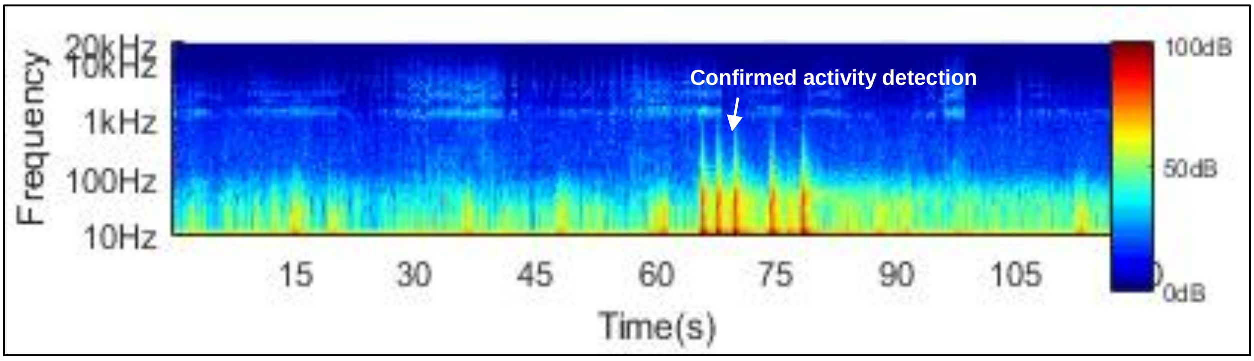


FIGURE 4.28: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS2

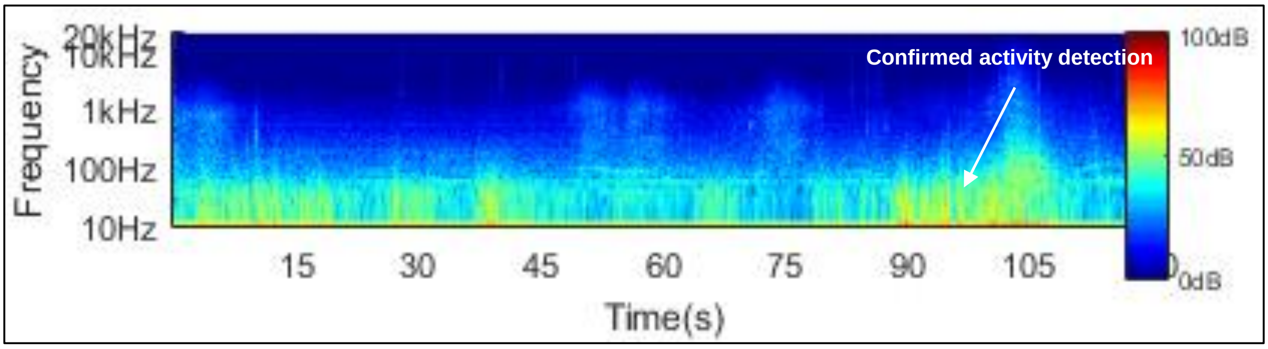


FIGURE 4.29: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS3

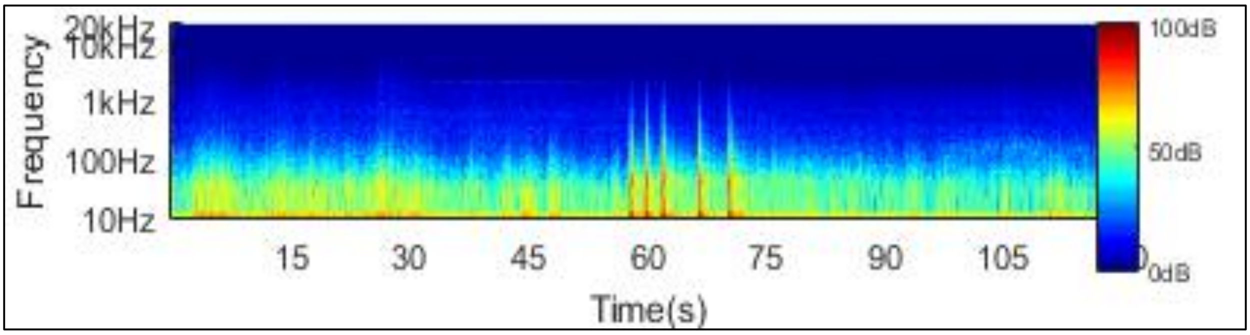


FIGURE 4.30: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS4

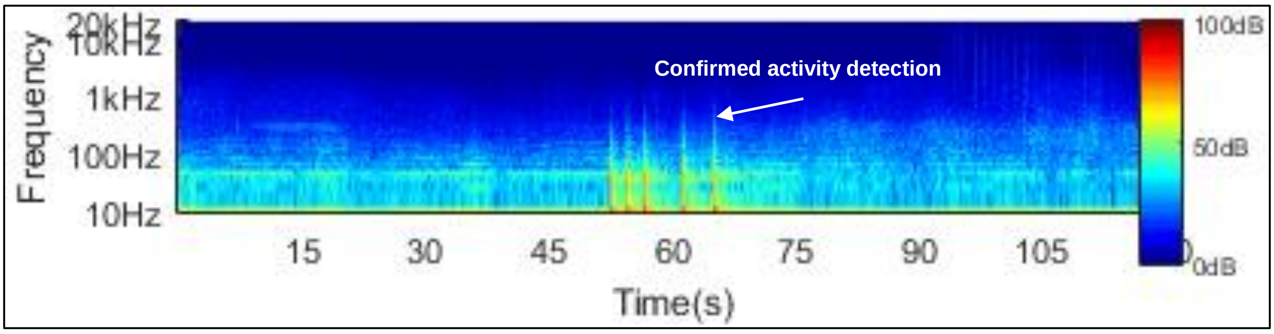


FIGURE 4.31: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS5

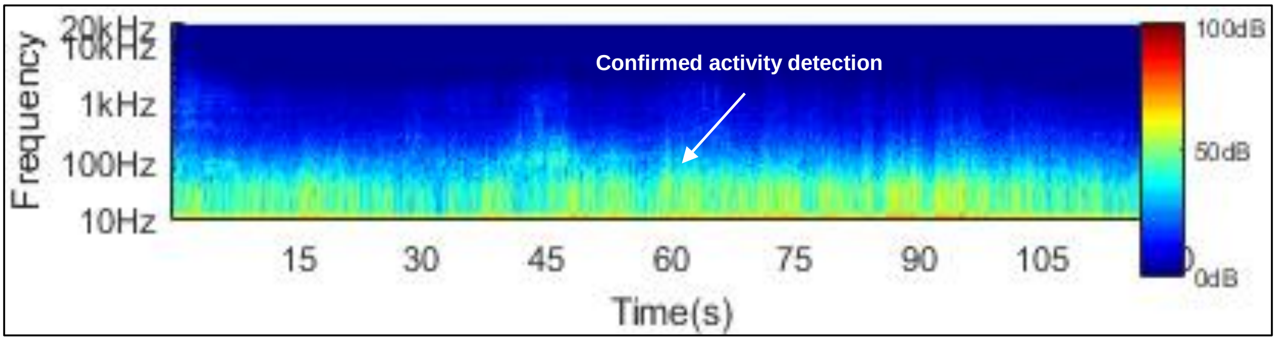


FIGURE 4.32: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS6

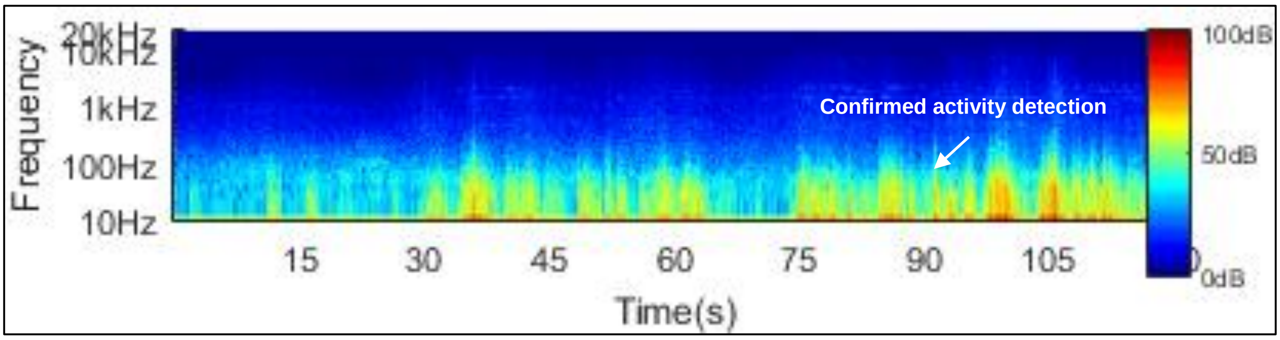


FIGURE 4.33: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS7

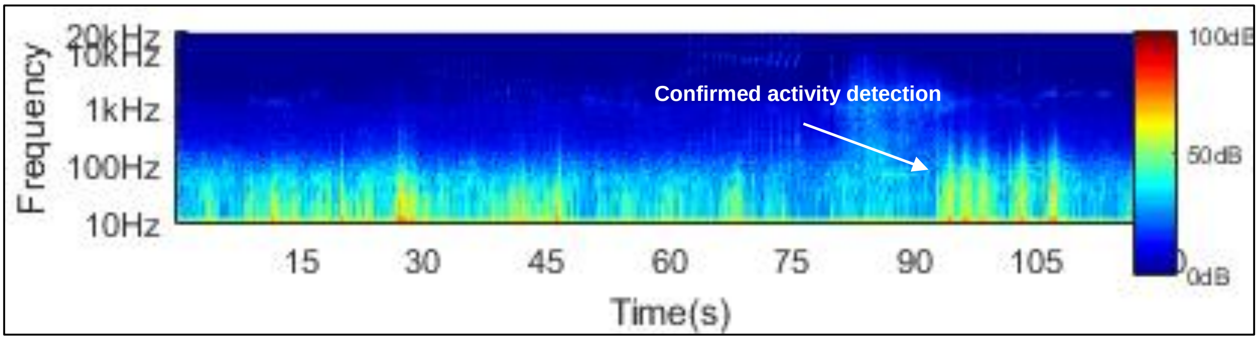


FIGURE 4.34: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS8

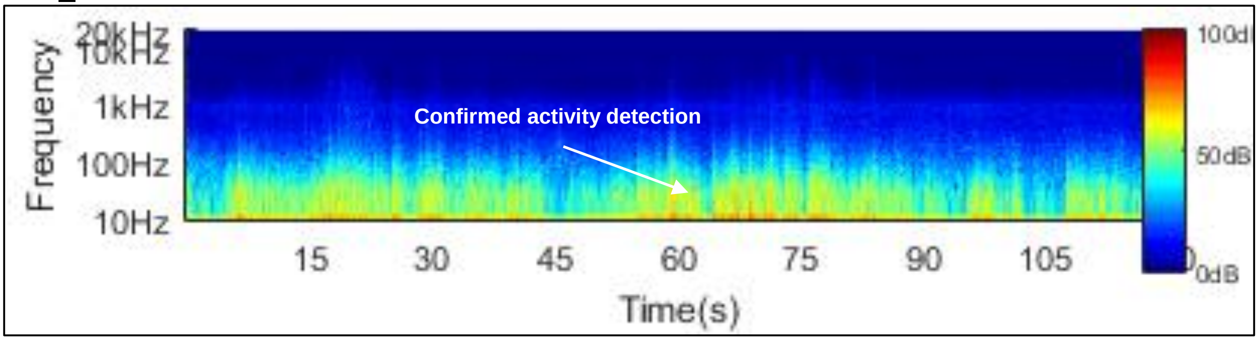


FIGURE 4.34: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS9

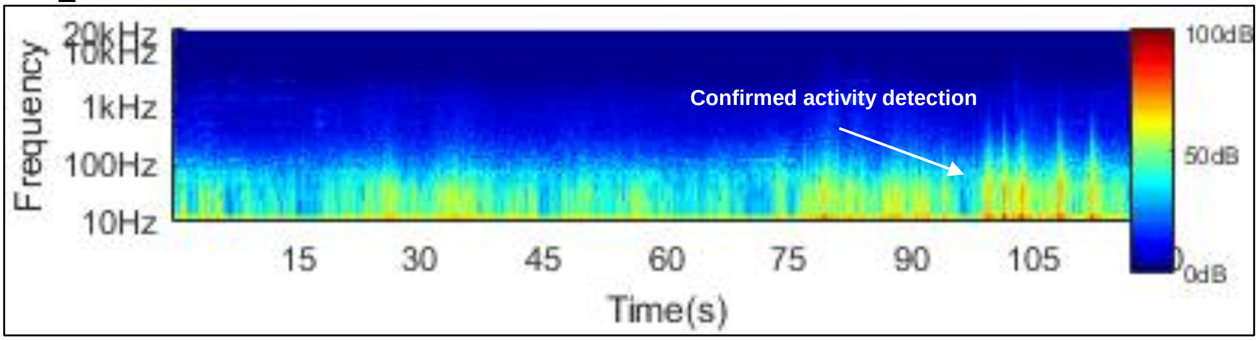


FIGURE 4.34: SPECTROGRAM – 13KG OPEN DET 14:31 10TH NOVEMBER 2015 – SHB_OS10

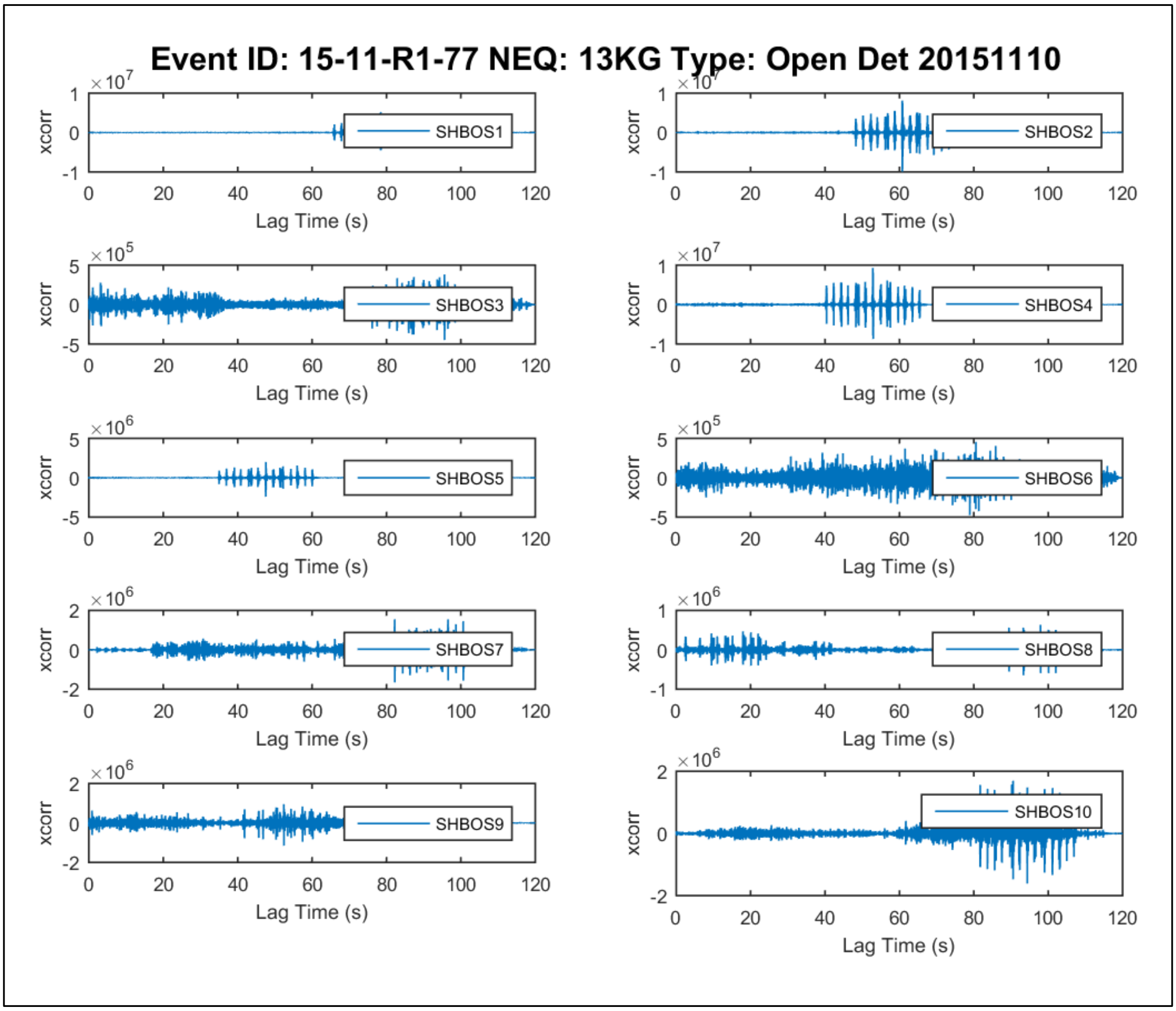


FIGURE 4.34: CROSS-CORRELATION – 13KG OPEN DET 14:31 10TH NOVEMBER 2015

Notes:

[1] where cross-correlation is a measure of the similarity as a function of time, specifically the time lag.

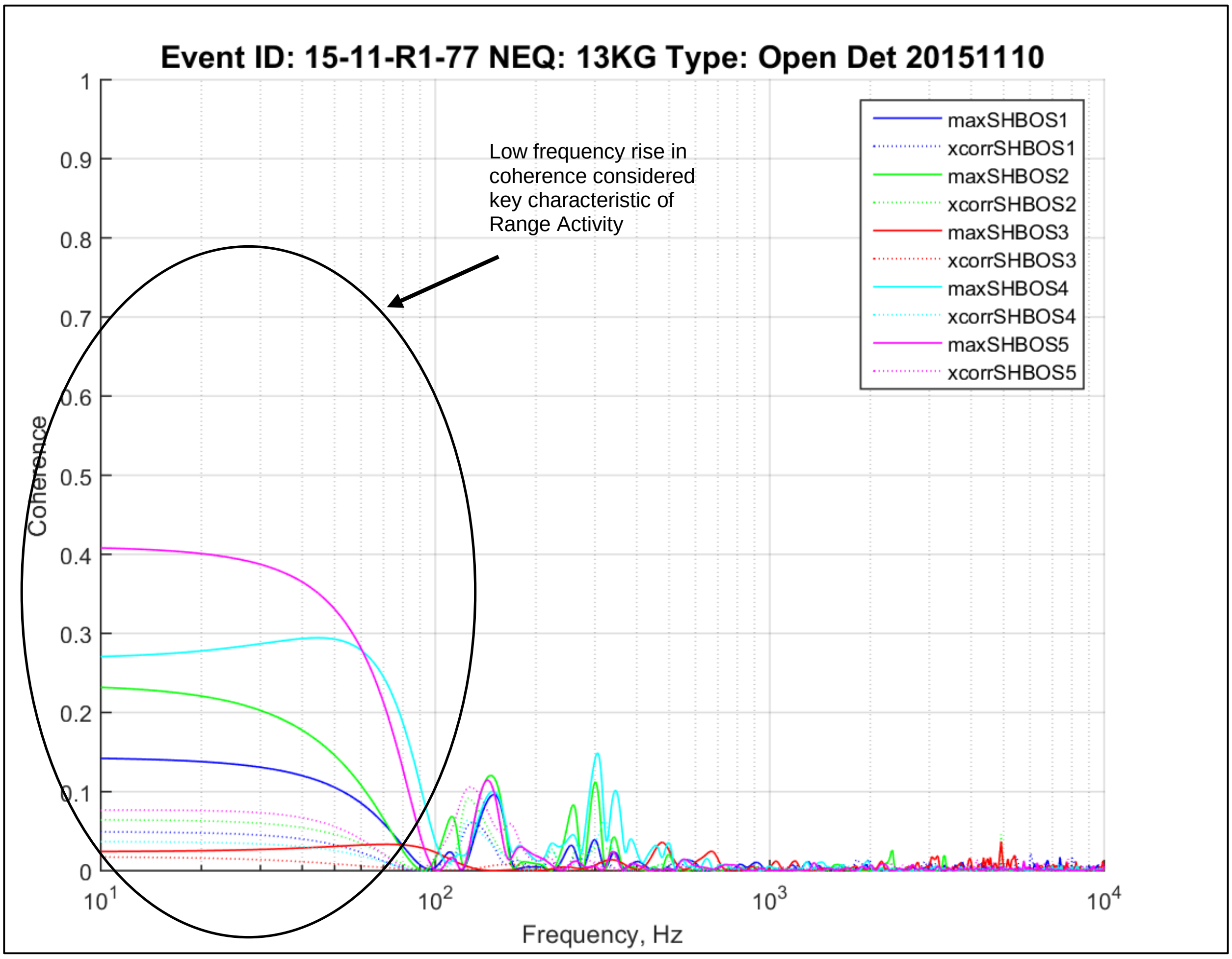


FIGURE 4.35: COHERENCE – 13KG OPEN DET 14:31 10TH NOVEMBER 2015, SHB_OS1 – SHB_OS5

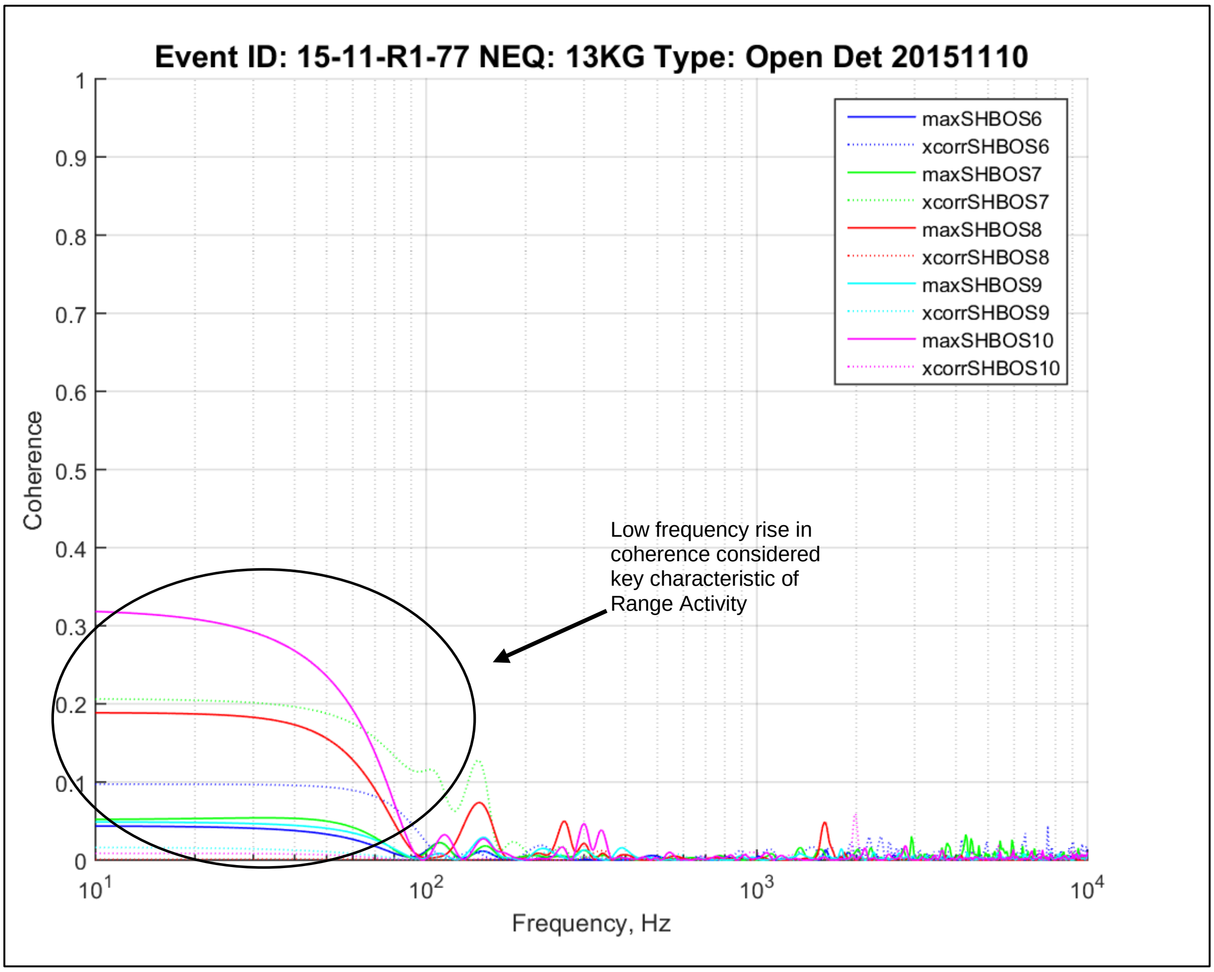


FIGURE 4.36: COHERENCE – 13KG OPEN DET 14:31 10TH NOVEMBER 2015, SHB_OS6 – SHB_OS10

Notes:

[1] 'max' presents the coherence of the maximum value in the audio signal; and

[2] 'xcorr' presents the coherence of activity found by cross correlation.

Detailed Example – Locally Triggered Non-Range Activity (dog barks) SHB_OS8

4.10.16 Figure 4.37 presents the spectrogram of a dog barking at Seasalter (SHB_OS8) and has been processed to show the differences in acoustic signatures between Range activities and non-Range activities contributing to the local noise environment. The example presented in Figure 4.37 can be considered to be typical of a dog bark. When compared to the open detonation activities, the absence of particularly low frequency energy is evident.

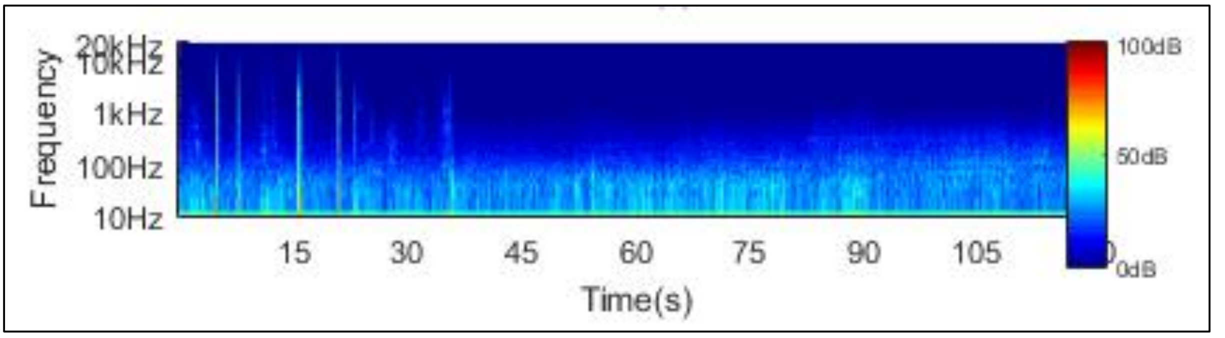


FIGURE 4.37: SPECTROGRAM – LOCALLY TRIGGERED ACTIVITY (DOG BARK) – SEASALTER SHB_OS8