CCAUV/15-54

Asia Pacific Metrology Programme

Short Report of the progress of CCAUV.V-K3

Qiao SUN

the 10th CCAUV meeting

25-27 Nov. 2015

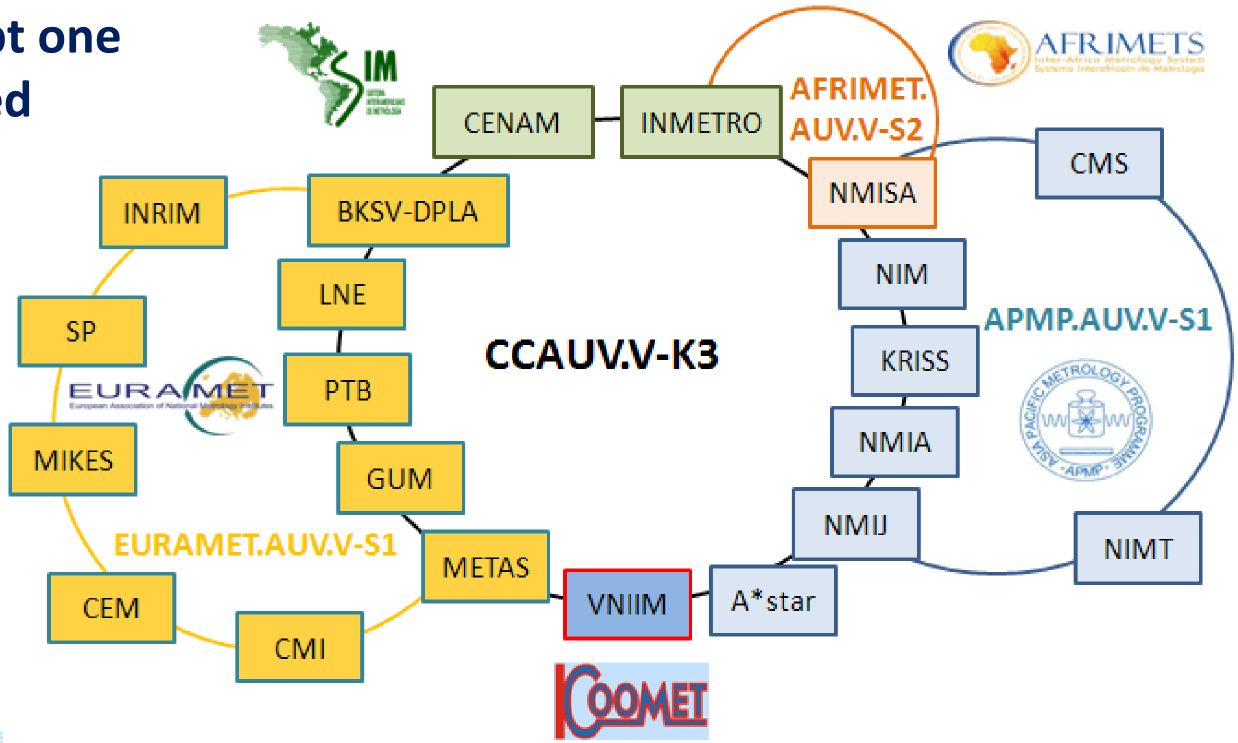
BIPM

Measurements completed

CCAUV.V-K3 0.1-40 Hz *low-frequency vibration comparison*

BKSV-DPLA , CENAM, GUM, INMETRO, KRISS, LNE, METAS, NIM, NMC, NMIA, NMIJ, NMISA, PTB and VNIIM (14).

- **all measurements completed**
- **all results received, except one in 12 months as scheduled**



Asia Pacific Metrology Programme

Remaining task

- Final check of the stability of artefact
- Data analysis
- Comparison report drafted
- Approval process

Publication expected in 2016

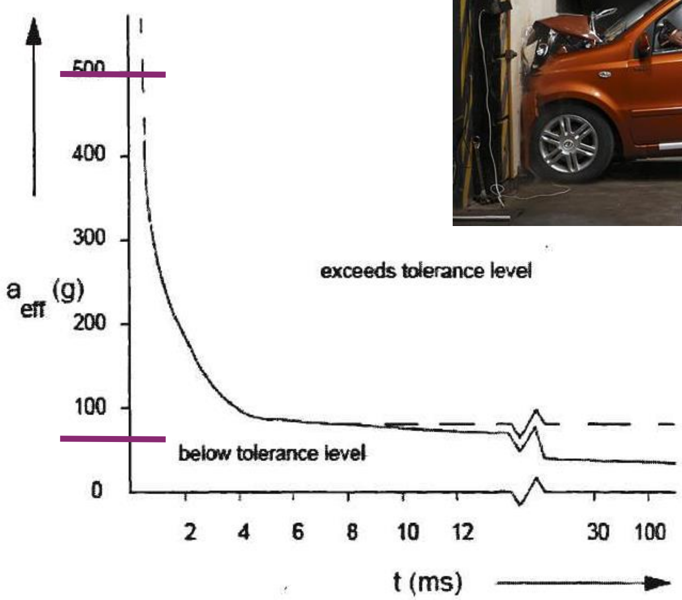
Proposal for Low-intensity Shock Key Comparison CCAUV.V-K4

1. Background
2. APMP Pilot Comparison in shock
3. Proposal of CCAUV.V-K4

Background

★★★★★ ——Possibility of serious injury≤10%

$$HIC = \left(\frac{1}{t_1 - t_2}\int_{t_1}^{t_2} a\,dt\right)^{2.5}(t_2 - t_1)$$



Wayne State Tolerance Curve

New Car Assessment Program

Background

Traceable Dynamic Measurement of Mechanical Quantities

EURAMET

JRP20i - Dynamic Measurement, 3584 k€, 242 PM

Shock acceleration

JRP Objectives

- Establish infrastructure for traceable dynamic measurements of force, pressure and torque
- Set up and validate primary calibration methods
- Develop methods for consistent measurement uncertainty calculation
- Provide dynamic traceability of electric measurement chain

Dynamic Force Measurement

Shock and sinusoidal forces

Dynamic Pressure Measurement

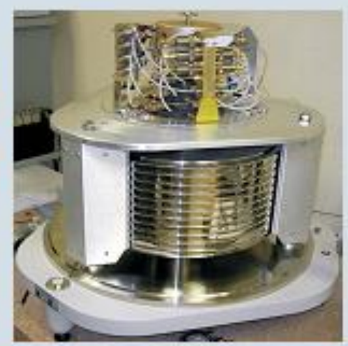
Shock pressure in gas and hydraulic fluids

Dynamic Torque Measurement

Sinusoidal torque under rotating and non-rotating conditions

State of the Art

- Static calibration only
- Transducer's response to dynamic signals is frequency-dependent
- Dynamic effects of electrical conditioning equipment not quantified
- Interaction with embedding mechanical structure not considered
- Static calibration not sufficient for dynamic applications



Background

AIST NMIJ

TC Initiative project on primary shock acceleration comparison with laser interferometry

Major objectives, activities and outcomes from the project

- To promote establishment of shock-acceleration calibration

1. NIM guest scientist stayed at the CMS-ITRI to make a planning study, to evaluate some equipments.
2. Findings were presented at the Workshop in conjugated with TCAUV meeting in 2011.

- Project Budget and Its Use
  - US$5000, to be used for equipments and bus transportation fee for on-site visit during the workshop

Source: APMP TCAUV Report for APMP GA 2011
by Dr. Takashi USUDA

Background

- **Meas. Sci. Technol., 2011**

  NMIJ

- **Measurement, 2012**

  CMS

- **Meas. Sci. Technol., 2014**

  NIM

IOP PUBLISHING MEASUREMENT SCIENCE AND TECHNOLOGY
Meas. Sci. Technol. 21 (2010) 065107 (10pp) doi:10.1088/0957-0233/21/6/065107

Calibration of vibration pick-ups with laser interferometry: part IV. Development of a shock acceleration exciter and calibration system

H Nozato, T Usuda, A Oota and T Ishigami

National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology,

Measurement 45 (2012) 2383–2387

Contents lists available at SciVerse ScienceDirect
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Measurement
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5000 m s^{-2} is a
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The set up of primary calibration system for shock acceleration in NML ☆

Yu-Chung Huang *, Jiun-Kai Chen, Hsin-Chia Ho, Chung-Sheng Tu, Chao-Jung Chen

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Primary shock calibration system
Airborne anvil

ABSTRACT

This paper mainly describes to set up and evaluate a sl 16063-13:2001 standard. T tronic spare parts, the produ met impact test and so o consideration of that, NML which calibrates the accele The shock machine structu speed hammer, airborne ha of primary shock calibratio
The electromagnetic cont hammer through the DC po mer impacts an airborne ha PU rubber which is fixed on An accelerometer which is age signal during the instar and different hardness rubb tion time. At the same time modified Michelson and Ma eter is derived through two from the displacement.
At present the acceleratio s^2 to 5000 m/s^2, the shock p expanded uncertainty is les to improve and expand the customers in the future.

IOP Publishing Measurement Science and Technology
Meas. Sci. Technol. 25 (2014) 075003 (7pp) doi:10.1088/0957-0233/25/7/075003

A primary standard for low-g shock calibration by laser interferometry

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Abstract

This paper presents a novel implementation of a primary standard for low-g shock acceleration calibration by laser interferometry based on rigid body collision at National Institute of Metrology, China. The mechanical structure of the standard device and working principles involved in the shock acceleration exciter, laser interferometers and virtual instruments are described. The novel combination of an electromagnetic exciter and a pneumatic exciter as the mechanical power supply of the standard device can deliver a wide range of shock acceleration levels. In addition to polyurethane rubber, two other types of material are investigated to ensure a wide selection of cushioning pads for shock pulse generation, with pulse shapes and data displayed. A heterodyne He–Ne laser interferometer is preferred for its precise and reliable measurement of shock acceleration while a homodyne one serves as a check standard. Some calibration results of a standard acceleration measuring chain are shown in company with the uncertainty evaluation budget. The expanded calibration uncertainty of shock sensitivity of the acceleration measuring chain is 0.8%, $k = 2$, with the peak acceleration range from 20 to 10 000 m s^{-2} and pulse duration from 0.5 to 10 ms. This primary shock standard can meet the traceability requirements of shock acceleration from various applications of industries from automobile to civil engineering and therefore is used for piloting the ongoing shock comparison of Technical Committee of Acoustics, Ultrasound and Vibration (TCAUV) of Asia Pacific Metrology Program (APMP), coded as APMP.AUV.V-P1.

Keywords: metrology, primary shock calibration, shock acceleration, laser interferometry, measurement uncertainty

Background

Strategic Planning 2013-2015 CCAUV — *Revision of 1 July 2013*

Strategy Document for Rolling Programme Development for 2013 to 2023

The Consultative Committee for Acoustics, Ultrasound and Vibration

7.V Vibration

Sub-area/ Reference No.	Description	Rationale	How far the light shines	Expected start
Vibration sine-excitation	Comparison of primary calibration in magnitude and phase	Coverage of traditional calibration services in acceleration	0.1 Hz to 200 Hz This will be a regular KC to be repeated in 8 y intervals (subject to discussion)	2013/14
Vibration sine-excitation	Comparison of primary calibration of magnitude and phase	Coverage of traditional calibration services in acceleration	40 Hz to 10 kHz This will be a regular KC to be repeated in 8 y intervals (subject to discussion)	2013/14 2021/22
Vibration: Shock excitation	Primary calibration with parameter identification	Increasing number of NMIs with the capability and demand for CMCs	100 m/s^2 to $10^5 m/s^2$ This will ultimately be a regular KC to be repeated in an 8 year interval. The precondition is a validated procedure and possibly a pilot study: This area may be split into high intensity shock and low intensity shock	2014/15 2021/2022

1. Background

2. **APMP Pilot Comparison in shock**

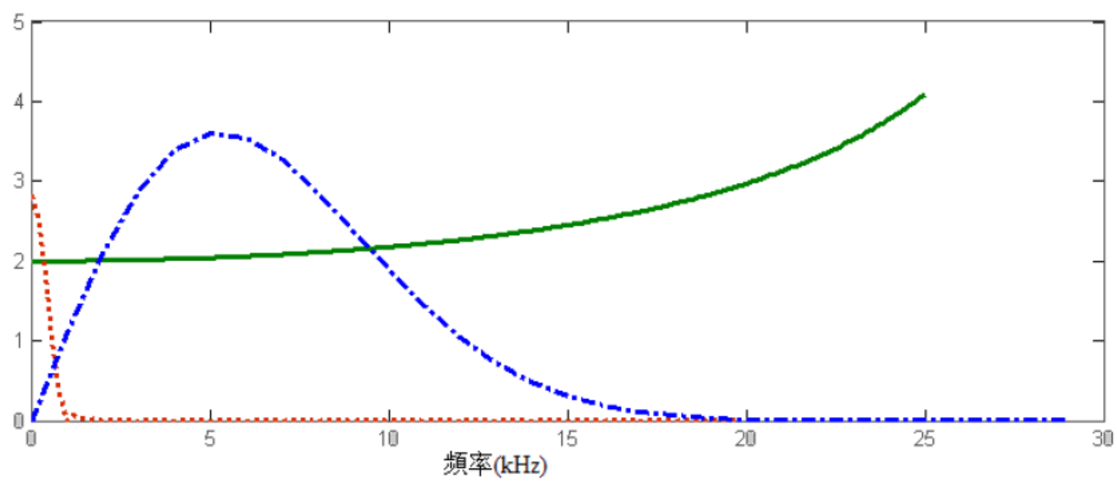
3. Proposal of CCAUV.V-K4

APMP Pilot Comparison in Shock

Three conditions for a possible comparison of shock sensitivity at low intensity

- **Similar pulse shape**
- **Wide pulse duration**
- **Low acceleration level**


Accelerometer dynamic frequency characteristic
Body motion exciting signal frequency response
Hokinson bar exciting signal frequency response

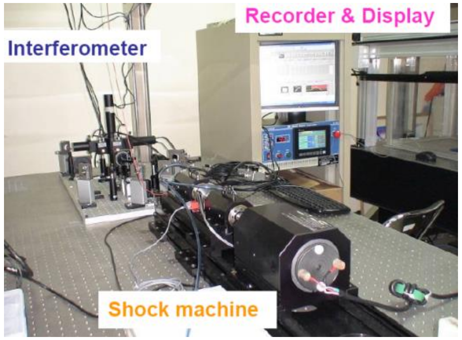


APMP Pilot Comparison in Shock

- The voltage sensitivity is calculated as the ratio of the amplitude of the Accelerometer Chain output voltage to the shock peak value at its reference surface.
- The peak acceleration range of the measurements was agreed to be from 500 m/s² to 5 000 m/s². Specifically, the laboratories are supposed to measure at the following acceleration levels (all values in m/s²).
  - 500, 1 000, 2 000, 3 000, 4 000, 5 000.
- Specific conditions for the measurements of this comparison are:
  - duration of monopole shock pulse is within 0.3 to 3 ms. A series of 0.5 ms, 1 ms, 1.5 ms and 2 ms are recommended, with the reference of 2 ms at a peak acceleration of 1 000 m/s².
  - duration of dipole shock pulse at 1 000 m/s² as option is within 0.03 to 0.2 ms. A series of 0.03 ms, 0.05 ms, 0.07 ms, 0.10 ms, 0.25 ms and 0.20 ms are recommended, with the reference of 0.1 ms at a peak acceleration of 1 000 m/s².

APMP Pilot Comparison in Shock

Various shock calibration standards



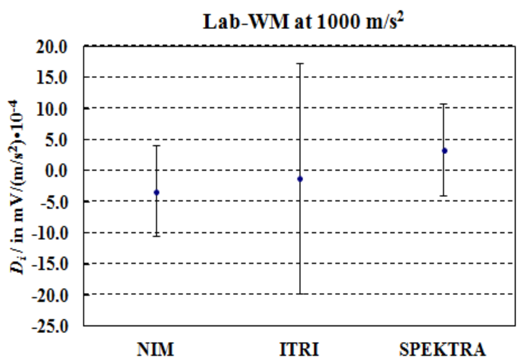
Hammer-anvil impact (2: CMS, NIM)

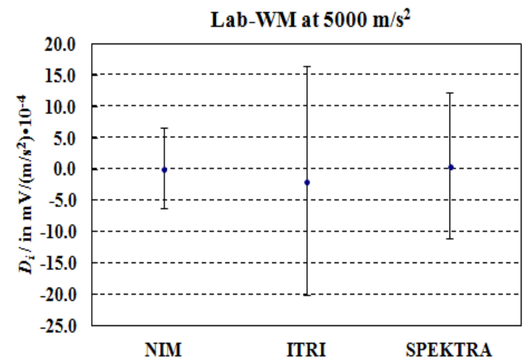
Hopkinson bar
(3: NIM, NIMT, SPEKTRA)

PN-LMS (1: SPEKTRA)

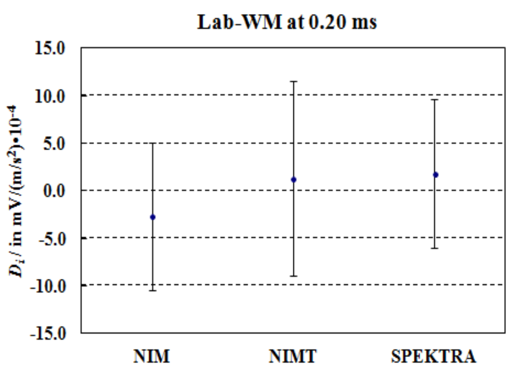
Note:
Self-developed and commercial types are employed with laser interferometry in the comparison.

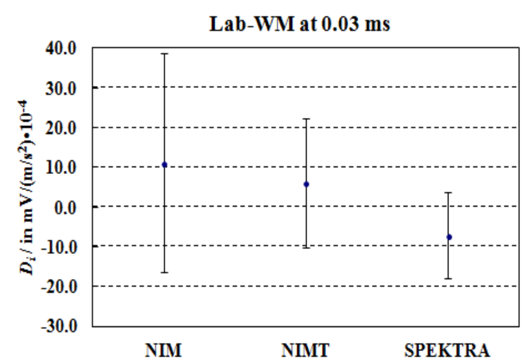
APMP Pilot Comparison in Shock





Degree of equivalence for voltage sensitivities under monopole shock excitation at 1000 m/s^2, 2.0 ms and 5000 m/s^2, 0.8 ms





Degree of equivalence for voltage sensitivities under dipole shock excitation at 1000 m/s^2, 0.20 ms and 0.03 ms

APMP Pilot Comparison in Shock

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Final report on pilot comparison of low intensity shock APMP.AUV.V-P1

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Tag this article

Abstract | Metrics

PILOT STUDY

This is the final report for pilot comparison APMP.AUV.V-P1 in the area of low-intensity 'shock', which in this case means monopole and dipole shock acceleration. The aim of this comparison was to measure the shock voltage sensitivity of one Accelerometer Chain with primary means under monopole shock excitation in the acceleration range from 500 m/s^2 to 5 000 m/s^2, and under dipole shock excitation with the reference acceleration of 1000 m/s^2 and pulse duration from 0.03 ms to 2.0 ms. Four laboratories with primary shock calibration capability have participated in the comparison with National Institute of Metrology, P R China as pilot lab. One standard accelerometer of back-to-back type with a charge amplifier (Accelerometer Chain) was circulated among the participants. The pilot comparison reference values have been calculated using the weighted mean value of the results. The degrees of equivalence calculated from the data submitted by the four laboratories, support the uncertainty of measurement reported by them for the calibration of the shock sensitivities of accelerometer. At the reference acceleration of 1 000 m/s^2 and pulse duration of 2 ms (specified in ISO 16063-13:2001), the participating laboratories calibrated the Accelerometer Chain with their claimed relative expanded uncertainty ($k = 2$), the smallest of which equal to 0.5%, i.e. smaller than the limit specified by the ISO standard. The completion of APMP.AUV.V-P1 can serve as part of the basis for a planned key comparison targeted at low intensity shock range at CC level.

Main text. To reach the main text of this paper, click on Final Report.

The final report has been peer-reviewed and approved for publication by the CCAUV.

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1. Background

2. APMP Pilot Comparison in shock

3. Proposal of CCAUV.V-K4

Proposal of CCAUV.V-K4

2016

Technical Protocol

2016

Stability Observation

2017-2018

Measurements & Report

Asia Pacific Metrology Programme

Thanks for your attention!

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