中国计量科学研究院
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The acoustic calibration service in transportation at NIM

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Outline

1. Calibration requirements
2. Calibration service at NIM
    - 2.1 Microphone
    - 2.2 Ultrasonic transducer and device
3. Conclusion

Outline

1. Calibration requirements

2. Calibration service at NIM

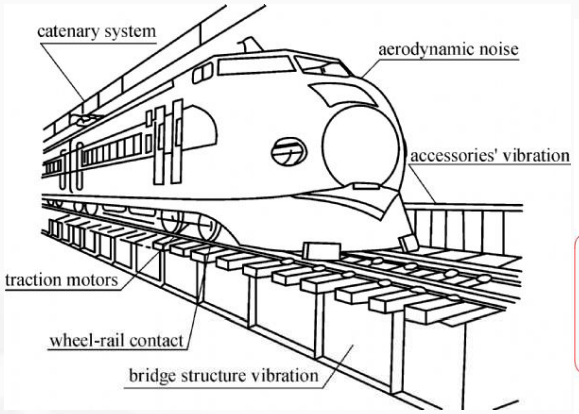
    2.1 Microphone

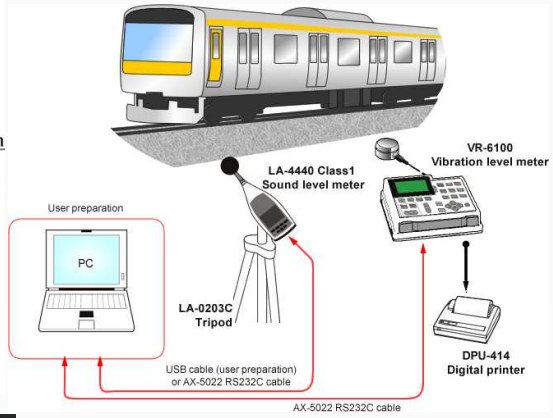
    2.2 Ultrasonic transducer and device

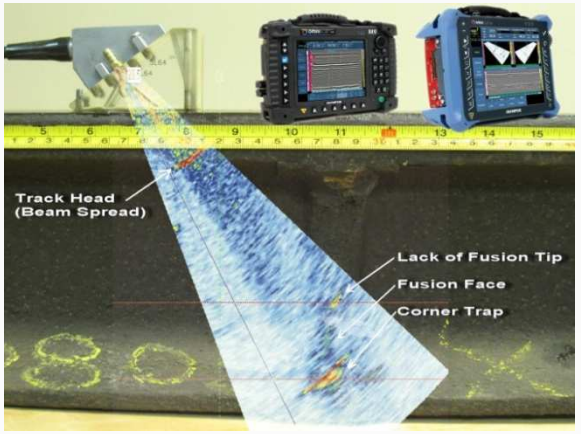
3. Conclusion

1. Calibration requirements

Transportation: Railway, Highway, Air transport …
Acoustic measurements applied in:







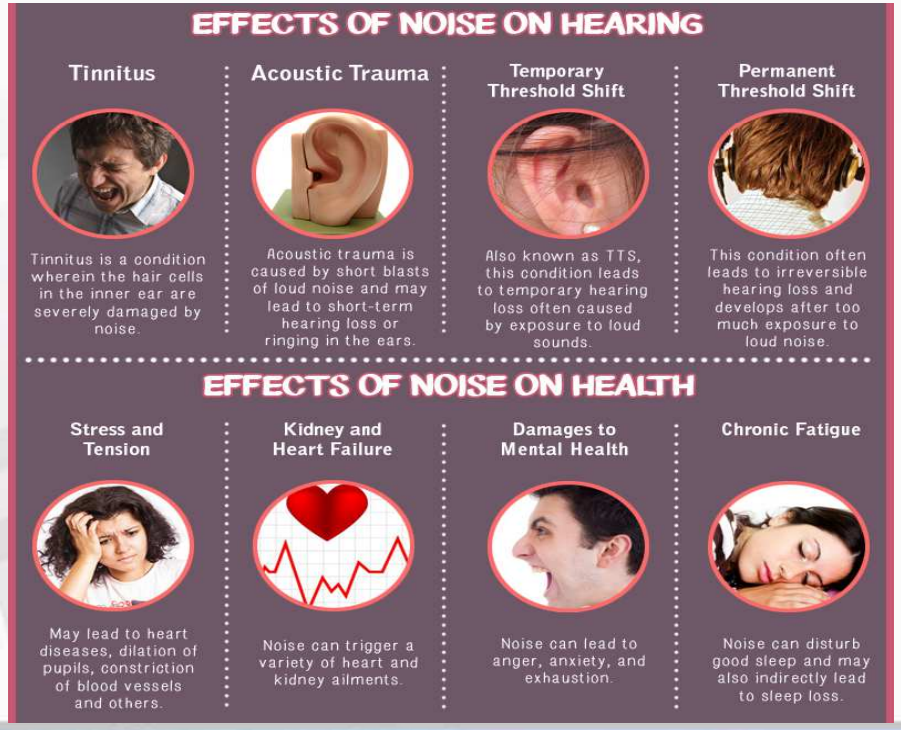
☐ Noise assessment

☐ Safety monitoring

1. Calibration requirements

Noise measurements

- Inside carriage
- On platform
- Along the railway line




INTERNATIONAL STANDARD **ISO 3095**

Third edition
2013-08-01

Acoustics — Railway applications — Measurement of noise emitted by railbound vehicles

Acoustique — Applications ferroviaires — Mesurage du bruit émis par les véhicules circulant sur rails


INTERNATIONAL STANDARD **ISO 3381**

Second edition
2005-08-15

Railway applications — Acoustics — Measurement of noise inside railbound vehicles

Applications ferroviaires — Acoustique — Mesurage du bruit à l'intérieur des véhicules circulant sur rails

Noise measuring device

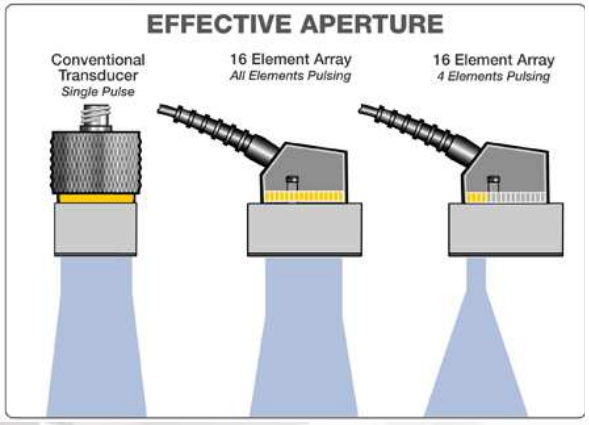
1. Calibration requirements

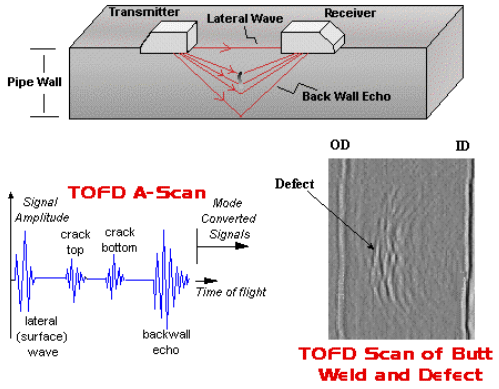
Safety monitoring

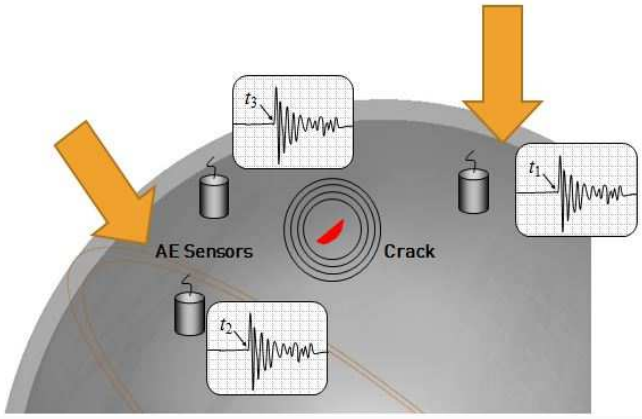
- Detecting flaws in rail and train wheel
- Ensuring the safety of railway traffic

Technique:

- Active detection: ultrasonic flaw detector
- Passive detection: acoustic emission







1. Calibration requirements

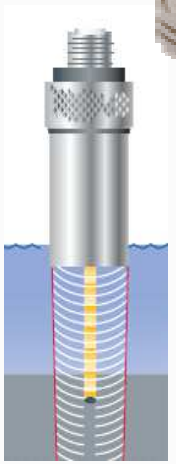
Calibration service about acoustic transducer

Microphone:

- WS condenser
- High sound pressure
- Infrasonic

Ultrasonic transducer:

- Active detection
- Passive detection



Outline

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2. Calibration service in NIM

WS microphone:

Model: B&K 4189, G.R.A.S. 46AE, BASW MPA201 …

Frequency: 20 Hz~20 kHz

Sound pressure level: <150 dB

Calibration method:

- Electrostatic actuator method
- Coupler comparison method

Calibration Parameter:

- Sensitivity and its frequency response

2. Calibration service in NIM

WS microphone:

Calibration setup: B&K 9721

Microphone Calibration System Type 9721 with its PULSE Analyser,
its Sensitivity Calibration Coupler Stand (left)
and its Electrostatic Actuator Setup (right)

- Comparison method
- Standard
- WS microphone

- Coupler
- Electrostatic actuator
- Pulse analyzer and software

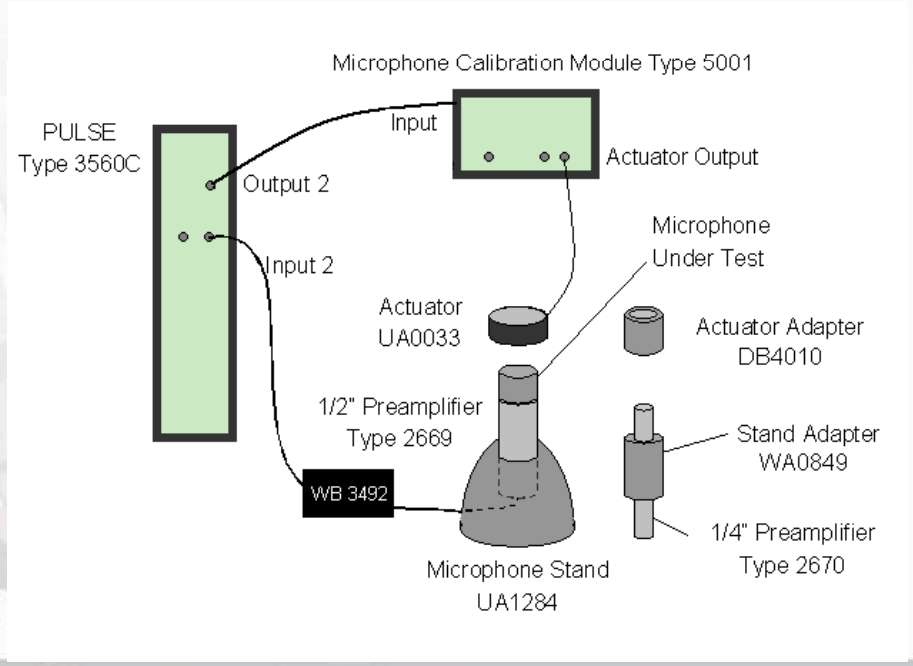
Uncertainty: 20 Hz ~ 20 kHz 0.24 dB (k=2)

2. Calibration service in NIM

WS microphone:

Electrostatic actuator method: Standard IEC61094-6

- Reference sensitivity at 250 Hz with SPL 124 dB
- Measured by B&K pistonphone type 4228

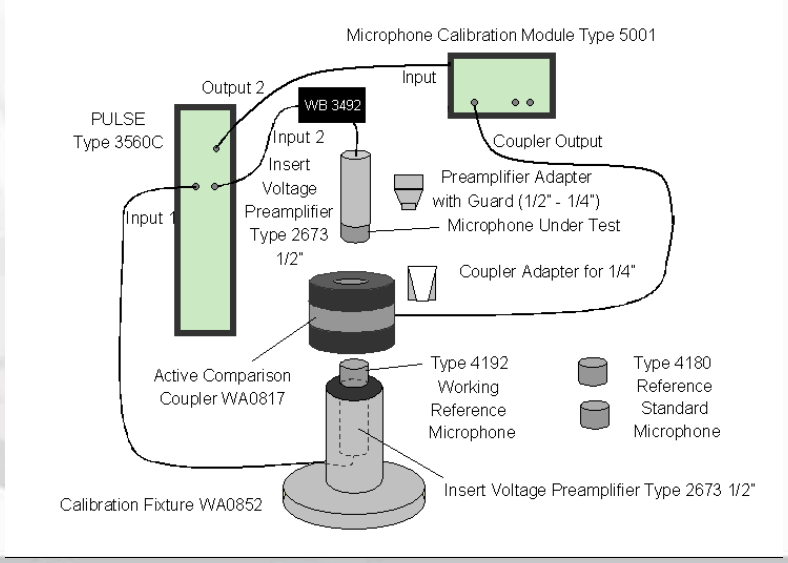


2. Calibration service in NIM

WS microphone:

Coupler comparison method: Standard IEC61094-5

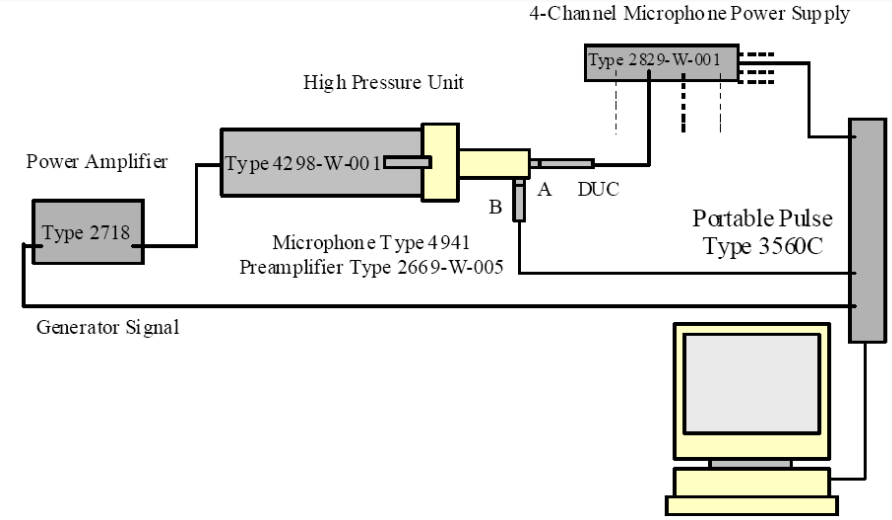
- Calibrate phase response with coupler WA-1544 or WA-1545 and Software WT-9651
- Calibrate non-standard dimensions with additional mechanical accessories, such as surface microphone (BK 4948)



2. Calibration service in NIM

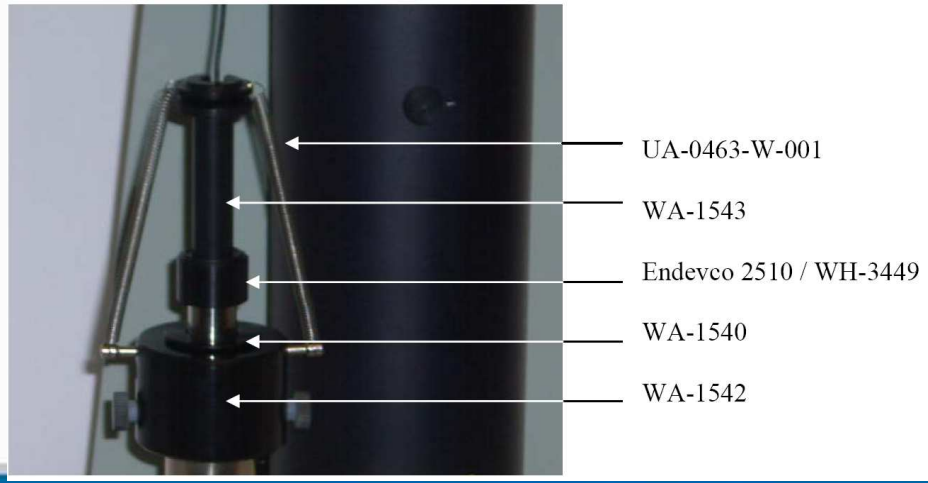
Microphone: high sound pressure

Calibration setup:



Sound source:

- Electro-dynamic loudspeaker
- Pure tone at 500 Hz
- SPL max: 174 dB
- Distortion: <0.5%



B&K 9719 system:

- Sine wave excitation
- Reference B&K 4941

2. Calibration service in NIM

Microphone: high sound pressure

Calibration setup: B&K 9719

Calibration parameter:

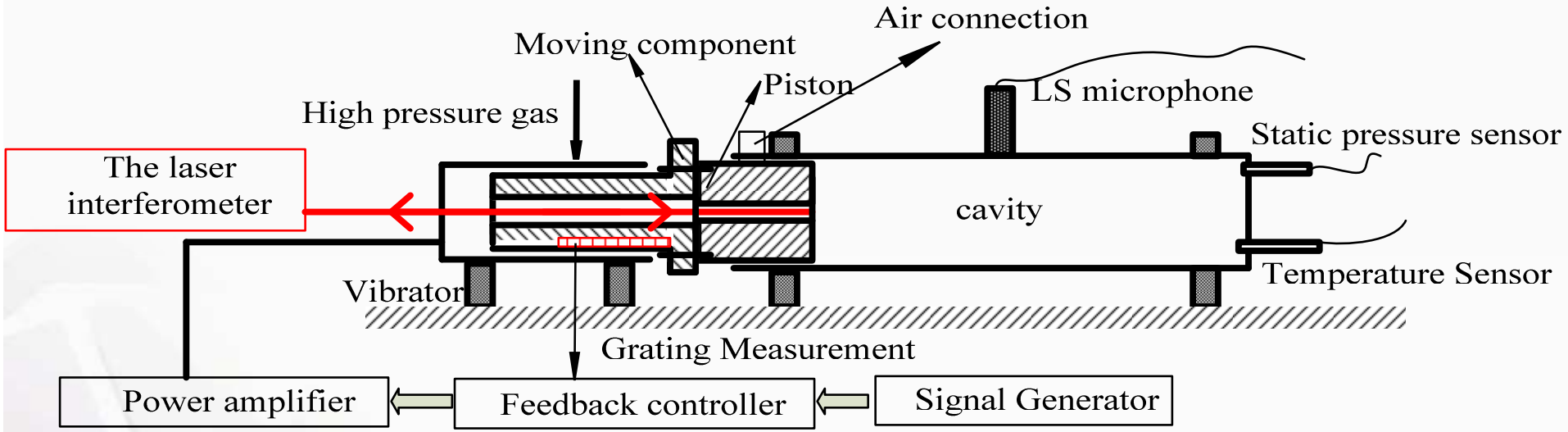
- dynamic linearity
  normalized at 124 dB
- harmonic distortion

- Frequency: 500 Hz
- SPL: 94~171 dB
- SPL max: 174 dB
- Uncertainty: 0.24 dB (k=2)

2. Calibration service in NIM

Microphone: infrasonic

Calibration setup: laser pistonphone



Principle: Gas-cavity dynamic pressure method (E. C. Wente)

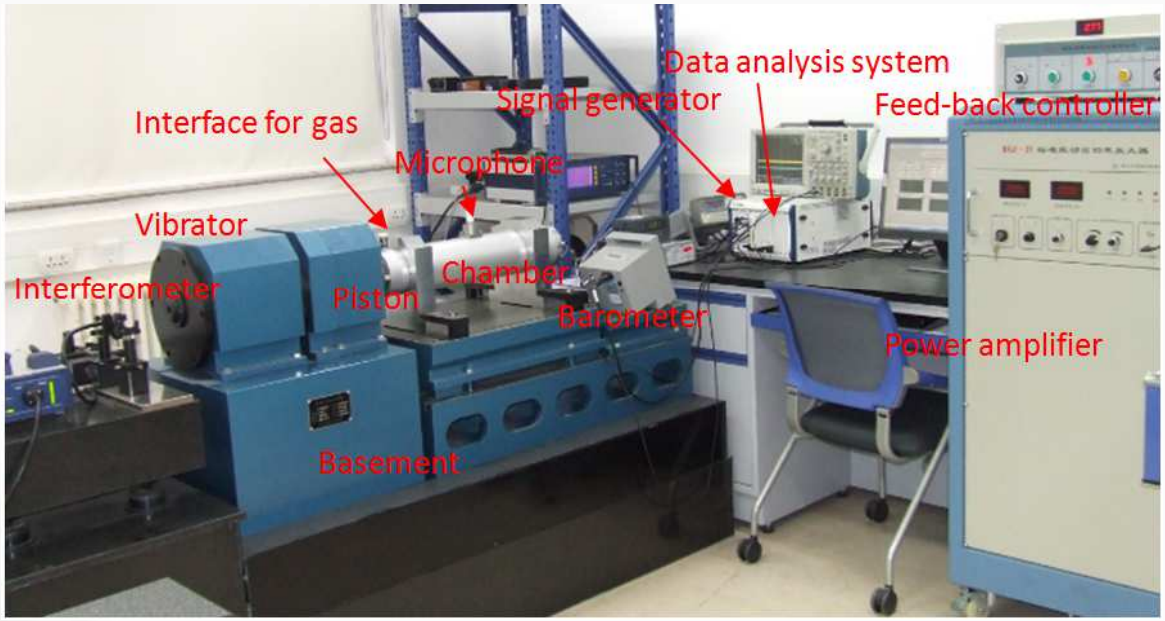
Improved:

- With piston displacement feedback to reduce distortion
- Optimize gas-cavity to increase leakage time

2. Calibration service in NIM

Microphone: infrasonic

Calibration setup: laser pistonphone



- Frequency: 0.1 Hz~20 Hz
- SPL: 114 dB~124 dB
- Distortion: <0.8%
- leakage time constant : >50s
- Uncertainty: 0.58dB to 0.04 dB (k=2)

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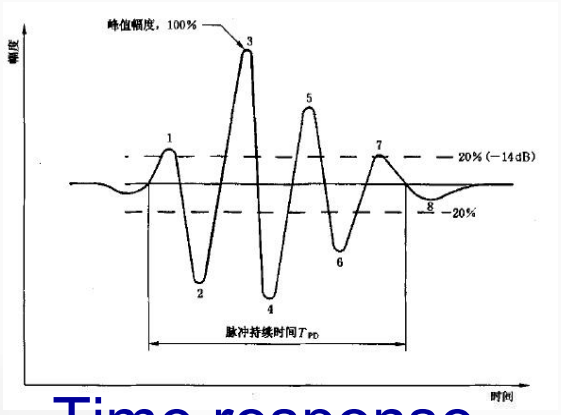
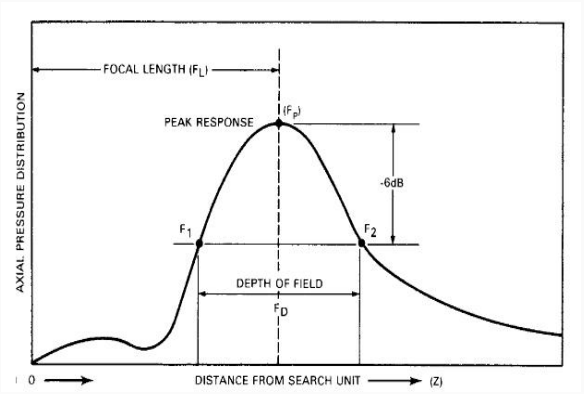
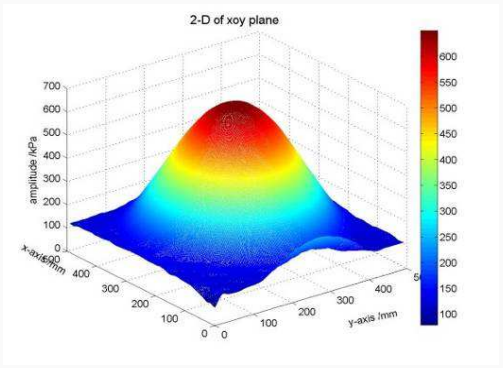
2. Calibration service in NIM

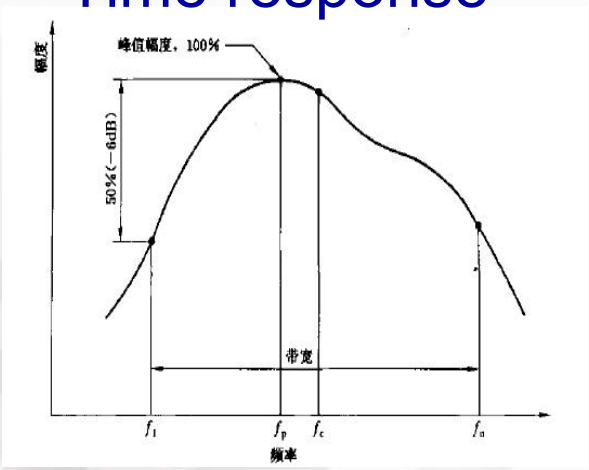
Ultrasonic flaw detection: transducer



Time response







Frequency response

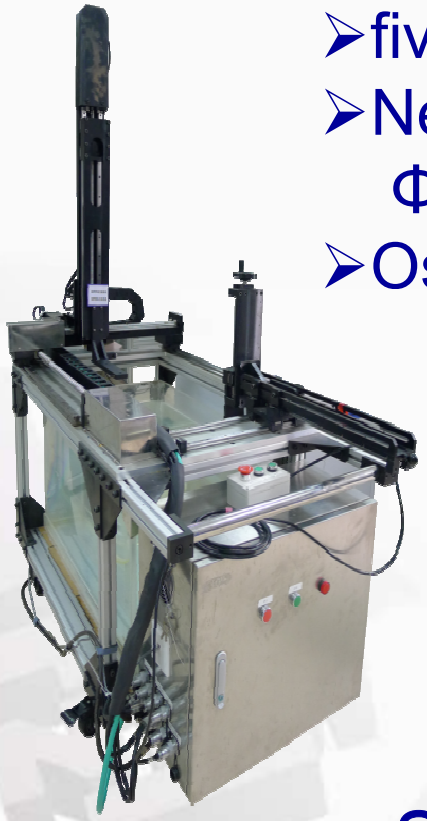
Calibration parameter:

- **Time domain**: pulse duration
- **Frequency domain**: relative BW, peak and center frequency
- **Sound field radiation pattern**: focus length, depth of field, peak response, beam width etc.

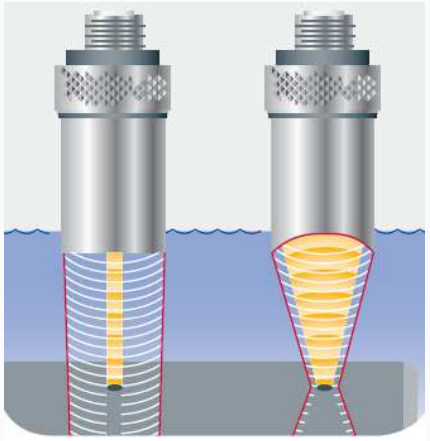
2. Calibration service in NIM

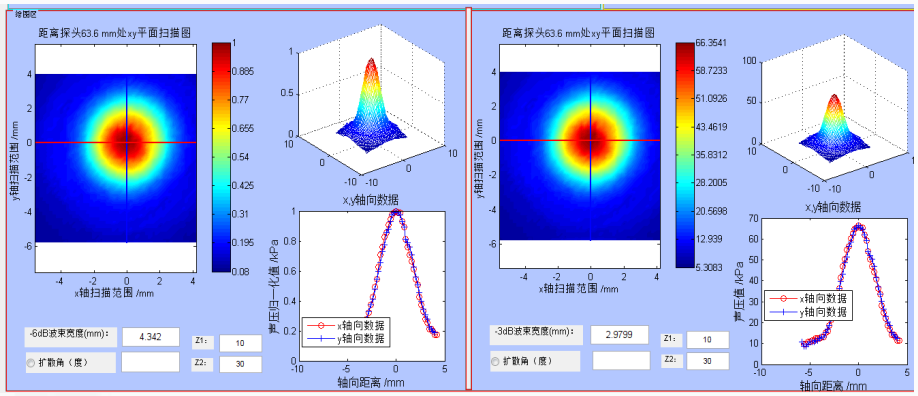
Ultrasonic flaw detection: transducer

Calibration setup:



- five degree-of-freedom scanning
- Needle hydrophone
  Φ1 mm, bandwidth>30 MHz;
- Oscilloscope and signal generator





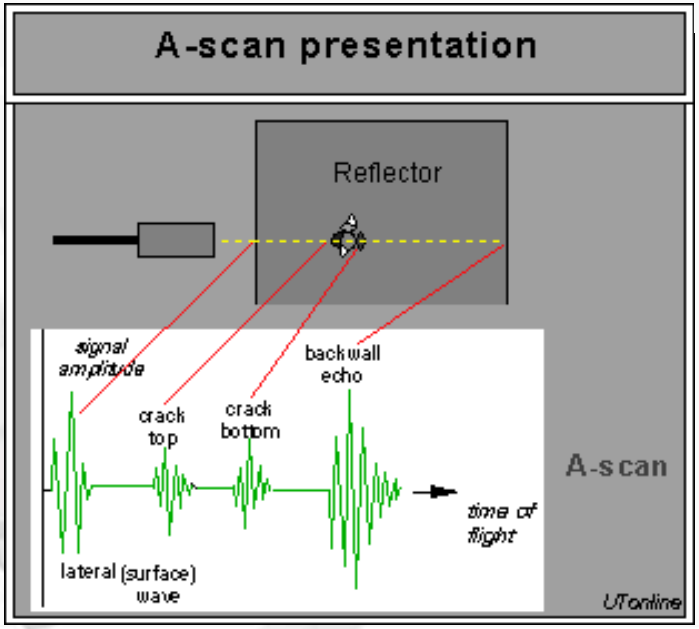
Customized software

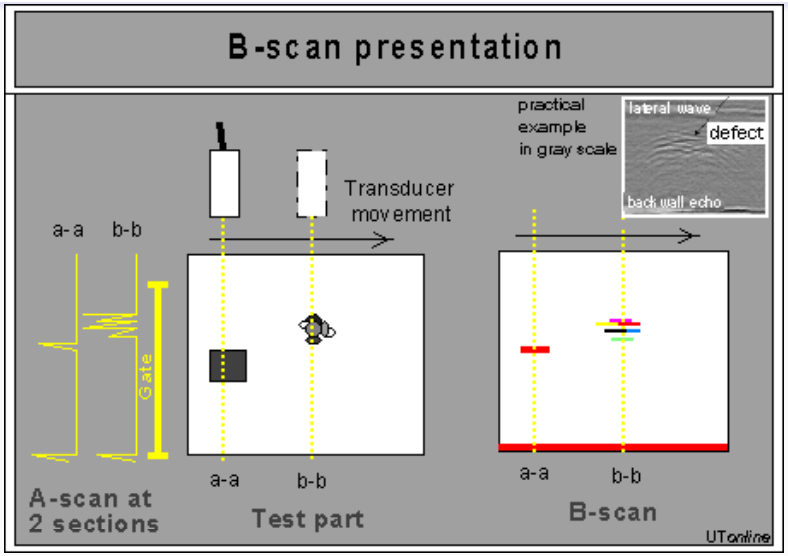
Standards: ASTM E 1065-08, GB/T 18694-2002

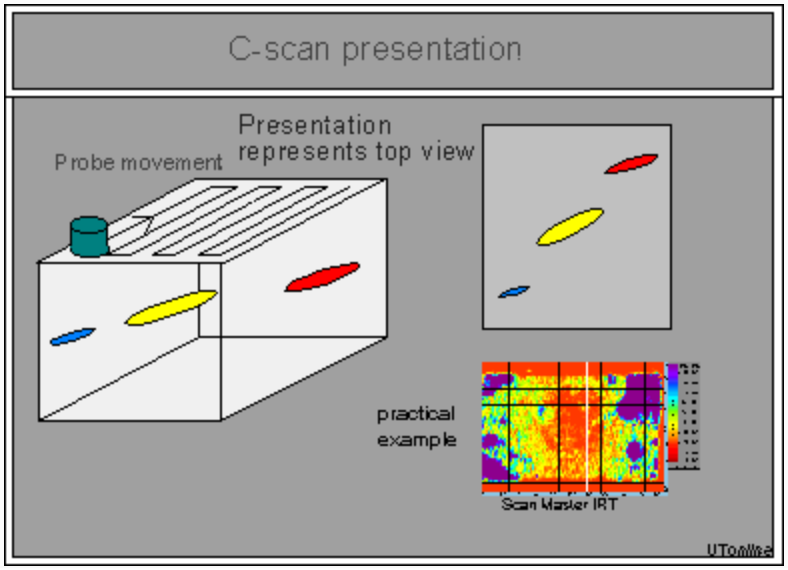
2. Calibration service in NIM

Ultrasonic flaw detection :device

Scanning and display mode







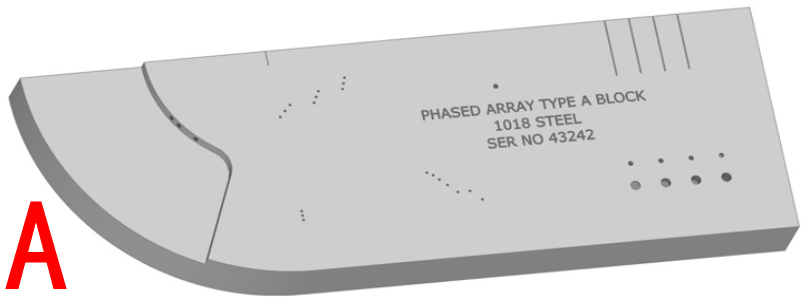
2. Calibration service in NIM

Ultrasonic flaw detection: device

- **Ultrasonic phased array flaw detector:** B mode display

Calibration setup: Standard Blocks

- Simulate flaws
- Regular through and blind holes
- Distributed with different position, angle and dimension



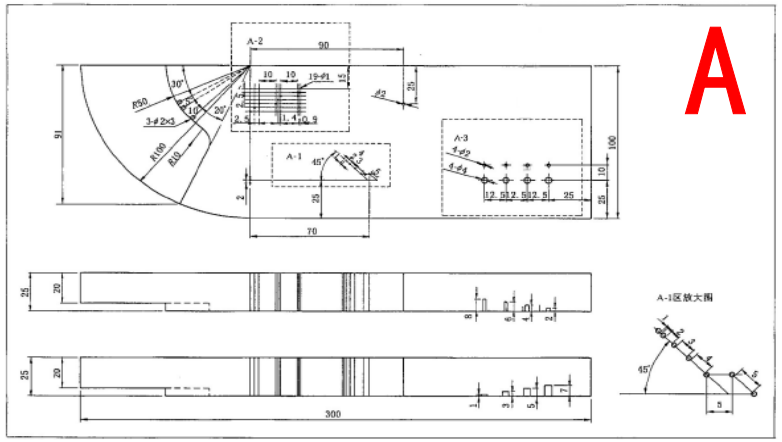
- Material: 45# steel
- Surface roughness: <1.6 μm
- Sound velocity: 5920 m/s

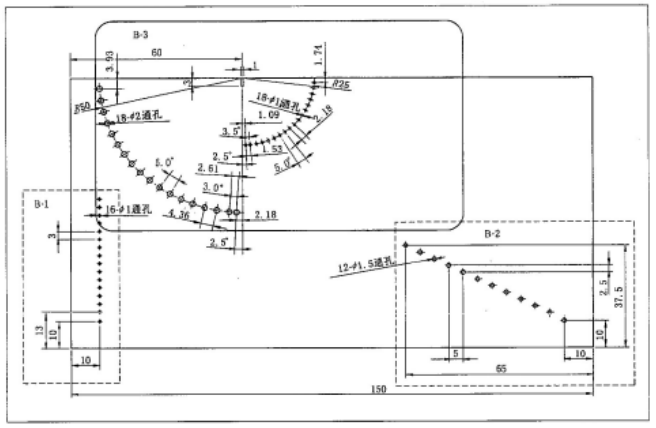
Standards: ASTM E 2491-06, JJF 1338-2012

2. Calibration service in NIM

Ultrasonic flaw detection: device

- **Ultrasonic phased array flaw detector:** B mode display
  - A-1: lateral imaging resolution
  - A-2: axial imaging resolution
  - A-3: short depth resolution
  - Relative uncertainty: 2% (k=2)
  - B-1/2: measured dimension error between two lateral holes
  - B-2: measured dimension error between two axial holes
  - B-3: scanning angle error and resolution





2. Calibration service in NIM

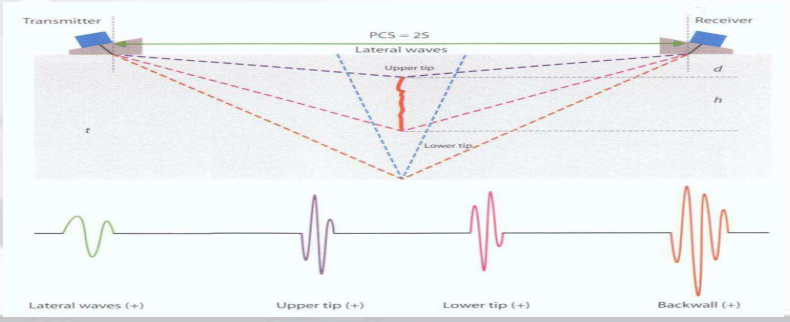
Ultrasonic flaw detection: device

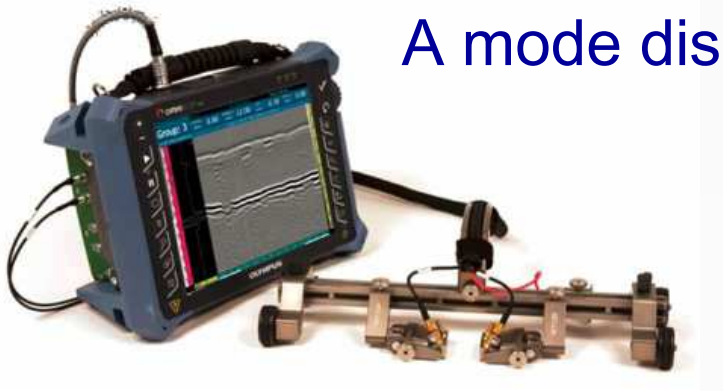
- **Ultrasonic flaw detector by time-of-flight diffraction**

Standards: ISO 10863, JJF 1447-2014

Calculation setup:

- Signal generator
- Standard attenuator
- Oscilloscope
- Motion stage
- Reference block





A mode display

Calculation parameter:

- Receiver bandwidth
- Rise time of transmission pulse
- Flaw depth, height and length

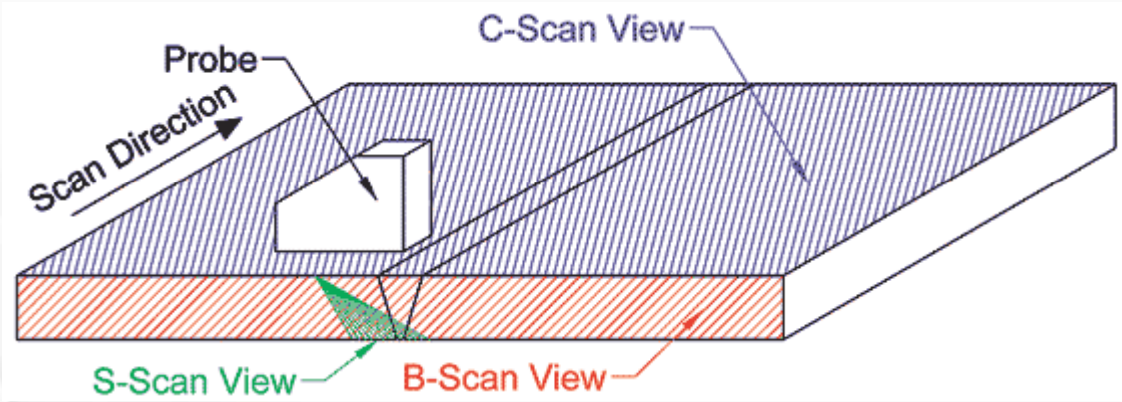
  Uncertainty: 5.6 mm (k=2)

2. Calibration service in NIM

Ultrasonic flaw detection: device

- **Ultrasonic flaw detector: C mode display**

  Established C scan system to study its calibration method



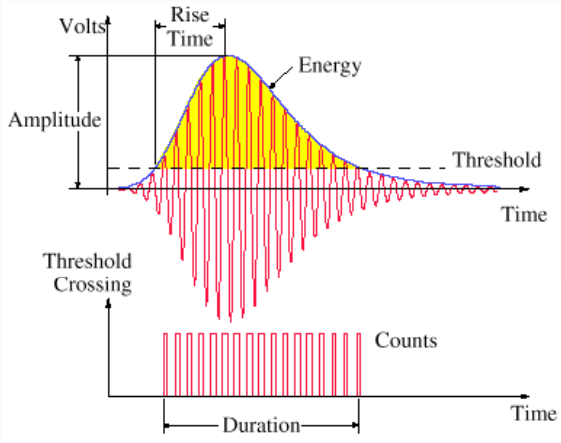
Under study:

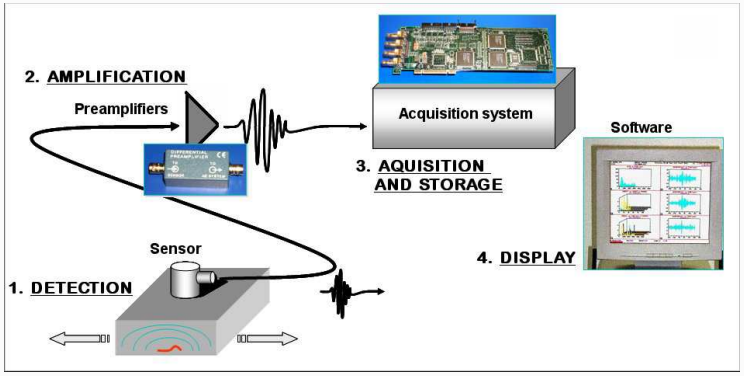
- Designing standard blocks
- Calibration regulations have been approved in China, expected to complete by the end of 2017.

2. Calibration service in NIM

Passive detection: Acoustic emission

Calibration setup: ISO 12714-1999, JJF 1337-2012



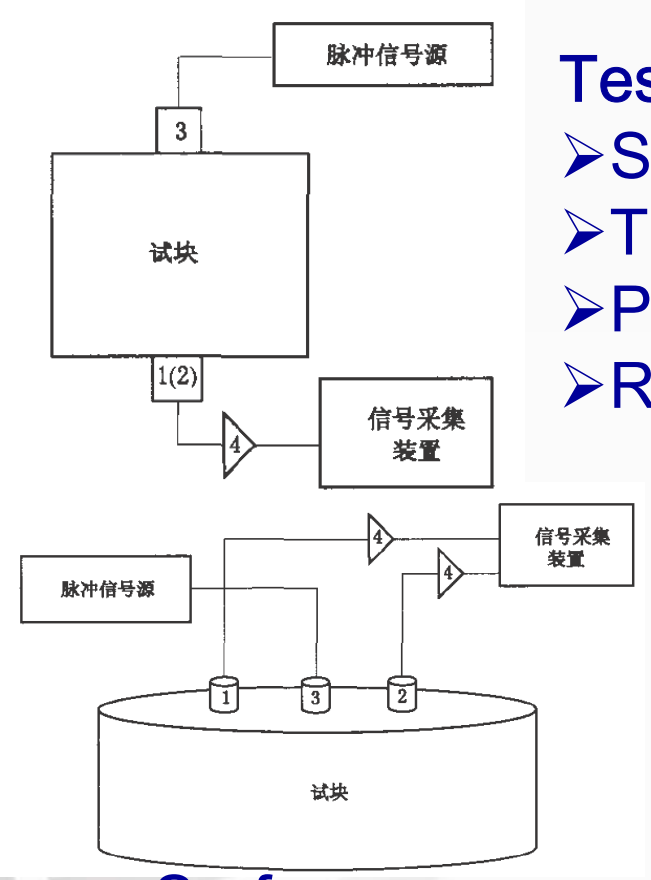


- Comparison method
- Frequency: 100 kHz ~ 1 MHz
- Surface and longitudinal wave

2. Calibration service in NIM

Passive detection: Acoustic emission

longitudinal wave



Test block : steel

- Size: >Φ400*180 mm for surface wave
- Thickness: >250 mm for longitudinal wave
- Parallel degree: < 0.12 mm
- Roughness: <1 μm (up) <3 μm (down)

Calibration parameter :

- Frequency response of Sensitivity
- Peak sensitivity and its frequency
- Uncertainty: 3.1 dB (k=2)

Surface wave

Outline

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2. Calibration service in NIM

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3. Conclusion

3. Conclusion

- Acoustic measurements have been widely used for noise measurement and safety evaluation in transportation;
- Microphone and ultrasonic transducer are basic sensor;
- Introduce acoustic calibration service at NIM about kinds of microphone, ultrasonic transducer and ultrasonic flaw detector applied in transportation;
- Following the development of transportaion such as high-way railway, acoustic measurement and calibration service have light potential.

Thank you for your attention