国家海洋标准计量中心

National Center Of Ocean Standards And Metrology

How we calibrate the Wave Height and Period Measurements from the Gravitational Acceleration Wave Buoys in RMIC/AP

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RMIC for the Asia-Pacific Region

National Center of Ocean Standards and Metrology, China

October, 2014

1. The Gravitational Acceleration Wave Buoys

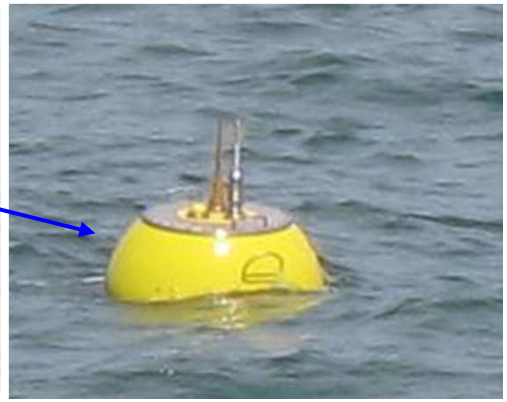
◆Wave information is usually one of the top variables requested by physical observations.

- ➢Wave/ surface winds/ currents;
- ➢Wave/ temperature/ salinity.

◆**The Gravitational Acceleration Wave Buoys** are used widely for wave information.

◆They measure near surface waves, and are ideal for collecting large quantities of wave data at a specific point.

◆They are often taken as the **measurement standards (reference instruments)** to assess the performance of other types of wave measuring instruments.

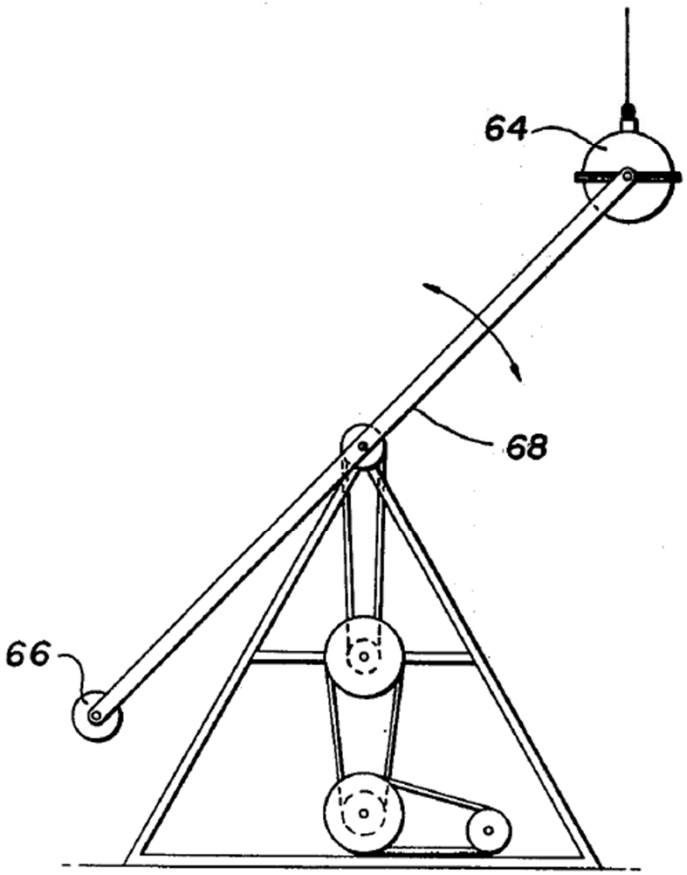


a ground-wave Radar array

1. The Gravitational Acceleration Wave Buoys

- **The Gravitational Acceleration Wave Buoys** measure vertical acceleration, integrate the acceleration signal twice to give displacement, and provide the **wave height** information.
- They measure the time **period** between successive waves.
- The directional buoy gives **direction** information.
- The wave signals are stored temporarily onboard the wave buoy and then transferred to a computer back at the shore by a **radio system**.

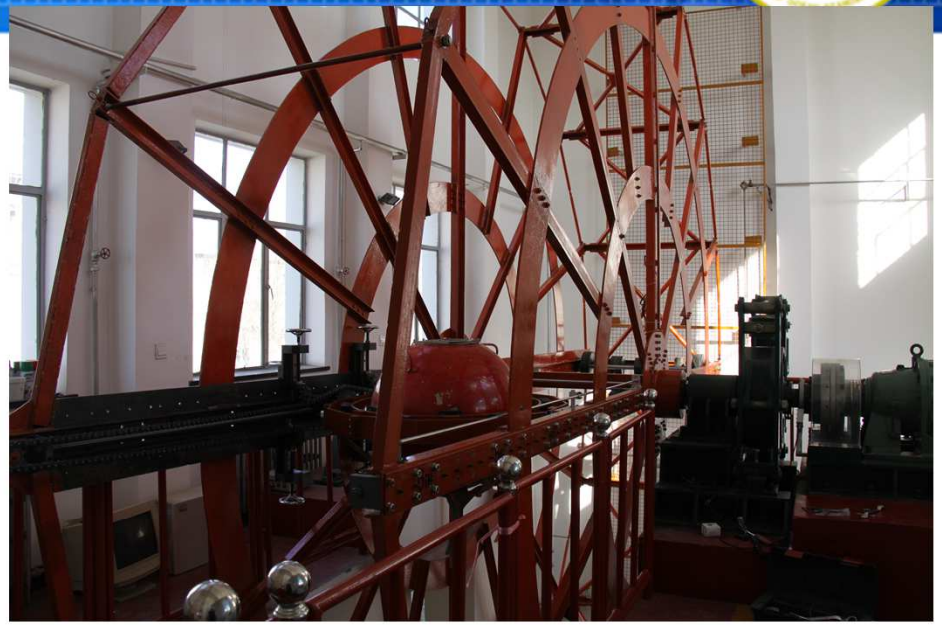
2. The method for calibrating a buoy/transducer



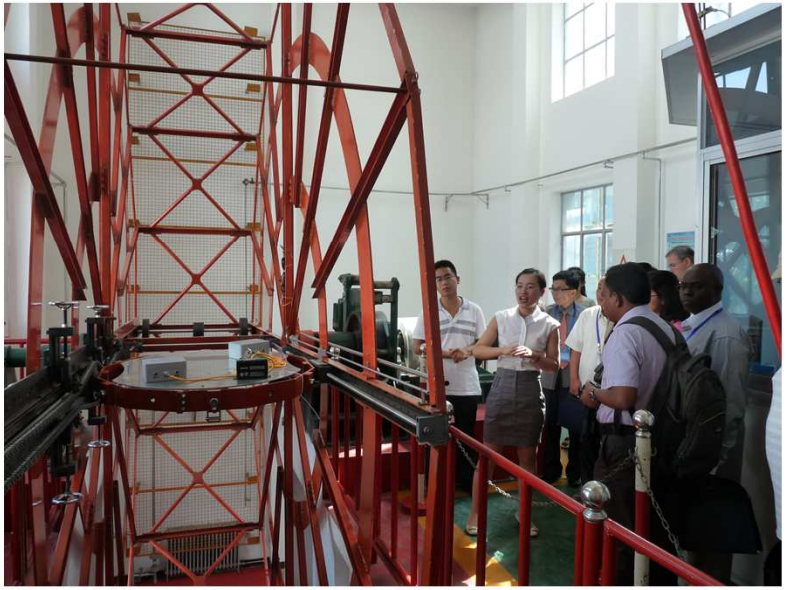
Vertical rotating arm method*

Calibration device in RMIC/AP

*:Vadasz Fekete. United States Patent (4,158,956). Jun. 26, 1979.




DO NOT STORE BELOW -5°C



3 The Measurement Standard For Public Service for the laboratory calibration of the Gravitational Acceleration Wave Buoys

- The Calibration Device of Wave Buoy was developed by RMIC/AP.
- Maximum Loading Weight: 180 kg, measurable diameter of buoys: (0.5～1.0) m.

Round truss

Driving and braking system

Control and data acquisition system

Frequency speed control and power supply system

4. NCOSM is authorized to carry out metrological verification, calibration and test

Items of authorized verification/ calibration/test	**Measuring range**	**Uncertainty/accuracy class/maximum permissible error**	**Verification regulation or technical specification**
Gravitational Acceleration Wave Buoys/ transducers	Wave height: (1～6) m Wave period: (2～40) s	Wave height: MPE:± 0.3%F.S *U*=11 mm (*k*=2) Wave period: MPE:± 0.5 s *U*=0.16 s (*k*=2)	JJG (Ocean) 04:2003 The Gravitational Acceleration Wave Buoy

4. NCOSM is authorized to carry out metrological verification, calibration and test

社会公用计量标准证书
Certificate of Measurement Standard for Public Service

[2005] 国 社量标 海洋 证字 第 069 号

根据《中华人民共和国计量法》第六条的规定，批准你单位建立的计量标准作为社会公用计量标准。

This is to certify that the measurement standard set up in your unit is authorized to be used for public service in accordance with article 6 of the Law on Metrology of the People's Republic of China.

建标单位 国家海洋计量站
Possessor of the measurement standard

计量标准名称 波浪浮标检定装置 代码 57110010
Name of measurement standard Code

测量范围 波高：(1~6) m
波周期：(2~40) s
Measuring range

不确定度或准确度等级 波高误差：±0.2%F.S
或最大允许误差 周期误差：±0.2s
Uncertainty/accuracy class/ maximum permissible error

发证机关（印章）
The issuing authority
发证日期 2013 年 04 月 15 日
Date issued
有效期至 2017 年 04 月 14 日
Date of expiry

计量标准考核证书
Certificate for Examination of Measurement Standard

[2004] 国 量标 海洋 证字 第 035 号

根据《中华人民共和国计量法》，按照《计量标准考核规范》的要求，考核合格。特发此证。

This is to certify that the measurement standard conforms with the requirements of the "Rule for the Examination of Measurement Standard" according to the Law on Metrology of the People's Republic of China.

建标单位 国家海洋计量站
Possessor of the Measurement Standard

计量标准名称 波浪浮标检定装置 代码 57110010
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测量范围 波高：(1~6) m
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Measuring Range

不确定度或准确度等级 波高误差：±0.2%F.S
或最大允许误差 周期误差：±0.2s
Uncertainty/Accuracy Class/ Maximum Permissible Error

发证机关（印章）
The Issuing Authority
发证日期 2013 年 04 月 15 日
Date Issued
有效期至 2017 年 04 月 14 日
Date of Expiry

The Certificate of Metrological Authorization

◆The calibration device was certified as a Measurement Standard for Public Service by AQSIQ in 2004.

◆**AQSIQ: the Chinese General Administration of Quality Supervision, Inspection and Quarantine**

4. NCOSM is authorized to carry out metrological verification, calibration and test

China National Accreditation Service for Conformity Assessment

LABORATORY ACCREDITATION CERTIFICATE

(Registration No. CNAS L3365)

National Center of Ocean Standard and Metrology

No.219, Jieyuan West Road, Nankai District, Tianjin, China

is accredited to ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories(CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence of testing and calibration.

The scope of accreditation is detailed in the attached appendices bearing the same registration number as above. The appendices form an integral part of this certificate.

Date of Issue：2014-04-08

Date of Expiry：2017-07-07

Date of Initial Accreditation：2008-02-22

Date of Update： 2014-04-08

Signed on behalf of China National Accreditation Service for Conformity Assessment

China National Accreditation Service for Conformity Assessment (CNAS) is authorized by Certification and Accreditation Administration of the People's Republic of China (CNCA) to operate the national accreditation schemes for conformity assessment. CNAS is the signatory to International Laboratory Accreditation Cooperation Multilateral Recognition Arrangement (ILAC MRA) and Asia Pacific Laboratory Accreditation Cooperation Multilateral Recognition Arrangement (APLAC MRA).

No.CNAS AL 2 0009435

ISO/IEC 17025 认可证书 CNAS-PD20/09-B/2

序号	测量仪器名称	校准参量	领域代码	规范代号（含年号）名称	测量范围	扩展不确定度（校准和测量能力，k=2）	限制说明	备注
4	海水声速仪	温度	1501	海水声速仪校准方法 Q/HBJ03.142-2011	(-2～35)℃	U=0.002℃		
		电导率	0401		(0～65)mS/cm	U=0.003mS/cm		
		压力	1320		(0～60)MPa	U_{rel}=0.015%		
		速度	1324		(1400～1600)m/s	U=0.05 m/s		
5	重力加速度式波浪浮标	波高	1303	重力加速度式波浪浮标检定规程 JJG(海洋)04-2003	(1～6)m	U=11mm		
		波周期	0412		(2～40)s	U=0.16s		
6	重力加速度式波浪传感器	波高	1303	重力加速度式波浪浮标检定规程 JJG(海洋)04-2003	(1～6)m	U=11mm		
		波周期	0412		(2～40)s	U=0.16s		
7	浮子式验潮仪（水位计）	潮位	1303	浮子式验潮仪检定规程 JJG587-1997	(0～8)m	U=3mm		
8	声学验潮仪（水位计）	潮位	1303	声学验潮仪检定规程 JJG947-1999	(0～6.5)m	U=3mm		
9	压力验潮仪（水位计）	潮位	1303	压力验潮仪检定规程 JJG946-1999	(0～8)m	U=3mm		
		压力			(0.1～6)MPa	U_{rel}=0.02%		
10	海水 pH 测量仪	pH 值	0233	海水 pH 测量仪校准方法 Q/HBJ 03.82-2011	0～14	U=0.01		

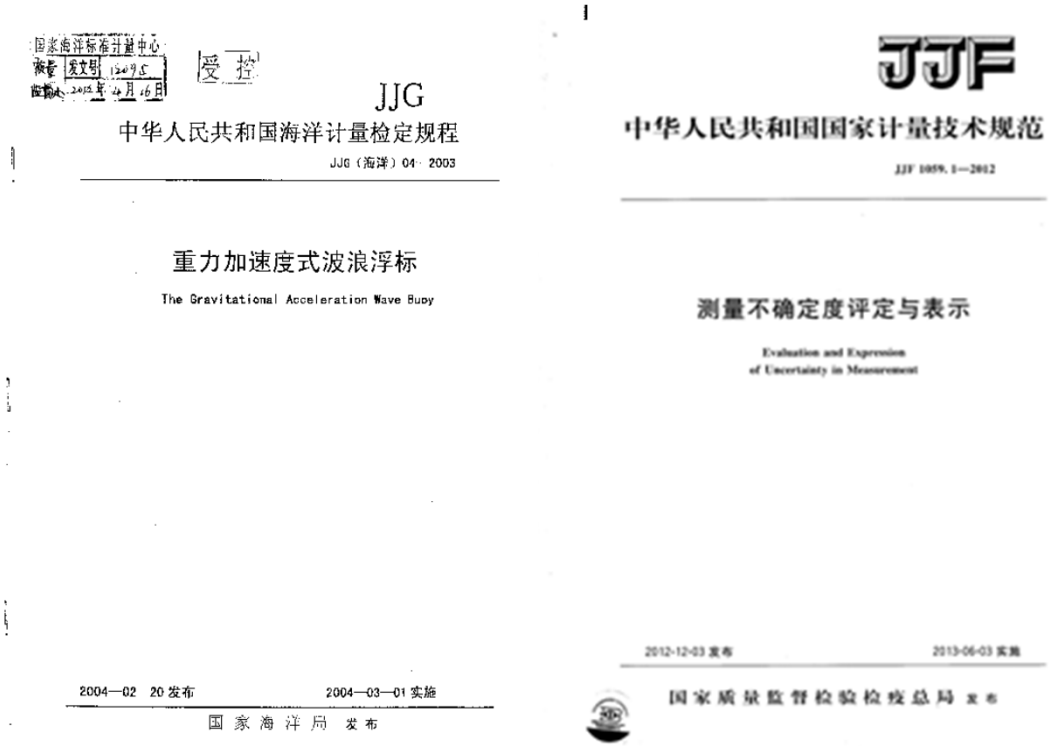
No. CNAS L3365 第 13 页 共 14 页

Should there be any inconsistencies between Chinese and English versions of the scope of accreditation, the Chinese version shall prevail in that the English version is provided by the conformity assessment body and is for reference only.

Registration No. CNAS L3365

5. The calibration procedure of the Gravitational Acceleration Wave buoys

- **Verification regulation or technical specification:**
  - JJG (Ocean) 04:2003 The Gravitational Acceleration Wave Buoy;
  - JJF1059 Evaluation and Expression of Uncertainty of Measurement.



国家海洋标准计量中心 受控

JJG

中华人民共和国海洋计量检定规程

JJG（海洋）04—2003

重力加速度式波浪浮标

The Gravitational Acceleration Wave Buoy

2004—02—20 发布　　2004—03—01 实施

国家海洋局 发布

JJF

中华人民共和国国家计量技术规范

JJF 1059.1—2012

测量不确定度评定与表示

Evaluation and Expression of Uncertainty in Measurement

2012-12-03 发布　　2013-06-03 实施

国家质量监督检验检疫总局 发布

GUM: Guide to the Expression of Uncertainty in Measurement

5.1 The setting of calibration points

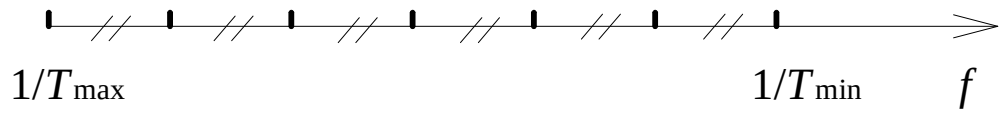
- The calibration points of wave height: **1.0m, 3.0m, 6.0m**;
- The calibration points of wave period: take **7** wave period values **at each calibration point of wave height** according to the principle of uniform frequency-point distribution within the period range of the buoy verified.

$$T_{0i} = \frac{6T'_{\max} \cdot T'_{\min}}{i \cdot T'_{\max} + (6-i)T'_{\min}}, \qquad T'_{\min} \geq \sqrt{\frac{21\pi \cdot H_0}{g}}$$

H_0=1.0 m, T'_{min}=2.6 s;

H_0=3.0 m, T'_{min}=4.5 s;

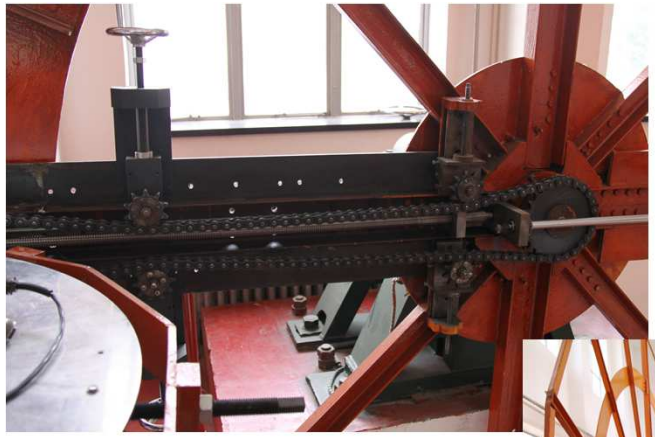
H_0=6.0 m, T'_{min}=6.4 s



H_0(m)	6.0 m						
T_0(s)	20.00	14.80	11.70	9.70	8.30	7.20	6.40
H_0(m)	3.0 m						
T_0(s)	20.00	12.70	9.30	7.30	6.10	5.20	4.50
H_0(m)	1.0 m						
T_0(s)	20.00	9.50	6.20	4.60	3.70	3.00	2.60

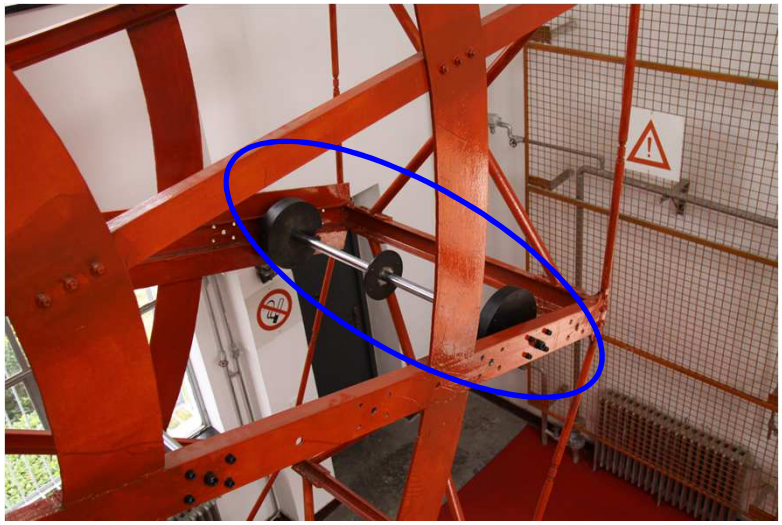
5.2 The calibration steps

- 1) Determine the **mounting point** on the radial arm of the device according to the requirements for the calibration point of wave height.
- 2) Mount the wave buoy to the buoy-holder on the radial arm, and **adjust the tension of chain reasonably** to make the chain tightly engaged with the gear.



5.2 The calibration steps

- 3) Increase/decrease the **counterweight** to regulate the balance of the device truss.



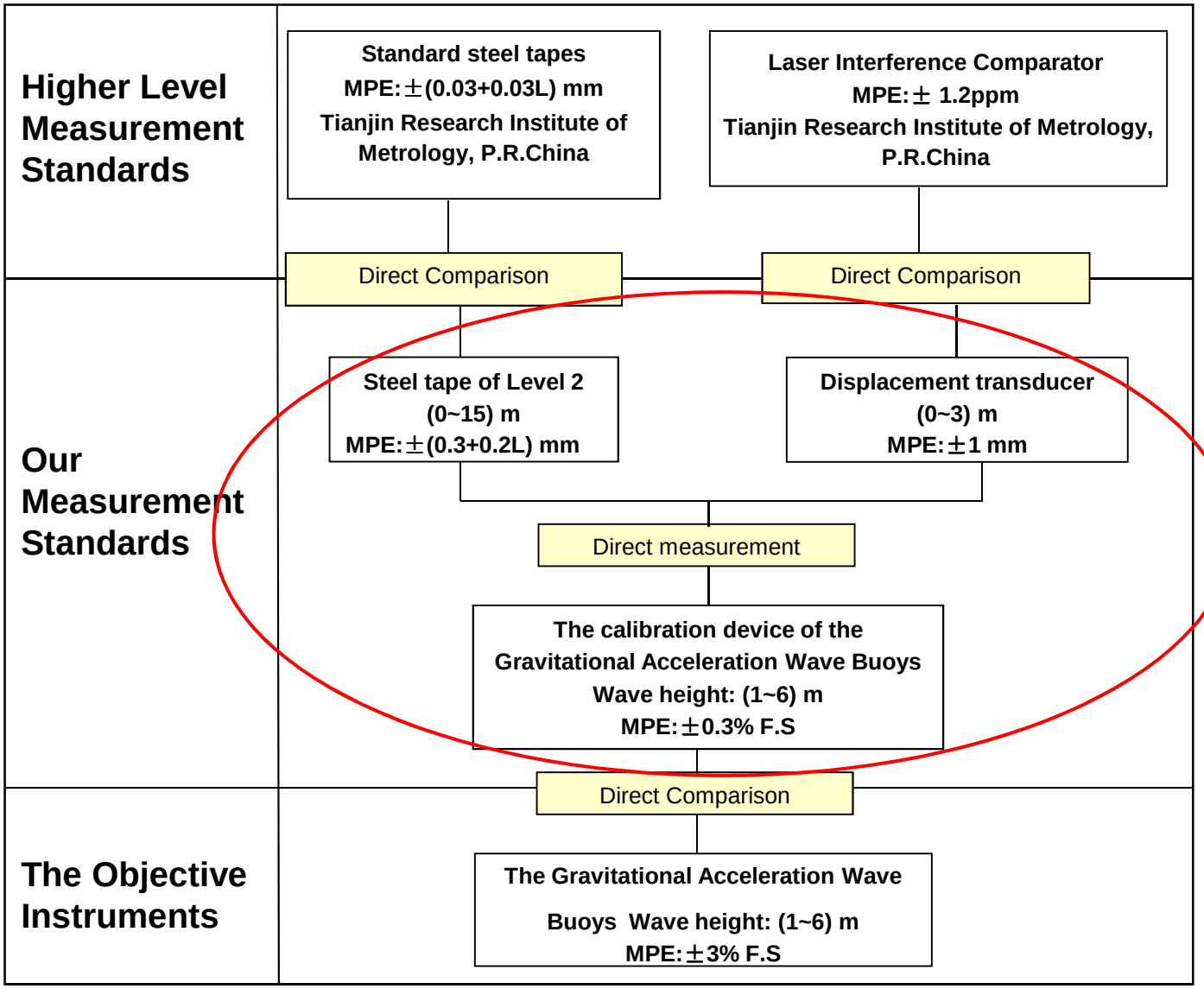
5.2 The calibration steps

- 4) **Set the standard period** in the control system and rotate the truss.
- 5) Start to perform measurement when the truss rotates at a **constant velocity state**.
- 6) Record the **standard** wave height *H*o and standard period *T*o of the calibration point, and the corresponding measurements of wave height and wave period from the **buoy being calibrated**.
- 7) Process the data and **issue a calibration certificate**.

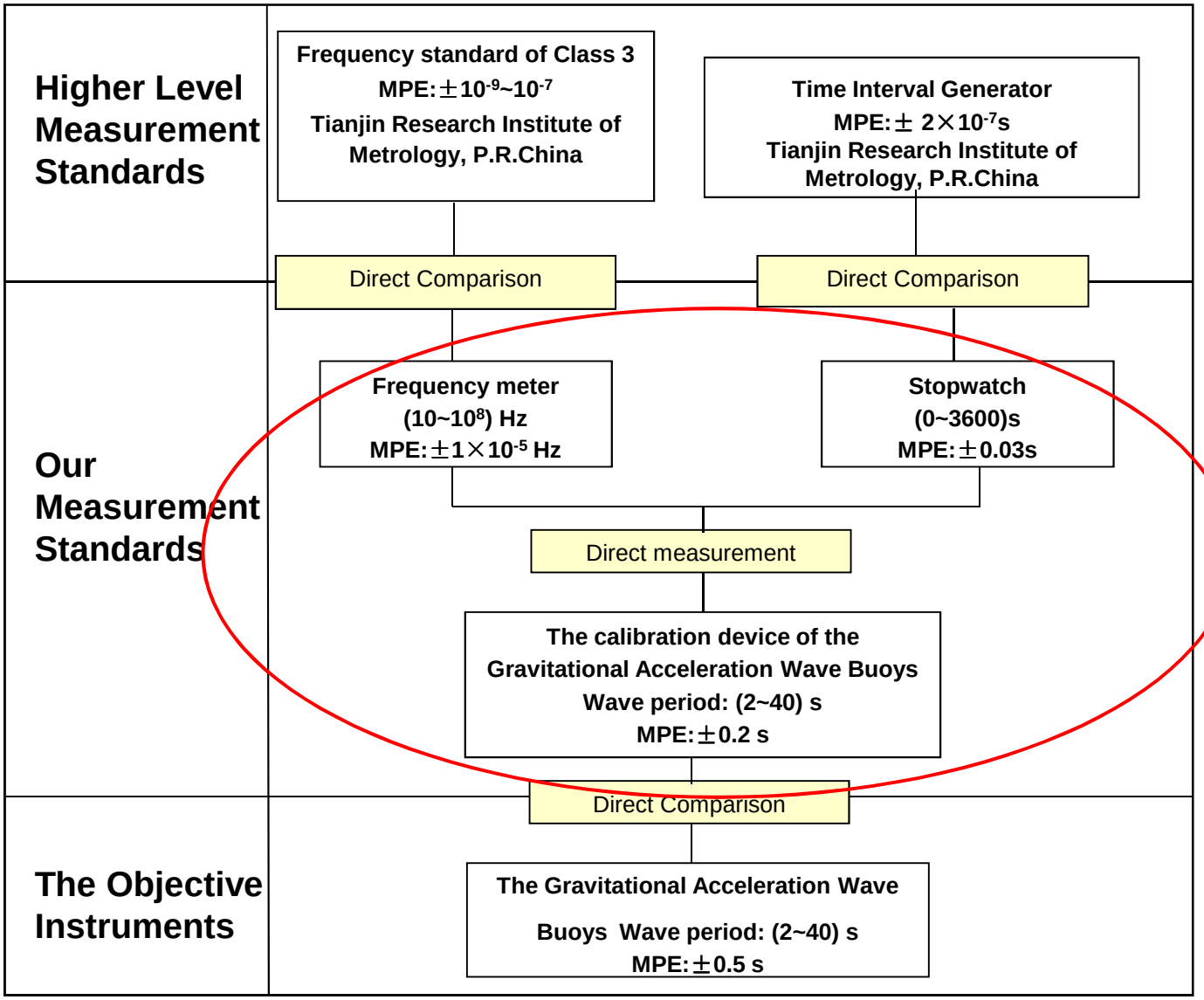
Measuring error:

$$\begin{cases} \Delta H = H - H_0 \\ \Delta T = T - T_0 \end{cases}$$

5.3 The measurement traceability systems
--- wave height



5.3 The measurement traceability systems
--- wave period



5.4 Evaluation of the uncertainty in measurement

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Uncertainty Source	Symbol	Standard Uncertainty（mm）
Measurement repeatability of the calibrated instrument	u_{rep}	5.00
Measurement error of the range from the buoy-holder to the center of the round-truss	$u_{\Delta R}$	0.85
Accuracy of the A/D conversion	$u_{A/D}$	ignored
Error of the rotation radian	$u_{\Delta\theta}$	0.64
Measurement error of the horizontal line	$u_{\Delta h_0}$	0.69

$$U = k \cdot u_c = 2 \times 5.16\text{mm} = 11\text{mm}\ (k = 2)$$

5.4 Evaluation of the uncertainty in measurement

For wave period measurement:

- The uncertainty sources of the wave period measurement calibration consist of:
  - (a) Measurement repeatability of the calibrated instrument;
  - (b) Error of the interrupt impulse for time interval (period).

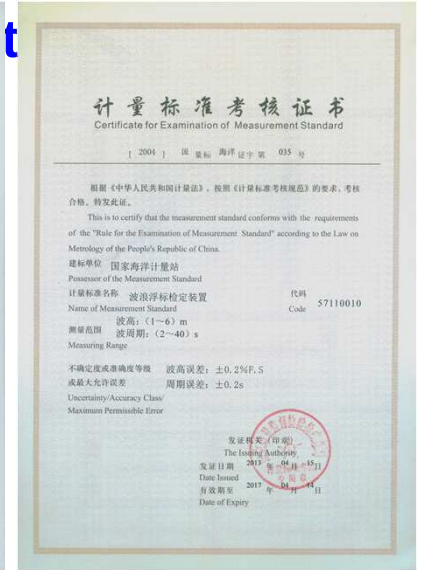
Uncertainty Source	Symbol	Standard Uncertainty（s）
Measurement repeatability of the calibrated instrument	$u_{t\,rep}$	0.08
Error of the interrupt impulse for time interval (period)	u_{stime}	ignored

$$U = k \cdot u_c = 2 \times 0.08\text{s} = 0.16\text{s}$$

6. The QA/QC for the calibration procedure

- The calibration is **traceable to the SI** through certified national measurement institutes. Main measuring parts of our calibration device should be calibrated/verified at regular intervals.
- It is in compliance with the **specific verification regulations** issued in China and **ISO/IEC 17025:2005**.
- The calibration device is checked by AQSIQ **every four years**. If qualified, it would be authorized to be **used for public service as a Measurement Standard** in accordance with the Law on Metrology of the People's Republic of China.
- Only well trained **engineers with metr** **t** permitted to carry out the calibration.


社会公用计量标准证书
Certificate of Measurement Standard for Public Service


计量标准考核证书
Certificate for Examination of Measurement Standard

7. Summary

- NCOSM is authorized to carry out metrological verification, calibration and test of the Gravitational Acceleration Wave Buoys and transducers.
- Developed by NCOSM, the wave buoy calibration device was certified as the Measurement Standards for Public Service in 2004.
- We built the measurement traceability systems of wave height and period calibration and do the QA/QC procedure.
- NCOSM acts as a technical supporter to ensure the accuracy and reliability of data in national marine observation projects in China.

Items of authorized verification/ calibration/test	**Measuring range**	**Uncertainty/accuracy class/maximum permissible error**	**Verification regulation**
Gravitational Acceleration Wave Buoys / transducers	**Wave height:** **(1～6) m** **Wave period:** **(2～40) s**	**Wave height:** **MPE:±0.3%F.S** ***U*=11mm (*k*=2)** **Wave period:** **MPE:± 0.5 s** ***U*=0.16 s (*k*=2)**	**JJG (Ocean) 04:2003 The Gravitational Acceleration Wave Buoy**

Thank you for your attention !

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