The Technical Status and Prospect of Natural Gas Flow Traceability System in China

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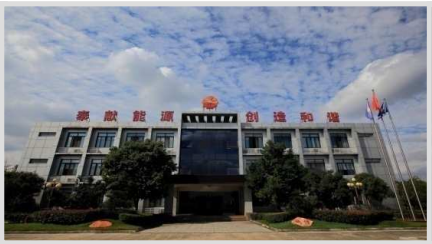
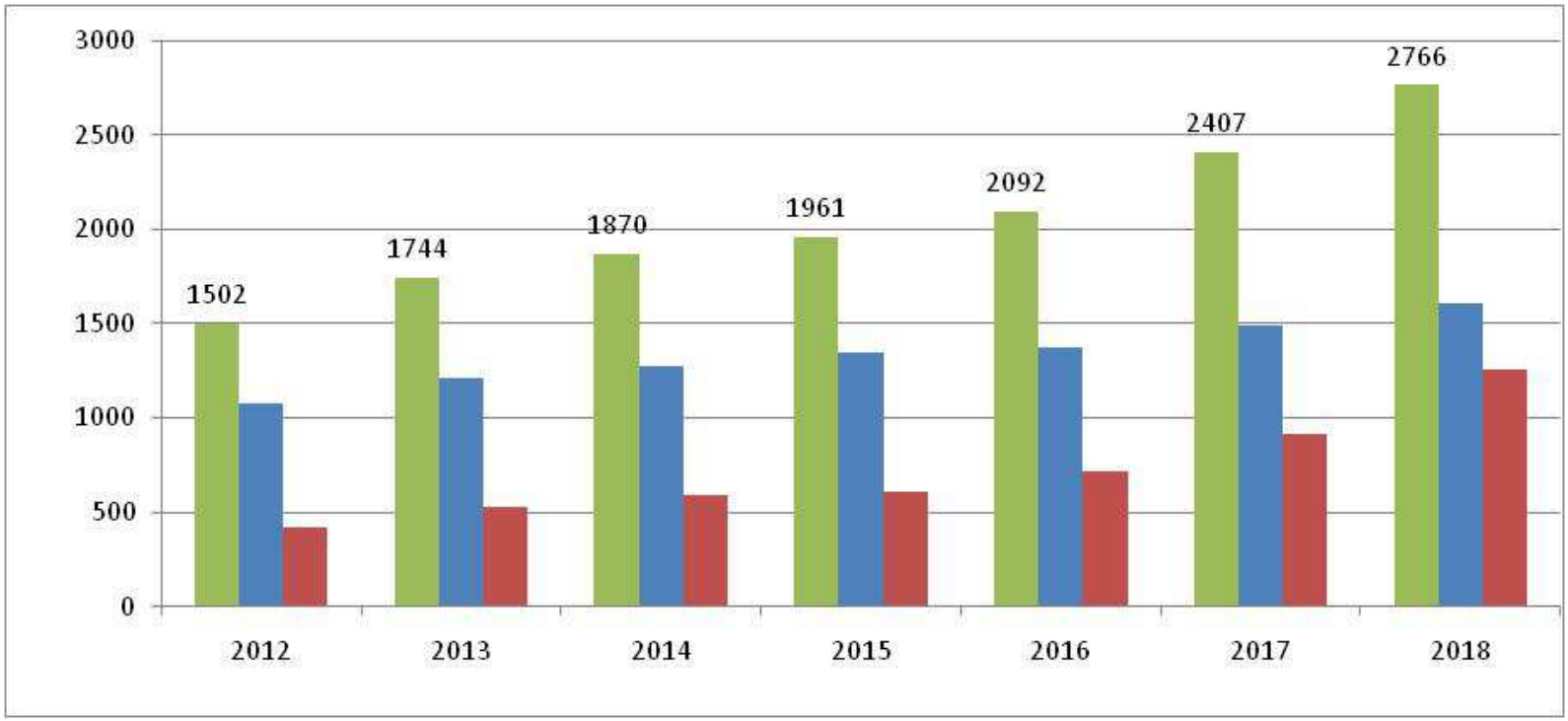


Concent

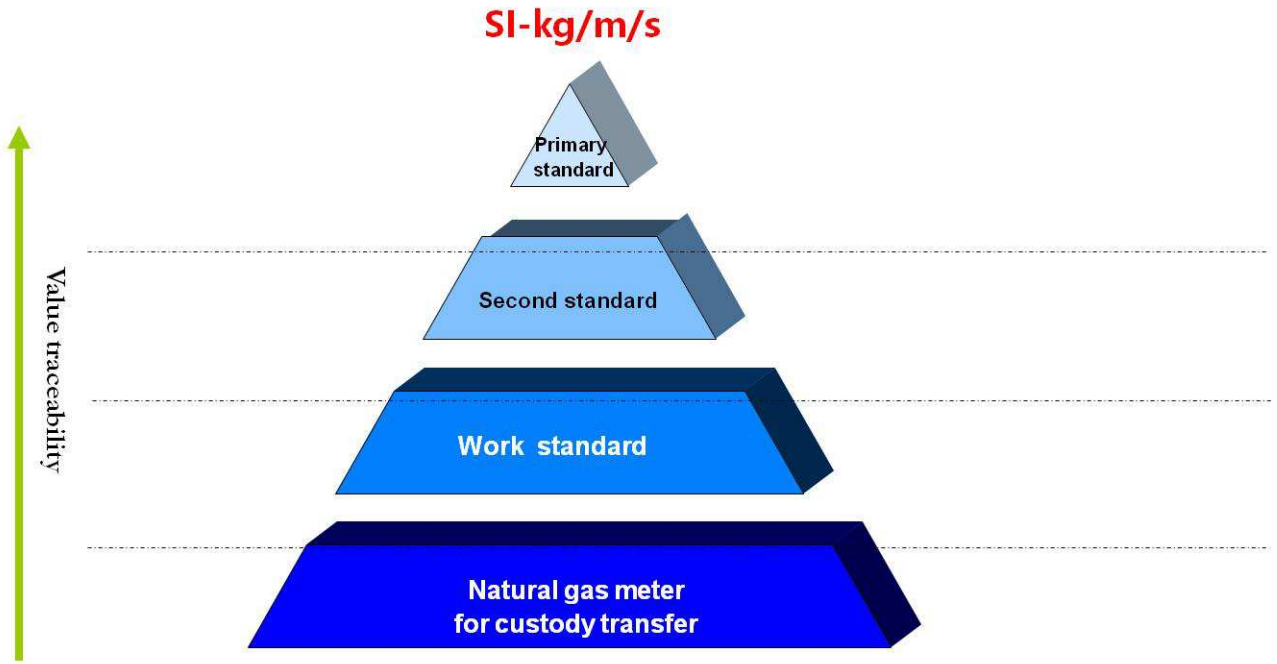
01

Introduction

In recent years, the volumes of natural gas import and production are rapid growing in China ,and China is one of the major consumer of natural gas in the world.



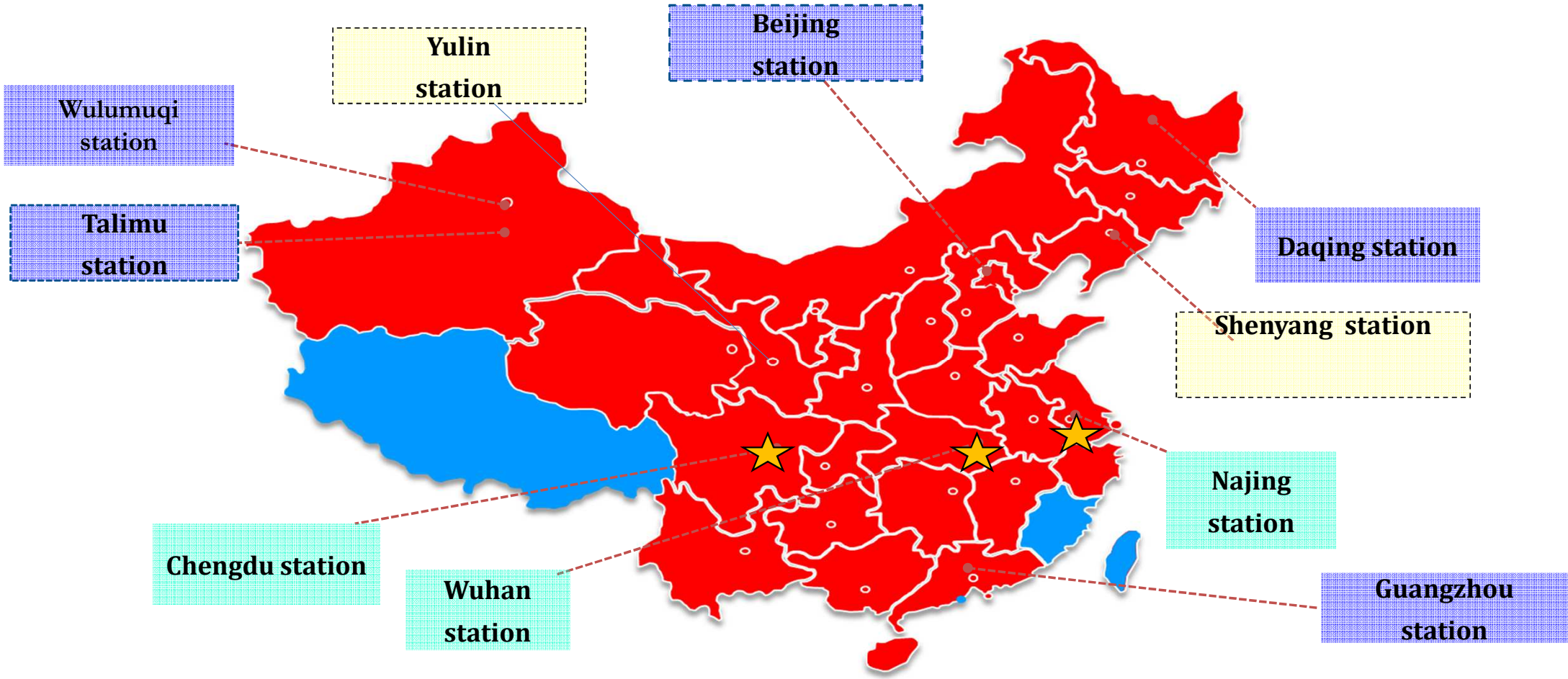
In order to meet the rapid growth of natural gas import and production, natural gas measurement technology has been developed rapidly in China. The volume flow and mass flow traceability systems have been established since 1997.



Natrural gas value traceability chain

02

The Technical Status of the Traceability in China



Natural gas stations distribution map in China

The flow measurement uncertainty of primary standard is reduced from 0.1% to 0.05% or 0.07%.

Traceability	Institution name	Primary standard	Pressure range(MPa)	Flowrate range(MPa) kg/s	Uncertainty，% (k=2)	Established
volume	Wuhan station	HPPP	2.5-10	20-480	0.07	2017
Mass-time	Chengdu station	*mt* (banlance)	0.3-4.0	0.005-2.47	0.1	1997
			0.3-2.0	0.004-1.2	0.07	2017
			2.0-6.0	1. 2-5.4	0.05	2017
	Nanjing station	*mt* (gyroscope)	2.5-10.0	0.04-6.0	0.1	2011
					0.05	2019

The primary standards in China have achieved first-class level in the world.

para	PTB Pigsar	GRI		NMi (Europe)	Chengdu station	Nanjing station	Wuhan station
		Low Pressure roop	High Pressure roop				
Established	1999	1990	1992	2010	2017	2018	2017
Pressure (MPa)	1.5 ~ 5.0	0.14 ~ 1.47	1.035 ~ 8.275	0.1 ~ 6.0	0.4 ~ 6.0	4.5 ~ 9.0	2.5 ~ 10.0
Flow rate	480 m^3/h	1020 m^3/h	2380 m^3/h	120 m^3/h	410 m^3/h	443m^3/h	480m^3/h
Type	HPPP	gravimetric *mt*	gravimetric *mt*	HPPP	Balance *mt*	Gravimetric *mt*	HPPP
Uncertainty (*k*=2)	0.064%	0.04% ~ 0.1%	0.04% ~ 0.1%	0.07%	0.05% ~ 0.07%	0.05%	0.07%

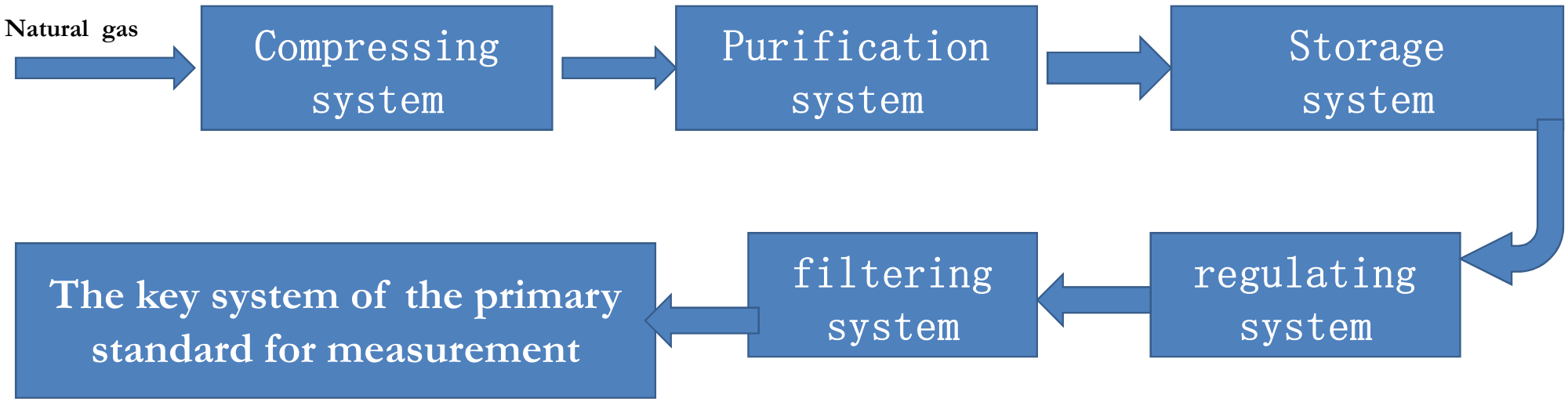
The flow measurement uncertainty of the secondary standard is reduced from 0.25% to 0.20%.

NO.	Institution name	Standard	Type	Uncertainty(%)	Gas	Pressure range(MPa)	Flow range (m^3/h)	Max.diameter(mm)	Established
1	Daqing station	Mobile	Sonic nozzel	0.32	Natural	2.0	1to4600	200	1990
			turbine/ultrasonic	0.32	Natural	< 10.0	45 ~ to8000	300	2010
2	Chengdu station	second	Sonic nozzel	0.20	Natural	0.4to6.0	5to5115	400	2018
		working	turbine	0.33	Natural	1.7to5.5	16to8000	400	2013
3	Najing station	second	Sonic nozzel	0.22	Natural	4.5to9.6	8to3160	250	2010
		working	turbine	0.29	Natural	4.5to9.6	15to12000	400	2010
4	Wuhan station	working	turbine	0.29	Natural	5.5to10	20to9600	400	2017
		transfer	turbine	0.16	Natural	5.5to10	20to1600	200	Builting
5	Guangzhou station	second	Sonic nozzel	0.22	Natural	4.1to9.8	7to3129	250	2015
		working	turbine	0.29	Natural	4.1to9.8	7to15000	500	2015
6	Wulumuqi station	second	Sonic nozzel	0.22	Natural	5to9.5	14to2500	250	2017
		working	turbine	0.29	Natural	5to9.5	25to10000	400	2017

03

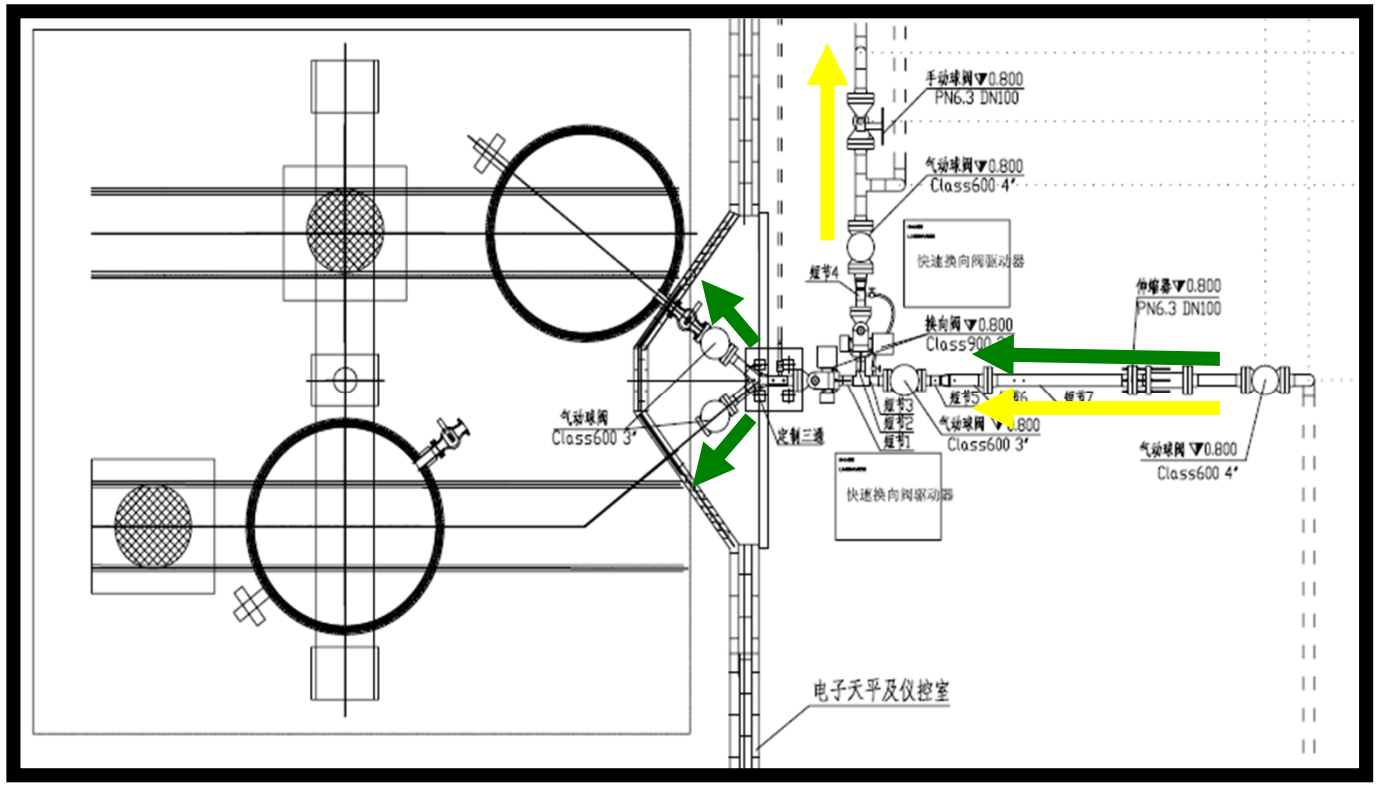
The critical technologies of the primary standard in CVB

- flow diagram of the primary system in CVB



Mass measurement system

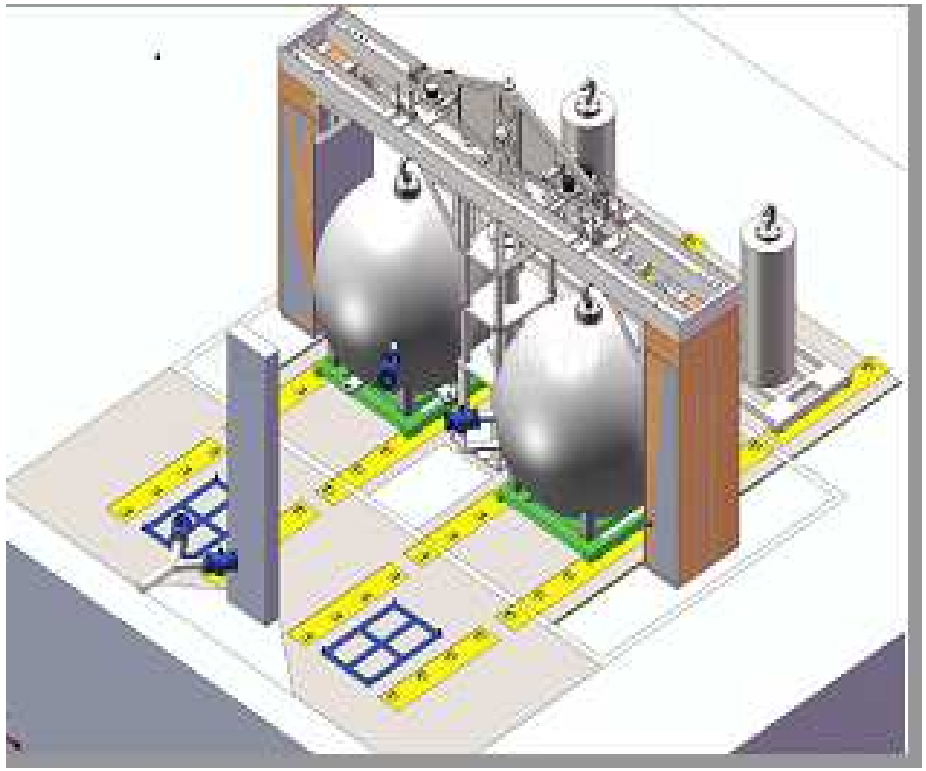
Fast diverting system



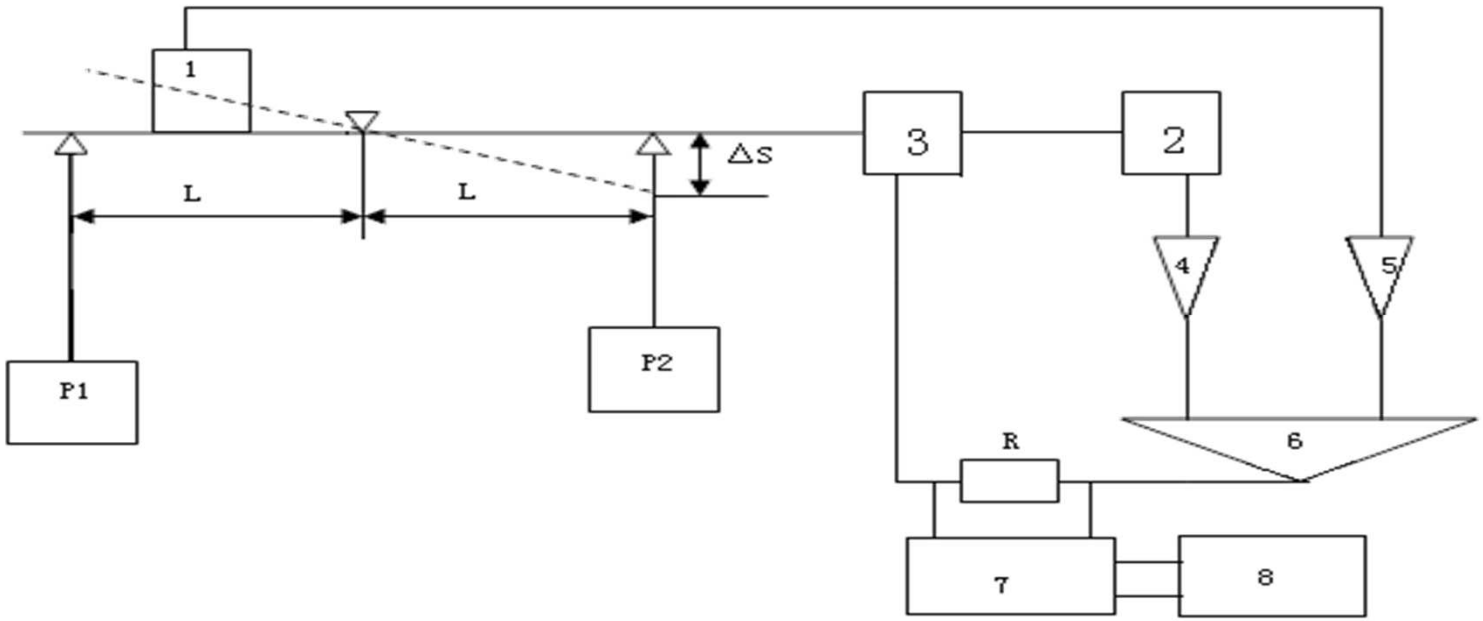
the weighing system

Time measurement system

The primary standard schematic diagram



compensation volume optimization; environment temperature and humidity control measures .



1—Displacement transducer2—Speed sensor 3—torquer

4—Speed amplifier 5—Displacement amplifier6—Summing amplifier7—Digital tabl 8—The microcomputer

diagram of electromagnetic balance working principle

- **Maximum load :3000 kg ;**
- **The actual dividing value： 0.1g，**

Verify the dividing value： 0.1g；

- **Gas flowrate range（5～2×130）kg；**
- **Uncertenty:1.0g（*k*=2）。**

中 国 计 量 科 学 研 究 院

证书编号 LSmt2017-0773

校 准 结 果

d = 0.1 g； e = 1.0 g； Max=132.1 kg

表 1

载荷值（kg）		误差（g）	对应天然气载荷值（kg）	测量扩展不确定度（g）（k=2）
天平示值误差	22.1	-0.5	110.0	1.0
	42.1	-0.3	90.0	1.0
	62.1	-0.9	70.0	1.0
	82.1	-1.0	50.0	1.0
	107.1	-0.8	25.0	1.0
	118.1	-0.8	14.0	1.0
	122.1	-0.8	10.0	1.0
	127.2	-0.9	4.9	1.0

说明：1、该天平的电子秤量范围 0.1 g~300 g；
2、天平最大载荷为 3000 kg；
3、天平重复性在 132.1 kg 载荷时进行测量；
4、罐内天然气质量 = 132.1 kg - 天平载荷。
以下空白

说明：
根据客户要求和校准文件的规定，通常情况下 12 个月校准一次。

声明：
1. 我院仅对加盖“中国计量科学研究院校准专用章”的完整证书负责。
2. 本证书的校准结果仅对本次所校准的计量器具有效。

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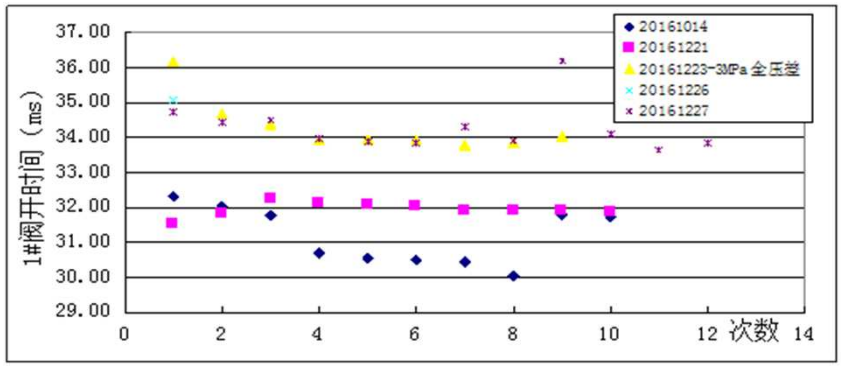
2014-jz

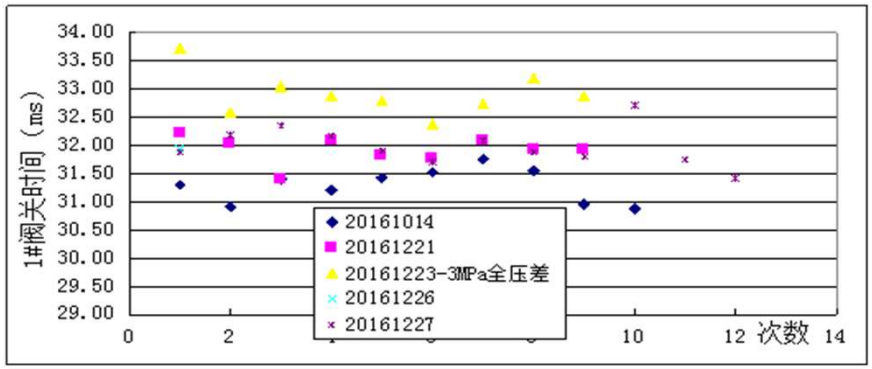
第 3 页 共 3 页

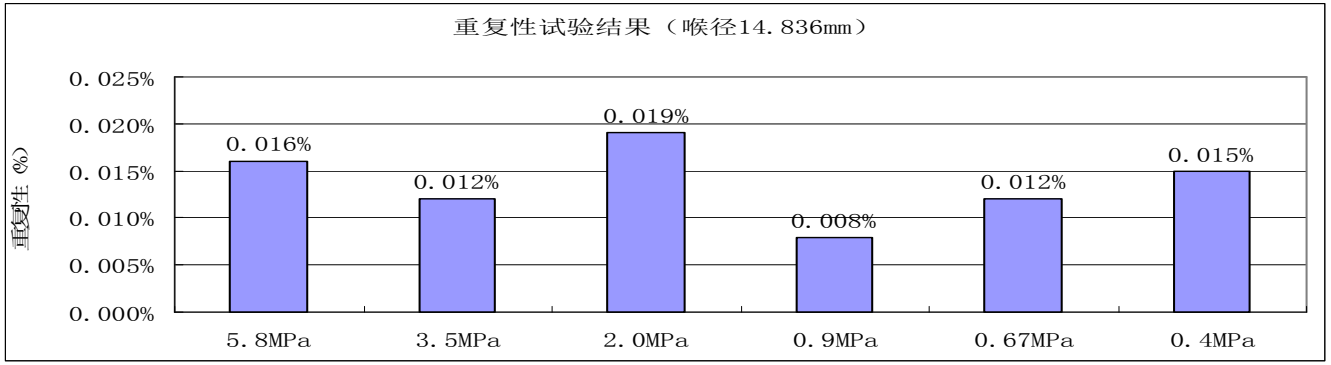
✓**Switching time :33ms±3ms ,**

With the characteristics of good repeatability and stability of switching time, it has reached the international advanced level

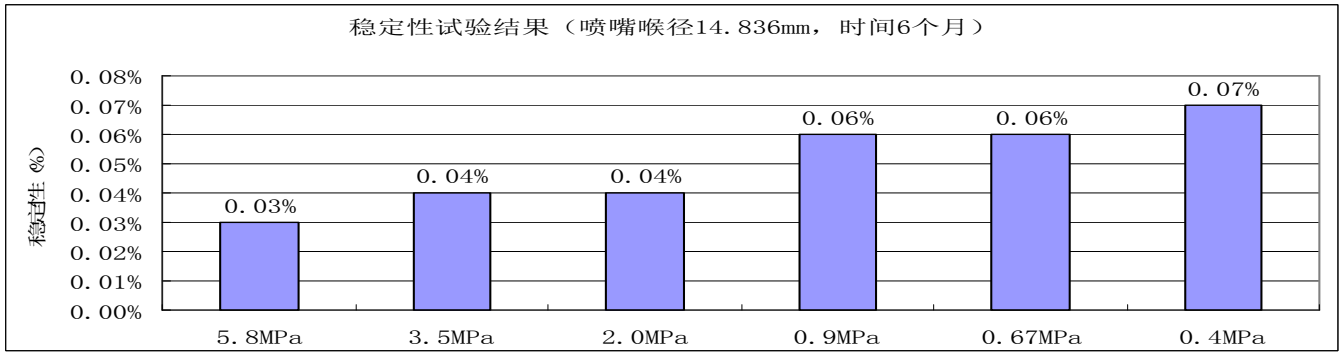
10,2016, Obtained the national invention patent "a rapid reversing system" 1 item.







repeatability≤0.02%



Stability: ≤0.05(2.0≤ P ≤ 6.0)MPa

Stability: ≤0.07% (0.4≤ P ＜ 2.0)MPa

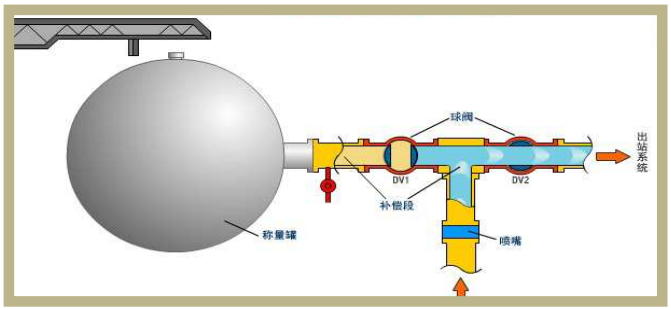
◆Uncertainty method

$$u_r(q_m)=\sqrt{c_r(t)^2\cdot u_r(t)^2+c_r(\Delta m_{补A})^2\cdot u_r(\Delta m_{补A})^2+c_r(\Delta m_{补B})^2\cdot u_r(\Delta m_{补B})^2+c_r(\Delta m_c)^2\cdot u_r(\Delta m_C)^2}$$

$$u_r(\Delta m_A)=\sqrt{u_r(\Delta V_A)^2+u_r(P_{Ai})^2+u_r(P_{Af})^2+u_r(T_{Ai})^2+u_r(T_{Af})^2}$$

$$u_r(\Delta m_B)=\sqrt{u_r(\Delta V_B)^2+u_r(P_{Bi})^2+u_r(P_{Bf})^2+u_r(T_{Bi})^2+u_r(T_{Bf})^2}$$

$$u_r(\Delta m_C)=\frac{\sqrt{u_w^2+u(m_r)^2+u_b^2+u_s^2+u_d^2}}{\Delta m_c}\times 100\ \%$$



Mass Uncertainty ≤ 0.02%

$$u_r(t)=\sqrt{u_r^2(t_{1a})+u_r^2(t_{1b})+u_r^2(t_2)}\qquad u_r(t_2)=E_r(t)=\sqrt{u_r^2(H_1)+u_r^2(H_2)}$$

Time uncertainty ≤ 0.02%

Experimental data summary of the influence of air buoyancy on weighing results of electromagnetic balance gas (2017)				
Test date	**Test pressure,MPa**	**Test time,hour**	**Nozzel folwrate,m^3/h**	**Changed value,kg**
9.19	**5.8**	**1**	**320**	**0.006**
9.10to9.11	**4.8**	**13**	**5**	**0.0017**
8.30	**3.5**	**1**	**320**	**0.0054**
9.7to9.8	**2**	**13**	**320**	**0.0027**
9.4	**1.5**	**1**	**320**	**0.009**
9.3	**0.9**	**1**	**320**	**0.0014**
8.31	**0.67**	**1**	**320**	**0.0014**
9.4	**0.4**	**1**	**320**	**0.0014**

Uncertainty	P≥2.0MPa			P < 2.0MPa			备注
	value	Sensitive coefficient	Uncertainty（k=2）	calcuation	Sensitive coefficient	Uncertainty	
$u\,(\triangle m_c)$	0.5g	1	0.5g	0.5g	1	0.5g	According certificate
$u\,(\triangle m_{Vb})$	0.023g	1	0.023g	0.026g	1	0.026g	
$u\,(\triangle m_{Va})$	0.046g	1	0.046g	0.282g	1	0.282g	
	0.4g	1	0.4g	0.4g	1	0.4g	Test data
$u_r(\triangle m)$			0.013%	$u_r(\triangle m)$		0.02%	
u_r(t)	0.01%	1	0.01%	0.01%	1	0.01%	
orthers	0.02%	1	0.02%	0.03%	1	0.03%	Known less
Combined Uncertainty			0.025%	Combined Uncertainty		0.035%	
Extended uncertainty （k=2）			0.05%	Extended uncertainty （k=2）		0.07%	

Nozzel is 40m³/h，pressure （0.25－2.0）MPa。En＜1）。

Reynolds number	NIM,China	Chengdu station	Different value	Satisfaction EN
2.47E+06	0.9963	0.9952	0.0011	0.89
2.47E+06	0.9963	0.9953	0.0010	0.81
2.48E+06	0.9963	0.9953	0.0010	0.81
1.71E+06	0.9961	0.9949	0.0012	0.84
1.71E+06	0.9961	0.9950	0.0011	0.77
1.71E+06	0.9961	0.9950	0.0011	0.77
1.28E+06	0.9960	0.9949	0.0011	0.77
1.26E+06	0.9960	0.9951	0.0009	0.63
1.26E+06	0.9960	0.9948	0.0012	0.84
8.85E+05	0.9967	0.9960	0.0007	0.50
9.51E+05	0.9964	0.9959	0.0005	0.36
4.63E+05	0.9960	0.9960	0.0000	0.01
4.63E+05	0.9960	0.9959	0.0001	0.08
4.63E+05	0.9960	0.9962	-0.0002	0.12
2.90E+05	0.9946	0.9954	-0.0008	0.52
2.89E+05	0.9946	0.9953	-0.0007	0.46
2.88E+05	0.9946	0.9954	-0.0008	0.53

d=4.7498mm 16m³/h		**mt (CVB)**	**mt (Najing)**	**Diferrent**	$\lvert E_n \rvert = \frac{\lvert y - y_a \rvert}{\sqrt{U_y^2 + U_a^2}}$
压力 (MPa)	Reynolds number	Flow coefficient (c_d)	Flow coefficient (c_d)	Flow coefficient ⑩ difference	**EN**
5.8MPa	**4.0128E+06**	**0.9951**	**0.9954**	**0.0003**	**0.17**
4.6MPa	**3.2441E+06**	**0.9945**	**0.9954**	**0.0009**	**0.49**
3.5MPa	**2.4854E+06**	**0.9937**	**0.9954**	**0.0017**	**0.94**
2.0MPa	**1.4395E+06**	**0.9936**	**0.9953**	**0.0017**	**0.96**
1.5MPa	**1.0925E+06**	**0.9944**	**0.9954**	**0.0010**	**0.49**
d=24.9199mm,410m³/h		**(mt) (chengdu station)**	**mt (Najing station)**	**Different value**	$\lvert E_n \rvert = \frac{\lvert y - y_a \rvert}{\sqrt{U_y^2 + U_a^2}}$
Pressure (MPa)	Reynolds number	Flow coefficient (c_d)	Flow coefficient (cd)	Flow coefficient ⑩ difference	**EN**
5.8MPa	**22651329.7**	**0.9930**	**0.9936**	**0.0006**	**0.34**

04 Prospect

1、The primary standard: uncertainty less than 0.05% (k=2)

flow rate (5to480) m^3/h , (0.4~10) MPa

2、second standard uncertainty from0.20%reduced to 0.17%(k=2).

Thanks for your attention ！