Asia-Pacific
Economic Cooperation

Asia-Pacific
Legal Metrology Forum

Handbook on Training Course on Gas Meters

APEC/APLMF Training Courses in Legal Metrology
(CTI 09/2009T)

Apr. 13 – 16, 2010
Chongqing, P. R. China

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Group photo

Photos taken during the training course

Contents

Foreword

This handbook is one of outcomes of the APEC/APLMF Seminars and Training Courses in Legal Metrology (CTI-09/2009T) titled "Training Course on Gas Meters" which was held on April 13-16, 2010 at the Golden Quality Hotel, Chongqing, China.

This training course was organized by APLMF secretariat and arranged as one of the APEC TILF projects, CTI-09/2009T. It was supported by General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) of the People's Republic of China, Measurement Canada, Chinese Measurement Society, Chinese Society for Measurement (CSM), Chongqing Academy of Metrology and Quality Inspection, China and Chongqing Bureau of Quality and Technical Supervision, China. There were 58 participants from 10 APEC economies attending this training course.

I would like to take this opportunity to give my sincere gratitude to staffs of AQSIQ and local Chinese government and metrology institute for their outstanding preparation. I also would like to thank two trainers, Mr. Steve Clyens and Mr. Brad Pavlove from Measurement Canada, for their excellent presentations. Also, special thanks should be extended to the APEC Secretariat for their great contributions.

Natural gas is one of the main energy sources in the earth and regarded as one of the cleanest, safest and most useful of all energy sources. The accurately measurement of the flow of natural gas using gas meters are both vital in natural gas industry and household gas billing. The establishment, implementation and enforcement of metrological control of gas meters for natural gas custody transfer and trade measurement applications enable to ensure reliable and accurate measurement and fair and equitable trade in the marketplace as well. The main objective was to provide the participants with a further understanding of the issues associated with the gas meter principles, type of gas meters and gas meter type approval and verification, international standards etc. The targeted participants of this training course were those who are actively involved in technical field in the trade measurement of natural gas in the APEC/APLMF member economies.

This is the first time that this gas meter training course was conducted. Due to the great contributions from the trainers as well as the effective collaboration between the host and APLMF Secretariat, I would like to say that this training course is certainly a fruitful activity!

Finally, I would like to express my deeply appreciate again to the APEC Secretariat's generosity in contributing to the development in legal metrology among the APLMF member economies.

May 5, 2010

Mr. Pu Changcheng

APLMF President

Summary Report

Introduction

Natural gas is a vital component of the world's supply of energy. It is one of the cleanest, safest, and most useful of all energy sources. This energy commodity is imported, exported and consumed internationally on a large scale. Measurement plays an extremely important role in the national and international trade of natural gas.

The meters and metering systems used in the trade measurement of natural gas and the methods and equipment used for testing are becoming more technically complex. In order to develop and maintain mutual confidence in the trade measurement of natural gas while reducing technical barriers to trade, APLMF member economies have recognized the need for effective and harmonized legal metrology programs.

Each economy's continued and expanded participation in international legal metrology organizations, sharing of knowledge and experience, and provision and receipt of education and training are all important steps to achieving increased harmonization.

Training Course Organizers

The APEC/APLMF Training Course on Gas Meters was held in Chongqing, P. R. China from April 13 to 16, 2010.

This course was organized by the Asia-Pacific Economic Cooperation (APEC) and the Asia-Pacific Legal Metrology Forum (APLMF) with support from the following organizations:

1. Measurement Canada
2. General Administration of Quality Supervision, Inspection and Quarantine of People's Republic of China (AQSIQ)
3. Chinese Society for Measurement (CSM)
4. Metrology Institute of Chongqing, China

Training Course Participants and Instructors

The level of attendance for this course was excellent with forty-five (45) trainees representing ten (10) economies including Viet Nam, Indonesia, Malaysia, Mongolia, Philippines, Singapore, Chinese Taipei, Thailand, Papua New Guinea and the host economy People's Republic of China.

The instructors for the course were:

Mr. Steve Clyens, Gas Measurement Specialist, Ontario Region, Measurement Canada

Mr. Brad Pavlove, Gas Measurement Specialist, Western Region, Measurement Canada

Measurement Canada is responsible for the administration of the legal metrology legislation for Canada.

Economic Reports

Prior to the delivery of the gas meter training portion of the course, one or more representatives from each of the participating economies made a brief presentation. The intent of each presentation was to address each of the questions below:

1. Explain about your organization and department.
2. Explain your professional experience in your organization.
3. Gas meters used in your economy.
4. Legal metrology system for gas meters in your economy.
5. Explain current situation in your economy about the compliance to the international standards/recommendations for gas meters.
6. Are there any other requirements from your economy?
7. Do you have any problems in order to implement the legal metrology system (budget, human resources, etc.)?

This exercise provided all of the course participants with a greater understanding and appreciation of the level of natural gas infrastructure and the various related legal metrology policies and practices of other APLMF economies.

Training Course Outline

The gas meter training covered a broad range of topics covering the natural gas industry, gas measurement theory, types of gas meters and metering applications and important elements of an effective legal metrology program for natural gas trade measurement. The following modules where presented:

1. Natural Gas Industry & Points of Measurement
2. Need for Metrological Control
3. Legal Units of Measure and their Determination
4. Gas Meters and Measurement Applications
5. Gas Meters——Approval of Type
6. Gas Measuring Apparatus, Standards and Test Equipment
7. Gas Meters——Verification

Additional Learning Opportunities

The trainees who attended the course possessed a variety of technical and legislative expertise in the trade measurement of natural gas. Trainees were strongly encouraged to ask questions and share their own knowledge and experience with the instructors and the other trainees. This provided an additional opportunity for learning and sharing of information and perspectives for the members of all participating economies.

The Metrology Institute of Chongqing was kind enough to provide a tour of their facility in order to highlight some of their calibration, inspection and test equipment and processes. This provided the trainees with an opportunity to ask questions and exchange knowledge with the local metrology experts.

The gas meter manufacturer, Qianwei Kromschroder Meters (Chongqing) Co., Ltd. provided a guided tour of their plant where course participants had the opportunity to see the processes used to manufacture, assemble and calibrate diaphragm meters. This tour concluded with a hands-on exercise for course attendees to practice verification testing of newly manufactured diaphragm meters using two types of volume flow standards: the wet gas meter transfer standard and a sonic nozzle prover.

Conclusion

The successful completion of this course is attributable to the hard work and active participation of all concerned. The excellent level of interaction and participation of the trainees contributed to a very positive and productive learning experience for all concerned.

The success of the training course is due in large part to the exceptional organization and continuous support of the APLMF Executive Secretaries, Mr. GUO Su and Dr. ZHANG Chao.

Mr. Steve Clyens
Gas Measurement Specialist
Measurement Canada

APEC/APLMF Seminars and Training Courses in Legal Metrology

(CTI 09/2009T)

Training Course on Gas Meters

Apr. 13 – 16, 2010

in Chongqing, China

Program

Organizers:

1. Asia-Pacific Economic Cooperation (APEC)
2. Asia-Pacific Legal Metrology Forum (APLMF)

Supporting Organizations:

1. Measurement Canada
2. General Administration of Quality Supervision, Inspection and Quarantine of People's Republic of China (AQSIQ)
3. Chinese Society for Measurement (CSM)
4. Metrology Institute of Chongqing, China

Trainers:

- Mr. Steve Clyens, Gas Specialist, Measurement Canada, Government of Canada
- Mr. Brad Pavlove, Gas Specialist, Measurement Canada, Government of Canada

Course Outline:

Natural Gas Industry & Points of Measurement

Need for Metrological Control

Legal Units of Measure and their Determination

Gas Meters and Measurement Applications

Gas Meters——Approval of Type

Gas Measuring Apparatus, Standards and Test Equipment

Gas Meters——Verification

Venue and Accommodation:

Accomodation for the participants will be prepared in the Golden Quality Hotel, Chongqing,

China with a rate of **50 US dollars** for a single room and **60 US dollars** for a double room, respectively. Please complete the hotel reservation form to make the reservation.

Travel Support:

- **APEC travel support**, composed of a roundtrip airfare in a discount economy class and per diem including accommodation, would be prepared for the participants from **Chile**, **P. R. China**, **Indonesia**, **Malaysia**, **Mexico**, **Papua New Guinea**, **Philippines**, **Peru**, **Russian Federation and Thailand**.
- **APLMF travel support** would be complementary prepared for the non-APEC and full-APLMF member economies; **Cambodia**, **DPR Korea and Mongolia**.
- The maximum number of supported participants is limited to **one** for each economy. The final eligible participants will be decided after an approval by the APEC/APLMF secretariat. All supported participants are **required to prepare a presentation** with a document during the course. The English proficiency of your selected participant will very much affect the training accomplishments, so we hope you can recommend the right participant for the right training course.
- The candidates of the **APEC support** will be **requested to submit an airfare quotation and itinerary in advance and have to wait to buy air ticket until it is approved by the APEC secretariat**. Basically, all payment will be reimbursed directly from APEC after the **travel is** finished. The supported participants have to pay their airfare and accommodation temporarily by themselves until the reimbursement.

Presentation from each economy:

- At least **one participant** from each economy will be requested to provide a **brief presentation** about the legal metrology system on gas meters in his/her economy. The **recommended topic-Gas Meters in each economy**. Some guides on presentation are given below.

1 Self introduction
  1.1 Explain about your organization and department.
  1.2 Explain your professional experience in your organization.
2 Gas Meters used in your economy
3 Legal metrology system for gas meters in your economy
4 Explain current situation in your economy about the compliance to the international standards/recommendations for gas meters.
5 Are there any other requirements from your economy? Do you have any problems in order to implement the legal metrology system (budget, human resources, etc.)?

Registration:

Please complete the attached "**Registration Form**" and send it to the APLMF Secretariat by **March. 8, 2010.**

Access Information:

It may take about 25 min to arrive the hotel from Chongqing Airport by taxi. The fare for the taxi should be less than 40 YUAN. A welcome card is attached for your convenience.

(**Please double click to open the file and print out for your convenience**)

Currency and Credit Cards:

The local currency is Chinese YUAN and JIAO. The notes includes 100, 50, 20, 10, 5, 1 YUAN and 5 JIAO (0.5YUAN) and 1JIAO (0.1YUAN). Major credit cards (Visa, Master Card, etc.) are accepted in Hotels and big department stores.

The exchange rate for 1 USD is about 6.8 YUAN.

Climate:

The average temperature is about (15 ~ 20)℃ in April in Chongqing.

Electricity Supply:

Chinese voltage is 220 ~ 240 volts AC, 50/60 cycles per second. The power plugs used in China are of the 3-pin. 2 pin power plugs are also used in some place.

Local Time:

GMT +8

Contact Persons:

- APLMF Secretariat (Registration, Travel support, Visa assistance, Hotel Reservation)
  Dr. ZHANG Chao & Mr. GUO Su

APLMF Secretariat
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Draft Program

Day 1 April. 13 Tuesday	08 : 30-09 : 00	*Registration*
	09 : 00-09 : 40	Welcoming address from the host economy Welcoming address from the Local Goverment Opening ceremony (APLMF Secretariat) Group photo taking
	09 : 40-10 : 00	Introduction
	10 : 00-10 : 45	Presentation by each economy
	10 : 45-11 : 00	*Coffee break*
	11 : 00-12 : 00	Presentation by each economy
	12 : 00-13 : 15	*Lunch break*
	13 : 15-14 : 15	Natural Gas Industry & Points of Measurement
	14 : 15-15 : 15	Need for Metrological Control
	15 : 20-15 : 35	*Coffee break*
	15 : 35-17 : 00	Need for Metrological Control (con't)
	17 : 00-17 : 45	Report by Invited Speakers
	18 : 30-21 : 00	*Welcome Dinner hosted by the AQSIQ*
Day 2 April. 14 Wednesday	08 : 30-10 : 20	Legal Units of Measure and their Determination
	10 : 20-10 : 35	*Coffee break*
	10 : 35-12 : 00	Gas Meters and Measurement Applications
	12 : 00-13 : 15	*Lunch break*
	13 : 15-15 : 20	Gas Meters and Measurement Applications (con't)
	15 : 20-15 : 35	*Coffee break*
	15 : 35-17 : 10	Gas Meters——Approval of Type
	17 : 10-17 : 45	Report by Invited Speakers
	18 : 30-21 : 00	*Dinner hosted by the Chongqing Bureau of Quality and Technical Supervision*

Day 3 April. 15 Thursday	08：30-10：30	Gas Measuring Apparatus, Standards and Test Equipment
	10：30-10：45	*Coffee break*
	10：45-12：00	Gas Meters——Verification
	12：00-13：15	*Lunch break*
	13：15-15：00	Gas Meters——Verification and Closing Summary
	15：00-18：00	Technical visit (Metrology institute of Chongqing, China)
	18：30-21：00	*Farewell Dinner hosted by APLMF Secretariat*
Day 4 April. 16 Friday	08：30-11：30	Technical visit (Qianwei Kromschroder Meters (Chongqing) Co., Ltd. On-site practice and demonstration
	11：30-12：30	Present certificate and closing ceremony
	12：30-13：45	*Lunch*

Participants List
APEC/APLMF Seminar and Training Courses in Legal Metrology (CTI-09/2009T)
Training Coures on Gas Meters

No.	Category	Economy	Name	Organization
1	APLMF	P. R. China	Dr. ZHENG Huaxin	APLMF Secretary, Department of Metrology, AQSIQ
2	APLMF	P. R. China	Dr. ZHANG Chao	APLMF Secretary, Department of Metrology, AQSIQ
3	APLMF	P. R. China	Mr. GUO Su	APLMF Secretary, Department of Metrology, AQSIQ
4	Trainer	Canada	Mr. Steve Clyens	Measurement Canada
5	Trainer	Canada	Mr. Brad Pavlove	Measurement Canada
6	Participant	Indonesia	Ms. Larisa Deviyani	Directorate of Metrology
7	Participant	Indonesia	Ms. Ema Andhajani	Directorate of Metrology
8	Participant	Thailand	Mr. Prathan Bunkhong	Central Bureau of Weights and Measure
9	Participant	Thailand	Ms. Lamoon Chanatalay	Central Bureau of Weights and Measure
10	Participant	PNG	Mr. Victor Gabi	Papua New Guinea-National Institute of Standards and Industrial Technology
11	Participant	P. R. China	Ms. Ren Tingting	Chongqing Acadamy of Metrology and Quality Inspection
12	Participant	P. R. China	Mr. Yang Youtao	Beijing Institute of Metrology
13	Participant	Philippines	Ms. Rhea B. Banglay	National Metrology Laboratory, Industrial Technology Development Institute (NML-ITDI)

14	Participant	Malaysia	Mr. Syahrul bin Manap	National Metrology Laboratory-SIRIM Berhad
15	Participant	Singapore	Mr. Lee Kok Kin	SP PowerGrid Ltd
16	Participant	Viet Nam	Mr. Duong Hong Son	Directorate for Standards, Metrology and Quality (STAMEQ)
17	Participant	Mongolia	Mr. Munkhbat Zaankhuu	MASM
18	Participant	Chinese Taipei	Mr. Hsien-Liang Chen	Bureau of Standards, Metrology & Inspection
19	Participant	Singapore	Mr. Pau Yuen, Adrian	SPRING Singapore
20	Participant	Singapore	Mr. Lim Yong Seng	SPRING Singapore
21	Participant	Singapore	Mr. Liao Deliang	SP PowerGrid Ltd
22	Participant	Indonesia	Ms. Sri Astuti	Metrological Training Centre
23	Participant	Indonesia	Ms. Yenni Marlin	Metrological Training Centre
24	Participant	Indonesia	Mr. Helmi	Regional Verification Offices
25	Participant	Indonesia	Mr. Djoko Yoel	Regional Verification Offices
26	Participant	Indonesia	Mr. Tony Endro	Regional Verification Offices
27	Participant	Viet Nam	Mr. Le Xuan Thai	Directorate for Standards, Metrology and Quality (STAMEQ)
28	Participant	Viet Nam	Mr. Dinh Van Bien	Directorate for Standards, Metrology and Quality (STAMEQ)
29	Participant	Viet Nam	Mr. Nguyen Xuan Thai	Directorate for Standards, Metrology and Quality (STAMEQ)
30	Host	China	Mr. Kong Xiaokang	International Cooperation Department, AQSIQ, China
31	Host	China	Mr. Liu Xinmin	Department of Metrology, AQSIQ, China

32	Local participant	China	Ms. Niu Lina	Hebei Provincial Institute of Metrological Supervision and Measurement
33	Local participant	China	Ms. Xiang Liping	National Institute of Measurment and Test Technology, China
34	Local participant	China	Mr. Xiong Tao	Chongqing Shancheng Gas Equipment Co., Ltd.
35	Local participant	China	Ms. Wan Lifen	Hubei Privincial Institute of Measurment and Test Technology
36	Local participant	China	Ms. Li Mei	Shanxi Institute of Metrology
37	Local participant	China	Ms. Zhang Weiwei	Heilongjiang Institute of Metrology
38	Local participant	China	Mr. Mo Xiao'ou	Yunan Institute of Metrology
39	Local participant	China	Ms. Zheng jianying	Zhejiang Institute of Metrology
40	Local participant	China	Mr. Zhan Zhijie	Zhejiang Institute of Metrology
41	Local participant	China	Mr. Liu Zhenzhong	Tianjin Institute of Metrology
42	Local participant	China	Mr. Wang Ke	Jiangsu Institute of Metrology
43	Local participant	China	Mr. Wang Zhen	Liaoning Institute of Metrology
44	Local participant	China	Mr. Han Cong	Liaoning Institute of Metrology
45	Local participant	China	Mr. Liu yiping	Shanghai Institute of Metrology

46	Local participant	China	Mr. Zhou Yu	Chongqing Jingyi instrument Co., Ltd.
47	Local participant	China	Mr. Xiao Bao	Chongqing Jingyi instrument Co., Ltd.
48	Local participant	China	Mr. Luo Huakui	Qianwei Kromschroder Meters(Chongqing) Co., Ltd.
49	Local participant	China	Mr. Tang Changshe	Guangdongi Institute of Metrology
50	Local participant	China	Mr. Xiang Dehua	Hunan Institute of Metrology
51	Local participant	China	Ms. Lv Yahui	Chongqing Shancheng Gas Equipment Co., Ltd.
52	Local participant	China	Mr. Tang Shuli	Chongqing Shancheng Gas Equipment Co., Ltd.
53	Local participant	China	Ms. Zhang Ruina	Chongqing Shancheng Gas Equipment Co., Ltd.
54	Local participant	China	Mr. Ji Jianying	Shandong Institute of Metrology
55	Local participant	China	Mr. Hu Zhipeng	Anhui Institute of Metrology
56	Local participant	China	Mr. Yu Chengwei	Tancy Instrument Group Co., Ltd.
57	Local participant	China	Mr. Long Xianhan	Itron Instrument System (Chongqing) Co., Ltd.
58	Local participant	China	Ms. Fu Sixiao	Ximei Instrument Co., Ltd.

Asia-Pacific Economic Cooperation

Asia-Pacific Legal Metrology Forum

Natural Gas Meters

APEC/APLMF Training Courses in Legal Metrology
April 13—16, 2010
Chongqing, China

Measurement Canada | Mesures Canada

Presenters: Steve Clyens, Measurement Canada
Brad Pavlove, Measurement Canada

Introduction

Our goal is to provide a general overview of legal metrological controls applied to trade measurement devices and systems in the natural gas industry.

The following topics will be presented and discussed:

1. Natural Gas Industry & Points of Measurement
2. Need for Metrological Control
3. Legal Units of Measure and their Determination
4. Gas Meters and Measurement Applications
5. Gas Meters —— Approval of Type
6. Gas Measuring Apparatus, Standards and Test Equipment
7. Gas Meters —— Verification

What follows is a brief description of the contents of each topic.

Course Outline

Natural Gas Industry & Points of Measurement

- brief description of natural gas
- natural gas industry from wellhead to burner tip
- points within the industry where measurement is done
- custody transfer and trade measurement applications

Need for Metrological Control

- brief overview of what is at stake when financial transactions are based on measurement
- why controls are necessary
- how legal metrology provides for this control
- how much control is required
- what form this control takes
- importance of not creating technical barriers to trade when establishing legal metrological controls

Course Outline

Legal Units of Measure & their Determination

- describes how an economy's metrology legislation defines legal units of measurement for the sale of natural gas
- permissible quantities and their units of measure
- review of some of the scientific gas laws and principles used in determination of legal units of measure

Gas Meters & Measurement Applications

- common types of gas meters and auxiliary devices used individually and in combination to establish legal units of measure
- design and construction
- principle of operation
- sizes and capacities
- types of applications

Course Outline

Gas Meters — Type Approval

- emphasizes the importance of type approval as a legal metrological control
- provides a general description of the type approval process

Gas Measuring Apparatus, Standards & Test Equipment

- shows various types of measuring apparatus and standards used in Canada for type approval and verification testing of gas meters and auxiliary devices

Course Outline

Gas Meters — Verification

- what is verification
- establishing verification requirements
- national and international verification requirements
- who conducts verification
- gas meter inspection and test procedures
- technical requirements for gas meters
- metrological requirements for gas meters
- verification marking and sealing
- verification certificate
- verification periods

Questions / Comments?

We welcome interactive comments and questions throughout the training sessions and outside of the training sessions.

We are here to share our own knowledge and experience as well as to learn from yours.

Asia-Pacific Economic Cooperation

Asia-Pacific Legal Metrology Forum

Natural Gas Industry & Points of Measurement

APEC/APLMF Training Courses in Legal Metrology
April 13—16, 2010
Chongqing, China

Measurement Canada | Mesures Canada

Presenters: Steve Clyens, Measurement Canada
Brad Pavlove, Measurement Canada

Developed by: Steve Clyens, Measurement Canada

What is Natural Gas?

Natural gas is:

- a vital component of the world's supply of energy
- combustible and when burned gives off a great deal of energy
- one of the cleanest, safest and most useful of all energy sources
- a mixture of hydrocarbon gases, primarily methane
- is colorless, shapeless and odorless in its pure form

End Uses of Natural Gas

Natural gas is used is many application, such as:

- home and commercial space heating and cooling
- fuel for cooking and clothes drying
- fuel for dedicated NGV vehicles, i.e taxis, buses, etc.
- residential, commercial & industrial hot water heating
- industrial and manufacturing processes
- electricity generation

Forms of Natural Gas

There are many terms used in the natural gas industry to describe the content, quality and state of natural gas (NG).

Raw NG	as extracted from source (crude oil, dry gas & condensate wells)
Wet NG	from condensate well, includes heavy hydrocarbon liquids
Sour gas	natural gas with hydrogen sulphide (> 5.7 mg/m^3)
Sweet gas	natural gas relatively free of hydrogen sulphide
Dry NG	processed, consumer grade natural gas
CNG	compressed natural gas
NGL	natural gas liquids, i,e ethane, propane, butanes, pentanes, etc.
LNG	liquefied natural gas, cooled to ~ –260 °C

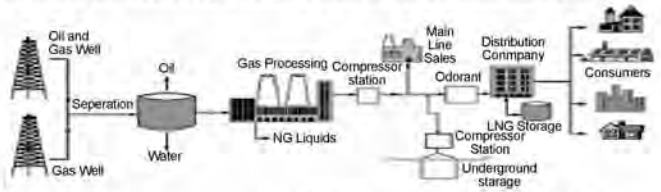
Natural Gas Composition

The composition of natural gas can vary widely. The table below outlines the typical makeup of natural gas before and after it is processed.

		Raw NG	Processed NG
Methane	CH_4	(70 ~ 90)%	(87.0 ~ 96.0)%
Ethane	C_2H_6	0 ~ 20%	(1.5 ~ 5.1)%
Propane	C_3H_8	0 ~ 20%	(0.1 ~ 1.5)%
Butanes	C_4H_{10}	0 ~ 20%	(0.01~ 0.3)%
Pentanes	C_5H_{12}		0.00 ~ 0.14%
Hexanes	$+C_6+$		0.00 ~ 0.06%
Carbon Dioxide	CO_2	0 ~ 8%	(0.1 ~ 1.0)%
Oxygen	O_2	0 ~ 0.2%	(0.01 ~ 0.1)%
Nitrogen	N_2	0 ~ 5%	(0.7 ~ 5.6)%
Hydrogen Sulphide	H_2S	0 ~ 5%	< 5.5 mg/m^3 (as odorant)
Water	H_20		< 80 mg/m^3

Natural Gas Industry Sectors

The natural gas industry, from wellhead to burner tip, is divided into 3 sectors.



Upstream

- exploration (land/offshore)
- extraction (land/offshore)
- preliminary processing (land/offshore)

Midstream

- gathering systems
- delivery to processing plants
- processing (separation/fractionation)
- NGL & NG Storage
- transmission

Downstream

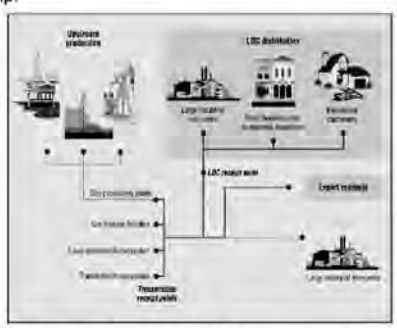
- transmission
- local distribution
- end users

Points of Measurement in Natural Gas Industry

Need to accurately measure the flow of natural gas at multiple points within the industry from well head to burner tip.

Points of measurement include:

- wellheads
- gas gathering inlets / outlets
- gas plant inlets / outlets
- transmission pipeline receipt
- storage injection / extraction
- import / export as NG & LNG
- LDC receipt
- power generation
- NGV (CNG) dispensers
- industrial, commercial & residential end users



• represents a point of measurement

Measurement Applications

Allocation Measurement

used to determine the portion of hydrocarbons attributable to one or more platforms, leases, units, or wells, in relation to the total production from a group

Fiscal Measurement

used in connection with purchase and sale and the calculation of taxes and royalties

Custody Transfer and Trade Measurement

used where there is a transfer and sale of processed natural gas from one party to another

Custody Transfer & Trade Measurement

The table below shows different categories of custody transfer applications.

Measurement Application	Pressure Range	Typical Meter Capacity
Residential (fixed delivery pressure)	< 0.5 psig < 3.5 kPag	up to 250 cfh up to 7.1 m^3/h
Small Commercial (fixed delivery pressure)	2, 5, 10, 15, 20, 25 & 30 psig 14, 35, 70, 105, 140, 175, 210 kPag	~250 to 7000 cfh ~ 7.1 to 200 m^3/h
Large Commercial Small Industrial (distribution pressure)	~ 40 to 60 psig ~ 280 to 420 kPag	~ 7000 to 60000 cfh ~ 200 to 1700 m^3/h
Large Industrial	~ 300 to 1000 psig ~ 2.1 to 7.0 MPag	~ 11000 to 230000 cfh ~ 300 to 6500 m^3/h
Transmission to LDC	~ 700 to 1500 4.9 to 10.5 MPag	~ 30000 to 230000 cfh ~ 850 to 6500 m^3/h
NG Storage Transmission Main Pipeline	~ 700 to 1500 4.9 to 10.5 MPag	up to 1500000 cfh up to 42500 m^3/h
CNG Fuel Dispensers	~ 3000 to 3600 psig ~ 21 MPag to 25.2 MPag	decreases as filling

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Need for Metrological Control

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What is at Stake?

Processed natural gas is a valuable commodity that is bought and sold on the basis of measurement at various points of custody transfer and end use.

The seller expects to receive the full financial value for the natural gas quantity actually delivered.

The purchaser expects to receive the actual quantity of natural gas for which they are paying.

Errors in measurement methods, measuring devices and measurement calculations can have very significant negative financial impact on the seller and the purchaser.

Need for Metrological Control

Metrological controls established, implemented and enforced by government for natural gas custody transfer and trade measurement applications ensure:

- reliable and accurate measurement
- standardized requirements and methods are used
- fair and equitable trade in the marketplace
- consumer protection & confidence
- prevention of fraud against vulnerable parties
- sustainable national and international trading economy

Government provides for metrological control through legal metrology.

Metrology & Legal Metrology

From OIML document, *International Vocabulary of Terms in Legal Metrology (VIML), Edition 2000*

metrology

science of measurement

legal metrology

part of metrology relating to activities which result from statutory requirements and concern measurement, units of measurement, measuring instruments and methods of measurement and which are performed by competent bodies

legal metrological control

the whole of legal metrology activities which contribute to metrological assurance

Level of Intervention by Responsible Authority

Each economy will identify and establish the responsible authority or authorities for legal metrology relating to natural gas measurement.

The responsible authority must determine its level of intervention in the natural gas industry.

It will identify where in the industry sector:

- are the vulnerable parties?
- are custody transfer and trade measurement occurring?

Does it need to intervene in the:

- upstream sector? If so, to what extent?
- midstream sector? If so, to what extent?
- downstream sector? If so, to what extent?

Legal Metrology Organization

The structure of the organization(s) concerned with legal metrology varies from one economy to another.

The legal metrology structure may consist of the following components:

- Science & Engineering
  - device type approval and measurement standard calibration laboratories
  - technical standards and specifications development
- Accreditation
  - evaluation, recognition and monitoring of alternative service companies
- Policy
  - development and administration, legislative review
- Enforcement
  - measuring device and installation/use verification, dispute resolution

Metrology Legislation

Legislation on metrology usually provides for the following:

- legal units of measurement
- hierarchy, traceability, calibration & certification of measurement standards
- development, implementation and enforcement of:
  - supporting regulations
  - metrological and technical specifications
  - administrative requirements
- metrological control of measuring instruments used in trade through:
  - type approval, verification, installation & use, re–verification
- offences & penalties
- dispute resolution

Technical Barriers to Trade

Metrology legislation must satisfy the needs of the economy while avoiding setting up technical barriers to international trade. An economy achieves this through:

1. Membership and participation in international metrology and legal metrology organizations, i.e BIPM, OIML, APLMF, WELMEC, AFRIMETS, SIM, etc.
2. Harmonization of their legal, technical and metrological requirements with that of other economies through full or partial adoption of international standards and recommendation documents.
3. Mutual Recognition Agreements with other economies to mutually recognize each others results of test and evaluation procedures for type approval of devices.
4. Mutual Acceptance Arrangements with other economies to mutually accept each others test results for use in their own type approval procedures.

Asia-Pacific Economic Cooperation

Asia-Pacific Legal Metrology Forum

Legal Units of Measure and their Determination

APEC/APLMF Training Courses in Legal Metrology
April 13—16, 2010
Chongqing, China

Measurement Canada / Mesures Canada

Presenters: Steve Clyens, Measurement Canada
Brad Pavlove, Measurement Canada

Developed by: Steve Clyens, Measurement Canada

Definition

From OIML document, *International Vocabulary of Terms in Legal Metrology (VIML), Edition 2000*

4.1 **legal units (of measurement)**

units of measurement required or permitted by regulations

Establishing Legal Units of Measure

The responsible authority identifies and defines the Legal Units of Measure for the sale of natural gas on the basis of measurement.

1. will the measured natural gas be in the gaseous state, liquid state or both?
2. what quantities and what corresponding units of measure will be permitted?
3. will non SI and/or SI (metric) units of measure be permitted?
4. how are the legal units of measure for each quantity to be established?

Natural gas, in the gaseous state, might be measured and sold in quantities, and corresponding units, of:

- Mass
- Volume
- Energy

Sale of Natural Gas by Mass

Potential legal units of measure for the sale of natural gas on the basis of mass include:

Non SI Units	SI (metric) Units
lbm	kg

Mass may be measured directly or calculated using measured volume and mass density.

Sale of Natural Gas by Volume (gaseous state)

Potential legal units of measure for the sale of natural gas by volume would be expressed as standard volume and include:

Non SI Units	SI (metric) Units
standard cubic feet (scf)	standard cubic metres (sm^3)

Standard Volume is the volume referenced to standard pressure and standard temperature.

This ensures equity in trade transactions and facilitates price setting.

Standard Volume

The responsible authority may define standard pressure and temperature values.

Consider the units and values in use by the natural gas industry and international trading partners.

Non SI Units

OPEC and much of the natural gas industry in North America use:

Imperial Standard Volume = cubic feet at 14.73 psia & 60 °F

SI (metric) Units

Natural gas companies in Europe and South America use:

Standard Volume = cubic metres at 101.325 psia & 15 °C

Other values for standard conditions may also be in use around the world.

Gas Physics and Laws

A quick review of some basic gas physics and laws will help demonstrate how standard volume is established.

- Absolute Pressure
- Absolute Temperature
- Boyle's Law
- Charles Law
- Ideal and Combined Gas Laws
- Real Gases and Compressibility

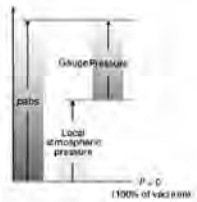
Absolute Pressure

Pressure measured or calculated on an absolute scale, the zero of which represents the pressure exerted by a total vacuum.

Absolute Pressure = Atmospheric Pressure + Gauge Pressure

Atmospheric pressure is the pressure exerted by the earth's atmosphere at any given location.

Gauge pressure is measured on scale the zero of which is atmospheric pressure at the time and place the measurement is taken.



non SI Units	SI (metric) Units
psi, atm, Torr, bar, in Hg, mm Hg, in wc	Pa

Absolute Temperature

Temperature measured or calculated on an absolute scale, the zero of which is absolute zero.

Non SI Units

Absolute Zero = −459.67 °F

Absolute Temperature (°R) = 459.67 + Temperature (°F)

SI (metric) Units

Absolute Zero = −273.15 °C

Absolute Temperature (K) = 273.15 + Temperature (°C)

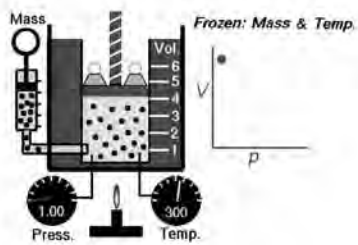
Boyle's Law

Volume of any definite mass of gas at a constant temperature varies inversely with change in absolute pressure

$V \propto \frac{1}{p}$ (constant T)

$pV = k$

$V_1 p_1 = V_2 p_2$



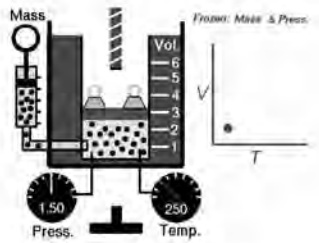
Charles Law

Volume of any definite mass of gas at a constant pressure varies directly with change in absolute temperature.

$V \propto T$ (constant p)

$\frac{V}{T} = k$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$



Ideal and Combined Gas Laws

When Boyle's and Charles' laws are combined, the resulting equation gives the relation between volume, pressure and temperature of a gas.

$\frac{Vp}{T} = k$ For ideal (perfect) gases, $pV = kT$, where $k = nR$

$pV = nRT$ (Ideal Gas Law)

$\frac{V_1 p_1}{T_1} = \frac{V_2 p_2}{T_2}$ (Combined Gas Law)

The ideal and combined gas laws hold true for ideal (perfect) gases.

Real Gases and Compressibility

Real (imperfect) gases deviate from the Ideal Gas Law. This deviation is related to the compressibility factor, z, of the gas.

$\frac{pV}{kT} = z$

$z = 1$ for an ideal gas at all p & T values

z varies for a real gas with changes in pressure, temperature and composition

$\frac{Vp}{Tz} = k$

$\frac{V_1 p_1}{T_1 z_1} = \frac{V_2 p_2}{T_2 z_2}$

$V_2 = V_1 \times \frac{p_1}{p_2} \times \frac{T_2}{T_1} \times \frac{z_2}{z_1}$

This equation holds true for real (imperfect) gases such as natural gas.

Compressibility Standards

The responsible authority may choose to define the conditions under which compressibility must be accounted for and the acceptable methods of calculation.

Some Standards that publish equations to calculate compressibility factors are:

1. A.G.A. Transmission Measurement Committee Report No. 8,1992 (1994 Rev)
   - adopted by American Petroleum Institute as A.P.I. Chapter 14.2
   - includes a Detailed method and two Gross Methods
2. A.G.A. Transmission Measurement Committee Report No. 8, 1985
   - includes a Detailed method and five Gross Methods
3. A.G.A. Report NX−19, 1962
   - developed for calculations of supercompressibility factors

Determination of Standard Volume

The Combined Gas Law for real gases would be used to convert volume metered at flowing conditions to volume at standard conditions.

$$V_S = V_R \times \frac{p_F}{p_S} \times \frac{T_S}{T_F} \times \frac{Z_S}{Z_F}$$

where,
- V_s is standard volume
- V_R is metered volume at flowing conditions
- p_F is absolute flowing pressure
- p_S is absolute standard pressure
- T_F is absolute flowing temperature
- T_S is absolute standard temperature
- z_F is compressibility factor at flowing conditions
- z_S is compressibility factor at standard conditions

$$V_S = V_R \times p_M \times T_M \times F_{PV}^2$$

where,
- V_s is standard volume
- V_R is the metered volume at flowing conditions
- p_M is the pressure multiplier
- T_M is the temperature multiplier
- F_{PV}^2 is the supercompressibility factor

In differential pressure metering applications, unsquared F_{PV} or $(z_S/z_F)^{0.5}$ is used and V_R is a calculated quantity.

Sale of Natural Gas by Energy

Potential legal units of measure for the sale of natural gas on the basis of energy include:

Non SI Units	SI Units
$BTU_{(IT)}$, $BTU_{(59)}$, $BTU_{(60.5)}$ therms, calories	Joules, kWh

The energy produced by combustion of a given quantity (mass or volume) of natural gas is called heating value, calorific power or energy density.

This is directly related to the quality or composition of the natural gas.

Heating Value – Gross or Net

Gross (or high, upper) Heating Value

The amount of heat produced by the complete combustion of a unit quantity of fuel.

Assumes all water (H_2O) produced by combustion and/or entering with fuel and air leaves as condensed liquid.

Net (or lower) Heating Value

Obtained by subtracting the latent heat of vaporization of the water vapour formed by the combustion from the gross or higher heating value.

Assumes all water leaves as vapour or steam.

Heating Value – Dry, Wet or as Delivered Basis

Dry Basis

Gross or Net Heating Value of a volume of gas at reference conditions which contains no water vapour.

Saturated Basis

Gross or Net Heating Value of a volume of gas at reference conditions which is saturated with water.

As Delivered (Wet) Basis

Gross or Net Heating Value of a volume of gas at reference conditions which delivered with variable water content. The water content must be known in order to specify the wet-basis heating value.

Heating Value – Ideal or Real Basis

Ideal basis

Volume based heating value is established based on ideal gas equations of state.

Real basis

Volume based heating value adjusted for the compressibility of natural gas at the applicable reference conditions for pressure and temperature.

Heating Value Standards

API MPMS 14.5, *Calculation of Gross Heating Value, Specific Gravity & Compressibility of Natural Gas Mixtures from Compositional Analysis*

GPA 2145, *Table of Physical Constants of Paraffin Hydrocarbons and other Components of Natural Gas*

GPA 2172, *Calculation of Gross Heating Value, Relative Density and Compressibility Factor for Natural Gas Mixtures from Compositional Analysis*

AGA Report No. 5, Natural Gas Energy Measurement

ISO 6976, *Calculation of Calorific Values, Relative Density and Wobbe Index from Composition*

Heating Value Units

The responsible authority may specify the following criteria for heating values used in the determination of legal units of energy.

- mass and/or volume based units
- gross (high) or net (low)
- dry, saturated or as delivered basis
- ideal or real basis

Mass based units	Volume based units
$BTU_{(?)}$/lb	J/m^3
J/kg	$BTU_{(?)}/ft^3{}_{(?)}$
kcal/kg	

(?) need to identify the specific BTU temperature reference component
(??) need to reference pressure and temperature conditions for the volumetric component

Examples: Gross (real, dry) HV = 1010 $BTU_{(IT)}$ / cf (at 14.73 psi & 60 °F)
37.5 MJ / m^3 (at 101.325 kPa & 15 °C)

Determination of Energy

Legal units of energy are determined using either of the equations given below:

Energy = Mass x mass-based Heating Value

Energy = Volume x volume-based Heating Value

The reference pressure and temperature of the measured volume should be the same as those for the volume-based heating value.

Example:

Energy = Volume x volume-based Heating Value

$$= 1000 \text{ SCF} \times 1010 \frac{BTU_{(IT)}}{SCF} \text{ (gross, dry, real, at 14.73 psi \& 60 °F)}$$

$$= 1010000 \, BTU_{(IT)} = 1010 \, MBTU_{(IT)}$$

Asia-Pacific Economic Cooperation

Asia-Pacific Legal Metrology Forum

Gas Meters & Measurement Applications

APEC/APLMF Training Courses in Legal Metrology
April 13—16, 2010
Chongqing, China

Measurement Canada | Mesures Canada

Presenters: Steve Clyens, Measurement Canada
Brad Pavlove, Measurement Canada

Developed by: Steve Clyens, Measurement Canada

Volume, Mass & Energy Measurement

1. Volume measurement of natural gas requires a means of:

- measuring volume at flowing conditions
- sensing temperature of flowing gas
- sensing pressure of flowing gas or ensuring gas is delivered at a fixed pressure
- converting volume at flowing temperature and pressure conditions to volume at standard pressure and temperature
- calculating and applying supercompressibility correction

2. Mass measurement of natural gas simply requires a mass flow meter.

3. Energy measurement of natural gas requires a means of:

- determining heating value of natural gas
- applying heating value to measured mass or measured standard volume

Gas Meters—Principle of Operation

A gas meter's principle of operation is generally categorized as positive displacement or inferential.

Positive Displacement

- precise volumes of gas are isolated and moved from the meter's inlet to it's outlet
- a known volume of gas is displaced for each complete cycle of the meter

Inferential

- volume or mass is inferred by some characteristic or measurement directly related or proportional to the volume or mass flow of gas through the meter
- meter incorporates into its design the relation between the detected parameter or property and the inferred quantity

Diaphragm Meter

- most common type of gas meter used in the natural gas industry
- principle of operation is positive displacement
- flow capacities range from 100 to 5000 acfh (28 ~ 140m^3/h)
- rated pressure ranges from 5 psig (35 kPag) for small diaphragm meters up to 100 psig (700 kPag) for larger diaphragm meters
- available in Imperial and SI units of volume
- non-temperature converting models for indoor use and temperature converting (TC) models for outdoor use
- TC versions register or indicate volume referenced to a base temperature value

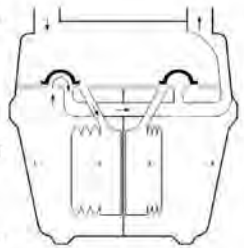
Diaphragm Meter— Construction

Main components of a diaphragm meter are:

1. body to contain the gas and form compartments
2. diaphragms (bellows)
3. valve covers and seats
4. linkage, crank shaft and STD (non-TC) or TC tangent
5. counter

Diaphragm Meter— Operation

- slight pressure drop across the meter causes it to operate (gas moves from high to low pressure)
- diaphragms (bellows) and compartments alternately fill and empty
- linkages convert linear motion of the bellows into rotary motion of a crank shaft
- crank shaft drives valve covers to move gas through the meter
- an adjustable non-TC or TC tangent is attached to the top of the crank to control the amount of rotation applied to the counter
- the counter records the non-TC or TC volume of gas passed through the meter



Diaphragm Meter — Flowrate Capacity

Manufacturers establish the flowrate capacity of their meters based on:

- a particular differential pressure across the meter, i.e ½ " w.c.
- absolute pressure of 14.73 psia at meter inlet
- specific gravity of flowing gas, i.e 0.60 or 0.64 for natural gas, 1.0 for air

$$\text{Flowrate Capacity (Air)} = \text{Flowrate Capacity (Natural Gas)} \times \sqrt{\frac{\text{SG (NG)}}{\text{SG (Air)}}}$$

Consider Elster American Meter Company's AL-425 diaphragm meter.

$$\text{Flowrate Capacity (Air)} = 425\,\text{acfh} \times \sqrt{\frac{0.64}{1}} = 340\,\text{acfh}$$

Measurement Canada requires air flowrate capacity to be marked on meter.

Diaphragm Meter — Classes

Diaphragm meters are generally organized in to classes based on flow capacities. Classes may vary between different economies and/or manufacturing standards.

Measurement Canada			ANSI B109.1 & B109.2 (North America)			Metric (SI) Classes (International)	
Class		Air Capacity (acfh)	Class		Gas Capacity (cfh)	Class	Gas Capacity (m^3/h)
Small	100	< 140	Small	50	50 ~ 175	G1.6	2.5
	200	140 ~ 200		175	175 ~ 249	G2.5	4
	300	201 ~ 300		250	250 ~ 399	G4	6
	400	301 ~ 400		400	400 ~ 499	G6	10
	500	401 ~ 500	Large	500	500 ~ 899	G10	16
Large	600	501 ~ 600		900	900 ~ 1399	G16	25
	700	601 ~ 700		1400	1400 ~ 2299	G25	40
	800	701 ~ 800		2300	2300 ~ 3499	G40	65
	900	801 ~ 900		3500	3500 ~ 5599	G65	100
	1000	901 ~ 1000				G100	160

Diaphragm Meter — Applications

Small diaphragm meters (< 500 cfh or 14 m^3/h) are used on residential and small commercial services.

A domestic pressure regulator upstream of the TC diaphragm meter ensures gas is delivered at a fixed pressure ~0.25 psig (~1.75 kPag).

V_{STD} = TC meter volume × fixed pressure multiplier (p_M)

Small and large diaphragm meters are used on commercial services.

A pressure regulator upstream of the TC diaphragm meter is used to deliver gas at a fixed pressure between 2 to 30 psig (14 to 210 kPag).

V_{STD} = TC meter volume × fixed (p_M)

Rotary Meter

- principle of operation is positive displacement
- measures gas volume at flowing conditions
- flow capacities up to 102000 acfh (2900 m^3/h)
- maximum rated working pressure is usually 125 psig or 175 psig (875 or 1225 kPag) and higher pressure versions are available
- available with Imperial and SI units of volume
- connection of mechanical or electronic attachments
  - ID (instrument drive)
  - standard counter
  - TC (temperature converted) counter
  - TC ID (temperature converted instrument drive)
  - electronic TC counter
  - electronic PTZ volume conversion device

Rotary Meter — Construction

Main components include:

1. pressure body
2. two lobed lobed impellers positioned 90° from each other
3. drive shaft, timing gear and output drive
4. optional temperature thermowell
5. optional mechanical or electronic auxiliary attachment

Some rotary meters have a removable measurement cartridge.

Rotary Meter — Operation

- enclosed spaces between impeller and wall of the pressure body traps a precise volume
- slight pressure drop across the meter causes the impellers to rotate
- rotating impellers move precise amounts of gas from the meter inlet to the meter outlet

- a complete rotation of each impeller displaces a known volume of gas. The volume displacement for each meter size is established by the manufacturer.
- rotation of the impellers is transferred to an output interface (rotating magnetic cup) that drives an auxiliary device
- a mechanical counter incorporates a gear reduction system to totalize displaced volume

Rotary Meter — Sizes

Rotary meters are available in many sizes based on flowrate capacity in Imperial and SI units.

Standard Imperial Sizes		Standard SI Sizes	
Model Designation	Qmax (cfh)	Model Designation	Qmax (m^3/h)
1M	1000	G16	25
1.5M	1500	G25	40
2M	2000	G40	65
3M	3000	G65	100
5M	5000	G100	160
7M	7000	G160	250
11M	11000	G250	400
16M	16000	G400	650
23M	23000	G650	1000
38M	38000	G1000	1600
56M	56000		

Rotary Meter — Applications

Rotary meters are used on commercial and small industrial services.

A pressure regulator upstream of the rotary meter with a mechanical or electronic TC counter ensures gas is delivered at a fixed pressure of 0.25 to 30 psig (1.75 to 210 kPag).

V_{STD} = TC counter volume × fixed pressure multiplier (p_M)

A rotary meter with an electronic volume conversion (PTZ) device is installed on a service at distribution pressure that may vary between 40 and 60 psig (280 to 420 kPag).

Volume measured by the rotary meter is converted to standard volume by the electronic volume conversion (PTZ) device.

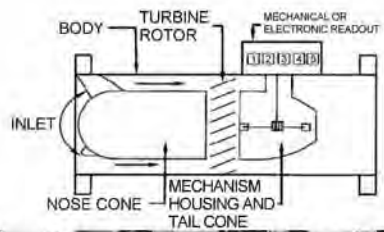
Turbine Meter

- principle of operation is inferential
- measures gas volume at flowing conditions
- flow capacities range from 900 to 230000 acfh (25.5 to 6500 m^3/h)
- maximum rated working pressure from 125 psig to 1440 psig (875 or 10080 kPag) and higher pressure versions are available
- available with Imperial and SI units of volume
- connection of mechanical or electronic attachments

Turbine Meter — Construction

Main components include:

1. piece pressure body
2. nose cone
3. turbine rotor
4. intermediate gear train
5. instrument drive output and/or high frequency pulse output
6. optional counter, mechanical or electronic auxiliary attachment



Turbine Meter — Operation

- gas enters the meter and is directed between nose cone and interior wall
- gas velocity increases as it moves towards the rotor
- as flowing gas contacts the angled rotor blades, the kinetic energy ($1/2\ mv^2$) of the gas causes the rotor to turn
- rotational speed of the rotor is directly proportional to volume flowrate
- rotor drives an intermediate gear train which drives a mechanical instrument drive volumetric output
- sensors detect rotor rotation and produce a proportional volumetric frequency output

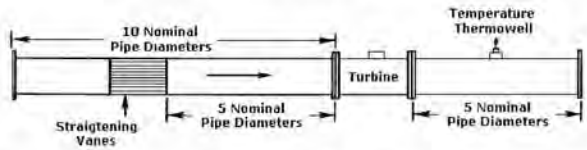
Turbine Gas Meter — Installation Configuration

Turbine meters are susceptible to installation effects (swirl, jetting, pulsations) that have a negative impact on accuracy of measurement.

Meter run installation configuration and in service maintenance are important to ensure continued accurate performance.

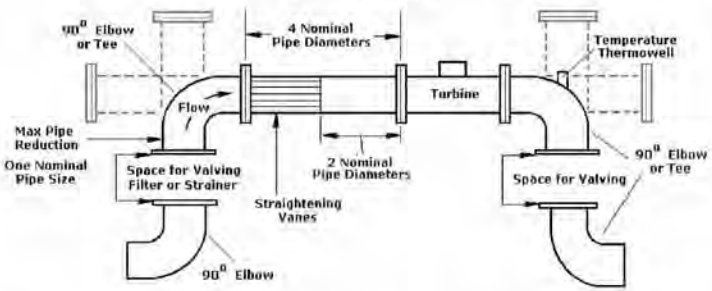
AGA Report No. 7 includes recommendations for turbine meter installation and use.

RECOMMENDED INSTALLATION OF AN INLINE GAS TURBINE METER
(Minimum Lengths)



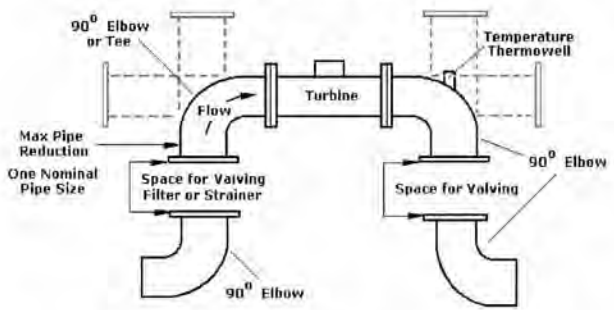
Turbine Gas Meter — Installation Configuration

SHORT COUPLED INSTALLATION OF AN INLINE GAS METER
(Minimum Lengths)



Turbine Gas Meter — Installation Configuration

CLOSE COUPLED INSTALLATION OF AN INLINE GAS METER
WITH INTEGRAL STRAIGHTENING VANES



Turbine Gas Meter — Applications

Turbine meters are used on:

- small industrial services at LDC pressures of 40 to 60 psig (280 to 420 kPag)
- large industrial end use services at high pressures > 60 psig (>420 kPag)
- LDC receipt gate stations and transmission pipeline receipt stations at high pressure up to 1500 psig (10500 kPag)



Auxiliary equipment is required to convert meter volume to standard volume.

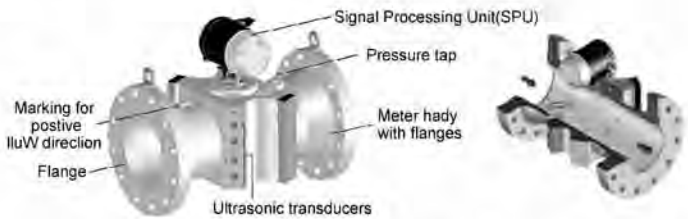
Transit Time Ultrasonic Meter

- principle of operation is inferential
- measures gas volume at flowing conditions
- meter spool pieces range in size from 3 to 30 inch diameters
- flow capacities range from 16000 to 1600000 acfh (450 to 45200 m^3/h)
- maximum rated working pressure ranges from 250 psig to 3600 psig (1750 to 25200 kPag) (300, 600, 900, 1500 & 2500 ANSI ratings)
- configurable in Imperial or SI units of volume
- uni or bi-directional flow measurement capability


Transit Time Ultrasonic Meter — Construction

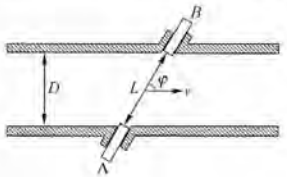
Main components include:

1. spool piece pressure body
2. one or more pairs of ultrasonic transducers in precise geometric configuration
3. signal processing unit
4. explosion proof electronics housing



Transit Time Ultrasonic Meter — Operation

- ultrasonic pulses are emitted and received back and forth between transducer pairs
- transit upstream and downstream is timed (dependent on gas velocity, speed of sound and density)
- volume flow is directly proportional to transit time downstream minus transit time upstream
- the meter's signal processing unit:
  - emits and receives ultrasonic pulses
  - measures upstream and downstream transit times
  - calculates speed of sound, flow velocity, actual volume flowrate
  - produces frequency output signals proportional to volume flowrate



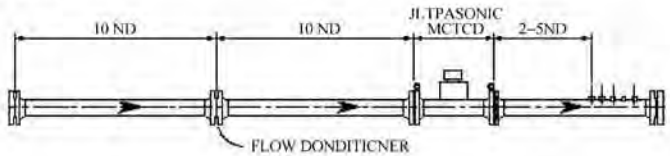
$$v=\frac{L}{2\cos\varphi}\times\left(\frac{1}{T_{AB}}-\frac{1}{T_{BA}}\right)$$

$$Q=v\times A=v\times\frac{\pi D^2}{4}$$

Transit Time Ultrasonic Meter—Installation & Use

Ultrasonic meters may be susceptible to installation effects (non-uniform flow profile, swirl, ultrasonic noise) that could have a negative impact on accuracy of measurement.

AGA Report No. 9 (2007) includes recommendations for ultrasonic meter installation and use.



Meter manufacturers and flow conditioner fabricators generally give their own recommendations for upstream piping configuration.

Transit Time Ultrasonic Meter — Applications

Ultrasonic meters are used on:

- large industrial end use services at high pressure (> 60 psig)
- LDC receipt gate stations and transmission pipeline receipt stations at high pressure up to 1500 psig (10500 kPag)

Auxiliary equipment is required to convert meter volume to standard volume.

Mechanical Volume Conversion Device

An auxiliary device that converts volume measured at flowing temperature to volume at base temperature.

- connects to, driven by and receives volumetric input from a rotary meter body
- bi-metallic coil responds to temperature of flowing gas
- a cam attached to bi-metallic coil controls length of swing of integrating mechanism driving the TC counter
- used in distribution applications with fixed pressure regulators upstream of meter

Electronic Volume Conversion Device

An auxiliary device that converts volume measured at flowing pressure and/or temperature conditions to volume at base pressure and/or base temperature.

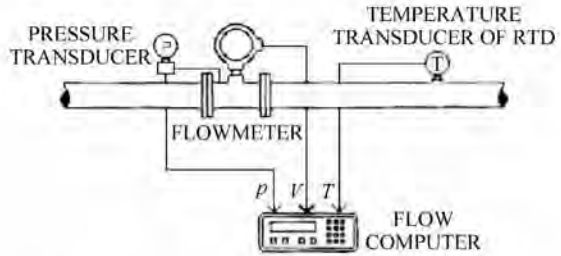
- connects directly to a gas meter or is remotely mounted
- receives volumetric input:
  - from a diaphragm, rotary or turbine meter's mechanical instrument drive or a rotary meter's magnetic coupling
  - as low frequency pulses from any gas meter
  - as high frequency pulses from any gas meter
- integral pressure and/or temperature sensors
- calculates and applies temperature, pressure and supercompressibility correction to meter volume

Flow Computer

- stand-alone, microprocessor-based system or computer that receives frequency, analog and/or digital input signals from:
  - gas meters (volume, mass)
  - RTD sensors
  - transmitters (static pressure, differential pressure, temperature)
  - gas analyzers (composition, RD, HV)
- uses input signals and user-configured measurement parameters to calculate:
  - actual volume and volume flowrate
  - mass and mass flowrate
  - standard volume and volume flowrate
  - energy and energy flowrate

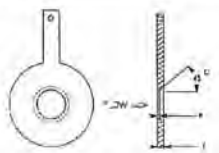
Flow Computer in Volume Meter Application

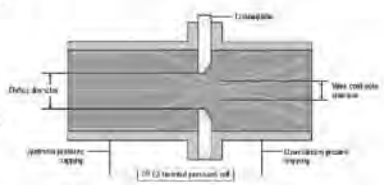
- similar to volume conversion device with expanded capabilities



Orifice Metering System

- flowrate is inferred by differential pressure across a concentric, sharp-edged orifice plate mounted perpendicular to direction of flow
- primary element includes:
  - orifice plate
  - upstream / downstream meter tubes
  - orifice flanges or fittings
  - flow conditioners
- secondary element includes:
  - static pressure measurement
  - differential pressure measurement
  - temperature measurement
  - flow computation





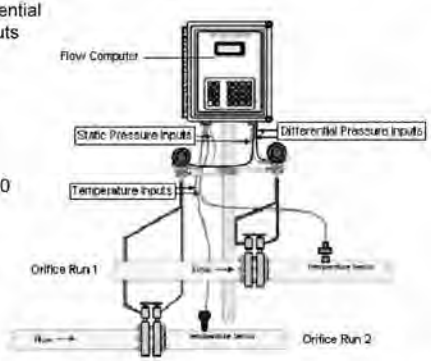
- very common in pipeline transmission custody transfer applications
- installation as per AGA Report No.3, API MPMS 14.3, ANSI 2350, ISO 5167

Flow Computer in Orifice Application

- receives static pressure, differential pressure and temperature inputs
- calculates mass and/or base volume flowrate
- flow calculations as per:
  - AGA Report No.3
  - API MPMS 14.3, ANSI 2350
  - ISO 5167

$$Q = C'\sqrt{p_f h_w}$$

where:
Q base volume flowrate
C' orifice flow constant
p_f absolute static pressure
h_w differential pressure



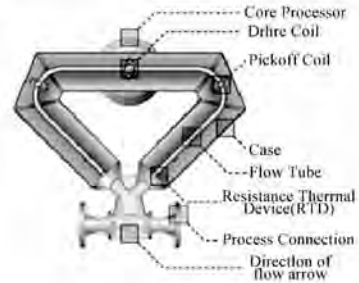
Coriolis Mass Meter

- principle of operation is inferential
- measures mass flow of gas at flowing conditions
- no need for pressure and temperature measurement
- immune to installation effects
- not affected by installation orientation; however mounting the tubes on the topside reduces potential for liquid to accumulate
- available in sizes from 0.25" up to 6" (6 to 150mm)
- flowrate capacities from 80 to 20000 lb/min (36 to 9000 kg/min)
- uni or bi-directional flow measurement capability

Coriolis Mass Meter—Construction

Main components include:

1. sensor housing
2. sensor
   - flow tubes
   - drive coil
   - pickoff coils
   - power and signal interface with transmitter
3. transmitter
4. register



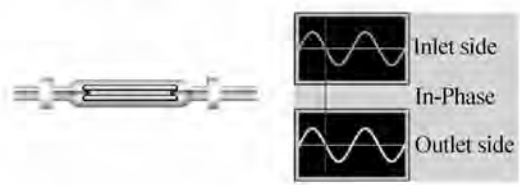
Coriolis Mass Meter—Operation

The Coriolis mass flow meter uses the Coriolis effect to infer mass flowrate.

- drive coil vibrates the flow tubes in opposition
- pickoff coils sense vibration of the inlets and outlets of the flow tubes
- frequency signals are generated for the inlets and outlets of the flow tubes

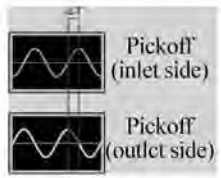
Coriolis Mass Meter—Operation

- with no flow the tubes vibrate at a natural frequency proportional to the mass density of the fluid
- with no flow the frequency signals from each pickoff coil are "in phase"



Coriolis Mass Meter—Operation

- with flow, Coriolis forces at the flow tube:
  - inlets resist vibration of the tubes
  - outlets adds to the vibration of the tubes
- this causes the flow tubes to twist in opposition to each other
- with flow, the frequency signals from each pickoff coil are "out of phase"
- phase relation varies directly with mass flowrate
- transmitter powers the sensor, detects pickoff coil signals, calculates mass flow



Coriolis Mass Flow Meter—Applications

Coriolis gas meters are used on:

- NGV dispensers for refueling CNG vehicles (3600 psig or 25200 kPag)
- large industrial end use services at high pressure (> 60 psig or 420 kPag)
- LDC receipt gate stations up to 1500 psig (10500 kPag)

Gas Analysis

Natural gas flowing through a meter station may be:

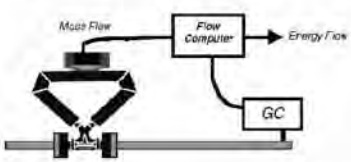
- sampled, removed and analyzed at a laboratory; or
- analyzed at the meter station in real-time using online devices such as:
  - densitometer (relative density)
  - calorimeter (heating value)
  - gas chromatograph (composition, RD, HV)

Gas composition and/or properties:

- are fed to flow computer as live or fixed inputs
- used by flow computer in calculation of:
- supercompressibility
- relative and/or mass density
- speed of sound
- heating value
- energy

Energy Measurement

- flow computer receives input signals and data for:
  - volume, pressure & temperature; or
  - mass; and
  - gas composition and heating value
- flow computer calculates energy
  - $E = V_{STD}$ x volumetric HV; or
  - E = mass x mass-based HV



Asia-Pacific Economic Cooperation

Asia-Pacific Legal Metrology Forum

Gas Meters——Type Approval

APEC/APLMF Training Courses in Legal Metrology
April 13—16, 2010
Chongqing, China

Measurement Canada / Mesures Canada

Presenters: Steve Clyens, Measurement Canada
Brad Pavlove, Measurement Canada

Developed by: Steve Clyens, Measurement Canada

Need a Type Approval

The metrology legislation of most economies require type approval for most gas meters and auxiliary devices intended for use in trade measurement applications.

A manufacturer wishing to make their gas meter or auxiliary device available within a particular marketplace for trade measurement must first obtain a type approval from the applicable responsible authority.

What is a Type Approval?

From OIML document, *International Vocabulary of Terms in Legal Metrology (VIML), Edition 2000*

Type Approval

Decision of legal relevance, based on the evaluation report, that the type of a measuring instrument complies with the relevant statutory requirements and is suitable for use in the regulated area in such a way that it is expected to provide reliable measurement results over a defined period of time.

The responsible authority grants a type approval and issues a certificate or notice for a particular type of gas meter or auxiliary device once it has been found to comply with all applicable legal requirements.

Purpose of a Type Approval

Represent a legal metrological control intended to ensure particular types or patterns of gas meters and auxiliary devices are suitable for trade measurement.

In particular, the intent is to ensure these devices:

- are fit for their intended use
- meet and maintain the necessary metrological performance requirements
  - over their range of operation
  - under expected environmental conditions of use
  - for the duration of their legislated term in service
- provide adequate protection against misuse, incorrect interpretations of results and fraud
- designed and constructed in accordance with legal requirements

Type approval reduces the amount of testing required for verification purposes.

Type Approval Specifications & Requirements

The responsible authority in each economy may:

- establish their own type approval specifications and requirements; or
- partially incorporate International Standards or Recommendations into their own type approval specifications and requirements; or
- fully adopt International Standards or Recommendations for type approval

National Type Approval Standards

Canada	LMB-EG-08, *Specifications for Approval of Type of Gas Meters and Auxiliary Devices* PS-G-06, *Approval, Verification, Installation & Use of Ultrasonic Meters*
China	CNS 14741, *Diaphragm Type Gas Meters with Micro Computers*
Taiwan	CNPA 31, *Technical Specification for Type Approval of Diaphragm Meters*
United States	NIST Handbook 44, Section 33.3, *Hydrocarbon Gas Vapor-Measuring Devices* ANSI B109 Metering Standards (for manufacturers)

International Type Approval Standards

European Union

- Measuring Instruments Directive (MID) 2004/22/EC
  - Annex MI-002 - *Gas Meters & Volume Conversion Devices*

Comite Europeën de Normalisation (CEN)

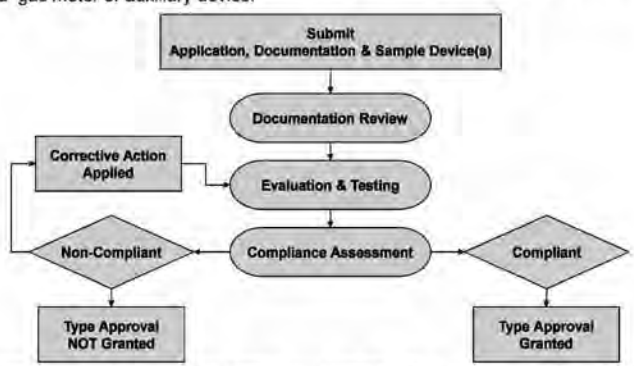
EN 1359:1998, Gas meters —— Diaphragm gas meters
EN 12480:2002, Gas meters —— Rotary displacement gas meters
EN 12261:2002, Gas meters —— Turbine gas meters
EN 12480:2002, Gas meters —— Rotary displacement gas meters
EN 14236:2007, Ultrasonic domestic gas meters

International Organization of Legal Metrology

- OIML R 137-1, *Gas Meters – Part 1: Requirements*, Edition 2006

Type Approval Process

The flow chart shows the general process for obtaining an initial type approval for a gas meter or auxiliary device.



Application & Documentation

The party seeking type approval must make official application to the responsible authority.

Supporting documentation to be included with the application includes:

- technical documentation describing the design, composition, construction and performance of the device,
- user manuals describing the operation, installation and use of the device
- test results showing the device complies with applicable requirements

The application and supporting documentation is reviewed and assessed against requirements.

Provision of Samples of Meter Type

The applicant is required to submit one or more sample gas meters or auxiliary devices for type approval evaluation and testing purposes.

Samples must represent future production of the gas meter or auxiliary device type.

All gas meters or auxiliary devices of the particular type should:

- be produced by the same manufacturer, i.e the applicant
- be of consistent quality, ie. produced under a QMS such as ISO 9001
- have the same uniform construction
- have the same parts and components
- have the same metrological properties
- have the same range(s) of operation
- have specified configuration(s)

The responsible authority may choose permit type approval of a family of gas meters (same type, different sizes).

Technical Requirements—Design & Construction

The gas meter and/or auxiliary device should be designed and constructed to retain its physical and performance characteristics over the range of expected influences, such as:

- environmental conditions
  - ambient temperature (extreme cold to extreme heat)
  - humidity
  - extreme weather (wind, rain, snow, ice)
- operating conditions
  - gas temperature
  - gas pressure
  - gas composition
  - flow rate
  - power variations and surges
  - mechanical (vibration) & electrical (EMI) interference
- length of service

Technical Requirements—Design & Construction

The gas meter and/or auxiliary device should:

- be water-proof and not leak or deform up to its maximum operating pressure during its service life
- not accumulate or totalize under no flow conditions
- include a pressure connection (tap) or its location on associated piping be specified by the manufacturer (installation and use)
- provide for direct or remote connection of a counter, register or indicating device to accumulate and display quantity in appropriate units of measure
- provide for effective application of sealing and verification marks in accordance with the responsible authority's requirements
- provide for accuracy testing, i.e test dial, pulse output, test mode

Technical Requirements—Electronics & Software

The gas meter and/or auxiliary device should provide for:

- intrinsic safety when used in hazardous location (usually requires separate safety approvals for this, ie. UL, CSA)
- retention of accumulated quantities and configuration parameters in event of power failure or battery exchange (mass memory)
- battery replacement without breaking seal
- potential variations in power supply and power surges
- prevention of unauthorized changes to software configuration or parameters

Technical Requirements—Marking

All marking and labelling shall be visible, easily legible and indelible under rated conditions of use.

Responsible authority specifies info to be marked / labelled, such as:

- meter owner name and badge number
- manufacturer name, model and serial number
- type approval number, code or designation
- gas flow direction
- volume units and register multiplier
- gear reduction ratio (rotary meter counters), change gears (turbine meters)
- flow rate parameters (Q_{max}, Q_{min} & Q_t)
- maximum operating pressure and ambient temperature range
- if temperature converting, temperature range and base temperature
- if pressure converting, pressure range and base pressure
- mechanical output volume per revolution
- pulse output constants (volume per pulse or pulses per unit volume)
- software, hardware and firmware versions

Metrological Requirements

The performance accuracy, repeatability and reproducibility of the gas meter is evaluated at multiple points over its operating flow range.

This is done over a range of different test conditions, for example:

- test environment, meter and flowing gas at same ambient temperature
- up to maximum operating pressure
- temperature differential between flowing gas and meter body
- simulated upstream installation effects, i.e.asymmetric flow, swirl, etc.
- different fluids
- applied mechanical interference, i.e. vibration and shock
- applied electromagnetic interference (EMI)
- differing orientation (where particular orientation not indicated)
- each direction of flow (where bi-directional)
- over-loading (flow)

Specific test conditions, test points and performance requirements are established by the responsible authority.

Evaluation & Testing

The responsible authority may:

- conduct all or a portion of the required evaluation and testing
- recognize, accept and use all or a portion of test results from a laboratory or test facility, i.e.ISO 17025 accredited lab
- accredit a laboratory or test facility to perform type approval functions for a defined scope of measuring devices, i.e.ISO 9001 Quality Program
- recognize and accept a type approval issued by the responsible authority of a different economy, i.e.via a mutual recognition or acceptance agreement

Notice or Certificate of Type Approval

Once the gas meter or auxiliary device found to be compliant with all applicable requirements for type approval, the responsible authority:

- issues a notice or certificate of type approval
- assigns a type approval number

The notice or certificate of approval may include the following information:

- name and address of applicant
- make and model of the gas meter or auxiliary device
- brief description of device
- approved operating ranges (may be less than rated ranges)
- any conditions or restrictions on use
- on provisions for sealing
- etc.

Modifications to Device Type

If an approved gas meter or auxiliary device is modified in any way, it is no longer the same device covered by the type approval and would not be legal for trade.

If the manufacturer wishes to modify sucha device to be used in trade, it must seek approval for the modification from the responsible authority.

Modifications may be categorized as:

- metrological
- non-metrological
- significant
- non-significant
- combination of all of above

The responsible authority will determine the scope of any required evaluation and testing.

Existing notice or certificate of approval would be revised and re-issued.

Asia-Pacific Economic Cooperation

Asia-Pacific Legal Metrology Forum

Gas Measuring Apparatus, Standards & Test Equipment

APEC/APLMF Training Courses in Legal Metrology
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Measurement Canada / Mesures Canada

Presenters: Steve Clyens, Measurement Canada
Brad Pavlove, Measurement Canada

Developed by: Brad Pavlove, Measurement Canada

Measurement Standards

Measurement Standards and Test Equipment

Considerations when selecting the appropriate measurement standards and test equipment include the following:

—— accuracy requirements of meter under test (MUT)

—— accuracy requirements of test equipment

—— the accuracy of all standards used to calibrate test equipment

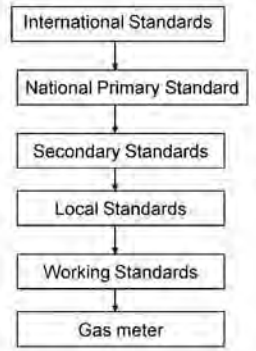
Measurement Standards

Other considerations include:

- ——Sensitivity
- ——resolution
- ——stability
- ——reproducibility
- ——uncertainty

In addition, accurate gas meter verification requires measurement standards and test equipment which are traceable to National and International standards.

Measurement Standards



Traceable is defined by the International Standards Organization (ISO) as:

"the property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or International standards, through an unbroken chain of comparisons all having stated uncertainties"

Measurement Standards

Measurement Canada uses a combination of 4 different pi-tapes. The 50 foot and 10 foot bells located in Ottawa are certified using a pi-tape that is traceable to the NRC or NIST.

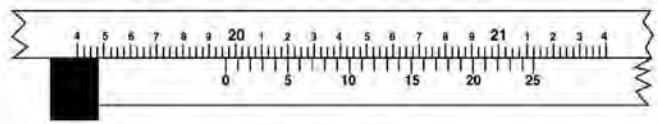
Pi-tape is also used to certify the level 2 Master Bells located in various locations across Canada.

The working level provers are traceable to or are **correlated** back to the master bell usually located on site.

Correlate: to put or bring into casual, complementary, parallel, or reciprocal relation.
Mutually related.

Measurement Standards

Pi-Tape is a linear measure that is traceable to the NRC or NIST



VERNIER SCALE

Each line on the gage member represents.025",while each line on the Vernier scale represents .001". When using the Outside Circumference tape,apply a snug pull of 5 pounds tension,first making certain the tape and part have been cleaned.

In the illustration,the divisions to the left of the Vernier zero are 19.900 inches plus 2 divisions or 19.950. The 5th line on the Vernier coincides with the line on the Linear Tape which represents .005".This is added to the 19.950,making a total circumference reading of 19.955 inches.

Measurement Standards

Bell Prover is exactly what it states a bell of a known Volume, which is used to prove or test a meter. The bell is filled with air. In addition, some means of filling and emptying the bell are required, as well as a seal to prevent the air from inside the bell form escaping to atmosphere.

The bells are of a known volume which is calculated by Measurement Canada personnel using a method known as "strapping". In strapping a bell , the diameter of the bell is measured at different place around the bell and a volume is calculated.

Measurement Standards

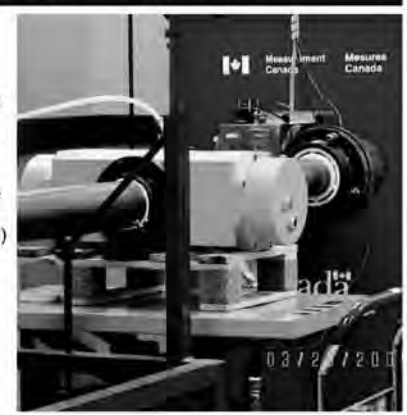
10 foot level 1 Bell

Measurement Standards

50 foot Bell Level 1

Measurement Standards

The 50 foot bell and the 10 foot level 1 bells are located in Ottawa, these are also quantified using three IRM dual rotaries a 1M (28m³), 1.5M (42.5m³)and a 2.5M(71m³) that have measurement results obtained from National Measurement Institute (NMI) in the Netherlands.



Measurement Standards

2 foot Master Bell Level 2 located at Utility

Measurement Standards

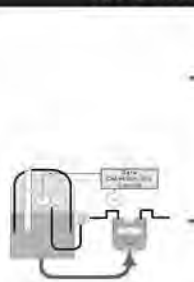
Traditional Correlation Model

The traditional method of establishing traceability in the process of the calibration of domestic gas meters involves the dissemination of the cubic foot from a local master bell prover to a number of concurrently located working level provers, done through use of transfer meters.

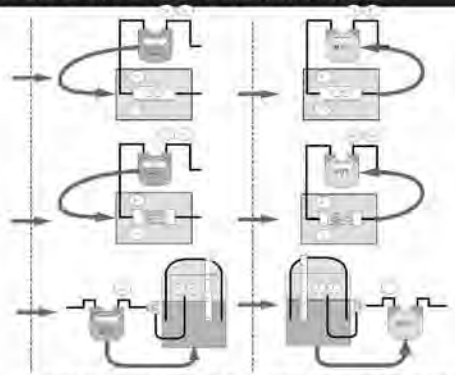
The cubic foot value is then transferred by way of a comparison process from the single local (level 2) master bell to the working level provers (level 3) found throughout the meter shop.

The working level (level 3) prover is then used to evaluate the performance of domestic meters prior to them being placed in service.

Measurement Standards



Transfer meter is calibrated by master bell.

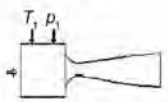


Working level 3 prover is calibrated to master bell using transfer meter.

Working level prover is used to calibrate domestic diaphragm meter.

Measurement Standards

Sonic Nozzle Provers:
A sonic nozzle prover is a gas measuring apparatus used in a meter test facility for the purpose of calibrating and verifying the volumetric accuracy of natural gas meters.



The sonic nozzle is basically a convergent-divergent nozzle manufactured to geometric specifications that provide for sonic flow at a precise operating pressure drop.

A sonic nozzle would be installed in line with piping or tubing providing for a continuous flow path. A pressure drop across the nozzle is required to produce flow. As gas enters the nozzle inlet and flows through the converging section towards the throat its velocity increases. The velocity reaches a maximum at the throat of the nozzle. The gas velocity becomes and remains sonic, or equal to the speed of sound, for a given pressure drop across the throat.

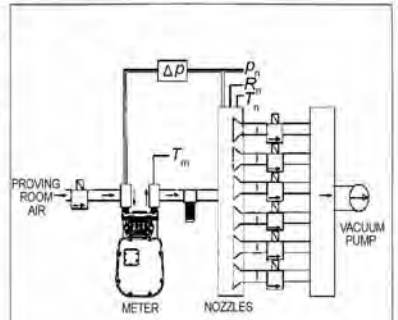
Measurement Standards

The sonic nozzle provers currently being used in meter test facilities within Canada are the SNAP and the ProSONIC.

Measurement Standards

The SNAP prover is a vacuum-based, or negative pressure, proving system. This means that air at atmospheric pressure is drawn from the proving room, through the test meter, into the sonic nozzle plenum, through the selected sonic nozzles and to the vacuum pump.

The ProSONIC is a positive pressure-based proving system. This means that a compressed air supply is required to provide approximately 90 psig to the prover. An electronically controlled regulator sets test pressures between 20 and 80 psig depending on the required flow rate.



Overoll SNAP Prover System

Measurement Standards

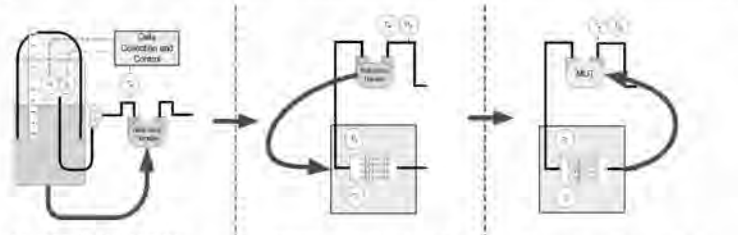
Sonic nozzle provers located at meter shop

Measurement Standards

Traceability Chain for Gas Measuring Apparatuses containing Sonic Nozzles Used for Calibrating Domestic Ultrasonic Meters

In order to calibrate domestic ultrasonic meters following the traditional bell prover and local master bell prover traceability chain, each prover in the chain requires the installation of additional instrumentation to allow for the digital communication between the meter and the provers. As an alternative to modifying the local master bell provers, the process simply replaces the local master bell prover from the traceability chain with the Primary bell prover located at Measurement Canada's Laboratory in Ottawa or by a test facility recognized by Measurement Canada.

Measurement Standards



Ultrasonic Reference transfer meter calibrated using primary bell or recognized laboratory.

Working level 3 prover is correlated using reference transfer meter.

Working level prover is used to calibrate domestic ultrasonic meter.

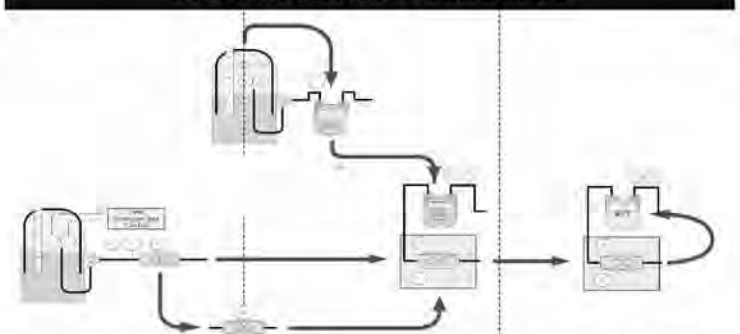
Measurement Standards

The Gas Measuring Apparatus containing Reference Rotary Meter used to calibrate diaphragm meters is called a Nobell.

Of importance is that a primary (Level 1) bell prover is used to calibrate a precision reference meter that in turn will be used as a reference standard inside of the domestic meter transfer prover or measuring apparatus. A certificate of calibration for the reference meter indicating an uncertainty not greater than ± 0.3% at k=2 is provided. This prover is also used to calibrate a qualification standard or check meter. The purpose of this meter is two fold; firstly, it can be used as a local volumetric standard having the same status and performing some of the same functions as the local master bell and secondly, it is used to monitor the performance of the transfer prover over time.

The working level (level 3) prover is then used to evaluate the performance of domestic meters prior to them being placed in service.

Measurement Standards

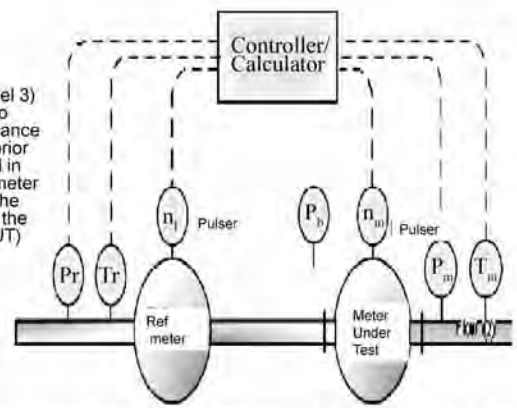


Primary bell used to calibrate reference meter and qualification meter.

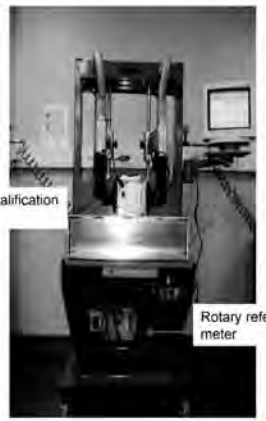
Working level 3 prover is used to calibrate domestic diaphragm meter.

Measurement Standards

The working level (level 3) prover is then used to evaluate the performance of domestic meters prior to them being placed in service by meter to meter inter-comparison of the reference meter and the meter under test (MUT)



Measurement Standards



Measurement Standards

NoBell rotary provers used to certify diaphragm meters.

Measurement Standards

Traceability Chain for Reference Meters Contained in Gas Measuring Apparatus

The majority of the processes used to evaluate the performance of trade meters rely on a direct comparison to a reference meter. These include the calibration of large diaphragm meters, rotary meters and low and high pressure turbine meter calibration. In each of these cases the reference meter is removed from the measuring apparatus or facility and then calibrated in relation to a higher level standard. These standards may be other reference meters, bell provers, pipe provers or a gravimetric weighing system. In any case, in order for the measuring apparatus to be recognized or legally traceable in Canada, the reference meters are required to be calibrated either by Measurement Canada or a facility that has been listed in Measurement Canada's Bulletin G-16, *Recognition of Test Data From Gas Meter Test Facilities*.

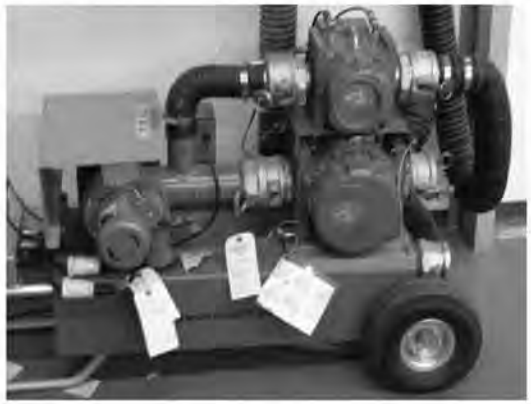
Measurement Standards

NoBell rotary prover used to certify rotary meters up to 85m^3.

Measurement Standards

Roots model 5 rotary prover.

57m³ reference meter and a 283m³ reference Meter. This prover can be used to certify Large diaphragm meters or rotary meters.



Measurement Standards

Atmospheric turbine prover used to calibrate turbine meters up to 2550m³.

Measurement Standards

Piping and header for different size turbines to be tested.

Measurement Standards

Atmospheric rotary/turbine prover, with a capacity of 1076m³

Measurement Standards

Rotary reference meter used to calibrate rotaries and turbines.

Measurement Standards

Recognition of Test Data-Bulletin G-16

The purpose of bulletin G-16 is to describe the requirements and conditions that apply to organizations seeking to be recognized by Measurement Canada to provide test data for natural gas meters. Test data from recognized test facilities may be used either by Measurement Canada, for the purposes of meter calibration, pattern approval, and measurement dispute investigation, or used by an organization accredited by Measurement Canada for the purposes of verification, reverification and sealing of meters.

Processes and Limitations to become Recognized

Measurement Canada Engineering and Laboratory Services will perform a technical evaluation in order to assess the organization's ability to provide the test data required.
The method employed is dependent on the location of the institute on the International Traceability Chain and current certifications or accreditations. Successful institutions will be listed in one of the five appendixes found in bulletin G-16.

Measurement Standards

Appendix A of this bulletin lists recognized National Measurement Institutes (NMIs) which are signatory to the Bureau International des Poids et Mesures (BIPM) Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes in Paris, 14 October 1999 and have their Calibration and Measurement Capabilities (CMC) listed in Appendix C of that agreement and evaluated by participating in an International Key Comparison (KC). As the National Research Council of Canada (NRC) is signatory to that document and actively participates in the comparisons, no additional review outside of that done during the KC is conducted. By way of inclusion into the BIPM recognition document, these institutions are deemed to meet the requirements of this bulletin.

Nederlands Meetinstitut (NMI) Delft, the Nederlands
Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

Measurement Standards

Appendix B of this bulletin includes Laboratories and Test Facilities that have been designated by a country whose National Measurement Institute is signatory to the BIPM Mutual recognition of national measurement Standards and of calibration and measurement certificates issued by national metrology institutes and have their Calibration and Measurement Capabilities (CMC) listed in Appendix C of that agreement. These test facilities are supported, but not owned by the designating country. As stated above, the NRC is signatory to the agreement, so no additional in-depth scrutiny is conducted. By way of inclusion into the BIPM recognition document, these institutions are deemed to meet the requirements of this bulletin.

TransCanada Calibrations (TCC), Île-des-Chênes, Manitoba, Canada
Gasunie Research, the Netherlands- Groningen, Utrecht, Bergum, Westerbork
PIGSAR facility (Ruhrgas), Dorsten, Germany

Measurement Standards

Appendix C of this bulletin lists Laboratories and Test Facilities that have been accredited to ISO 17025 by an institution which is recognized by the International Laboratory Accreditation Cooperation (ILAC) to which the Standards Council of Canada (SCC) is a signatory member. These also include laboratories that are accredited under the Calibration Laboratory Assessment Service (CLAS) program in Canada and National Voluntary Laboratory Accreditation (NVLAP) in the United States of America. A documentation review and on-site technical review is conducted by Measurement Canada to ensure compliance with this bulletin.

Colorado Engineering Experiment Station Inc. (CEESI), Nunn, Colorado, USA
Colorado Engineering Experiment Station Inc. (CEESI), Ventura, Iowa, USA

Measurement Standards

Appendix D of this bulletin lists laboratories or test facilities that have been accredited or recognized under some other existing accreditation program. In these instances, in-depth technical scrutiny is conducted by Measurement Canada to ensure compliance with this bulletin.

Terasen Gas Inc., Penticton, B.C., Canada Triple Point Turbine Meter Calibration Facility
Dresser, Inc., Houston, Texas, USA

Appendix E of this bulletin lists the laboratories and test facilities which are currently under evaluation by Measurement Canada for initial recognition, or which are currently under evaluation for renewal of their existing recognition.

Sensus Metering Systems Inc., DuBois, PA, USA

Measurement Standards

1.Traceability
The organization shall submit sufficient information to demonstrate traceability to a relevant national standard.
A certificate of accreditation to ISO/IEC 17025 by an accrediting body recognized by the National Research Council (NRC) or the Canadian Standards Council (SCC) will be deemed as proof of compliance.

2. Measurement Uncertainty

The organization shall state its overall measurement uncertainty and the methods used in its determination. The method used shall be as prescribed in the ISO Guide for the Expression of Uncertainty (GUM).
For the purposes of trade meter calibration, the expanded uncertainty (U) shall be less than 0.33 percent of the applicable device tolerance at the 95 percent confidence interval in order for the facility to be recognized by Measurement Canada. If recognition is desired for the calibration of reference meters as well, then a further reduced uncertainty value will be expected. Note that no indication of the value of uncertainty claimed by any organization will be provided in the Appendices of this bulletin.

Measurement Standards

3. Proficiency Testing and Monitoring of Results

In order to assess the proficiency of the organization and to ensure continued compliance with the requirements of bulletin G-16, the organization shall utilize methods such as:
a) participation in intercomparisons of meter calibrations with one or more of the other Laboratories or Test Facilities that have been recognized by Measurement Canada
b) monitoring the performance of reference standards
c) use of check or monitoring standards
The results of these monitoring processes shall be provided to Measurement Canada upon request.
Measurement Canada may require Proficiency Testing to assess Laboratories/Test Facilities.

Measurement Standards

4. Status Indicators

A recognized organization shall affix a status indicator to meters that have been calibrated and are to be presented to Measurement Canada for verification or reverification or which are the subject of a dispute. In instances where the meter can be sealed, the organization shall affix a seal in order to prevent unauthorized access to the meter's adjustments. The seal shall identify the organization that applied it.
Meters tested or calibrated at a recognized test facility must be verified and sealed by Measurement Canada, or by an Accredited Meter Verifier, prior to being placed into service.

Measurement Standards

5.Test Reports

Effective upon issuance of this bulletin, a recognized organization shall utilize a test report format that includes the following information:

a) a title (e.g. "Test Report")
b) name and address of the test facility and location where the tests were carried out, if different from the address of the laboratory or recognized organization
c) unique identification of the test report (such as a serial number), and on each page an identification in order to ensure that the page is recognized as part of the test report
d) the name and address of the organization that owns the meter and that has requested the testing
e) a description and identification of the meter that was tested, including the serial numbers of all controlled components, where required
f) the date(s) that the testing took place
g) test or calibration results with the units of measurement, including all details necessary to demonstrate that Measurement Canada's metrological performance requirements have been assessed
h) identification of the test procedure(s) followed and any installed meter accessories or influencing components, as may be applicable
i) the stated uncertainty (at the 95 percent confidence interval) associated with the test results. Indication of any factors not included in the estimate of uncertainty

Measurement Standards

6. Design and Construction of Test Equipment

The organization shall submit information related to the design and construction of the test equipment, process and instrumentation drawings, and instrumentation specifications for all the equipment used to obtain meter test results.

7. Technical Procedures

The organization shall submit copies of the test procedures used to calibrate meters. Note that a certificate of accreditation to ISO/IEC 17025 by an accrediting body recognized by the National Research Council or Canadian Standards Council will be deemed as proof of compliance.

Measurement Standards

Recognition

Measurement Canada will monitor the recognized organization's performance and will determine whether or not to continue recognizing the test facility based upon the results of the review. Recognized organizations will be re-evaluated every four (4) years. Measurement Canada may perform on-site audits as part of the evaluation and monitoring of recognized test facilities.
The suitability of Measurement Canada's recognition process and requirements will be periodically evaluated for effectiveness and may be modified or discontinued as necessary. Recognized organizations must be prepared to update processes and procedures to meet any changes in Measurement Canada requirements.
Requirements may be technical or administrative. Organizations may, in future, be required to fulfill some quality system requirements as Measurement Canada adjusts its recognition program.

Measurement Standards

Pressure measurement is important for the accurate measurement of natural gas because the volume occupied by a gas is dependent upon the pressure of the gas. In legal metrology applications, repeatability and absolute accuracy are essential to fair trade.

Traceability of Pressure Standards

Measurement Standards

Types of pressure measurement:

Pneumatic dead weight tester or P-K tester the accurate pressure is produced by bringing into equilibrium the pneumatic pressure on the underside of a ball of known area by weights of a known mass on top of the ball. When weights are added or removed from the weight carrier, the ball rises or lowers, affecting the air flow. The regulator senses the change and adjusts the pressure under the ball to bring the system into equilibrium, changing the output pressure accordingly. Thus regulation of output pressure is automatic with changes in weight mass on the spherical piston (ball). When minimum supply pressures are maintained, the unit equilibrium is unaffected by variations in supply pressure.

Inspector's working level pressure standard

Measurement Standards

Capacitance Pressure Sensor
Capacitance change results from the movement or deflection of a diaphragm element. The variable capacitance is a function of deflection of the diaphragm. Therefore, the detected capacitance is an indication of the process pressure. The capacitance is converted into either a direct current or a voltage signal that can be read directly by panel meters or microprocessor-based input/output boards.

Potentiometric Pressure Sensor
The potentiometric pressure sensor consists of a precision potentiometer mechanically linked to a Bourdon or bellows element. The movement of the wiper arm across the potentiometer converts the mechanically detected sensor deflection into a resistance measurement.

Measurement Standards

The Resonant Wire Pressure Sensor
A wire is gripped by a static member at one end, and by the sensing diaphragm at the other. An oscillator circuit causes the wire to oscillate at its resonant frequency. A change in process pressure changes the wire tension, which in turn changes the resonant frequency of the wire. A digital counter circuit detects the shift.

Piezoelectric Pressure Sensors

When pressure, force or acceleration is applied to a quartz crystal, a charge is developed across the crystal that is proportional to the force applied.

Inductive/Reluctive Transducers

Inductance is that property of an electric circuit that expresses the amount of electromotive force (emf) induced by a given rate of change of current flow in the circuit. Reluctance is resistance to magnetic flow, the opposition offered by a magnetic substance to magnetic flux.

Measurement Standards

Optical Pressure Transducers

A light emitting diode (LED) is used as the light source, and a vane blocks some of the light as it is moved by the diaphragm. As the process pressure moves the vane between the source diode and the measuring diode, the amount of infrared light received changes.

Strain Gauge Sensors

Strain gauges are designed to convert mechanical motion into an electronic signal. A change in capacitance, inductance, or resistance is proportional to the strain experienced by the sensor. If a wire is held under tension, it gets slightly longer and its cross-sectional area is reduced. This changes its resistance (R) in proportion to the strain sensitivity (S) of the wire's resistance.

Measurement Standards

Primary Pressure Standard located in Measurement Canada's pressure laboratory.

Automatic dead weight tester

Measurement Standards

Primary Pressure Standard located in Measurement Canada's pressure laboratory.

Manual dead weight tester

Measurement Standards

Different types of inspector working level standards.

Mechanical Designs, the first pressure gauges used flexible elements as sensors. As pressure changed, the flexible element moved, and this motion was used to rotate a pointer in front of a dial.

Measurement Standards

Various types of electronic pressure standards. Intrinsically safe, the DPI 610 can accommodate an external transducer to increase pressure range.

Measurement Standards

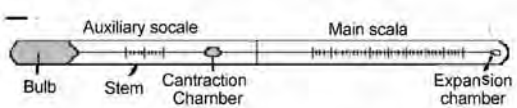
Dual pressures testing capabilities

Transcat has the capability to generate pressure used primary for the certification of measurement equipment.

Measurement Standards

Temperature measurement is important for the accurate measurement of natural gas because the volume occupied by a gas is dependent upon the temperature of the gas. We can describe the temperature of an object as that which determines the sensation of warmth or coldness felt from contact with it. If we define cold as the absence of heat, and temperature as a measure of heat, in a quantitative manner we can numerically state how far a temperature is from the lack of heat (the theoretical zero point).

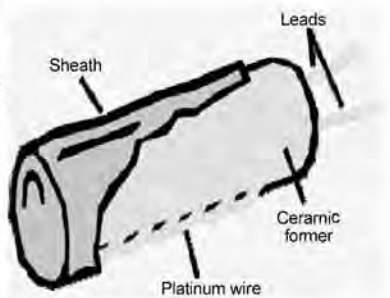
Liquid-in-glass thermometers use the fact that most fluids expand on heating. The fluid is contained in a sealed glass bulb, and its expansion is measured using a scale etched in the stem of the thermometer.



Measurement Standards

A resistance thermometer makes use of the change of resistivity in a metal wire with temperature. As electrons move through a metal, they are impeded by the thermal vibrations of the atoms in the crystal lattice. The higher the temperature the greater the impedance and the higher the resistivity.

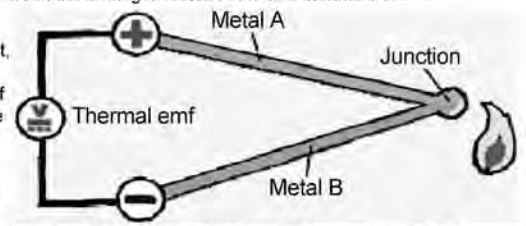
This effect is very marked in pure metals, and for a well-behaved material enables measurements of temperature to be made to better than 0.001 ℃. Usually platinum wire is used in the construction of the thermometer, since it is a noble metal which is un-reactive over a wide range of temperatures.



Measurement Standards

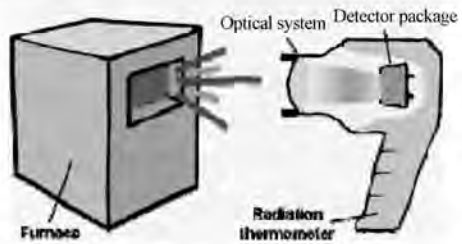
Thermocouples depend on the principle of the Seebeck effect: when a conductor is placed in a temperature gradient, electrons diffuse along the gradient and an emf, or thermovoltage, is generated. The magnitude of the emf depends on the material and also on its physical condition. To measure the generated thermal emf (or Seebeck emf), the circuit must be completed using a second different conductor. This is joined to the first conductor at the point of measurement and passes through the same temperature gradient, forming a thermocouple. The thermocouple emf is then the difference between the emfs generated in the two conductors.

The simplicity, ruggedness, low cost, small size and wide temperature range of thermocouples make them the most common type of temperature sensor in industrial use.



Measurement Standards

Radiation thermometry makes use of the fact that all objects emit radiation in the infrared and visible parts of the spectrum, the intensity of which varies strongly with temperature. The radiation can be measured remotely, enabling measurements to be made of objects that are moving, very hot, in a hostile environment or rapidly changing in temperature, or in situations where contamination of a product must be avoided.



Measurement Standards

The Triple Point of a substance is where all three phases of a substance are in equilibrium. Therefore at the Triple Point of Water the solid (ice), liquid and gas (water vapour) are in equilibrium. This occurs in water where initially ice and water are together (two phase equilibrium) then the space above the water is evacuated until it is only occupied by water vapour under vacuum, (three phase equilibrium) now the temperature is 273.16°K or 0.01°C. If the pressure is returned to atmospheric then the temperature will drop to 0°C or 273.15°K and there is no equilibrium condition between the gas and liquid.

Different types of triple point cells.

Measurement Canada uses triple point cells for traceability of Standards. Gallium cell is also used which has a stable temperature of 29.7646°C at melting point.

Measurement Standards

Primary standard used at Measurement Canada's laboratory.

Measurement Standards

Inspector working level temperature standards

Asia-Pacific Economic Cooperation

Asia-Pacific Legal Metrology Forum

Gas Meters——Verification

APEC/APLMF Training Courses in Legal Metrology
April 13—16, 2010
Chongqing, China

Measurement Canada / Mesures Canada

Presenters: Steve Clyens, Measurement Canada
Brad Pavlove, Measurement Canada

Developed by: Steve Clyens, Measurement Canada

What is Verification?

From OIML document, *International Vocabulary of Terms in Legal Metrology (VIML), Edition 2000*

Verification of a Measuring Instrument

procedure (other than type approval) which includes the examination and marking and/or issuing of a verification certificate, that ascertains and confirms that the measuring instrument complies with the statutory requirements

Verification of gas meters and auxiliary devices is achieved through inspection and testing procedures established to assess compliance with the responsible authority's legal technical and metrological requirements.

Initial Verification

From OIML document, *International Vocabulary of Terms in Legal Metrology (VIML), Edition 2000*

Initial Verification

verification of a measuring instrument which has not been verified previously

The metrology legislation of most developed and developing economies requires that most new or renewed gas meters and auxiliary devices be subject to initial verification before being used in trade.

This serves as a means of legal metrological control of measuring devices used in trade.

National Verification Requirements

The responsible authority may:

- establish their own distinct specifications and requirements for verification of each type of gas meter and auxiliary device; or
- partially adopt and/or incorporate International Standards or Recommendations into their own specifications and requirements; or
- fully adopt and/or incorporate International Standards or Recommendations into their own specifications and requirements

National Verification Requirements

National verification requirements documents from some economies include:

Taiwan	CNMV 31, *Technical Specifications for Verification and Inspection of Diaphragm Gas Meters*
China	CNS 14741, *Microcomputer Diaphragm Gas Meters for Natural Gas, (2003(E))*
Germany	Verification Ordinance, *Appendix 7 (EO 7) gas meters*
United Kingdom	*The Measuring Instruments (Gas Meters) Regulations 2006 (SI 2006/2647)*
Canada	S-G-02, *Specifications for the Verification and Reverification of Diaphragm Gas Meters* PS-G-06, *Approval, Verification, Installation & Use of Ultrasonic Meters*

International Requirements & Recommendations

International verification requirements and recommendation documents include:

European Union

- Measuring Instruments Directive (MID) 2004/22/EC
  - Annex MI-002 - *Gas Meters & Volume Conversion Devices*

International Organization of Legal Metrology

- OIML R 137-1, *Gas Meters – Part 1: Requirements*, 2006
- OIML R 139, *Compressed Gaseous Fuel Measuring Systems for Vehicles*, 2007
- OIML R 140, *Measuring Systems for Gaseous Fuel*, 2007

R 137-1 and R 140 supersede the previous editions of:

- R 31, *Diaphragm Gas Meters, 1995*
- R 32, *Rotary Piston Gas Meters and Turbine Gas Meters*, 1989
- R 6, *General Provisions for Gas Volume Meters, 1989*

Who Conducts Verification Activities?

The responsible authority may:

- conduct verification activities for all or certain types of gas meters and/or auxiliary devices; and/or
- recognize, accept and use, for verification purposes, all or a portion of test results from various laboratories or test facilities; and/or
- recognize and accept verification certificates issued by the responsible authority of a different economy or an international test facility, i.e via a mutual recognition or acceptance agreement; and/or
- accredit another party to conduct verification activities on their behalf for a defined scope of gas meters and/or auxiliary devices. Such parties might include meter manufacturers, transmission companies, local distribution companies, third party companies, test facilities, etc.

100% Inspection & Acceptance Sampling

Verification of new or renewed gas meters and auxiliary devices may be achieved by:

100% Inspection (Screening)

- each individual gas meter or auxiliary device is inspected, tested and verified

Acceptance Sampling

- a homogeneous population of gas meters is verified based on the performance of a random sample selected from that population
- using sampling plans developed, adopted or accepted by the responsible authority, i.e ISO 2859-2:1985, Measurement Canada specification S-S-04
- may be based on variables, attributes, or a combination of both

Inspection & Test Procedures

The organization conducting verification inspection and testing should document and work from device specific procedures.

These procedures would:

- identify the scope of their application
- provide for safety considerations and equipment
- reference all applicable requirements and specifications documents
- identify all necessary test equipment and measuring standards
- provide directions on how to prepare and use test equipment
- include instructions on how to access necessary information from meter
- provide specific directions on how to inspect and/or test against:
  - technical (non-performance) requirements
  - metrological (performance) requirements
- provide instructions for application of seals and verification marks

Procedures help ensure consistent implementation, provide for training of new staff, and give auditors a reference from which to audit.

Verification—Technical Requirements

Verification testing begins with visual inspection of the gas meter or auxiliary device against technical (non-performance) requirements and includes the following:

- is there a type approval issued by the responsible authority?
- does it conform to the design and condition in the type approval?
- does the marking conform to type approval and verification requirements?
- what features / functions does it have and are they approved for use?
- does it use software / firmware versions covered by the type approval?
- is the correct register installed and are dials / drums properly aligned?
- how is it configured? Need values of certain parameters for test purposes (pulse weight, p_{BASE}, T_{BASE}, fixed gas composition and/or properties)
- does it leak?

Technical Requirements—Marking

Typical information to be marked, labelled or accessible via a register or via software communication may include:

- meter owner name and badge number
- manufacturer name, model and serial number
- type approval number, code or designation
- gas flow direction
- volume units and register multiplier
- gear reduction ratio (rotary meter counter modules)
- change gears (turbine meters)
- flow rate capacity (Q_{max})
- maximum operating pressure and ambient temperature range
- if temperature converting, temperature range and base temperature
- if pressure converting, pressure range and base pressure
- mechanical output volume per revolution
- pulse output constants (volume per pulse or pulses per unit volume)
- software, hardware and firmware versions

Technical Requirements—Leak Testing

Prior to commencing meter accuracy testing, and with the meter connected to the gas measuring apparatus (prover), a leak test should be performed to detect any leaks in the meter and/or the proving system.

The leak should be performed manually if it is not performed automatically as part of the prover's automated test cycle.

A leak in the proving system between the reference standard and the meter under test will produce incorrect meter test results.

Ideally, the leak test process should be capable of detecting a leak rate equivalent to 0.1% of the lowest flowrate test point for the meter under test.

The responsible authority may include leak testing requirements in specifications for calibration/certification of flow standards and/or verification specifications.

Verification—Metrological Requirements

Verification testing continues with dynamic inspection of the gas meter or auxiliary device against metrological (performance) requirements and includes the following:

- accuracy testing at specified test points, i.e.flow rate, pressure, temperature
- verify mechanical drive, analog, digital and/or frequency inputs / outputs
- verify volume conversion functions, i.e.pressure, temperature, super compressibility
- verify calculator functions, i.e. flowrate, volume conversion, heating value, energy
- verify correction / linearization functions

Metrological Requirements—Measuring Standards

Verification of gas meters and auxiliary devices against metrological (performance) requirements should be conducted using measuring standards that are:

- calibrated to national standards (traceable)
- certified for use in verification activities by the responsible authority
- metrologically suitable for the intended verification application, i.e. accuracy, resolution, repeatability, long term stability, etc.
- functionally suitable for the application, i.e. range, flow setting ability and stability, non-leaking, etc.
- providing acceptable test uncertainty ratios (TUR)

$$\text{TUR} = \frac{\text{MPE or specification limit for device under test}}{\text{calibration uncertainty of measuring standard}}$$

Metrological Requirements—Test Conditions

For verification purposes, gas meters should be tested in a controlled environment where conditions are continuously monitored and recorded.

Such conditions may include:

- ambient air temperature within test area
- temperature of air / gas supplying and within proving system
- relative humidity within test area
- relative humidity of air supplying and within proving system

Verification requirements for each type of gas meter should identify:

- allowable range for setting ambient conditions
- allowable variation in each condition over a given time period
- allowable deviation between ambient and proving conditions, etc.

Controlling gas meter test conditions helps to reduce and the uncertainty these contribute to the overall uncertainty of the test results.

Metrological Requirements—Test Conditions

For verification purposes, gas meters should ideally be tested as close as possible to the conditions (pressure, temperature, gas type) under which they will be used.

Gas meters used on domestic, commercial and small industrial type services, at pressures below 60 psig, are most often tested for accuracy:

- using air
- at low or atmospheric pressure
- at controlled ambient temperature

Gas meters used in high pressure and/or transmission pipeline applications are most often tested for accuracy:

- using natural gas
- at high pressure (intended operating pressure)
- at controlled ambient temperature

Metrological Requirements—Flow Ranges

OIML R137-1 defines the flowrate characteristics of a gas meter by the values of Q_{max}, Q_{min} and Q_t.

Maximum flowrate (Q_{max})

Highest flowrate the meter must operate within the maximum permissible error

Minimum flowrate (Q_{min})

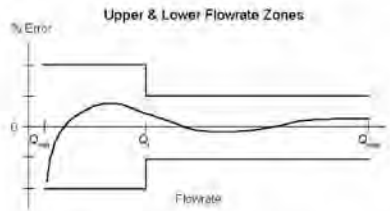
Lowest flowrate the meter must operate within the maximum permissible error

Transitional flowrate (Q_t)

Flo wrate between Q_{max} and Q_{min} that divides the flowrate range into upper and lower zones, each generally with its own maximum permissible error.

Metrological Requirements—Flowrate Zones

The diagram shows the upper and lower flowrate zones and the corresponding change in maximum permissible error between these zones.



Q_{max}/Q_{min}	Q_{max}/Q_t
≥50	≥10
≥5 and < 50	≥5

Using the table above from OIML R137-1, assume Q_{max} = 100 and Q_{min} = 5 then Q_{max} / Q_{min} = 20 (≥ 5 and < 50) so $Q_{max} / Q_t \geq 5$

Therefore, Q_t is between 5 and 20 (to be established by manufacturer)

Metrological Requirements—Flowrate Test Points

OIML R 137-1 recommends flowrate test points be established in accordance with the equations below:

$$Q_i = \left(\frac{Q_{min}}{Q_{max}}\right)^{\frac{i-1}{N-1}} Q_{max} \qquad N = 1 + M \cdot \log\left(\frac{Q_{max}}{Q_{min}}\right)$$

Q_i	is test flowrate
Q_{min}	is meter's rated minimum flowrate
Q_{max}	is meter's rated maximum flowrate
i	is rank number of test flowrate
N	is number of test points rounded to nearest integer
M	is number of test points per logarithmic decade
$\log\left(\frac{Q_{max}}{Q_{min}}\right)$	is number of logarithmic decades

For initial verifications $M \geq 3$ and $N \geq 6$

Metrological Requirements—Flowrate Test Points

Using the equations from OIML R 137–1, the table below gives the flowrate test points for a gas meter with:

$Q_{max} = 100$ and $Q_{min} = 1$

for $Q_{max} / Q_{min} = 100$	
i	% Q_{max}
1	100
2	46.4
3	21.5
4	10
5	4.6
6	2.2
7	1
Test at target flow ± 5%	

OIML R137–1 recommends multiple test points over the flow rate range of the gas meter but allows the national authority to use a reduced number of flowrates.

For diaphragm meters, *verification may be performed at* Q_{max}, $0.2Q_{max}$ *and* Q_{min}.

Metrological Requirements — Flowrate Test Points

For verification of each specific type of gas meter, an economy's responsible authority may adopt OIML recommendations or establish their own flowrate test points.

The table below shows existing flowrate test points used by Measurement Canada for various types of gas meters.

Meter Type	Low Load	High Load
Diaphragm (TC)	0.45 ± 0.05 Q_{max}	1.45 ± 0.05 Q_{max}
Rotary	0.20 ± 0.05 Q_{max}	0.95 ± 0.05 Q_{max}
Turbine	0.20 ± 0.05Q_{max}	0.95 ± 0.05 Q_{max}
Domestic / Commercial Ultrasonic (TC)	0.30 ± 0.05 Q_{max}	0.95 ± 0.05 Q_{max}
Pipeline Ultrasonic (high pressure)	5 equally spaced between 0.10 Q_{max} & Q_{max}	

Diaphragm meter test points are a function of rated air capacity.

Metrological Requirements—Test Duration

The test duration and test quantity should provide for sufficient resolution in the determination of the test error.

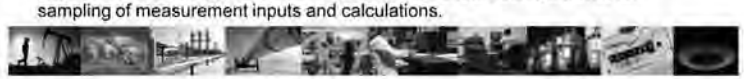
Measurement Canada requires sufficient test quantity to resolve the test error to the nearest 0.1%.

$$\%\,\text{Resolution} = \frac{\text{smallest quantity increment}}{\text{test quantity}} \times 100\%$$

$$\text{Test Quantity} = \frac{\text{smallest quantity increment}}{\%\,\text{resolution}} \times 100\%$$

If the device under test is used to gate the test, then the resolution of the reference standard dictates the required test quantity.

A minimum test duration should be established to ensure sufficient time for sampling of measurement inputs and calculations.



Accuracy Test Results—Error Calculations

Test results are expressed and calculated in different forms, for example:

Absolute Error = $R-T$

% True Error = $\frac{R-T}{T} \times 100$

% Fiducial Error = $\frac{R-T}{FS} \times 100\%$

where,

R the quantity registered (indicated) by the meter under test
T the true value of the quantity indicated by the reference meter
FS full scale or span

Metrological Requirements — MPEs

OIML document R137-1 defines accuracy classes for gas meters based on maximum permissible errors (MPE) for accuracy under rated operating conditions.

Flow rate (Q)	Type Approval & Verification Accuracy Class		
	0.5	1.0	1.5
$Q_{min} \leq Q < Q_t$	± 1.0 %	± 2.0 %	± 3.0 %
$Q_t \leq Q \leq Q_{max}$	± 0.5 %	± 1.0 %	± 1.5 %

Per R 137-1, a mechanical gas meter with a single temperature converted (TC) volume register, the MPEs in the table are increased by 0.5 % in a range of 30°C extending symmetrically around a temperature specified by the manufacturer.

Metrological Requirements—MPEs

For verification of each specific type of gas meter, an economy's responsible authority may:

- adopt a given OIML R137-1 accuracy class
- establish its own MPEs, tolerances or specification limits

The table shows existing accuracy specification limits and MPEs used by Measurement Canada.

Meter Type	Low Load	High Load	Tolerance Type
Diaphragm (TC)	±1.6%	±1.6%	Spec Limit
Rotary	±1.5%	±1.0%	MPE
Turbine (low pressure testing)	–2.0%, + 1.0%	–2.0%, + 1.0%	MPE
Turbine (high pressure testing)	±1.0%	±1.0%	MPE
Domestic / Commercial Ultrasonic (TC)	±1.5%	±1.5%	MPE
Pipeline Ultrasonic	±1.0%		MPE

Measurement Uncertainty

The ISO definition for **Measurement Uncertainty** is:

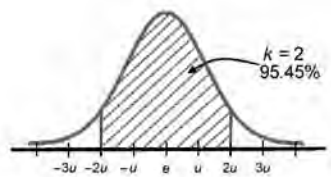
Parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand.

The measurement uncertainty associated with all accuracy test results should be established based on the ISO Guide to the Expression of Uncertainty in Measurement (GUM)

Error Interval = Test Error (e) $\pm ku$

where,

u is combined standard uncertainty
k is coverage factor for a specific level of confidence, i.e. k=2 for a 95.45% confidence interval



Impact of Uncertainty on Compliance Assessment

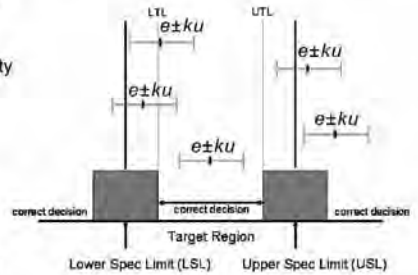
The uncertainty associated with gas meter accuracy test results can introduce a risk of making incorrect compliance assessment decisions.

Risk of accepting a non-compliant meter error is reduced by:

- ensuring suitable test uncertainty ratios are used
- using adjustable test limits

  upper test limit = USL - ku
  lower test limit = LSL + ku

where, k is coverage factor
u is standard uncertainty



Metrological Requirements — Reduced MPEs

The MPEs for the various accuracy classes given in OIML R 137-1 represent test limits.

Test errors are assessed against these MPEs.

OIML R 137-1 requires the expanded uncertainty (k=2) associated with a verification test result to be less than one third the applicable MPE.

Where this cannot be met, the MPE is reduced to $\pm$ (4/3 MPE − U).

For example, MPE = 1.0% and U = 0.40%

New MPE = $\pm$ (4/3×1.0 − 0.4) = $\pm$ 0.93

The greater the expanded uncertainty the tighter the reduced MPE.

Uncertainty Based Specification Limits

Measurement Canada's specification limit for verification of TC diaphragm meters is $\pm$1.6%.

This applies to the Error Interval = Test Error (e) $\pm$ $k\,u$

where, u is combined standard uncertainty of test error
k=3 for 100% inspection

Test limits (MPEs), also called sealing limits, for test errors are:

lesser of $TL_u = 1.60 - k\,u$ or $TL_u = 1.00\%$
greater of $TL_L = -1.60 + k\,u$ or $TL_L = -1.00\%$

If an uncertainty estimate has not been made, test limits of $\pm$ 0.80% are used.

Meter errors must not exceed the applicable test limits in order to be accepted, verified and sealed.

Measure of Absolute Deviation from Target

Measurement Canada specifies a limit for the maximum allowable deviation of TC diaphragm meter test errors from the calibration target.

The calibration target for meter accuracy should be 0.0%.

MADT —— Measure of Absolute Deviation from Target
—— median of absolute value of all test errors

MADT limit is 0.6 for small TC diaphragm meters (≤ 500 cfh)
0.8 for large TC diaphragm meters (> 500 cfh)

This encourages companies to calibrate the meter to 0.0% error over its full operating range.

Meters with MADT values exceeding the MADT limit are not accepted, verified and sealed.

Verification Marking & Sealing

Verification Marks

- indicate the gas meter has been inspected and verified
- includes any seal, stamp, tag, or label which identifies the verifier and the year in which the verification takes place
- design and use is subject to review and acceptance by the responsible authority

Seals and Sealing Arrangements

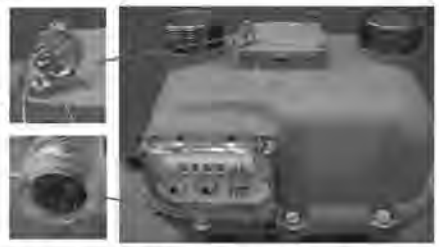
- protects metrological properties and memorized quantities of the meter
- accomplished via mechanical sealing and/or via electronic sealing devices
- shall be able to withstand outdoor conditions for the duration of the verification period
- Intended to deter tampering and show evidence of potential tampering
- design and means of application is subject to review and acceptance by the responsible authority

Verification Marking & Sealing

The image shows two methods of sealing applied to a diaphragm meter in conformance with Measurement Canada requirements.

1. a three point wire and lead seal arrangement
   - secures hand-hole cover, register cover and top cover
   - seal bears mark of the verifier and the year of verification
   - wire runs through lead seal
   - lead seal is crimped

2. plastic sealing caps
   - prevent access to screws
   - must destroy to remove
   - bear mark of verifier and year of verification



Verification Certificate

Verification results of a gas meter or population of gas meters should be recorded, as evidence of compliance with specified requirements, in the event of an audit or measurement complaint.

The record should include:

- a distinct identification number
- test date and location
- name of meter owner
- name of organization conducting verification
- identification of measuring standards used
- meter make, model, serial number, etc.
- all approved and verified measurement functions
- all associated test errors
- name & signature of verifier

Verification Period

The responsible authority determines the period of time a verified gas meter or auxiliary device may remain in service before coming due for reverification.

The table gives Measurement Canada's initial verification periods for various gas meters and auxiliary devices.

Meter Type	# of Years
Diaphragm (TC)	7
Rotary	20
Turbine (low pressure testing)	6
Turbine (high pressure testing)	6
Domestic / Commercial Ultrasonic (TC)	6
Pipeline Ultrasonic	6
Volume Conversion Device	6
P, DP & T Transmitters	7

Subsequent Verification

From OIML document, *International Vocabulary of Terms in Legal Metrology (VIML), Edition 2000*

Subsequent Verification

any verification of a measuring instrument after a previous verification and including:

- mandatory periodic verification
- verification after repair

NOTE

Subsequent verification of a measuring instrument may be carried out before expiry of the period of validity of a previous verification either at the request of the user (owner) or when its verification is declared to be no longer valid.

Subsequent Verification

The use of subsequent verification, or reverification, is intended to ensure that gas meters are removed from service before reliability deteriorates or accuracy drifts beyond in service maximum permissible errors.

Measurement Canada | Mesures Canada

Canada

Legal Metrology & Natural Gas Trade Measurement in Canada

Natural Gas in Canada

Canada is the second largest natural gas producer in the world after the United States.

Proven natural gas reserves as of January 2008 were 57.9 trillion cubic feet.

The majority of natural gas is produced from the large Western Canadian Sedimentary Basin with production on a smaller scale from Eastern Canadian offshore sources.

In Canada, natural gas is used primarily in the:

- residential and commercial sectors for heating
- industrial sector for process heat in the production of chemicals
- generation of electricity

Natural Gas Import / Export

Natural gas exports to the United States in 2007 were 10 billion cubic feet per day.

It is imported from the USA where and when cheaper than Western Canadian gas and to take advantage of existing pipeline infrastructure and storage facilities.

Legal Metrology in Canada

The National Research Council of Canada (NRCC) is our national metrology organization.

Measurement Canada (MC), a special operating agency of Industry Canada, is our national legal metrology organization.

Our mandate is to ensure integrity and accuracy of trade measurement through the administration and enforcement of the:

- *Weights and Measures Act and Regulations, and the*
- *Electricity and Gas Inspection Act and Regulations*

Measurement Canada has produced a video to highlight our role in the Canadian marketplace.

E&G Inspection Act & Regulations

This legislation sets rules for purchase and sale of natural gas and defines legal units of measurement.

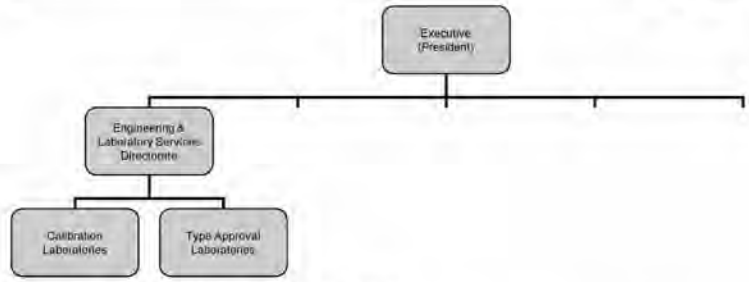
The Act requires that:

- natural gas meters be approved for use in trade in Canada
- only approved and verified gas meters are used in trade, and
- the accuracy of natural gas meters be subsequently verified in accordance with the time periods stipulated in the Regulations

The Act permits the:

- accreditation of private sector organizations to perform verification on Measurement Canada's behalf
- investigation of measurement disputes between buyers and sellers of natural gas

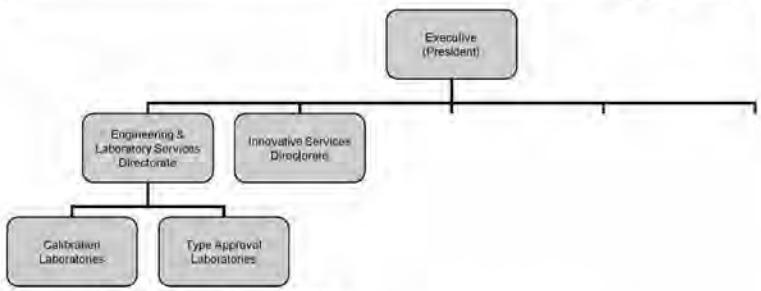
Organization



Engineering and Laboratory Services

Provides engineering consultation and advice, measuring device approval evaluation and measurement standards calibration services.

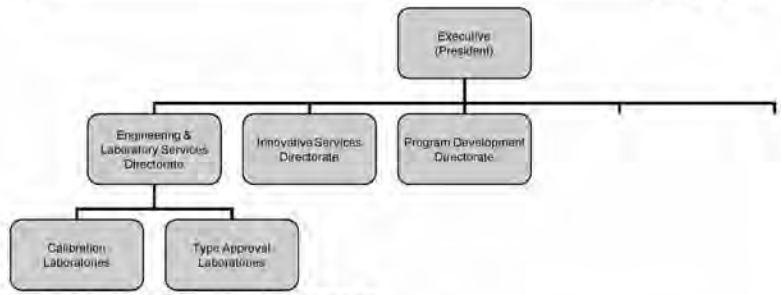
Organization



Innovative Services Directorate

Plans, develops, implements and monitors the Agency's quality management systems, technical training and Alternative Service Delivery (accreditation) programs.

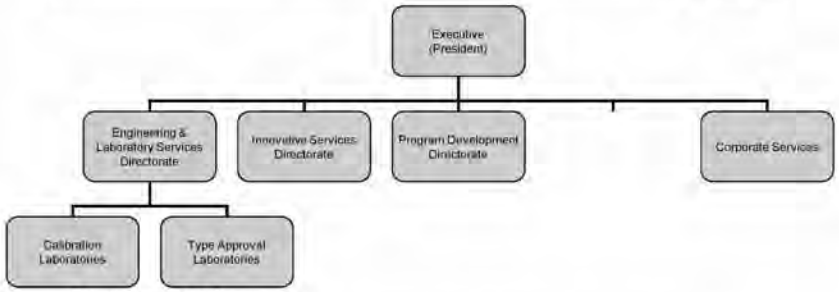
Organization



Program Development Directorate

Plans, develops and assesses the impact of national policies, procedures and specifications and legislative and regulatory reforms.

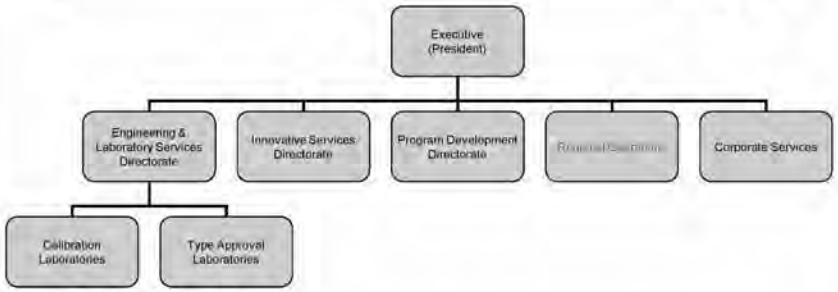
Organization



Corporate Services

Provides planning and performance evaluation, business applications coordination, client services, communication services, Web publishing and administrative, human resources and financial services.

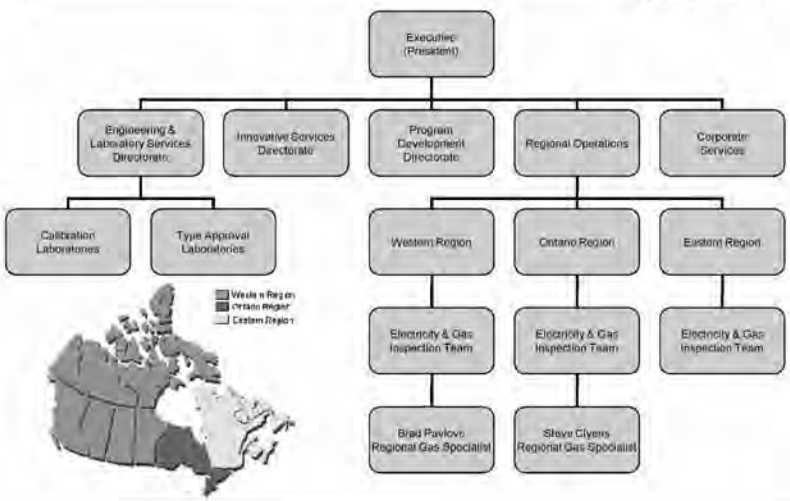
Organization



Regional Operations

Manage the delivery of measuring device inspection, Alternative Service Delivery programs, measurement standard calibration services, and measurement dispute investigations.

Organization



Regional Gas Specialists

Steve Clyens, Gas Specialist, Ontario Region

Graduated college as Mechanical Engineering Technologist, 1989
21 years with Measurement Canada as:

- electricity and gas metering inspector, 1989 ~ 1998
- electricity metering training course coordinator & instructor, 1991 ~ 1998
- gas measurement specialist, 1998 ~ present
- gas metering training course coordinator & instructor, 2000 ~ present

Brad Pavlove, Gas Specialist, Western Region

22 years with Measurement Canada as:

- weights and measures inspector, 1988 ~ 1994
- gas metering inspector, 1994 ~ 2001
- accreditation auditor, 2001 ~ 2004
- gas measurement specialist, 2004 ~ 2007
- participated in a trade sector review, 2007 ~ 2008
- gas measurement specialist, 2008 ~ present

Gas Meters

Gas meters used in trade applications include:

- diaphragm, rotary
- turbine, ultrasonic, orifice
- fluidic oscillator
- vortex
- coriolis

- fixed pressure (PFM) regulators

- volume conversion devices (mechanical & electronic)
- P, T, DP transmitters & flow computers

- gas chromatographs

- AMR (automatic meter reading) & telemetering devices

MC & International Standards / Recommendations

Measurement Canada (MC) has not yet adopted:

- OIML R 137 (Gas meters); or
- OIML R 140 (Measuring systems for gaseous fuel)

MC is waiting for OIML Technical Committee TC8/SC7 to revise both of these Recommendations and harmonize their requirements.

However, many of the requirements in our existing Specifications for gas meters are already aligned with or similar to the requirements in R 137.

MC has not yet made a decision on whether to adopt the requirements in OIML R 139 (Compressed gaseous fuel measuring systems for vehicles).

MC & International Standards / Recommendations

MC is proceeding towards the adoption of OIML D 31 (General requirements for software controlled measuring instruments)

MC has recently formed a Canadian Joint Work Group to develop specifications for:

- security and control of software & firmware used in electricity and gas meters
- Event Loggers incorporated in electricity and gas meters

MC & International Standards / Recommendations

MC has aligned many of its requirements with USA requirements by adopting the following gas industry standards:

- American Gas Association (AGA) Report No. 3 ~ *Orifice metering of natural gas*
- American Gas Association (AGA) Report No. 7 ~ *Measurement of natural gas by turbine meters*
- American Gas Association (AGA) Report No. 8 ~ *Compressibility Factor of Natural Gas and Related Hydrocarbon Gases*
- Gas Processors Association (GPA) Standard 2145 ~ *Table of physical properties for hydrocarbons and other compounds of interest to the natural gas industry*
- Gas Processors Association (GPA) Standard 2172 ~ *Calculation of gross heating value, relative density, compressibility, and theoretical hydrocarbon liquid content for natural gas mixtures for custody transfer*

These are referenced in some of our specifications for pattern approval and meter verification.

MC Specifications

For some types of gas meters, MC has developed and published its own Specifications and Provisional Specifications for:

- pattern approval
- verification and reverification
- installation and use

MC has developed and published its own set of statistical sampling specifications for:

- Acceptance Sampling (for verification and reverification of gas meters)
- Compliance Sampling (for extension of the seal period or reverification interval of gas meters in service)

Implementation Issues

MC has approximately 317 employees, of which 97 work for headquarters and 220 work in Regional and District offices across Canada.

Only a small percentage of these employees are involved in activities relating specifically to the regulation of natural gas trade measurement.

Most gas meter verification activities are performed by MC accredited organizations in accordance with our accreditation standard, S-A-01.

Our limited resources are used to monitor the marketplace by annually targeting various types of meters and metering installations for inspection and testing.

Recent budget expenditure freezes for all government departments will further limit the financial resources (operational and salary) that MC needs to continue implementing our legal metrology program.

Thank you

Gas Meters In P.R.CHINA

Presentation by Yang Youtao

Beijing Institute of Metrology

April 13, 2010

Outline

1. Introduction
2. Natural Gas In P.R.China
3. Gas Meters used in P.R.China
4. Legal metrology on Gas Meters
5. Compliance to the ISO/OIML
6. Standards &Test Rigs for Gas Meters
7. Verification & Type Approval

Introduction Who?

Name: Yang Youtao
Robert.Yang

1. Employer: **Beijing Institute of Metrology (BIM)**

2. Duty: Director of Technology Department of Beijing Institute of Metrology (BIM)
   Senior Engineer
   National Registered Metrologist

P.S Chairperson of the Working Group on Metrological Control System (MCS) of APLMF.

Introduction

professional experience

Major: Test & Flow Measurement
For 10 Years Work Experience in Flow Measurement

- Committeeman of Flow Measure Committee of Chinese Society for Measurement
- Published 4 Books of Flow meters

Published Books of Flow meters by China Metrology Publishing House

author

BEIJING INSTITUTE OF METROLOGY (BIM)

1. **Beijing Institute of Metrology (BIM) is a legal metrology Institute.**
2. **Which is belongs to Beijing Bureau of Quality & Technology Supervision. (Beijing municipality)**
3. **BIM is the technical entity institute of Northern-China Area Metrology &Test Center.**

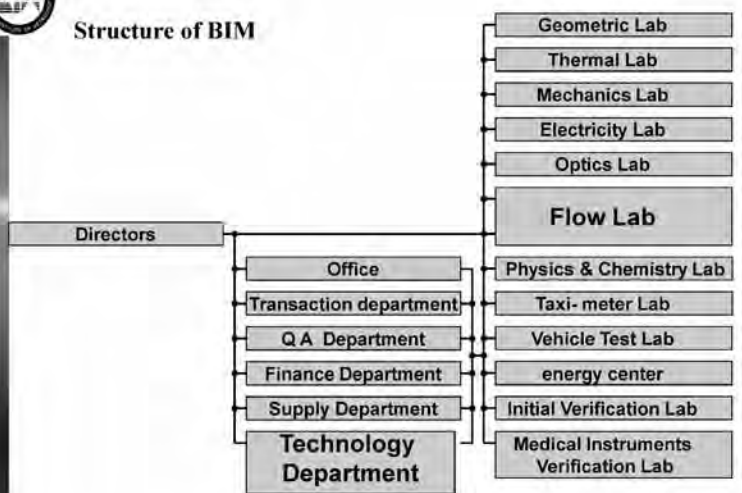
To research, set up and maintain the primary reference and regional measuring standard in the region of Beijing & Northern China. Ensure theTraceability reliability, precisely in the region .

BIM Staff: 260

Northern-China Metrology &Test Center

Northern-China Area cover 5 provinces including of Beijing, Tianjing, Shanxi, Hebei, and Neimonggu.
The approximate total area is 1.5 million square kilometers

Structure of BIM



OIML Certificate (——Gas Meters)

Approved by China National Accreditation Service for Conformity Assessment (CNAS)

MRA ON Gas Meters

The Agreement of Mutual Recognition with Netherlands


MUTUAL RECOGNITION AGREEMENT OF TEST RESULTS

AT EFFECTIVE PERIOD

• The Mutual Recognition Agreement will become effective upon signatory of both parties

AQSIQ or NMi may terminate this agreement by informing the other party in writing at least six months in advance

For AQSIQ

August 22, 2006

Mr. Xuan Xiang
Director General

For NMi

August 22, 2006

Mr. Pieter van Breugel M.Sc
Director

The Agreement of Mutual Recognition with Great Britain


Laboratory which continue to function as the OIML Issuing Authorities in their respective countries, subject to confirmation in writing by both parties at the time.

Signed

on behalf of the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic Of China by:

Mr. Xuan Xiang
Director General, Department of Metrology

and

on behalf of the National Weights and Measures Laboratory by:

Dr Jeff Llewellyn
Chief Executive

This agreement is dated 15th July, 2005

Qualification and Competence

The Facilities for National Pattern Evaluation on Gas Meters

Transient Electric Impulse Group Test Instrument

Electromagnetic Compatibility Laboratory

The Facilities for National Type Approval Test on Gas Meters

Vibration Tester

Sonic Nozzle Standard

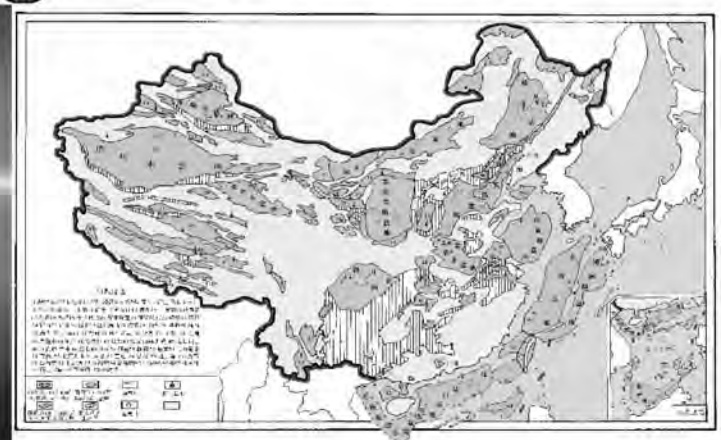
Bell prover

Summarize of Natural Gas In P.R.China

Before 2000

1. natural gas fiscal output: 7 billion m^3
2. long distance gas pipeline: about 1000 km (total length)
3. pipeline system: separate gas field and local distribution
4. metering meters: orifice, swirl and positive displacement
5. only standard: natural gas metering with orifice system

Sketch Map of Gas Field Distributing In China



In 2008, Natural Gas In P.R.China

1. natural gas output: 76 billion m^3
2. long distance gas pipeline: total length 30,000 km
3. pipeline network output: 60 billion m^3
4. major trade fiscal meters:
   ultrasonic, turbine (high pressure pipeline)
   turbine, positive displacement (low pressure system)
5 standards: one for natural gas metering system,
   six for metering meters

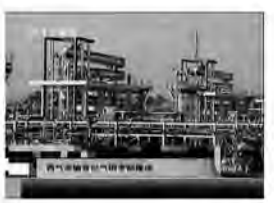
2 Pipeline Network of Natural Gas In China

2 Output of Natural Gas In Future

1. 2009 natural gas output: 89.6 billion m^3
2. 2010 natural gas output: 100 billion m^3
3. 2015 natural gas output: 250 billion m^3
4. 2020 natural gas output: 310 billion m^3

3 Survey of Gas Meters used in China

1. The delivery pipeline network mostly adopting ultrasonic & orifice meters (high pressure)
2. In Towns basicaly using turbine & rotary displacement meter,sometimes vortex precession meter (middle pressure)
3. Resident family basicaly using Diaphragm Gas Meters (low pressure)

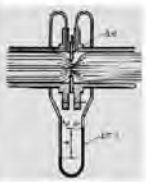


The delivery pipeline network mostly adopting ultrasonic & orifice meters (Transport Measurement high pressure) Pressure / Flow control

City Gate Stations (large and industrial stations)







In Towns basicaly using turbine & rotary displacement meter, vortex precession meter (middle pressure)





rotary displacement meter(middle pressure)


Resident family basicaly using Diaphragm Gas Meters (low pressure)

Statistics of Diaphragm Gas Meters
——11 million in 2008 (made in China)








THE STANDARDS FOR METERING METHODS

By now China has issued 8 National or Petroleum industry standards for different metering meters:

1. **ultrasonic meter**
2. **turbine meter**
3. **orifice meter**
4. **rotary displacement meter**
5. **vortex precession meter**
6. **difference pressure Gas meter**
7. **Coriolis meter**
8. **Diaphragm Gas Meters**

THE STANDARDS RELATED TO METERING

compliance to the international standards / recommendations for gas meters.

No.of standards	Name of standards	Reference standards
GB/T 11062-1998	Natural gas-Calculation of calorific values,density, relative deusity and Wobbe index from composition	Neq ISO 6976:1995
GB/T 17747-1999	Natural gas-Calculation of compression factor	Eqv ISO 12213:1997
GB/T 19205-2003	Natural gas-Standard refereuce conditions	Neq ISO 13443:1996
GB/T 13609-1999	Natural gas-Sampling guidelines	Eqv ISO 10715:1997
GB/T 13610-1992	Analysis of natural gas by gas chromatography	Neq ASTMD1945:1996
GB/T *****-2009	Natural gas euergy measurement(under drafting)	Eqv ISO15112:2007(DIS)
GB/T *****-2010	Speed of sound in natural gas and others related hydrocarbon gases(under drafting)	Eqv AGA No.10:2003
GB17820-1999	Natural gas	Neq ISO13686:1998

THE STANDARDS FOR METERING METHODS

compliance to the international standards / recommendations for gas meters.

1. **To ensure the accuracy and reliability of natural gas metering results, aseries of standards have been worked out or revised in the past few years in China with the related ISO/OIML Documents as references.**
2. **The fundamental standard in the series is Technical requirements of measuring system for natural gas, and the method standards deal with the routine flow meters including turbine, ultrasonic, rotary displacement, vortex,orifice and Coriolis meters**
3. **regulations —— OIML R137(2006), R 6 (1989), R 31 (1995) and R 32 (1989).**

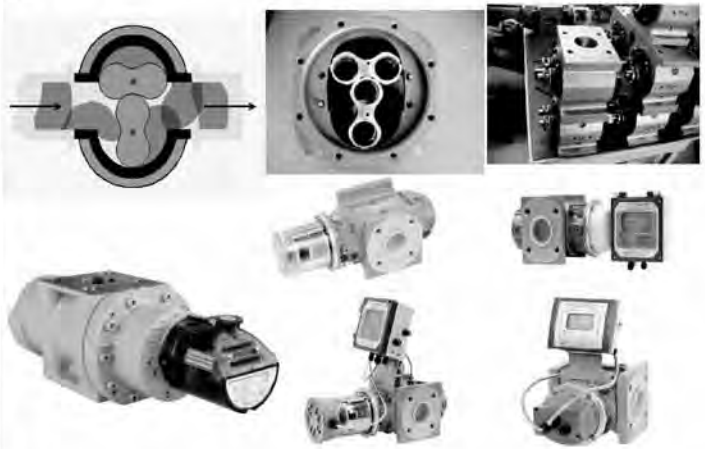
D25——1996 Vortex meters used in measuring systems for fluids

Diaphragm Gas Meters —— R31,R137

Regulations —— the related ISO/OIML Documents as references, OIML R137(2006), R 6 (1989), R 31 (1995) and R 32 (1989)

1. **ultrasonic meter —— JJG 1029—2007**
2. **turbine meter —— JJG 1037—2008**
3. **orifice meter —— JJG 620—2008**
4. **rotary displacement meter —— JJG 633—2005**
5. **vortex meter —— JJG 1029—2007**
6. **Diaphragm Gas Meters —— JJG 577—2005**

Rotary Displacement Gas Meter



Gas Meter manufacturer in China

machining center

automation aging test system

metalworking workshop

Turbine Gas Meter

Difference Pressure Gas Meter

Statistics of Gas Meters in Beijing only

1. 13 million people in Beijing, 3.79 million Diaphragm Gas Meters in resident.
2. 24 thousands Industry Diaphragm Gas Meters
3. 4951 Turbine Gas Meters (DN40 ~ DN400)
4. 9566 Rotary Piston Gas Meters (DN50 ~ DN100)
5. 4873 vortex precession meters (DN25 ~ DN200)
6. 19 ultrasonic Gas meters (DN300 ~ DN400)

Standards &Test Rigs facility for Gas Meters

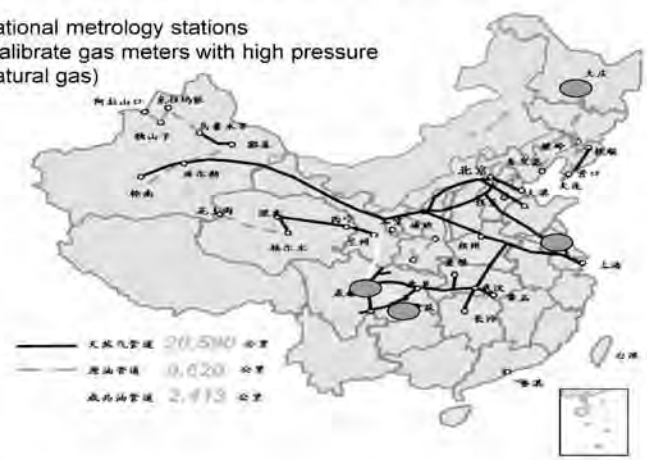
a. There are 4 national metrology stations (To calibrate gas flow meters with high pressure natural gas)
   1. Daqing
   2. Chengdu
   3. Nanjing
   4. Chongqing

b. Almostly Every province technology institute of Metrology got their Test Rig on Gas Meters (low pressure ,Air media)

In the "Law on Metrology in China": the working measuring instruments used for settling trade accounts are subjected to compulsory verification.

the West-East Gas Pipeline

4 national metrology stations
(calibrate gas meters with high pressure natural gas)



Daqing national metrology station

10m³ **bell prover**

Chengdu national metrology station

"mt " test Rig

(0.005～2.4) kg/s，*U*=0.1%

Sonic Nozzle Test Rig

(26～10.0×10⁴) m³/h，*U*=0.25%

p≤4.0MPa

1. To calibrate gas flow meters with high pressure natural gas Flow Standard Facilities: mt primary standard, sonic nozzle secondary standard, master meter working standard, truck-mounted mobile standard. Labs of temperature, pressure and gas composition

1. Designed Pressure：10MPa
2. Calibration Pressure：（4.5～9.6）MPa
3. Flow Range：（8～12000）m³/h
4. Size of MUT：DN50 ～ DN400
5. Using high pressure natural gas directly as flowing medium to calibrate gas meters; To calibrate gas meters under working conditions，eliminating the installation influence

Picture of standards and small test benches room

Nanjing Natural Gas Measurement and Calibration Center

Inlet & Outlet Pipeline

Filters

Pressure regulators

Flow regulators

Flow Standard Facilities and Traceability

1. mt primary standard(8~443)m^3/h;Uncertainty:0.10%(k=2)
2. Sonic nozzle bank——secondary standard (8~3160)m^3/h;Uncertainty:0.25%(k=2)
3. Parallel mounted turbine meter——working standard
4. Ultra sonic meter——checking standard
5. TM & USM—— Mobile standard

The primary standard room and station skid

Truck-mounted Mobile Standard

Mobile standard connected in NMC

Flow Range : (80 ~ 8000) m^3/h

Uncertainty : 0.35% (k=2)

It takes 10000 $ to Calibrate 1 Gas Meter, (DN300)

Back view picture

High Pressure Test Rig

pigsar

Pressure: (14 ~ 50) bar

Operating Volume Flow : (8~ 6500) m^3/h

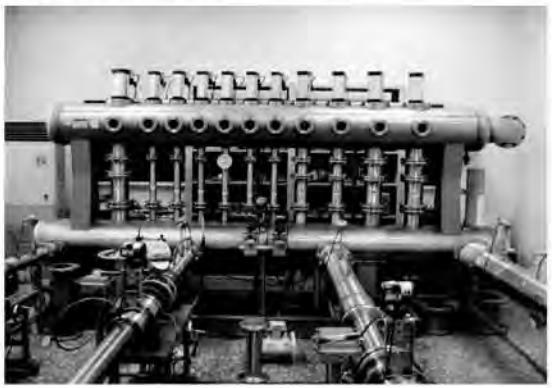
TransCanada Calibration

Sonic Nozzle Test Rig (air,low pressure)

Sonic Nozzle Test Rig Standard with Atmosphere Air

- **2.5 m^3/h to 2500 m^3/h U=0.3% (k=2)**

Accuracy of the nozzles 0.2%

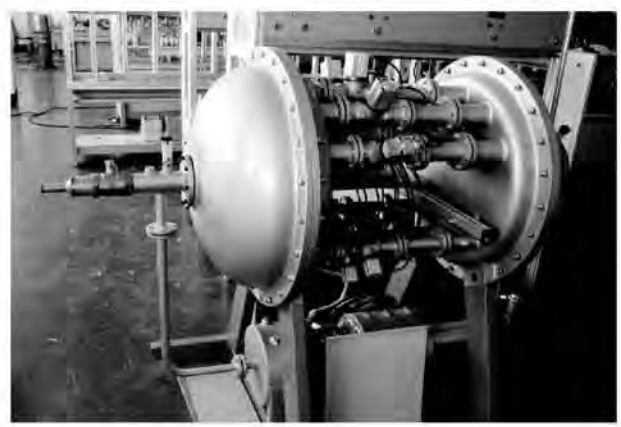


Sonic Nozzles Prover Rig is Suitable for

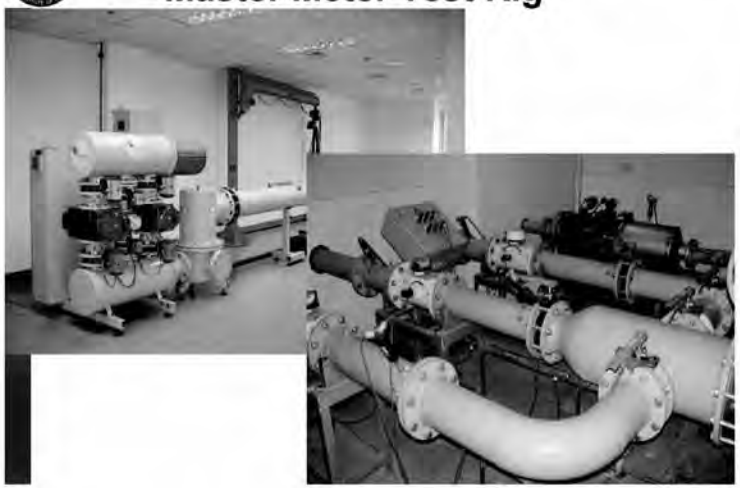
- Rotary Meters
- Turbine Meters
- Ultrasonic Meters
- Diaphragm Gas Meters etc.

Sonic Nozzles

Sonic Nozzle Test Rig for Diaphragm Gas Meters



Master Meter Test Rig



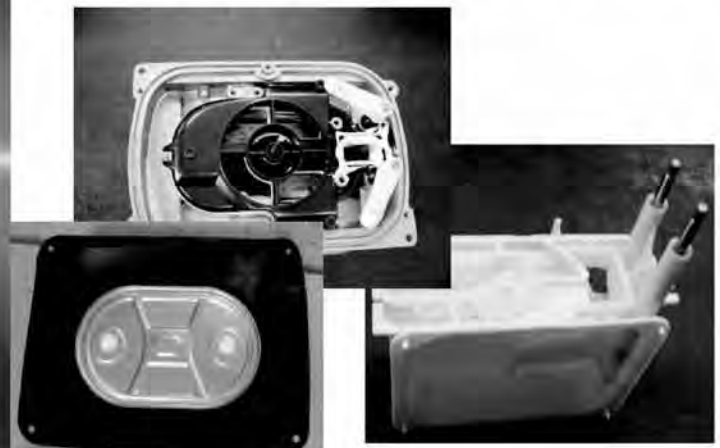
Master Meter Test Rig

Sonic Nozzle Prover for Diaphragm Gas Meter

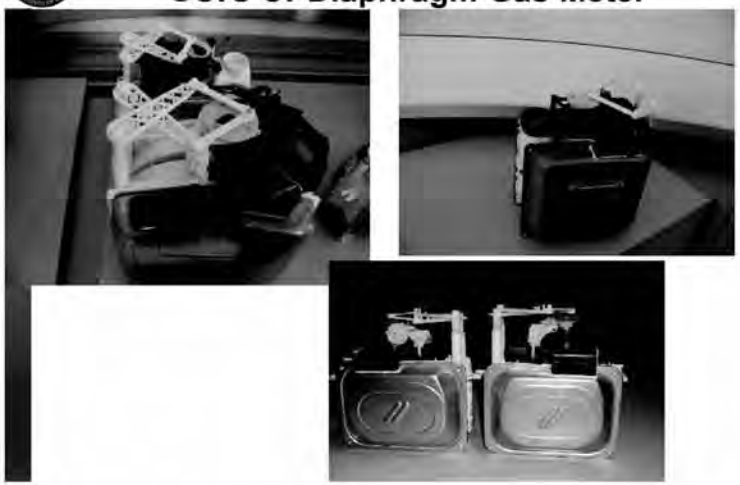
Sonic Nozzle Prover for Diaphragm Gas Meter

Sonic Nozzle Prover for Diaphragm Gas Meter

Part of Diaphragm Gas Meter



Core of Diaphragm Gas Meter



Master Meter Test Rig for Diaphragm Gas Meter

Bell Prover

Bell Prover Test Rig for Diaphragm Gas Meters

Legal metrology on Gas Meters
Conformity Assessment

1. Type approval (national)

—— by National Authority Body

—— Before placing on the market

2 Initial verification (Local)

—— by Local Authority accredited party

—— Before putting into use (100% requirement)

3 Re-verification (subsequent ,Local)

—— Periodic, after repaired, after breaking seals

4 IN-SERVICE INSPECTIONS

—— Instruments in the field (gas meters)

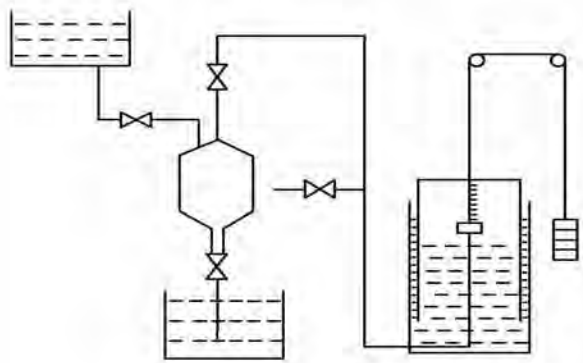
Traceability on Gas Meters in China

NIM, primary Gas flow standard
(pVTt, piston,bell prover,length,tem,pressure,mass,time etc.0.05%~0.1%)

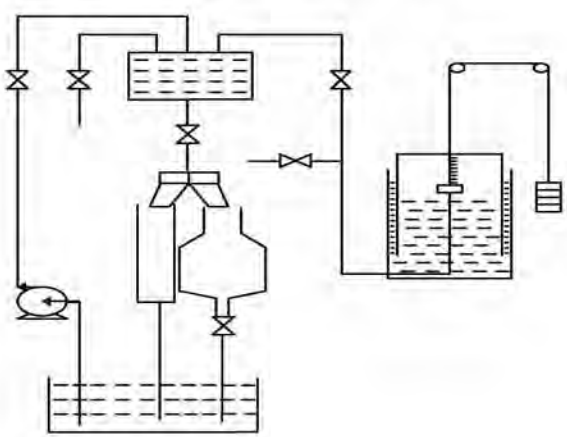
Every Province Institute of metrology, Gas flow standard
(sonic nozzle,master maters,bell prover,etc. 0.2%~0.5%)

Gas Meters
(0.5% below)

Traceability on Bell prover



Traceability on Bell prover



Requirements

1. Re-verification Periodic for Diaphragm Gas Meter? Time? Sample?
2. Low pressure calibration but the gas meter was used in high pressure,how to ensure its accuracy?
3. Type approval test on EMC, high/low temperature test?

Thank you for your attention Q?

CHONGQING, 13–16 APRIL 2010

GAS METER IN INDONESIA

Who am I?

- My name is Larisa Deviyani
- I work for Directorate Metrology Ministry of Trade since 2006.
- My duty is drafting a policy concerning the standard of legal measurement.

Legal Metrology System in Indonesia

- The conduction of legal metrology system is ruled under the Legal Metrology Law No. 2 Year 1981.
- Legal Metrology System in Indonesia is conducting the changing of government administration system from centralized to decentralized (regional autonomy). The metrological operational (e.g. re/verification and metrological inspection) is done by 54 regional verification offices.
- In general, legal metrology system in Indonesia consists of legal control of measuring instruments, legal control of pre-packaged goods, and metrological supervision.

Why my economic controls the using of gas meter?

- The using of gas meter is carried out by National Gas Company (PGN) which is spread in a certain city such as Medan, Jakarta, Bogor, Cirebon and Surabaya.
- There must be quantity guarantee in custody transfer of gas between seller (PGN) and buyer.
- The government should guarantee legal assurance to the validity of the measurement.

The rules that related on gas meter are:

- Article 18 Legal Metrology Law No. 2 Year 1981
- Trade Ministerial Decree no 8 Year 2010 on Legal Measuring Instruments that should be verified initially and subsequently
- Director General of Domestic Trade Decree no 29/PDN/KEP/3/2010 On Technical Requirements of Diaphragm Gas Meter
- In general, the technical regulation of gas meter is adopted from OIML R 6 and OIML R 31

other requirements

- Oil and Gas Law, No 22 Year 2001, article 42 (c) "application of good engineering principles"
- Government Regulation about The operations of the downstream business of oil and gas, No 36 Year 2004 Article 44 (f) "guarantees and is responsible for the accuracy of measuring instruments and systems used"

Based on the consumer, gas meter is divided into two classifications:

- Domestic gas meter
- Industry gas meter

Legal Metrology System for gas meter

- Meter that will be used in Indonesia should have a permission called type approval
- Before meter gets a type approval, it should meet the technical and metrological requirements
- After that, meter should be controlled by initial verification and subsequent verification
- The verification range for gas meter is once in 5 year

Traceability

The major problems to practical the implementation legal metrological system are:

- Gas meter is one of the utility meter
- The cost to adjust the meter when it's time to subsequent verification is much higher than the new one.


Thank You...
100%
INDONESIA


Overview of
Gas Meter In Indonesia
By
Ema Andhajani
DIRECTORATE OF METROLOGY
MINISTRY OF TRADE REPUBLIC OF INDONESIA


Indonesia
Thailand
Laut Cina Selatan
Filipina
Samudera Pasifik
Brunei
Malaysia
Malaysia
SUMATERA
KALIMANTAN
MALUKU
SULAWESI
IRIAN JAYA
AMBON
Samudera Hindia
JAWA
LOMBOK
BALI
Timor Leste
Land areas : 1,922,570 km²
Populations : 219.2 million
Capital City : Jakarta (JKT)
DOM Location : Bandung (BDG)
Approx. 200 km from Jakarta

Content

- Self Introduction
  - —about organization and departement
  - —experience in organization
- Gas meter used in Indonesia
- Legal metrology system for gas meters
  - —Type approval
  - —Verification & re-verification
- The compliance to the international standars/ recommendations for gas meters
- Problems to implement the legal metrology system

Self Introduction

Directorate of Metrology (DOM)

DOM belongs to Directorate General of Domestic Trade, the Ministry of Trade Republic of Indonesia.

DEPARTEMEN PERDAGANGAN
REPUBLIK INDONESIA

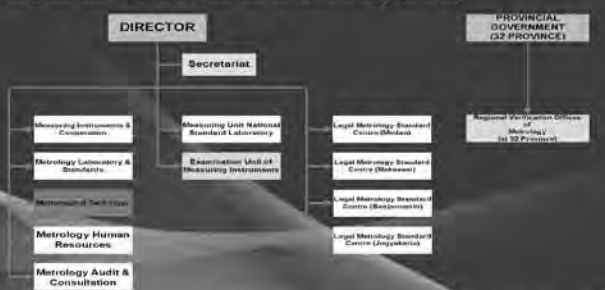
Self Introduction

What is your position and responsibility in your economy?

My position is staff in metrological technique and my responsible are planning and designing standard of procedure, technical regulations for legally measuring instrument.

Type of Organization

Organization of Directorate of Metrology (DOM)



- Planning and Policy making for legal metrology
- Technical service for issuing certificate of type approval
- Administration and Supervision of legal metrology system
- Dissemination of legal metrology system
- International cooperation

Gas Meter used in Indonesia

- Gas Meter that utilized in Indonesia is arranged by minister regulation.
- and that have been arranged technical requirement are :
  - gas meter rotary and piston
  - low meter of pressure gas that is meter of diaphragm gas

Gas meter

Legal Metrology System for Gas Meters

Legal Metrology Syterms

Type Approval	Legal Metrology Bodies (DOM → Metrological Technique) Issuing Type Approval Certificate Issuing Authorities (DOM →Examination unit of Measuring Instrument) Perform Type test & Issuing test report
Initial Verification	Designated verification bodies are in charge initial verification of Gas Meter
Re-Verification	— Each provincial government (Regional Verification Offices) are in charge of Gas Meter of periodical verification & Inspection of Gas Meter — Duration of re-verification Gas meter : 5 year

The compliance to the international standars/ recommendations for gas meters

To implement the recommendations OIML have been adopted into technical requirements and adjusted to the conditions of the gas meter widely used in indonesia

—R31 (1995) diaphragm gas meters
—R32 (1989) rotary piston gas meters & turbin gas meters

Problems to implement the legal metrology system

Problem

has not yet optimism control aspect at:
— Verification
— Initial verification at manufacture

there is no authority on third party to coduct operational verification

SIRIM

SIRIM BERHAD

Gas Meters in Malaysia

By Syahrul b. Manap

National Metrology Laboratory - SIRIM Berhad

MALAYSIA

SIRIM

SIRIM BERHAD

Organization Profile

- President's Office
- Malaysian Design Council Secretariate
- Group Legal & Company Secretarial Dept
- WARTRO Secretariate
- Group Strategic Planning Dept.
- Group Quality & OSHE Dept
- Group Finance Dept
- Group Human Resource & Administration Dept
- Group Corporate Affairs
- Tender, Contract & Procurement Dept
- Branch Management Secretariat

CORPORATE DIVISION

SUBSIDIARIES

- National Centre for Machinery & Tooling Technology
- Advanced Manufacturing Technology Centre
- Advanced Materials Research Centre
- Environment & Bioprocess Technology Centre

RESEARCH & TECHNOLOGY DIVISION

STANDARDS & QUALITY DIVISION

- Standards Management Dept
- National Metrology Laboratory
- Intellectual Property Services, Knowledge Management & Information Services Dept
- Quality Services Dept

MARKETING & BUSINESS DEVELOPMENT DIVISION

- Marketing and Sales Center
- Marketing, Business Development Sales Department

ENGINEERING & SUPPORT SERVICES DIVISION

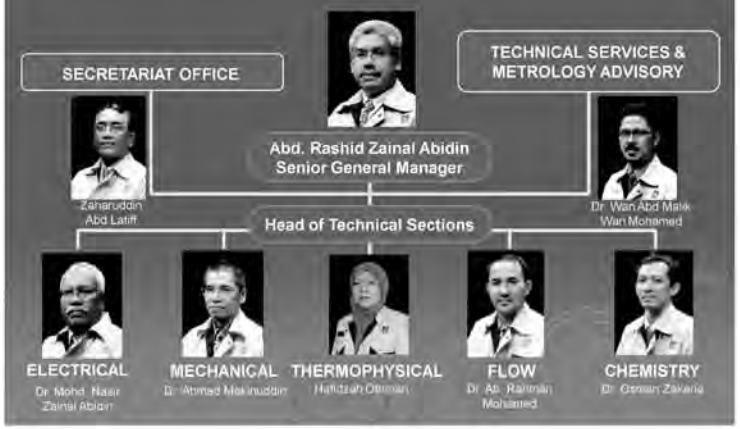
- Printing & Packaging Design Dept
- Engineering & Project Management Dept
- Property Management & IT Services Dept

NML

NATIONAL METROLOGY LABORATORY

SIRIM

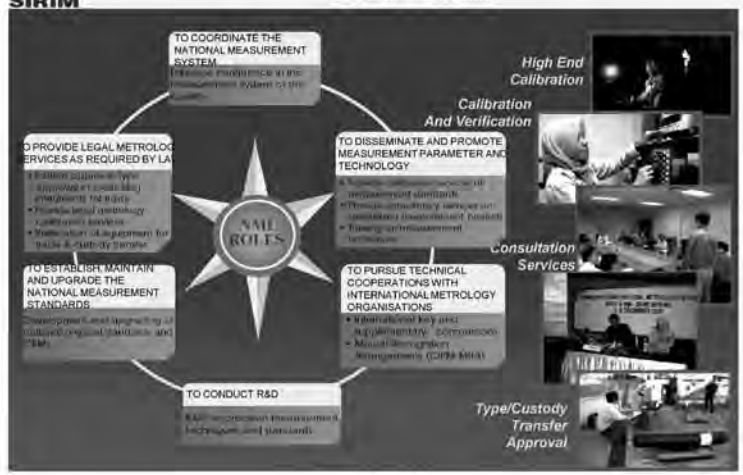
Department Profile



NML—SIRIM BERHAD

SIRIM

Department Profile



NML—SIRIM BERHAD

SIRIM

Department Profile

NATIONAL METROLOGY LABORATORY

NML - A Brief History

- Began with the establishment of the Metrology Unit under the Standards and Industrial Research Institute of Malaysia (SIRIM) in 1975.
- In 1979, SIRIM was appointed as the Custodian of Weights & Measures by the Ministry of Trade and Industry under the Weights and Measures Acts 1972.
- In 1993, it was delegated the responsibility to maintain the Malaysian Standard Time following the appointment of SIRIM as the National Time Keeper.
- In 1996, SIRIM was corporatized into a government wholly owned company known as SIRIM Berhad.

NML—SIRIM BERHAD

SIRIM

Department Profile

Implementation Of A Laboratory Quality Management System

As part of the global MRA requirements for the NMIs, NML is planning to seek accreditation for its quality and management system in accordance with **ISO/IEC 17025**. Documentation of the quality system manual and quality procedures have been completed.

Regional & International Metrology Membership

The NML participates in the activities of the following organizations for which Malaysia is a member of:

- •APMP —— since 1977
- •OIML —— since 1989 (corresponding Member)
- •APLMF —— since 1994
- •Metre Convention —— since 3 Sept 2001 (full member)

NML—SIRIM BERHAD

Background & Professional Experience

- Graduated from University of Technology Malaysia in 2000
- Holder of Bachelor Degree in Mechanical Engineering
- Jan' 01 ~ May'01 : Work as IQC Engineer at Brothers Industries Technologies
- June'01 ~ Oct'01 : Work as QA Engineer at Celestica Electronics Malaysia
- Nov'01 ~ present : Work as Metrologist at National Metrology Laboratory – SIRIM
- Currently in charge of Low Pressure Gas Flow Laboratory, Flow Metrology Section
- Involve in :

i) Scientific Metrology : Maintaining the standards in the lab – Bell Prover, Std. Wet Gas Meter, Molbloc-Molbox, etc.

ii) Industrial Metrology : Calibration of gas flow meter – Wet Gas Meter, Diaphragm Gas Meter, Rota Meter, Mass Flow Meter & Controller, Bubble Soap Flow meter, etc.

iii) Legal Metrology : Pattern Approval of Flow Meter, Fuel Dispenser, Water Dispenser, Custody Transfer Verification & Calibration Activities.

NML—SIRIM BERHAD

Gas Flow Meters in Malaysia

Type of gas flow meters used in Malaysia :

i) Upstream (offshore e.g: platform processing plant)
- —— Ultrasonic meter
- —— Turbine meter

ii) Downstream (onshore e.g: processing plant, refinery plant)
- —— Ultrasonic meter
- —— Turbine meter
- —— Rotary gas meter
- —— Orifice flow meter

iii) Industrial (manufacturing factory, testing & calibration lab, research lab)
- —— Wet gas meter
- —— Diaphragm gas meter
- —— Mass flow meter
- —— Mass flow controller
- —— Rota meter
- —— Bubble soap meter
- —— Sonic nozzle

NML—SIRIM BERHAD

Legal Metrology System in Malaysia

Conducts pattern approval testing for gas meter before it can be used in Malaysia	Custodian of NMS Act	NML – SIRIM Berhad
Gives approval for the installation of gas meter in Malaysia	Authorized Agency	Energy Commision
The applicant who intends to sell their products in Malaysia	Vendor	Emerson, E & H, Krohne, etc.
The company who wants to buy gas meter from the vendor for their business operation	Clients	Petronas, Gas Malaysia, etc.
Performs inspection and verification activities	Inspector, Verifier	MDTCC, MCM

NML—SIRIM BERHAD

Current Situation in Malaysia

—— In Malaysia, the gas meter can be divided into 2 categories :

i) high pressure gas meter, HPGM (e.g: ultrasonic meter, turbine meter, etc.)

ii) low pressure gas meter, LPGM (e.g: wet gas meter, diaphragm gas meter, MFM, etc.)

—— For HPGM, the approval of a brand new HPGM is much more easier to be done with the assistance from the client (Petronas, Shell, Exxon-Mobil) where they require for any gas meter installed in their compound must get pattern approval from NML—SIRIM Berhad.

—— The re-verification of HPGM is done based on verification schedule planned by the client (once a year, etc) and attended by MCM or NML-SIRIM Berhad.

—— For LPGM, the approval of a brand new LPGM is slightly difficult because most of the clients (civilian) are not aware of the requirement for pattern approval.

—— The re-verification of LPGM is done only when there is a dispute from the client about the health of the gas meter (overcharge bill, etc).

NML – SIRIM BERHAD

Implementation Problem in Malaysia

- For HPGM, the implementation of legal metrology system is easier because the clients have awareness on the legal metrology requirements.
- For LPGM, the implementation of legal metrology system is difficult because the clients do not have awareness on the legal metrology requirements.
- The authorized agency, Energy Commission also lack of awareness about the legal metrology system. Many of LPGM installed in Malaysia do not have pattern approval from NML-SIRIM Berhad.
- No verification is done on the LPGM in Malaysia. This is because MCM do not receive any instruction from Energy Commission to carry out the task.
- The re-verification of LPGM is done after there is a request from client. Normally the LPGM will be sent to NML-SIRIM Berhad for calibration.

NML – SIRIM BERHAD

Implementation Problem in Malaysia

- The main reason for the difficulty in implementing the legal metrology system in Malaysia is mainly in LPGM due to :
  - i) lack of awareness from authorized agency
  - ii) lack of awareness from clients (civilian)

NML – SIRIM BERHAD

MALAYSIA : Country Report

Training Course on Gas Meters
13 – 16 April 2010

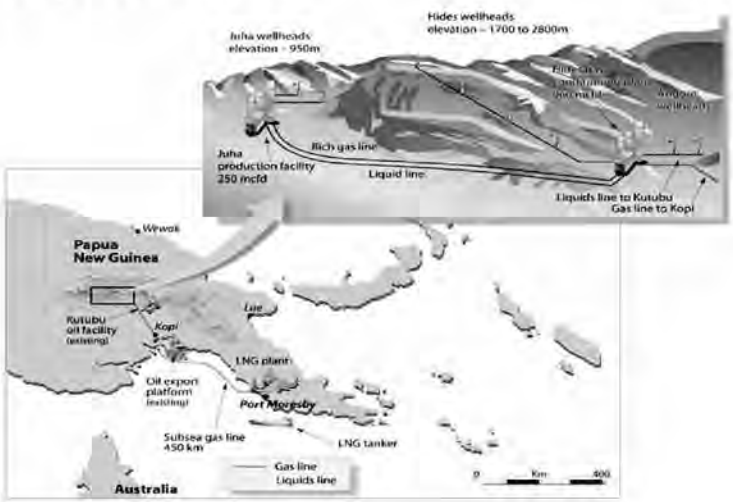
By: Victor. Gabi

National Institute of Standards & Industrial Technology

Objective

- Overview of the PNG ——LNG Project
- Proposed Liquefaction and Storage Facility
- Project timeframe
- International Markets
- Who are the Joint Venture Partners
- What does Metrology Division intend to do to support the Project
- KPI's for the way forward (Action Plan)

Project Overview



PNG LNG PROJECT

- Since April 2007 the PNG LNG Project co-ventures have been working to develop the early design basis and feasibility for a world class LNG project in PNG.
- The project proposes to commercialize the underdeveloped petroleum resources in the Hides, Angore and Juha fields and the associated gas resources in the currently operating oil fields of Kutubu, Agogo, Gobe and Moran in the Southern Highlands and Western provinces of PNG.
- The gas will be conditioned for transportation by pipeline to an LNG facility 20 km Northwest of Port Moresby on the coast of the Gulf of Papua.
- Here the gas will be liquefied and the resulting LNG product (approximately 6.3 million tonnes per annum) loaded onto ocean going LNG tankers and shipped to gas markets overseas.

Time Frame

- Major projects like the PNG LNG Project take many years to design and develop. An optimal concept design, preferred pipeline route and location for an LNG plant and vessel berth have been identified. The Project is currently undertaking front end engineering design (FEED) and securing LNG sales and project financing.
- It is also consulting with government and the community on plans to address social and environment impacts.
- The Preliminary schedule indicates a final investment decision in late 2009 with a target of first LNG cargo in late 2013 or early 2014. Once fully constructed, the project lifetime or production phase is expected to be around 30 years.

Benefits

- The demand and international market for LNG is growing rapidly, particularly in the Asia Pacific region. Many countries including Australia, Malaysia, Qatar and Indonesia currently export LNG. Selling gas internationally brings many benefits to exporting nations in terms of direct income to the state, improvement in the balance of trade, and direct income and other benefits to the impacted communities.

Joint Venture Partners

- The PNG LNG Project is operated by Esso Highlands Limited, a subsidiary of Exxon Mobil Corporation, on behalf of the co-ventures which include Oil Search, Santos, Nippon Oil, Mineral Resources Development Company (MRDC) and Eda Oil. The PNG State is expected to join as an equity participant at a later date.
- Exxon Mobil is the worlds largest publicly traded oil and gas company. It markets more then 11 billion cubic feet per day of natural gas in 28 countries
- Oil Search is PNG's largest oil and gas producer and operator of PNG's producing oil fields. Santos is Australia's largest domestic gas producer with global interest and operations in other energy producing regions.
- Nippon Oil is Japans largest integrated energy company, MRDC is the trustee and manager for landowner interests in PNG oil and gas and, Eda Oil is a subsidiary of Petromin, a PNG State owned corporation.

KPI's for Way forward

- Identify and Understand Metrological Requirements of Natural Gas Industries

  Q. Where should the Controls be established along the LNG pipeline?
- Infrastructure

  1. Understand different OIML Approved Types of Gas Meters,
  2. Understand different types of Approved Methods and Procedures and the Equipment used to Apply them,
  3. Indentify various suppliers of the standards and Test equipment.
- Have some hands on practice if possible

THE END !

Gas Meter Training Course

APEC/APLMF Seminars and Training Courses in Legal Metrology
(CTI 09/2009T)
Chongqing, China

April 13—16, 2010

The National Metrology Laboratory Philippines

NML Goal—Provide accurate international traceability of the physical measurements undertaken in the country.

The National Metrology Laboratory

NMLPhil Laboratories

The Malampaya Deep Water Gas-to-Power Project

Natural Gas Vehicle Program for Public Transport

Legal Metrology System in the Philippines

The Republic Act No. 9236

Known as *"The National Metrology Act of 2003."*

AN ACT ESTABLISHING A NATIONAL MEASUREMENT INFRASTRUCTURE SYSTEM (NMIS) FOR STANDARDS AND MEASUREMENTS, AND FOR OTHER PURPOSES

Legal Metrology System for Gas Meters

DOE CIRCULAR NO. 2002-08-005

Known as the Interim Rules and Regulations Governing the Transmission, Distribution and Supply of Natural Gas

EXECUTIVE ORDER NO. 290

Implementing the Natural Gas Vehicle Program for Public Transport

APEC/APLMF Training Course on Gas Meters——Economy Report

Presented by
Lim Yong Seng
Inspector, Weights and Measures Office (WMO)
SPRING Singapore
13 April 2010

SPRiNG singapore

Outline

1. Weights and Measures Programme
2. Activities of WMO, SPRING Singapore
3. Legal Metrology Requirements for Gas Meters
4. Going Forward

The Weights and Measures Programme

- Governed by the Weights and Measures Act & Regulations
  - —— regulates weighing and measuring instruments for trade use and net contents of pre-packaged goods
  - ——penalises suppliers on short weights and measures
- Ensures a uniform and accurate system of weights and measures so that buyers get what they paid for
- Ensures fair trade and correct excise tax computation

Activities of WMO

Manages Authorised Verifier (AV) Scheme

- Weights and Measures Act and Regulations were amended in Dec 2005, allowing SPRING Singapore to designate AVs.
- AV Scheme took effect from 1 Jan 2006. From 1 Jan 2009, 100% verification work is undertaken by AVs.
- To date, 22 AVs have been designated.
- The AV Scheme increases the pool of verifiers resulting in lower cost and reduced turnaround time for businesses.

Activities of WMO

Registers patterns of new instruments for trade use

- All patterns of new weighing and measuring instruments for trade use have to be tested and certified to meet the applicable OIML Recommendation.
- To date, over 250 patterns of weighing and measuring instruments have been registered with SPRING Singapore for trade use.

Activities of WMO

Administers the Accuracy Label

- To further boost the confidence of consumers and businesses alike, Accuracy Labels (above) are affixed on all verified weighing and measuring instruments for trade use.
- Contain AV's identification code, e.g. "01", "02" and date of verification.
- All 40,000 weighing and measuring instruments for trade use are affixed with the Accuracy Label.

Activities of WMO

Post-market Surveillance and Audit Inspections

- Inspects weighing and measuring instruments for inaccuracies & tampering
- Conducts audit reviews on Authorised Verifiers
- Investigates complaints on short weights & measures

Legal Metrology Requirements for Gas Meters

Gas Meters and its usage

- Gas meters (mainly diaphragm meters) are installed on domestic and commercial utility gas system and LPG pipe system.
- Energy Market Authority (EMA) is the regulator of town and natural gas. The town gas pipeline network serves about 50% of the households in Singapore. Town gas is used mainly for cooking and water heating by domestic and commercial customers. Natural gas is imported into Singapore from Malaysia and Indonesia via four offshore pipelines.
- LPG pipe system is regulated for safety aspects by the Singapore Civil Defence Force (SCDF).
- The accuracy of the LPG gas meter is yet to be regulated.
- For feedback on LPG gas meters, WMO is currently working with EMA/SP Power Grid to test the gas meters that customers (users) claim to be inaccurate.

Going Forward

1. Expand the scope of the Authorised Verifiers to include new areas like verification of CNG dispensers, working standards, etc.
2. Develop verification capabilities in emerging areas including Flowmeters, Gas Meters and Hydrogen dispensers
3. Equip WMO Inspectors/Authorised Verifiers with latest updates of relevant OIML Recommendations

Gas Metering Legislation & Regulations in Singapore

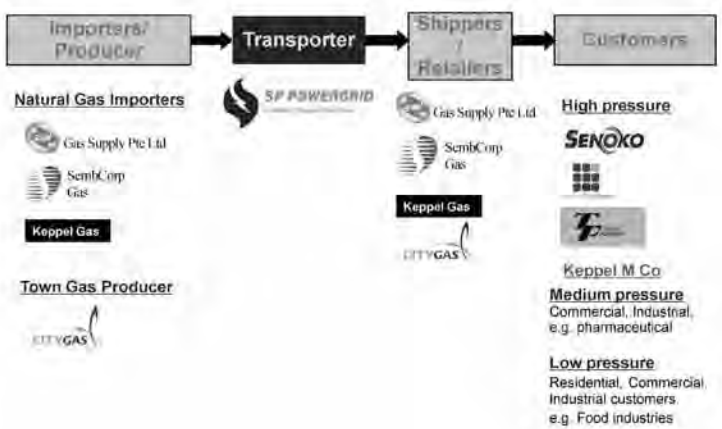
13-16 Apr 2010
Gas Meter Training Course
Chongqing, China

Lee Kok Kin

Introduction

- PowerGas is a Gas Transporter Licensee
- SP PowerGrid ("SPPG") is a Gas Transport Agent Licensee
- SPPG manages the gas transportation system in Singapore on behalf of PowerGas
- Energy Market Authority (EMA) is the Regulator

Introduction



Regulatory Regime

- Gas Act
- Gas Metering Regulations
- Gas Metering Code

Type of Meter Installations

Balancing Period Read Meter ("BPRM")

i) Meter Reading is conducted for each Balancing Period

ii) Meter Data is recorded in the Meter Installation for each balancing period

iii) Meter Data is available to the Designated Gas Transporter at hourly intervals

iv) At least 35 calendar days of meter data measured and recorded for each balancing period

v) Have a Gas Chromatograph and flow computer installed at all Transmission Network Injection Points and the Distribution Network Injection Points

Type of Meter Installations

Balancing Period Capable Meter ("BPCM")

i) Meter Reading is not conducted for each Balancing Period

ii) Meter Data is recorded in the Meter Installation for each balancing period

iii) Meter Data is available to the Designated Gas Transporter at intervals longer than every hour

iv) At least 35 calendar days of meter data measured and recorded for each balancing period

Type of Meter Installations

Daily Read Capable Meter ("DRCM")

i) Meter Data is recorded in the Meter Installation for each day

ii) Meter Data is available to the Designated Gas Transporter at intervals longer than every day

iii) At least 35 calendar days of meter data measured and recorded daily

Type of Meter Installations

Manually Read Meters ("MRM")

i) Meter Data is not recorded in the Meter Installation for each day

ii) Meter Data is available to the Designated Gas Transporter at intervals longer than every day

iii) Capable of measuring the volume of gas supplied or amount of energy supplied

Classification of Meters

Category	Maximum Volumetric Flowrates (scmh)	Description of Meter Installation
Category 1 BPRM	> 150,000	(b), (c) or (d) with pressure and temperature correction, SCADA connection facilities, flow computer.
Category 2 BPRM	>30,000 ≤150,000	(b), (c) or (d) with pressure and temperature correction, SCADA connection facilities, flow computer.
Category 3 BPCM	>6,000 ≤30,000	(a), (b), (c), (d) or (e) with pressure and temperature correction, flow computer balancing period readings retrievable.
Category 4 DRCM	>3,000 ≤6,000	(a), (b), (c), (d) or (e) with pressure and temperature correction, daily readings retrievable.
Category 5 MRM	< 3,000	(a), (b), (d) or (e) with pressure correction when supply pressure to the premises is at pressure of 10kpag or above.

Type of Meters

a) Orifice Plate Meter

b) Turbine Meter

c) Ultrasonic Meter

d) Mass flow Meter

e) Positive Displacement Meters (Rotary or Diaphragm)

System Points

The various defined system points:

- Transmission Network Injection Point — GC + FC
- Distribution Network Injection Point — GC + FC
- Transmission/ Distribution Point — BPRM
- System Critical Point — BPRM
- Transmission Offtake Point — BPRM
- Distribution Offtake Point — BPRM

Accuracy Limits

Category	Hourly flow rate range (inscm/hr)	Accuracy Limits (volume)
1	> 150,000	±0.7%
2	>30,000 ≤150,000	±1.0%
3	>6,000 ≤30,000	±1.5%
4	>3,000 ≤6,000	±2.0%
5	< 3,000	±2.5%

Periodic test & Calibration of meter installations

Category	Peak Flow Rate of connection point	Pressure and Temperature Calibration frequency	Gas Chromatograph Calibration Frequency	Meter Test Frequency
1	> 150,000	Semi-Annually	At least once every two (2) weeks	Annually
2	>30,000 ≤150,000	Semi-Annually	At least once every two (2) weeks	Annually
3	>6,000 ≤30,000	Annually	At least once every two (2) weeks	Annually
4	>3,000 ≤6,000	Annually	At least once every two (2) weeks	Annually
5	< 3,000	Annually	N.A.	Once in ten (10) years

SPPG Meters Inventory

Gas Meter Type	Customer Type	Typical Sizes	Typical Flow rates (m^3/hr)
Diaphragm	**Domestic (MRM)**	G1.6 to G10	1 to 16
Rotary	**Commercial (MRM)**	G25 to G250	1 to 400
Turbine	**Industrial (MRM/ DRCM/ BPCM)**	G65 to G1600	10 to 2500
Ultrasonic	**Transmission Offtakes (BPRM)**	4" to 24"	2000 to 200,000

Meter Calibration Requirements

All meters before installation and during service shall be calibrated by

- A laboratory approved by the Singapore Accreditation Council under the Singapore Lab Accredited Scheme (SAC-SINGLAS); or
- Any of the test facility specified eg: NMi, Holland
- Test results shall be kept for a period of at least 6 years

Facility

3 Meter test benches setup for calibrating flow meters.

Accredited by Singapore Accreditation Council - SINGLAS for ISO:IEC 17025 " Calibration and Measurements" since 9 May 2005

BPG—R SN 2.5 Test Bench

SP POWERGRID

Flow Rate: 1m³/hr

Type: G1.6 Diaphragm Gas Meter (side entry)

Method: Sonic Nozzle

Best measurement Capability: +/- 0.45%

ACCREDITED LABORATORY SAC-SINGLAS

BPG SN G10 Test Bench

SP POWERGRID

Min Flow Rate: 0.4m³/hr
Max Flow Rate: 16m³/hr

Type: G4 to G10 Diaphragm Gas Meter

Method: Sonic Nozzle

Best measurement Capability: +/- 0.15%

ACCREDITED LABORATORY SAC-SINGLAS

GM G1600 Test Bench

SP POWERGRID

Min Flow Rate: 0.6m³/hr
Max Flow Rate: 2500m³/hr

Type: Rotary & Turbine meter

Method: Master Meters

Best measurement Capability: +/-0.22%

ACCREDITED LABORATORY SAC-SINGLAS

GM G1600 Test Bench

SP POWERGRID

Master Meters

1) Rotary Piston G65 (10 to 100m³/hr)

2) Turbine G1600 (650 to 2500m³/hr)

3) Rotary Piston G400 (100 to 650m³/hr)

ACCREDITED LABORATORY SAC-SINGLAS

Thank You

Current Legal Measures on Diaphragm Gas Meters in Chinese Taipei

Hsien- Liang Chen
Bureau of Standards, Metrology and Inspection,
Ministry of Economic Affairs
June 22, 2009

Contert

Introduction

- Bureau of Standards, Metrology and Inspection (BSMI in short)

  BSMI is the sole legal metrology authority in Chinese Taipei,However,it charges three main jobs

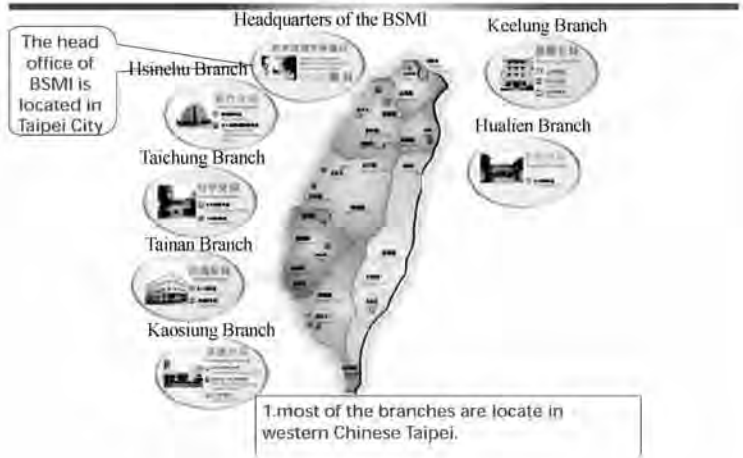
  - Development and promotion of standards
  - Legal metrology control
  - Inspection of commodities for import and domestic Market

  There are 7 departments in the head office in Chinese Taipei and 6 branches island-wide.

- Self-introduction

  I am in charge of legislation affairs and type approval of the diaphragm gas meters since last September. Before that I work for other types meters.

Map of BSMI Office Locations



Scope & Type

- Scope
  - Any gas meters used for commerce measurement are subject to legal metrology control, e.g. home-use diaphragm gas meters or industry-use turbine meters.
- Category
  - Currently, most of home-use diaphragm gas meters belong to mechanical type and only a small part of gas meters equip with micro-computer.

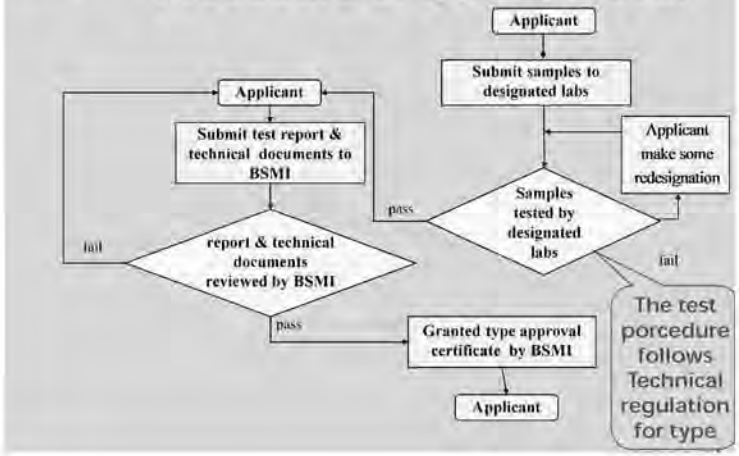
Competent Authorities

Source of instruments	The gas meters used in Chinese Taipei could be made by local manufacturers, but a large portion of gas meters are foreign products. However, local manufacturers produce only diaphragm meters with maximum flow rate less than 16 m^3/h.
Purchasers	The only buyers of diaphragm gas meters are city gas distributors and they take the responsibility to install gas meters. On the other hand, the users of the larger flow rate meters used in plants buy their own meters.
Legal metrology authorities	1.BSMI drafts and approves all the technical regulations related with legal metrology control on gas meters. 2.BSMI issues the manufacture license, repair license, and import license to the applicants who want to run the business related with gas meters. 3.When do type approval, BSMI designates a laboratory to do the test as technical the regulation. 4.BSMI do the verification on diaphragm gas meters. However, we have authorized 2 local laboratories to do the initial verification for their own products.
Market Surveillance	BSMI do market surveillance non-periodically via purchasing sample from open market and testing the sample to make sure the gas meters fulfill the type approval requirement.

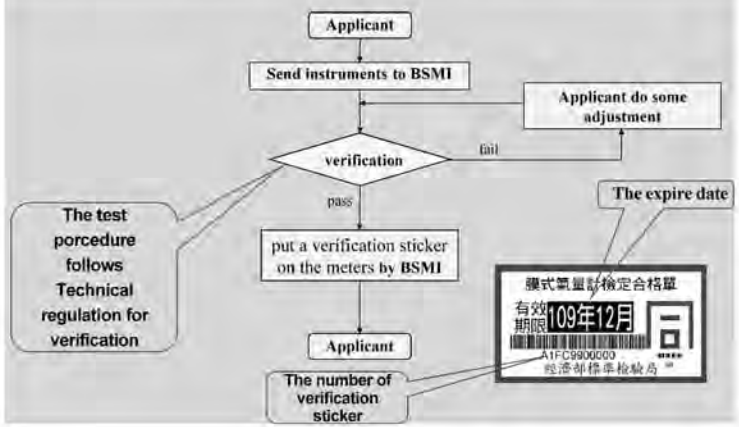
Legal Measures

License	All gas meters' manufacturers, repairers and importers are license required. BSMI is the sole authority to issue the license.
Type approval	1.The applicants for type approval have to received a license issued by BSMI. 2.Any diaphragm gas meter with maximum flow rate not larger than $16m^3/h$ is type approval required. 3. Market surveillance is done by BSMI non-periodically.
Verification	1.The applicants for initial verification have to received a license issued by BSMI. 2.Any diaphragm gas meter with maximum flow rate not larger than $90m^3/h$ is verifications approval required. 3.Initial verification can either be done by BSMI or done by a authorized private laboratory. 4.Re-verification required after repaired or verification sticker expired and this can only be done by BSMI.
Inspection	Inspection can be done irregularly with MPE twice as that of initial verification. BSMI is the sole authority to do inspection.

Procedure of type approval



Procedure of verification



Self-verification

- BSMI set 5 requirement for the potential applicants of self-verification as below:
  - ISO 9000 certificated manufacture
  - ISO 17025 accredited laboratory located in Chinese Taipei area
  - Adequate equipment with periodical calibration
  - Qualified technicians
  - One fifth verification fee collected by BSMI
- BSMI have to do supervision from time to time to make sure the gas meters fulfill verification requirement.

Introduction of regulation-1

Technical regulation for type approval

Applicant requirements	A qualified applicant need a license from BSMI
Test item	Initial performance test. Constant temperature test. Pressure absorption test. Endurance test.
Testing and report format	The Testing and report format are same as OIML R 31.
Validity	The validity of type approval is 10 years. The certificate can be extended if the applicant submit a request prior the expired day.

Introduction of regulation-2

Technical regulation for verification

Applicant requirements	1.Applicants for verification have to the owner of type approval. 2.Before we do verification test, the technician will check if the meter is fulfill the type approved.
Test item	1.Airtight testing with 10 kPa for lasting 3 min by sampling method Pressure absorption testing. 2.Errors test at 2 different flow-rate, $Q_{min} \leq Q < 0.1\ Q_{max}$ and $0.1Q_{max} \leq Q \leq Q_{max}$ with MPE 3.0% and 1.5% respectively. 3.The absolute value of the errors of $0.1Q_{max} \leq Q \leq Q_{max}$ shall not exceed 1% when these errors are all of the same sign.
Test method	The testing method are same as OIML R 31.
Validity	1.The verification validity is 10 years. The validity for re-verification is **also 10 years.** **2.The verification applies to every single gas meter.No gas meters which is subject to verification can be put on market or sold before it passes.**

-- Thank you --

APEC / APLMF Training Course on Gas Meter
April 13—16, 2010 Chongqing , China

Inspection Gas Meter in Thailand

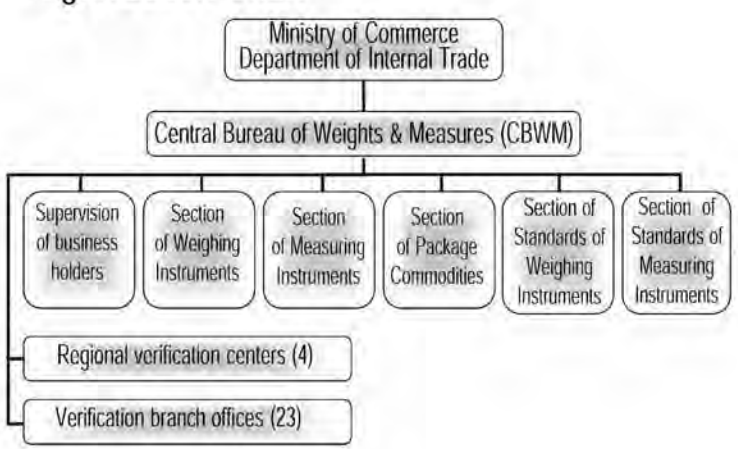
Mr.Prathan Bun-khong
Central Bureau of Weights and Measures
Department of Internal Trade , Ministry of Commerce

1.Self Introduction

1.1 My organization and department.

I work for Bureau of Weights and Measures (CBWM) is under Department of Internal Trade, Bureau consists of head office in Nonthaburi, 4 Reginal verification Center and 23 Branch Offices.

Oganization Chart



Duties and services of Bureau of weights and measures

1.Services to be carried out for the purpose of consumer protection through

- Providing. Calibrating and maintaining the standards of weights and measures
- Precribing the rules and supervising the businesses of munufacture, import, repair, and sale of weighing and measuring instrument, including the business of providing weighing and measuring services

Duties and services of Bureau of weights and measures (Continued...)

- Verifying the weighing and measuring instruments and inspecting of such instruments in operation.
- Prescribing the sizes and the displaying methods of net content of packaged goods and inspecting their net content.

2.Servics which aim to promote the benchmarks of weighing and measuring instruments for consumers and industrial sector.

1.2 My professional experience in the organization.

I started at position of weights and measures officer in section of measuring instruments around 4 years.

I am responsible for verification of measuring instruments which are manufactured, repaired, Sold and imported and supervision of the uses of measuring instruments to ensure that no taking advantage of abuse of such instruments takes place and make public understanding regarding a correct means on the use of measuring instruments.

2.Gas Meters used in Thailand

Gas Meter (mass flow meter) used in compressed natural gas as a motor-fuel (Car, taxis car, buses and trucks)

Gas Meters used in Thailand (Continued...)

There are currently 245 serviced CNG Stations in Thailand which there is the CNG gas dispenser approximately 1,793 units used for trade.

Nowadays, The CNG gas supply by PTT Public Company Limited.

3. Legal metrology system for gas meter in Thailand

There is the specify ministerial regulation controls Mass flow meter at used a measuring CNG gas dispensor effective October 5, 2009.

The CNG gas meter shall be examined and verified every 2 years.

Nowadays, providing verification of CNG gas dispenser for serviced CNG stations at setup in the station already.

Testing Procedures of CNG gas meter

The testing procedures have been determined yet, used CNG Prover providing verification of CNG gas dispenser.

Testing Procedures of CNG gas meter (Continued...)

The Testing CNG gas dispenser of quantity (M)

- 10 kg.
- 15 kg.
- 20 kg.

The Regulation of CNG

The examined and verified CNG gas dispenser

The ministerial regulation specify of the permissible error ±2% (Not less than 2 kg.), Repeatability ⩽ 0.8%

Quantity (M), kg	MPEs
0.1 to 0.2	0.08 M
0.2 to 0.4	16 g
0.4 to 1	0.04 M
1 to 2	40 g
Not less than 2	0.02 M

4.Current situation in your economy about the compliance to the international standards/ recommendation for gas meter

The current situation the compliance of National Institute of Standards and Technology (NIST)

Handbook 44–2008
Section 3.37 Mass Flow Meter

5. Are there any requirements from your economy? Do you have any problems in order to implement the legal metrology system

- The method inspecting CNG gas dispenser
  I want the method inspecting CNG gas dispensor by must not use prover because the prover expensive.

Thank you

APEC / APLMF Training Course on Gas Meter

April 13–16, 2010 Chongqing China

"Gas Meter"

Miss.Lamoon Chanatalay
Central Bureau of Weights and Measures
Department of Internal Trade
Ministry of Commerce

SELF INTRODUCTION

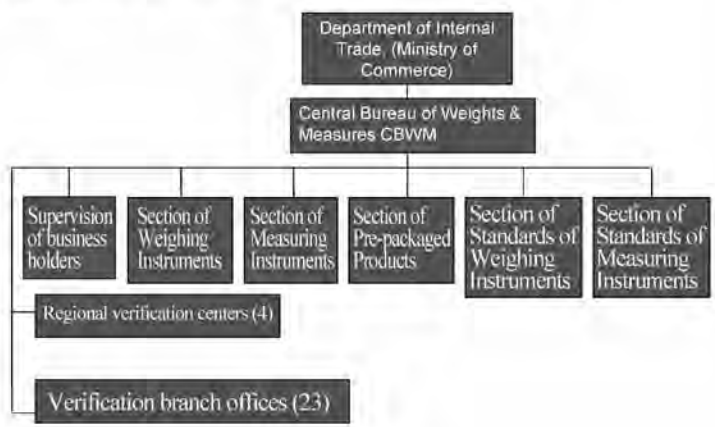
My organization and department.

I work for Central Bureau of Weights and Measures (CBWM) which under to Department of Internal Trade.

My professional experience in the organization.

I am responsible for verification of measuring which are manufactured, repaired and imported and supervision of uses of measuring to ensure that no taking advantage of abuse of such instruments takes place.

Organization Chart



Calibration CNG Dispenser in Thailand

——By Master Meter
——By Standard Scale

Testing Procedure , Quantity (M)
10 kg 15 kg 20kg

The Regulation of CNG Dispenser

The maximum permissible errors 2 %

(Not less than 2 kg.)

Repeatability 0.8 %

Calibration By Standard Scale

Determination

$$\text{Formula} = \frac{\text{standard scale - display}}{\text{standard scale}} \times 100$$

Example at 10 kg

$$= \frac{10.10 - 10.00 \times 100}{10.10} = 0.99\ \%$$

In case of is incorrect have to adjustment

In case of is correct have to Sealing

Thank you

OVERVIEW
OF THE LEGAL METROLOGY SYSTEM ON GAS METERS IN VIET NAM

Presentation: Mr. Duong Hong Son
Directorate for Standards and Quality
STAMEQ VIET NAM

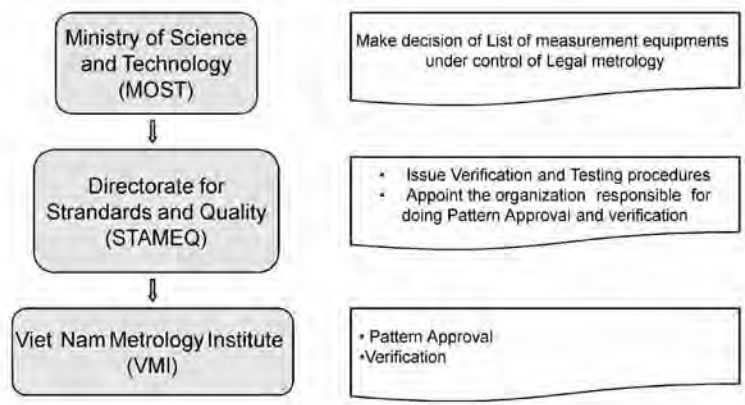
Viet Nam

- Location : South – East Asia
- Population: 86 million
- Capital: Hanoi

Using of Gas Meters in Viet Nam

- Gas meters has been used widely in many fields:
  - —— Oil and Gas exploitation/processing/transportation Industries
  - —— Gas Power plans
  - —— Ceramic industry
  - —— Households (cooking fuel)
- Gas meters used in custody transfer systems (trading purpose) are subject to legal Metrology

LEGAL METROLOGY SYSTEM
on custody transfer meters in Viet Nam



Custody transfer Gas Meters in Viet Nam

Type of Meter	Dia-phragm	Orifice	Turbine	Ultra-sonic	Coriolis	Thermal mass	Vortex
DN (mm)	25~50	50~300	100~200	150~400	75~150	25~200	50~200
Number in use*	>50.000	54	22	34	6	86	50

* Estimated value

Regulations on Custody transfer Gas meters

From 1/1/2009 Gas Meters used in households and custody transfer systems are subject of Legal Metrology in Viet Nam

Type of Meter	Diaph-ragm	Orifice	Tur-bine	Ultra-sonic	Coriolis	Thermal mass	Vortex
Testing procedures (for pattern approval)	OIML R31: 1995	TCVN 8113 (ISO: 5167)	OIML R32: 1989	No	No	No	No
Verification procedures	DLVN 155 : 2005	DLVN 236 : 2009	No	No	No	No	No

Our tasks relating to Gas meters

- Prepare procedures (Testing for pattern approval / Verification) for Gas Meters
- Conduct test for pattern approval
- Supply Verification/Calibration services
- Consult enterprises on applying of appropriate gas metering systems

Testing for pattern approval
of diaphragm gas meter in Viet Nam

Problems to implement the legal metrology system in Viet Nam

- Lack of procedures for testing and verification of the new types of Gas meters (e.g. Ultra-sonic, Coriolis,Thermal mass, Vortex)
- Lack of human resource
- Lack of equipment for testing and verification of gas meters

Thank you very much

APEC/APLMF Seminars and Training Courses in Legal Metrology (CTLM)

Training Course on Gas Meters
13–16 April, 2010
in **Chongqing, China**

MONGOLIAN AGENCY FOR STANDARDIZATION AND METROLOGY

Zaankhuu MUNKHBAT

VERIFICATION OFFICER OF VOLUME MEASURING LABORATORY

E-mail: masm@mongol.net , Tel: +976-51-263647 Fax +976-11-458032

Self introduction

- My name is MUNKHBAT. Short name is Bat.
- My qualification is a engineer
- I have been working in Volume and Flow Measuring instruments Verification Laboratory by verification officer for three years.
- Also I have been verifying mass flow meters for petrol in many types but I have less experiences for verifying gas meters for LPG and CNG due to first gas meters were is established in April 2009.

MAP OF MONGOLIA

Capital: Ulaanbaatar

Location: Northern Asia, between China and Russia

Quick facts about Mongolia

- Population: 2,8 mil.(with low density of 1,5 persons per sq.km)
- More than 10 ethnic groups, (75%-Khalkha, 7%-Kazakhs and others)
- Language: Mongolian
- Religion: More than 90%-Tibetan Buddhist Lamaism, 6%-Muslim
- Climate: Extreme continental, 4 distinct seasons (-45C in January; +25C in July)

MONGOLIAN AGENCY FOR STANDARDIZATION AND METROLOGY

Legal environment

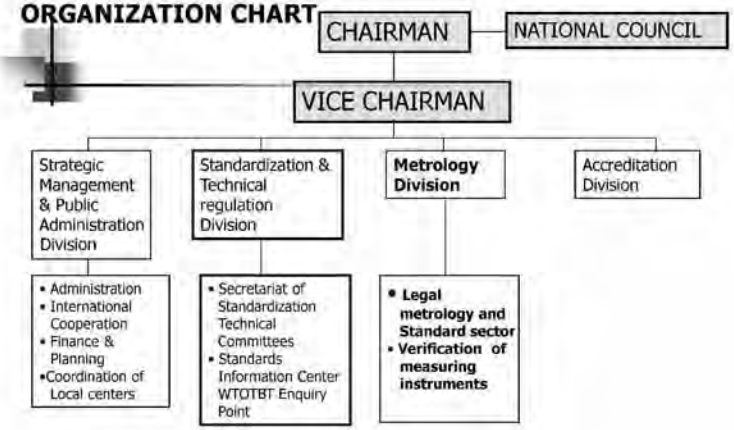
Mongolian Agency for Standardization and Metrology (MASM) is governmental regulatory body which responsibility is determined by the Law on "GUARANTEE THE UNIFORMITY OF MEASUREMENT" adopted in 1994 and revised in 2003. Based on this law legal metrology activity in Mongolia is conducted in the following manner:

- type testing of measuring instruments and its registering
- verification of measuring instruments
- appointing the licensed repairers, manufacturers, importers and installers

MONGOLIAN AGENCY FOR STANDARDIZATION AND METROLOGY

- **The main functions are:**
  - Standardization
  - Conformity assessment
  - Establishment of national measurement standards
  - Legal metrology
  - Accreditation
  - Training and consulting
  - International cooperation

ORGANIZATION CHART



MAIN FUNCTIONS OF METROLOGY DIVISION

- Development of national measurement standard system
- Development and registration of certified reference materials
- Maintenance and improvement of accuracy of measurement standards
- Traceability of measurement standards
- Pattern approval of measuring instruments
- Calibration of measurement standards or measuring instruments
- Licensing for manufacture, repair, installation and sale of measuring instruments
- Training
- Others

Type approval

Type testing and approval procedure adopted by MASM is based on the recommendations of OIML. During pattern approval, type of measuring instrument is tested fully or partially and if its test result is issued under OIML certificate system the pattern is recognised without duplicate testing. Once the pattern of an instrument has been approved a certificate of approval is issued. 45 types of utility meters were subjected pattern approval for 2009.

Calibration

MASM provides calibration service of measuring instruments for industry and customer. More than 4500 measuring instruments were subjected to the calibration from industry and customer every year.

MECHANICAL STANDARD LABORATORY: VOLUME

Volume standard was approved as a National Standard by the Mongolian Government in 1999.

Range: from (up 1 to 50) l

Accuracy: 0.03 %

Calibration in 2009:

—Over 420 volume measuring instruments

Problems

- In current situation we use the method specified by the manufacturer of the equipment due there is no any international and national standards for performing verification on gasmeters at the place of service.
- Lack of working standards in legal metrology.
- Lack of training and retraining of verification officers.

Summary

The participation in the training course will benefit to understand current legislation and procedures on type approval and verification of gas meter.

Thank you for your attention