



Study on Application of Wet Gas Metering Technology in Shale Gas Measurement

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Outline

- Background
- Basic principles of wet gas flow meters
- Wet gas flow meter test
- Conclusions and Suggestions



Background

Shale gas production and wellhead flow condition changes rapidly, it is necessary to monitor the shale gas production to get the reservoir information and to evaluate the gas well production capacity.



Current shale gas metering technology :

- Each well equipped a separator
- Complex process pipe system
- Well site covers a large area
- High investment cost
- Heavy operation and maintenance work

Wet gas meter technology can greatly simplify the process pipe system and reduce the investment cost by measure the well production of each well at the wellhead directly .



Background

Flow conditions features of shale Gas wellhead

The exploitation of shale gas can generally be divided into four stages according to the wellhead working conditions features

Production Stage	Period	Wellhead Pressure (MPa)	Gas Production Rate ($10^4\text{Nm}^3/\text{d}$)	Liquid Output Rate (m^3/d)
drainage exploitation stage	0-45day	40 \searrow 26	25	200-500
early Exploitation stage	46day-8month	26 \searrow 10	10-15	20-200
	8month-10month	10 \searrow 7	10	10-20
	11month-3year	7 \searrow 2	10 \searrow 5	1-10
middle exploitation stage	4year-5year	2 \searrow 1	5 \searrow 1.5	0.5-1
late exploitation stage	after 5 year	1	\leq 1.5	\leq 0.5

The gas production, liquid output and the wellhead pressure of shale gas gradually decrease as the extraction time increases



Outline

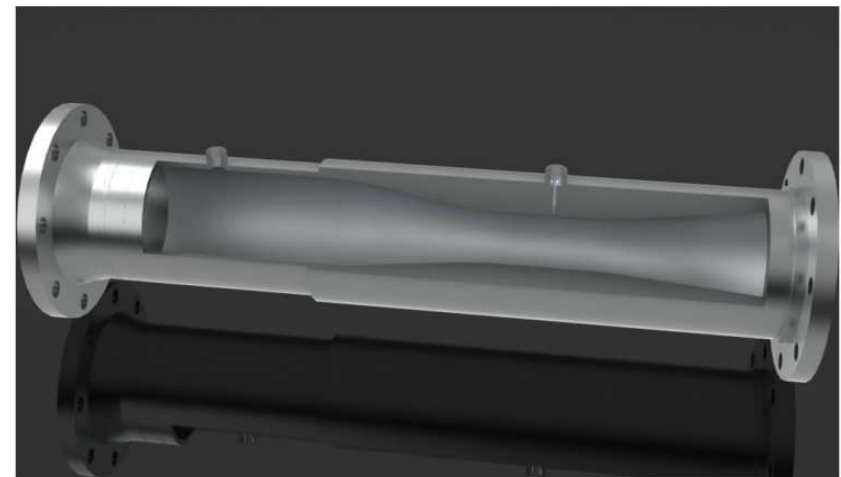
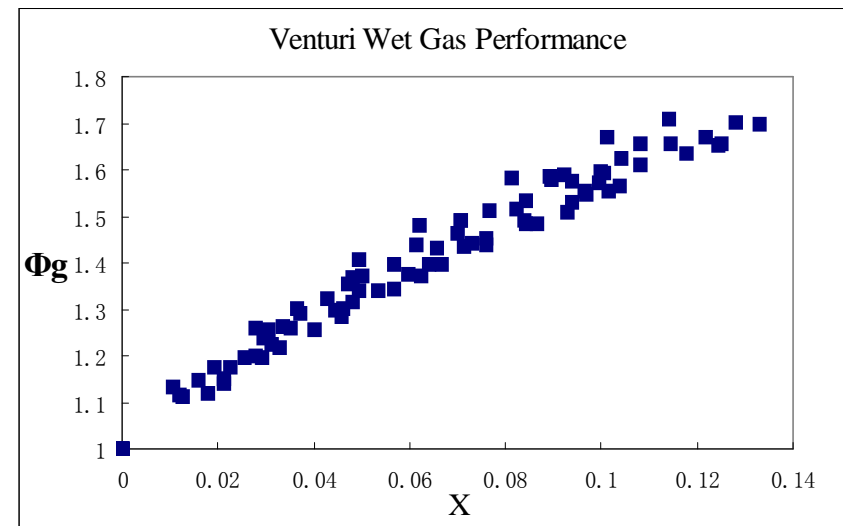
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Basic principles of wet gas flow meters

Measured by correction

- Based on single phase flow meter (DP meter)
- Correct the meter bias caused by the liquid in the gas flow
- Wet gas correlation model hold the key of wet gas meter
- Wet gas correlation model are created based on large amount experiment data

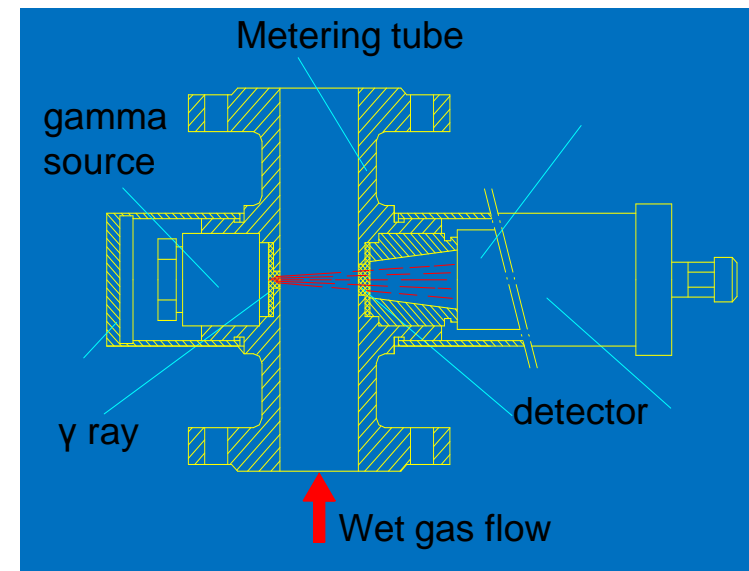




Basic principles of wet gas flow meters

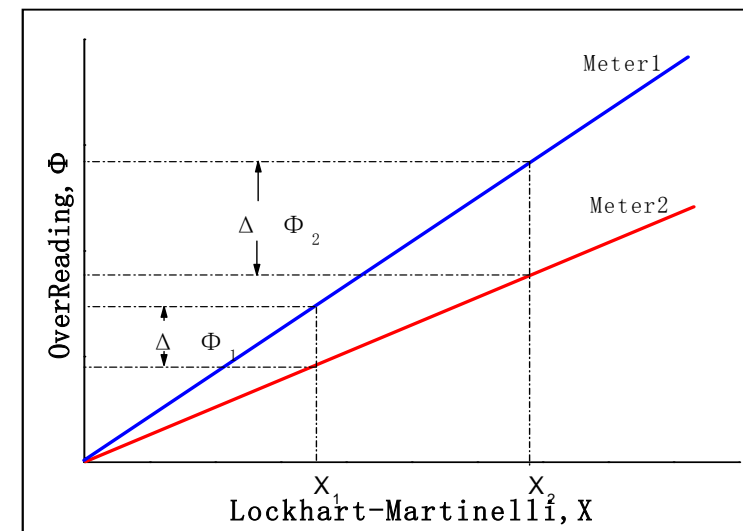
1. Liquid detection technology + wet gas correlation

Using the liquid fraction detecting technology such as gamma ray device or microwave technology to measure the liquid fraction directly and provide this measured liquid fraction information to the correlation models to calculate the gas and liquid flow rates of wet gas flow.



2. Two meters in series

The two meters provide the same flow rate for dry gas but each meter has a different wet gas performance when liquid is present, and use the difference of two meters responses to the wet gas flow conditions to determine the liquid fraction of wet gas flow and then calculate both the gas and liquid flow rates by the correlation models





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Wet gas flow meter test

Wet gas test facility of CVB

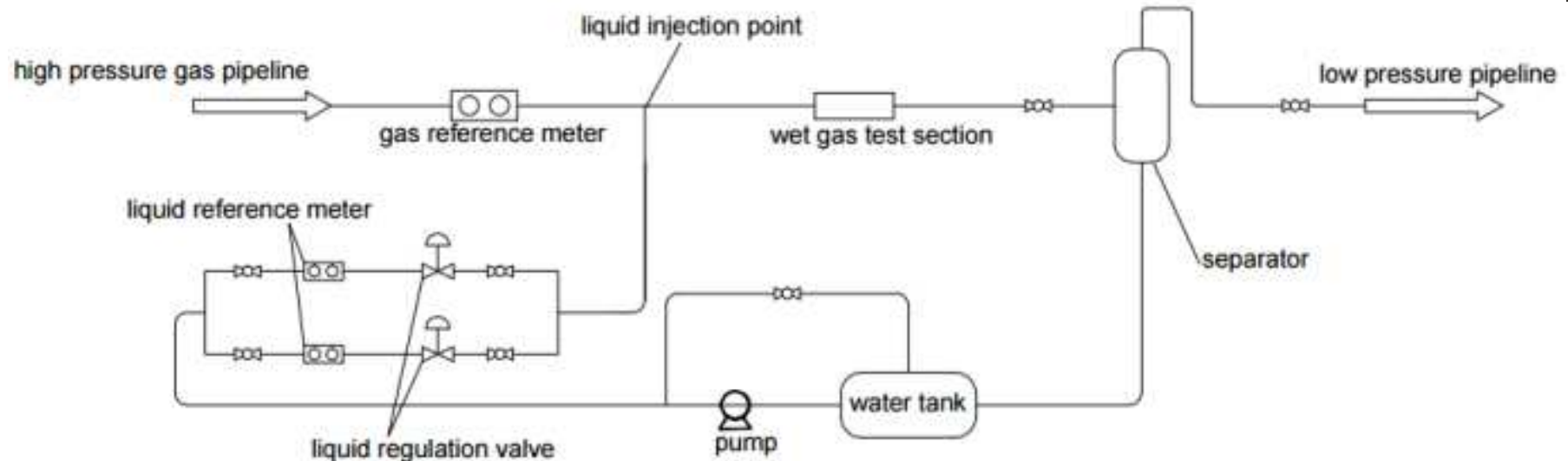
Test pressure range : 15bar to 40bar

Test fluids : natural gas , water

Gas flow range : (8~650)m³/h

Liquid flow range : (0.05~8)m³/h

Line size : 50mm to 150mm





Wet gas flow meter test

Test method



Test matrix

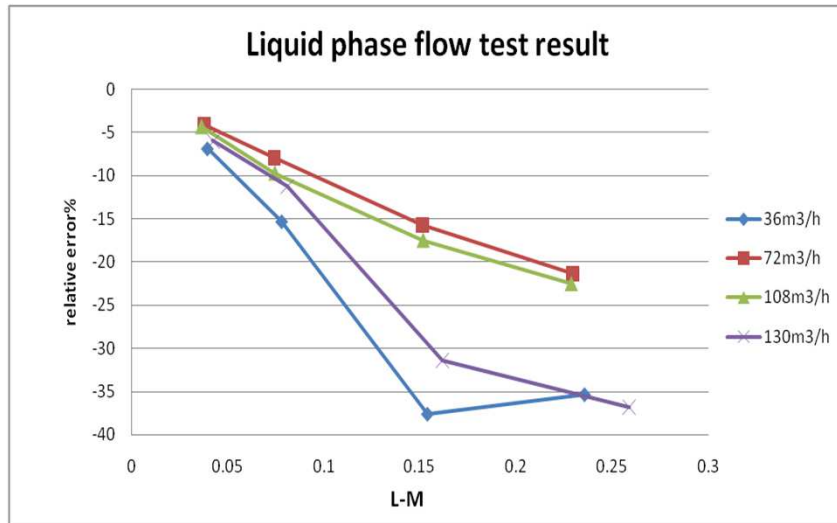
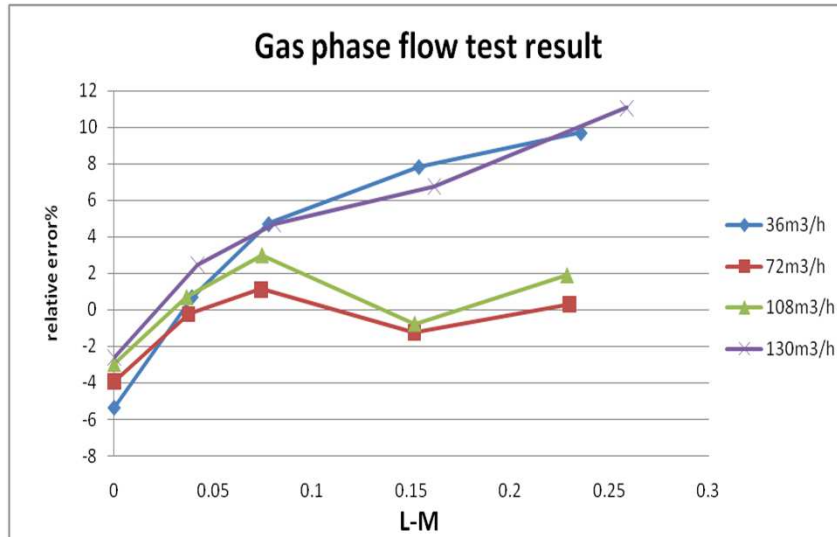
gas flow rate	36 m ³ /h	72m ³ /h	108 m ³ /h	130 m ³ /h
liquid flow rate (m ³ /h)	0	0	0	0
	0.19	0.36	0.52	0.74
	0.38	0.71	1.06	1.43
	0.74	1.44	2.16	2.88
	1.1	2.20	3.23	4.49



The performance of wet gas flow meter at single-phase dry gas is first tested as the base reference for the wet gas flow test. After the dry gas test, the liquid is gradually injected into the natural gas flow from less to more to conduct the wet gas flow test.



Wet gas flow meter test

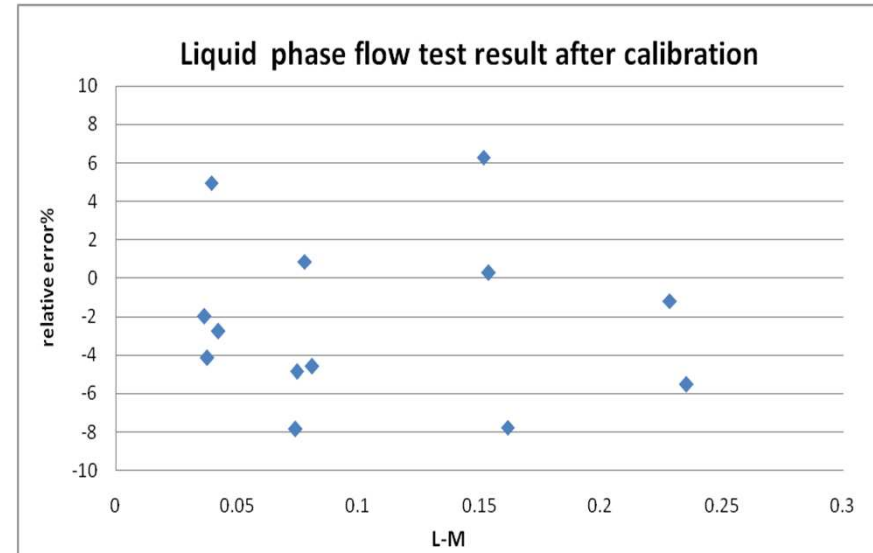
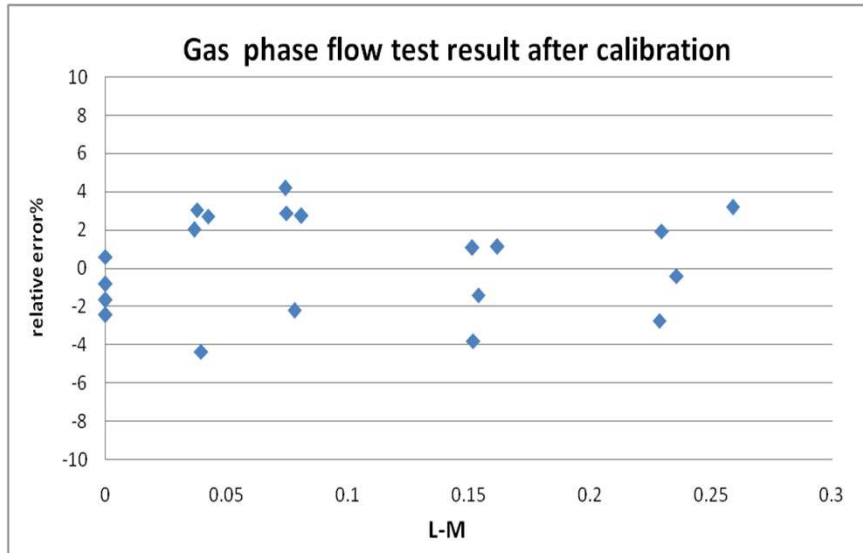


- Gas and liquid measurement error of wet gas flow meter increase as the liquid hold up of wet gas flow increase.
- Gas and liquid flow measurement error of wet gas flow meter are in opposite directions.
- Dry gas flow measurement accuracy of wet gas flow meter is lower than that of single phase gas flow meter.

The wet gas correlation developed with the air and water as test medium at low pressure bias when it used at wet natural gas as the test medium and flow condition changes.



Wet gas flow meter test



Gas and liquid flow metering accuracy of the wet gas flow meter improved a lot after the correlation model modified using test data.

The gas flow measurement accuracy is better than $\pm 4\%$

The liquid flow measurement accuracy is better than $\pm 10\%$



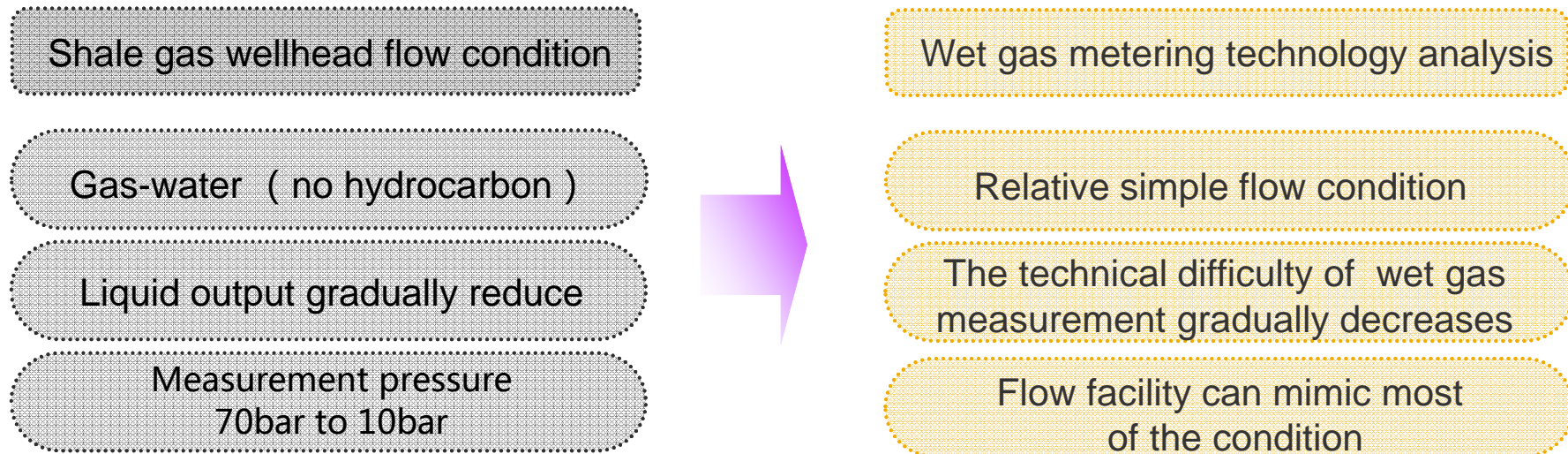
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Conclusions and Suggestions

Feasibility analysis applying wet gas metering technology on shale gas



The wet gas flow of shale gas it is a particular simple case of gas-water two phase flow, it is possible to mimic most of flow conditions of shale gas wellhead by wet gas test facility and establish the correlation models for the wet shale gas.

Compared with the conventional natural gas extraction, it is possible to popularize and apply wet gas flow meter technology in shale gas metering.



Conclusions and Suggestions

Technical characteristics of current wet gas flow meter

- The metering principles and methods of the current wet gas flow meters are workable, measurement correlation model is the core of wet gas meter.
- There would be an uncertain deviation of the wet gas flow correlation when the flow condition changes (pressure, fluids etc.).
- It better to calibrate the wet gas correlations of wet gas flow meter according to the working conditions it will be used.



Conclusions and Suggestions

Suggestions

First, to establish the wet gas correlation model in the test range of the wet gas facility, and then carry out the shale gas wellhead field test in the range of the correlation model to study the field adaptability of wet gas correlations in the tested ranges and improve the measuring accuracy and adaptability of wet gas correlations

Second, to study the performance of the correlations when extrapolate the flow conditions out of the test range of wet gas facility, to expand the applicable scope of the correlation model.

Third, to update the pressure and liquid holdup test range of current wet gas test facility of CVB to enhance the test ability that could cover a wider range of test conditions and could able to mimic all the flow conditions of shale gas wellhead



Thanks for your attention!

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