On The Online Detection Method for Gas Flow Meter by Using Mobile Standard

Chen HuiYu, Xie Yu
Chengdu branch for natural gas flowrate of national oil large flowrate calibration station
Tel:0086-28-85605490 , Fax: 0086-28-85605490, E-mail:chhy@petrochina.com.cn

Abstract: The accuracy of gas flow meter field measurement is directly associated with the economic benefits of both parties of the business. Thus, the accuracy of flow measurement is getting more and more attention. The field inspection, examination, and calibration of the gas flow meter are effective way and method to ensure the accuracy of gas measurement. The article explores and analyzes the method of using mobile standard device to online calibrate the gas flow meter, and proposes an accurate and reliable suggestion for ensuring the field examination of flow meter.
Keywords: **mobile standard; online detection**

1. Introduction

In the production field, some of flow meters cannot be dissembled to be taken to laboratory for offline examination due to production needs, while some meter of high-pressure, large diameter is difficult to be installed and dismantled to be taken to laboratory for offline examination; or due to the limited condition of the laboratory, when the condition is substantially different with the site actual working condition (such as installation condition, pressure, temperature, and component), the flow meter is needed to be online examined or calibrated, to accurately represent the measurement performance of the flow meter.

Chengdu Branch for Natural Gas Flowrate of National Oil Large Flowrate Calibration Station has one set of mobile gas supersonic flow standard device (refer to mobile standard device below). It conducted several examinations on natural gas field. The Branch has gathered rich experience on onsite experiment by using mobile standard device.

2. Introduction to Mobile Standard Device

Mobile gas supersonic flow detection device is composed of vehicle body, hoister system, two sets of gas supersonic flow meter (standard gauge), online chromatographic analyzer, and associated pressure, pressure difference, temperature transmitter, and data collecting system.

2.1 Technical Index of Standard Gauge

Mobile gas supersonic flow standard device is equipped with two sets of gas supersonic flow meter as the standard gauge. For the technical index of the flow meter,

refer to Table 1.

Table 1 Technical Index of Gas Supersonic Flow Meter

	DN100 Supersonic Flow Meter	DN300 Supersonic Flow Meter
Factory No.	2403	2404
Model/Specifications	Q.sonic-3 / DN100	Q.sonic-5 / DN300
Flow Range	(40～800) m^3/h	(160～8000) m^3/h
Pressure Level of Flow Meter	64bar (6.4MPa)	64bar (6.4MPa)
Inaccuracy	0.4%	0.4%

3. Onsite Experiment for Mobile Standard Device

Taking the examination of the orifice flow meter of DN200 in the gas distribution stations by mobile standard device as an example, onsite experiments include the test by mobile standard device to the orifice flow meter on the average instantaneous flow and cumulative flow rate, with the test pressure and test flow rate determined in accordance with the onsite condition, and introduce the method of on-site detection by using mobile standard device.

3.1 Check before Onsite Experiment of Mobile Standard Device

Before the mobile standard device arriving on site, the metering performance of the DN300 gas supersonic flow meter which is the standard gauge shall be checked, using standard device of higher level of accuracy to examine the working condition of the standard gauge, and the signal quality and the sound velocity of the mobile standard device shall be test in order to judge if it is satisfy the requirement, and make foundation for the onsite experiment. The test result refers to Table 2.

Table 2 Result of the Check before Onsite Experiment of Mobile Standard Device

Item	Test Result	Standard Requirements	Conclusion
Flow Indication Error	0.20%	≤0.4%	Satisfied
Repetitiveness	0.06%	≤0.13%	Satisfied
Automatic Gain Control (AGC)	4812	≤65025	Satisfied
Signal Acceptance Rate	100%	≥50%	Satisfied
Deviation between Average Sound Velocity and Theoretical Sound	0.09%	≤0.2%	Satisfied

Velocity			

3.2 Onsite Experiment

After the mobile standard device arrives at the site, the DN300 gas supersonic flow meter which is the standard gauge shall be check for the metering performance. The result of the test refers to Table 3.

Table 3 Result of Performance Test after the Mobile Standard Device Arriving at Site

Item	Test Result	Standard Requirements	Conclusion
Automatic Gain Control (AGC)	4850	≤65025	Satisfied
Signal Acceptance Rate	100%	≥50%	Satisfied
Deviation between Average Sound Velocity and Theoretical Sound Velocity	0.08%	≤0.2%	Satisfied

3.2.2 Technical Index of the Checked Flow Meter

Technical index of DN300 orifice meter refers to Table 4.

Table 4 Technical Index of the Checked Flow Meter

Name	DN200 Senior Orifice Valve
Factory No.	990002
Model/Specifications	GKFM-40/DN200
Flow Range	(0～100) kPa
Pressure Level of Flow Meter	4.0MPa
Accuracy	1.5%
d_{20}(mm)	144.996
D_{20} (mm)	205.130

3.2.3 Installation for Onsite Flow Meter

DN300 gas supersonic flow meter is installed on the preserved interface in the gas distribution station. By switching valves, standard gauge and the checked gauge can be connected by series connection, as shown in Fig. 1:

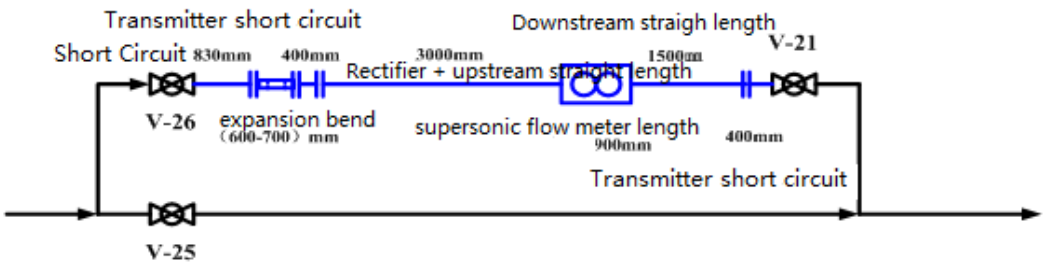

Fig. 1 Installation of Mobile Supersonic Flow Meter

3.2.4 Preparation for Experiment

3.2.4.1 Checking for Pressure Measurement System

Connect the pressure checking system and pressure transmitter to the pipeline at the same time. Blow out the pressure in the pipeline, while measure the zero point of pressure, then input the measured zero point of pressure into the system, and then increase the pressure of the pipeline. Then examine the system according to the checking regulation for pressure transmitter and technical requirement of metering system.

3.2.4.2 Checking for Temperature Measurement System

Systematic checking shall be done according to the checking regulation for temperature transmitter and technical requirement of metering system.

3.2.4.3 Checking for Chromatography System (Component Data)

The deviation between the component data acquired by online chromatographic analyzer and the component date offline analyzed data on the metering site shall be within the repeatability range specified in GB/T13610.

3.2.5 Data Acquisition

3.2.5.1 Data is repeatedly collected for 3-6 times at each flow point.

3.2.5.2 The pressure and temperature fluctuation in the data acquisition process should remain its relative stability on the basis of the onsite situation.

3.2.5.3 The mobile gas supersonic flow measuring device data acquisition includes pressure, temperature, supersonic instantaneous flow average and time; the hole plate data acquisition includes pressure, temperature, differential pressure, and the cumulative flow provided by the flow totalizer of this high-hole valve metering system;

3.2.5.4 Natural gas composition analysis is processed and completed by

vehicle-mounted online analyzer and is monitored along the whole process.

3.2.6 Average Instantaneous Flow Value Test Result

Because the pressure and flow rate stability from gas station are unable to compare with that from the laboratory, the project team can only collect the data intermittently when the pressure and flow rate are relatively stable. Before experiment starts, the local atmospheric pressure is measured as 98.32kPa through air box pressure gauge, which is the same atmospheric pressure value from what the metering station data acquisition system indicates. Please refer to Table 5 for the test result of gas supersonic detection of Orifice flow meter.

Table 5 Test Result of Gas Supersonic Detection of Orifice Flow Meter.

S/N	Working Flow Rate(m^3/h)	Test Absolute Pressure (MPa)	Test Temperature (℃)	Gas Supersonic Standard Flow Rate (Nm^3/h)	Orifice Standard Flow Rate (Nm^3/h)	Error (%)	Average Error (%)	Repeatability (%)
1	2461	1.961	18.16	48526.363	48524.414	0	-0.18	0.15
		1.908	17.77	46270.41	46156.398	-0.25		
		1.902	17.72	47246.68	47116.189	-0.28		
2	2643	1.95	18.07	50753.086	50686.694	-0.13	-0.02	0.14
		1.948	18.04	51279.024	51258.403	-0.04		
		1.945	18.03	51733.713	51691.842	-0.08		
		1.943	18.01	52038.339	52132.072	0.18		
3	3149	1.924	17.79	59520.924	59748.82	0.38	0.26	0.08
		1.922	17.78	60459.246	60599.993	0.23		
		1.921	17.77	60970.169	61092.836	0.2		
		1.921	17.77	61217.155	61349.553	0.22		
4	3712	1.917	18.26	70977.676	71126.491	0.21	0.23	0.11
		1.979	18.21	73481.004	73602.2	0.16		
		1.981	18.22	73596.368	73714.902	0.16		
		1.983	18.23	73766.483	74087.999	0.44		
		1.985	18.23	73907.418	74012.581	0.14		
		1.987	18.24	73993.622	74209.766	0.29		
5	4034	1.857	18.07	75064.956	75356.49	0.39	0.32	0.10
		1.861	18.07	75041.073	75308.495	0.36		
		1.862	18.2	75030.073	75187.495	0.21		

Conclusion: The flow meter with 1.5 level of accuracy has the largest relative indication error of 0.32% and maximum repeatability of 0.15, which meets the

requirements of JJG640-1994 "Differential Pressure Flow Meter Checkup Regulation". The test result is satisfactory.

3.2.7 The comparisons between mobile gas supersonic flow measuring devices and cumulative flow by flow meter

The mobile gas supersonic flow measuring devices and cumulative flow by flow meter comparisons is on the basis of 1 hour data and 2 hours data cumulative flow rates. Please refer to Table 6 and Table 7 for the test results.

[1] 1 hour cumulative data

Please refer to Table 6 for the test results

Table 6. 1 hour cumulative flow rate comparison results

S/N	Test Pressure (MPa)	Test Temperature (℃)	Standard Flow Rate (Nm^3)	Gas Supersonic Test Orifice Flow Rate (Nm^3)	Deviation (%)
1	2.018	17.89	9634546.32	9624498.72	-0.12
2	1.922	18.08	9927961.26	9914060.82	-0.14
3	1.852	17.96	9786169.02	9775355.22	-0.11
4	1.857	17.18	9775613.58	9768717.06	-0.07
5	1.794	17.04	9691806.90	9668539.68	-0.24
6	2.007	18.15	9495879.48	9481596.24	-0.15
7	1.856	18.10	9217680.12	9224132.40	0.07
8	1.807	17.20	9041141.88	9025730.10	-0.17
9	1.848	17.40	8554303.74	8564525.10	0.12
10	1.888	18.31	8766525.96	8773493.16	0.08
11	1.925	18.34	8503120.74	8509032.12	0.07
12	1.935	17.78	2368461.24	2371518.96	0.13

[2] 2 hours cumulative data

Please refer to Table 7 for the test results

Table 7. 2 hours cumulative flow rate comparison results

S/N	Test Pressure (MPa)	Test Temperature (℃)	Standard Flow Rate (Nm^3)	Gas Supersonic Test Orifice Flow Rate (Nm^3)	Deviation (%)
1	1.857	17.20	18344907.00	18311859.24	-0.18
2	1.812	17.91	19482746.52	19443754.56	-0.20

Conclusions:

[1] The maximum deviation of the comparison between the mobile standard device and flow meter's 1 hour cumulative standard flow is -0.24% which meets the requirements of JJG640-1994 "Differential Pressure Flow Meter Checkup Regulation". The test result is satisfactory.

[2] The maximum deviation of the comparison between the mobile standard device and flow meter's 2 hours cumulative standard flow is -0.20%, which meets the requirements of JJG640-1994 "Differential Pressure Flow Meter Checkup Regulation". The test result is satisfactory.

4. Verification of measurement performance after onsite experiment of DN300 Supersonic Gas Flow Meter

Working flow, signal quality and sound speed verifications of DN300 gas supersonic flow meter need to be checked after the onsite experiment has been carried out and back to Chengdu branch for natural gas flowrate of national oil large flowrate calibration station. Please refer to Table 8 for the test results

Table 8. Verification Test Results of Mobile Standard Equipment before Site Experiment

Item	Test Result	Standard Requirements	Conclusion
Flow Indication Error	0. 17%	≤0.4%	Meet Requirement
Repeatability	0.06%	≤0.13%	Meet Requirement
Auto Gain Control Information	4880	≤65025	Meet Requirement
Signal Acceptability	100%	≥50%	Meet Requirement

Deviation between average sound speed and theoretic sound speed	0.07%	≤0.2%	Meet Requirement

5. Suggestions of the mobile standard equipment for the guarantee and operation of the site experiment:

5.1 In order to ensure an accurate and reliable test result, the test time must be selected according to the specific conditions from the production site. Upon the flow meter repetitive testing, the pressure should be no more than ±0.5%; the temperature variation should not exceed ±0.5℃; the instantaneous flow rate relative stable time continuous acquisition of data will be considered as the instantaneous flow meter indication error and repetitive evaluation data. The acquisition time for each flow point should be ≥100S.

5.2 Due to variable changes of the production site conditions, the cumulative flow detection should be utilized in the site testing. Time slice when flow rate is rather stable should be selected to collect data. The data acquisition for cumulative flow detection normally lasts for over 1 hour. Pressure and temperature fluctuation only have a minor affect to the test result.

5.3 During the process of site testing, the density variation range which was caused by natural gas composition fluctuation should be less than 0.2%, so that the affects of the natural gas composition fluctuations to density component and compression factor measurement result can be ignored.

5.4 The mobile standard equipment need to be examined before, during and after the onsite experiment in order to ensure the measurement performance of the mobile standard equipment during the process of onsite testing. Under the premise that the equipment performance meets the requirement, the flow meter onsite testing and calibration can be carried out.