Probe into methods about the comparison of gas flowmeters

Dannal Cheng[1*], Feng Gao[2], Junfeng Mao[3], Shi Wu[2], Xinli Dong[4], Han Zhang[4], Qian Zhang[4]

[1]SIERRA Instruments (Shanghai) Co., Ltd., Second floor Building 5, Senpu Industrial Park, Pudong New District, Shanghai, China,
[2]National Institution of Metrology (NIM), Beijing, China,
[3]Wuxi Institute of Inspection, Testing and Certification, Jiangsu, China,
[4] Beijing Gas Group Company Limited, Beijing, China
E-mail (corresponding author): Dannal@sierra-asia.com

Abstract

At present, the way to check the flowmeter accuracy is disassemble them and send to flow lab and verify it. But customer don't like it, because it will affect or stop their production. What the customer really need is to know the meter accuracy but non-disassemble flowmeters. It is not an easy way, this paper describes a feasible solution about inline comparison of gas flowmeter by inline drilling, inline installation, power supply and data recording & analysis. In the end, cited a field case about comparison of gas flowmeter.

1. Introduction

The flow meter accuracy need to be verified periodically to avoid the loss which caused by inaccurate measurement. So uninstall flowmeter and send to flow lab to verify the meter accuracy is a good solution. But many site flowmeters can not uninstall, cause there is no bypass pipes or valves, it can not stop production, too big to uninstall, too high to uninstall, too dangerous to uninstall etc. Customers have imperious demands about inline flowmeter accuracy verification. It is a very large potential market if someone can solve it.

At present, it is not difficult for liquid flow verification, customer is using clamp on ultrasonic flowmeter to check a liquid pipe flow and its accuracy is achieving ±0.5%RD.
But it is not easy for measuring gas flow by using clamp on ultrasonic flowmeter. Its accuracy was limited by pipe ID, pipe material, pipe thickness, gas, gas pressure etc. So gas flowmeter inline comparison has been still blank.

The core of inline comparison for gas flow is that install a high accuracy standard flowmeter in the same pipe which installed DUT (Device Under Test) and compare their total flow in a set time interval. Then we can get the DUT error. So the immersible standard gas flowmeter will be a good solution and this paper study how to install, test and compare the flow.

2. Solutions for gas flowmeter comparison

2.1 Inline drilling

It is easy to drill a hole and insert flowmeter, but most comparison meters are under working, positive pressure in the pipe. So we have to solve the inline drilling problem. There are three methods for inline drilling.

2.1.1 Manual drilling

Weld a threadolet on the pipe, install a ball valve, then install manual drilling machine. Shaking the sealed handle and the drill goes down. Once drill it through, pull the drill out and close the ball valve, uninstall the drill machine.

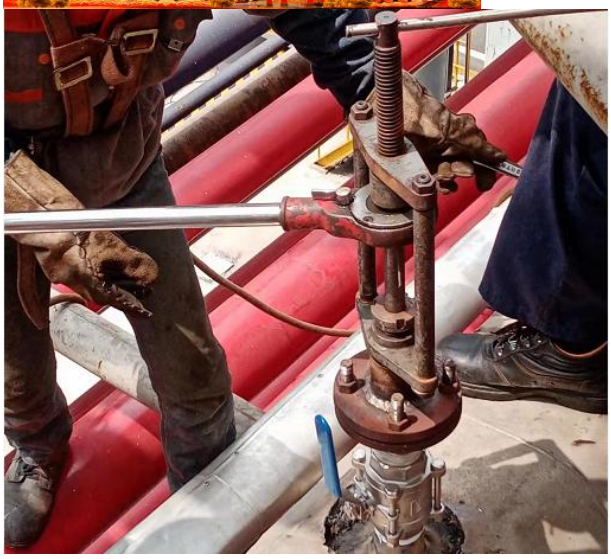

Figure 1: Manual drilling device.

2.1.2 Semi-automatic drilling

Weld a threadolet on the pipe, install a ball valve, install drill machine body. Put the adjustable electric hand drill machine. It has a bypass valve, scrap iron will be blowed out through bypass pipe. Once drill it through, pull the drill out and close the ball valve, uninstall the drill machine.

Figure 2: Semi-automatic drilling device.

2.1.3 Full-automatic drilling

Weld a threadolet on the pipe, install a ball valve, install drill machine body and the electromotor. Power on and start to drill, turn the handwheel to lower the drill. Once drill it through, pull the drill out and close the ball valve, uninstall the drill machine.

Figure 3: Full-automatic drilling device.

2.2 Select standard gas flowmeter

The standard meter should have high accuracy, high repeatability, big rangeability, good versatility and easy to installation. Besides, easy to change gas and engineering units, easy to change the tube or pipe ID.

2.2.1 Select micro flow standard gas flowmeter

Micro flow range normally is 0~0.1sccm~1000slpm, pressure range is -0.9~3.0MPag. Pipe size less than 1 inch. The mass flow accuracy better than ± 1.5%FS. One principle is heat transfer, the accuracy going to ≥±0.5%FS. Another principle is measure the differential pressure in a laminar part and measure gas pressure, temperature, humidity, compensation. These standard meter calibrated by high accuracy (better than ±0.25%RD), primary standard, piston provers.

Figure 4: Heater transfer micro gas flowmeter sensor.

Figure 5: Heater transfer micro gas flowmeter.

Figure 6: High accuracy primary standard piston prover.

2.2.2 Select big flow standard gas flowmeter

Big flow means pipe ID bigger than 1 inch, gas is Air, N2, O2, Ar, H2, He, CH4, CO2 etc. This standard meter should have better accuracy than ± 1.5%FS, integrated mass flow, temperature, pressure sensor in one probe. Easy to change the pipe ID. Easy to switch other gases.

According to above requirements, insertion multivariable thermal mass flowmeter is a good solution. Its accuracy is ± 0.75%RD, measure mass flow, temperature and pressure in one probe. This standard flowmeter is calibrated in positive gas loop.

Figure 7: Immersible multivariable thermal sensor.

Figure 8: Positive gas loop calibration system.

2.2.3 Select big pipe, low velocity, low pressure, mixed gas, dirty standard gas flowmeter

Thermal flowmeter have good low velocity characteristics, but it is not very suitable to measure mixed gas. Pitot tube is a good solution for this application, but it becomes instability after velocity lower than 5m/s. And it needs to drill a big whole, hard to install with no leakage.

Figure 9: Insertion pitot tube sensor.

Too measure lower velocity, insertion multivariable turbine with temperature & pressure compensation flowmeter is a good solution. The sensor measures gas velocity (1.0~60m/s), temperature and pressure, mass flow output after compensation. The accuracy is in 1.0%~2.0%FS. Both pitot tube and turbine is calibrated in wind tunnel.

Figure 10: Insertion multivariable turbine sensor.

2.3 Inline installation with no leakage

After drill a hole in the pipe, we need to insert the standard flowmeter with no leakage.

2.3.1 Small flow hot-switch installation.

For small pipe which smaller than 1 inch, normally put valve subassembly in series or put standard flowmeter in DUT inlet or outlet before it works.

See figure 11, DUT is working and valve D&E closed, valve B open. Take standard flowmeter, inlet pipe connect to valve D, outlet pipe connect valve E, open valve D&E, close valve B, then DUT have the same flow with standard flowmeter. Finished the test, open valve B, close valve D&E, take off standard flowmeter.

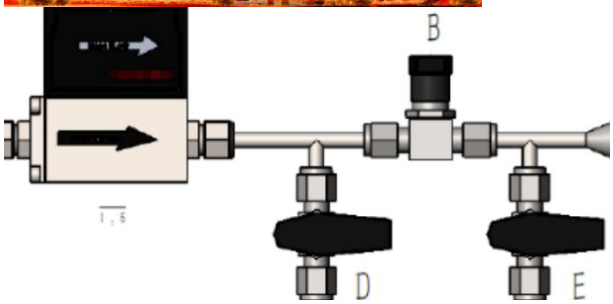

Figure 11: Three ball valve subassembly.

2.3.2 Big flow hot-tap installation

According to the pressure value, we divide it into two classes. One is low pressure which lower than 10 barg, another is high pressure than 10 barg.

2.3.2.1 Big flow low pressure hot-tap installation

See figure 12, weld a threadolet in the pipe, install a ball valve and install sealed part which won't leak when it pull out or insert. There is a high strength safety rope which will stop the meter jumping out in positive pressure pipe. And close the valve once the rope was straightened, then uninstall the flowmeter.

Figure 12: Low pressure hot-tap parts.

2.3.2.2 Big flow high pressure hot-tap installation

See figure 13, weld a flange base in the pipe, install a flanged gate valve, then install the hot-tap devices. If you want to insert the flowmeter, loosen two screws which used to fix the gland, then turn the handwheel clockwise, the probe will start to insert by transfer gears.

Figure 13: High pressure hot-tap parts.

2.4 How to solve the power problem and record the comparison data.

2.4.1 Battery power supply.

Use high capacity battery is a good solution for field power supply. Normally use 12VDC and 24VDC power.

2.4.2 Data record by touching screen PLC.

It contains below 3 main functions:

(1) Record and store the standard meter flow data.
(2) Analyze the record data and display mass velocity, volume velocity etc parameters. See figure 14.

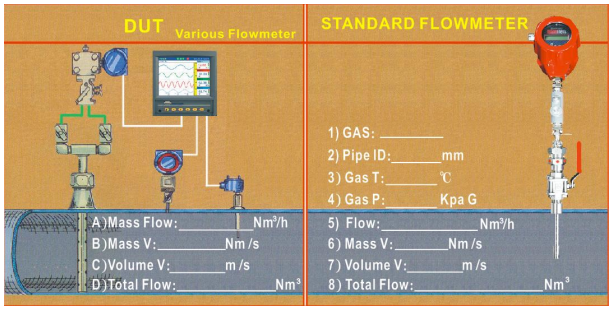

Figure 14: Display operation interface.

(3) Receive DUT flow signal and record. Put the standard and DUT curve together which make user easy to see the flow changes.
(4) Export data with Excel files and user can put in computer to do further analysis.

2.4.3 Remote wireless transmission.

It needs several hours to do the comparison, the device will be put in field several hours. If user want to see the data timely, we can add a wireless

transmission module. Then anyone can see the data and curve timely in anywhere by computer or phone.

2.5 Field gas comparison application.

See figure 15, It is a CDA pipe which ID is 250mm , pressure is 7.8 barg, temperature is 3.4℃. Inline install and test 28min, the standard total flow is 1674.4Nm^3/h(N is 20℃, 1ATM) from 448.4Nm^3/h, difference is 1226 Nm^3/h. The DUT total flow is 10532Nm^3/h from 9323Nm^3/h, difference is 1209Nm^3/h. Total difference between DUT and standard meter is 17 Nm^3/h. DUT FS is 5100Nm^3/h, accuracy is ± 1.5%FS= ± 76.5 Nm^3/h. The comparison result shows the DUT is under its accuracy, it can keeps working.

Figure 15: Field comparison.

2.6 Probe into method is a good solution

Based on above analysis, probe into method is a good solution for current customer requirement. But there is no regulation about comparison, we have to study more and gather more data to push address the comparison regulation.

References

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