

The Discussion of Influence of the Inlet Temperature Measurement on the CFVN Calibration

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Abstract

When the CFVN calibration is carried out, the inlet temperature measurement of the CFVN is detailed described in both “ISO 9300:2005 Measurement of gas flow by means of critical flow Venturi nozzles” and “JJG 620-2008 Critical Flow Venturi Nozzle”. But in some cases, the sensing element can not be strictly confirmed to the requirement for some reasons. To explore the influence of the inlet temperature measurement, two different kinds of installation are presented in this paper. Differences between the two installations are the diameter of the sensing element and the location of the sensing element. As the results shown, the inlet temperature measurement has non-negligible influence on the CFVN calibration. According to the comparison, to ensure the accuracy and reliability of traceability, the CFVN should be calibrated under the same installation conditions as that on site. And both the interlaboratory measurement comparison and proficiency testing of CFVN should take the installation impact as an important factor if there are some differences.

1. Introduction

The CFVN is widely used as standard of flow calibration facility for its character of good stability, with no moving part, long calibration period and so on. It is usually calibrated using the mass-time method high pressure natural gas flow primary standard facility or pVTt method facility. The installation requirements are detailed described in both ISO 9300:2005 Measurement of gas flow by means of critical flow Venturi nozzles [1] and JJG 620-2008 Critical Flow Venturi Nozzle [2]. But in some cases, the installation can not be strictly confirmed to the requirement for some reasons.

To explore the influence of the inlet temperature measurement, two different kinds of installation are presented in this paper. Differences between the two installations are the diameter of the sensing element and the location of the sensing element. CFVNs at different flow rate are selected to compare the influence. And experiments are carried out using the mass-time method high pressure natural gas flow primary standard facility with natural gas as medium at different pressure.

This paper contains parts as follows: the requirements of regulations, the information of CFVN under test and the installation condition description, the results and analysis of calibration, and the conclusion.

2. The requirements of the regulations

According to GB/T 21188-2007/ISO 9300:2005: Measurement of gas flow by means of critical flow Venturi nozzles (ISO 9300:2005, IDT), the installation requirements of CFVN include the upstream pipeline, downstream requirements, pressure measurement, drain holes, temperature measurement, density measurement [3]. The factors of temperature measurement discussed in this paper are as follows.

2.1 The diameter of the sensing element

The diameter of the sensing element shall be not larger than $0.04D$. If the diameter of the sensing element is not less than $0.04D$, the sensing element shall be located at the place that the sensing element does not affect the pressure measurement.

2.2 The location of the sensing element

The sensing element shall not be aligned with a wall pressure tapping in the flow direction. This requirement is also proposed to make that the sensing element does not affect the pressure measurement.

3. The information of CFVN under test

There are two designs of standard CFVN: the toroidal-throat Venturi nozzle (Figure 1) and the cylinder-throat Venturi nozzle (Figure 2). [1] As the name suggests, the main difference between these two designs is that the throat of the cylinder-throat Venturi nozzle is cylinder.

CFVNs at different flow rate are selected in the experiment, and the detailed information of the CFVNs is shown in Table 1.

Table 1: The information of the CFVN.

CFVN No.	CFVN Type	Throat Diameter d (mm)	Flow-rate (m^3/h)
A	Toroidal-throat Venturi nozzle	9.5	50
B		7.4	32
C		3.8	8

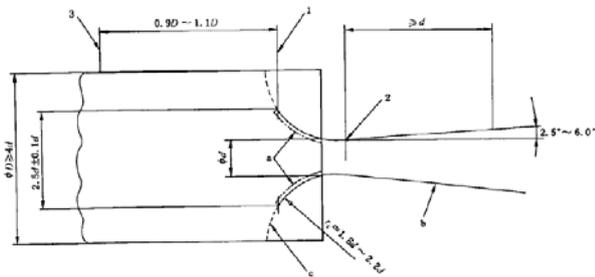


Figure 1: Toroidal-throat Venturi nozzle [1]

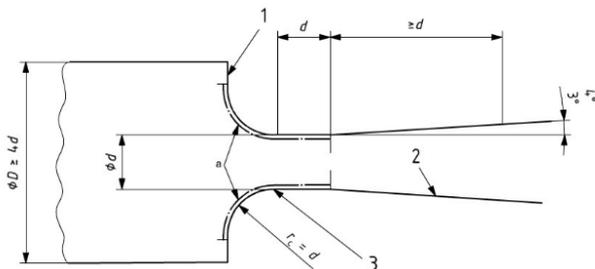


Figure 2: Cylindrical-throat Venturi nozzle [1]

4. The installation condition description

The CFVN is installed under these two conditions described in Table 2, and the sensing element location is shown in Figure 3 and Figure 4.

All the experiments are carried out using the mass-time method high pressure natural gas flow primary standard facility with natural gas as medium. The mass-time method high pressure natural gas flow primary standard facility which is used to reproduce the mass flowrate can calibrate CFVNs of natural gas at high pressure. The major components include the gyro scope, the spherical weigh tank, a pair of high speed hydraulically actuated plug valves, timer, the measuring instruments, piping components and so on. [4,5]

Table 2: Differences between the two installations.

Installation No.	The sensing element	
	Diameter	Location
(1)	$\leq 0.04D$	Perpendicular to the pressure measurement position
(2)	$> 0.04D$	In line with the pressure measurement position

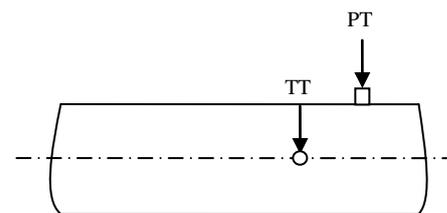


Figure 3: Installation No. (1).

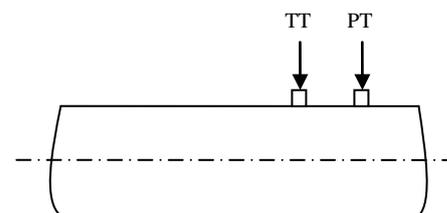


Figure 4: Installation No. (2).

The platinum resistance sensor of sensing element in installation No. (1) is directly installed into the pipeline, while the platinum resistance sensor of sensing element in installation No. (2) is connected to the thermowell mounted to the pipeline. So the diameter of the thermowell is more than $0.04D$, and the diameter of the platinum resistance sensor of sensing element in installation No. (1) is less than $0.04D$.

5. The results and analysis of calibration

The calibration results at different pressure point are compared and analysed. And the results of the CFVN calibration are shown in Table 3.

Table 3: The results of the CFVN calibration.

CFVN No.	Pressure (MPa)	Discharge coefficient	
		Installation No. (1)	Installation No. (2)
A	5.5	0.9945	0.9953
	5.0	0.9943	0.9953
B	5.5	0.9945	0.9952
	5.0	0.9946	0.9950
C	5.5	0.9910	0.9916
	5.0	0.9910	0.9914

As shown in Table 3, the diameter and location of the sensing element has influence on the results of CFVN calibration. Compare the discharge coefficient of each CFVN under these two conditions, the discharge coefficient of installation No. (2) is bigger than the discharge coefficient of installation No. (1).

And the deviation from the equation (10) in ISO 9300 is calculated for each installation.

$$C_d = a - bRe_{nt}^{-n} \quad (1)$$

Where, C_d stands for discharge coefficient, Re_{nt} stands for throat Reynolds number, and $a=0.9959$, $b=2.72$, $n=0.5$.

Table 4: The deviation from the equation (10) in ISO 9300.

CFVN No.	Pressure (MPa)	The deviation (%)	
		Installation No. (1)	Installation No. (2)
A	5.5	-0.04	0.04
	5.0	-0.06	0.04
B	5.5	-0.03	0.04
	5.0	-0.02	0.02
C	5.5	-0.34	-0.28
	5.0	-0.34	-0.30

And as shown in Table 4, the discharge coefficient of installation No.(2) is bigger than the discharge coefficient calculated from the equation (10) in ISO 9300 for CFVN No. A and B, while the discharge coefficient of installation No.(1) is smaller than the discharge coefficient calculated from the equation (10) in ISO 9300 for CFVN No. A and B. But the discharge coefficient is smaller than the discharge coefficient calculated from the equation (10) in ISO 9300 for CFVN No. C.

6. Conclusion

- (1) The inlet temperature measurement has non-negligible influence on the CFVN calibration.
- (2) The CFVN should be calibrated under the same installation conditions as that on site.
- (3) Both the interlaboratory measurement comparison and proficiency testing of CFVN should take the installation impact as an important factor if there are some differences.
- (4) The other two combination of diameter and location of the sensing element are not compared. More experiments should be carried out to compare the influence of the inlet temperature measurement.
- (5) Numerical simulation can be used to check the influence of sensing element in the further research.

References

- [1] ISO 9300: *Measurement of gas flow by means of critical flow Venturi nozzles*, 2005.
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