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DIVIDED FLOW TECHNIQUE FOR THE CALIBRATION OF GASFLOWMETERS

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Abstract: This article describes the Flow Laboratory necessities for a new facility, and how to extend the calibration flow rate using a meter with no moving parts, easy to operate and with low uncertainty. The proposal alternative is using two meters in parallel as the working standard: one sonic nozzle and one rotary piston (CVM) its the measurement uncertainty and some results.

1 INTRODUCTION

The Flow Laboratory of IPT – Institute for Technological Research – carry out gas flowmeter calibration since 1984, and uses two calibration benchs named low and high flowrate benches. The high flowrate bench, works in the range of 5 up to 3200 m³/h (in august of 2000 the maximum capacity will be 4500 m³/h), using rotary piston meters (CVMs) and turbine meters. The low flowrate bench operates from ≈0 up to 24 m³/h using burettes and wet test meters as working standards. This laboratory calibrates more than 3 hundred flowmeters every year.

Figures 1 and 2 show the operational range and standards of the Gas Flow Laboratory.

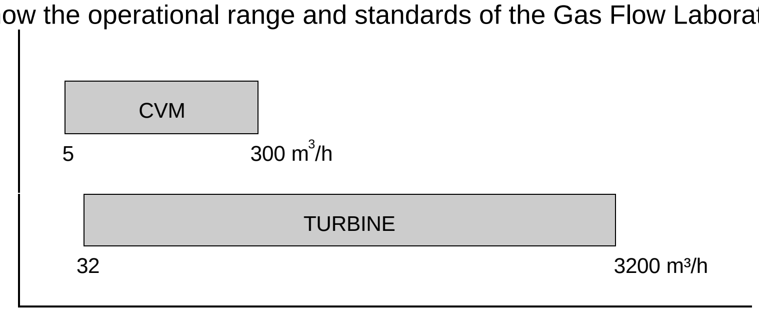


Figure 1. Operational range and standards of the high flowrate bench.

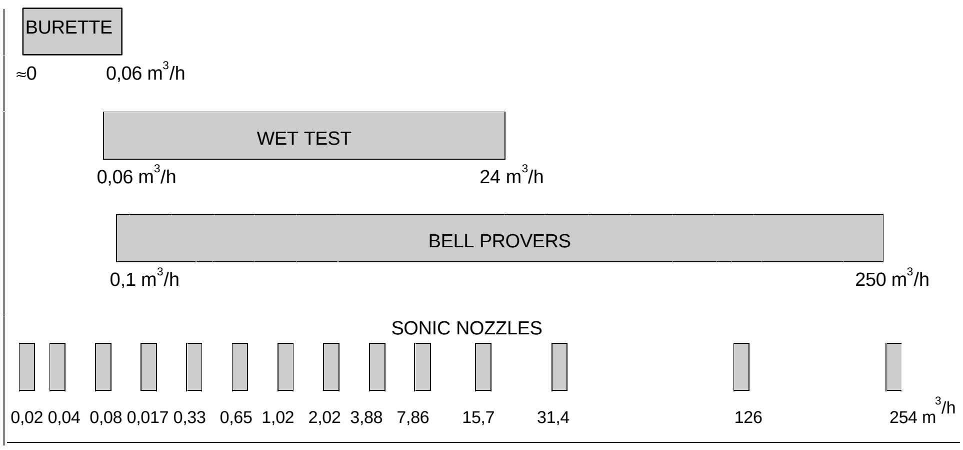


Figure 2. Operational range and standards of the low flowrate bench

2 THE SUBSTITUTION OF WET TEST GAS METER (WTM) BY SONIC NOZZLES

In the range of 5 a 24 m³/h we use WTMs as the working standards, like many other laboratories, but to keep uncertainties in the level of 0,1 to 0,3%, they need a very strict control, training of the operator and special conditions of use, specially in the adjustment of the liquid level. In order to overcome these difficulties it was decided to change the principle of operation for this flow rate range.

A good alternative would be a meter with no moving parts, easy to operate and with low uncertainty.

The best option available was considered to be the sonic nozzle, with its characteristics of low uncertainty (0,1 to 0,2% in vacuum operation) and extremely stable flow rate. Main disadvantage is that the flow rate is limited to only one value, in vacuum operation.

Of course it is possible to extend its range of operation changing the pressure condition, but some parameters like compressibility factor (Z) and critical flow coefficient (C*), may present great variations and need a set of complex equations to obtain reliable results.

So the problem was how to extend the calibration flow rate using sonic nozzles in vacuum operation. The solution was to make an arrangement using two meters in parallel as the working standard: one sonic nozzle and one rotary piston (CVM).

Figure 3 shows the results of the calibration of a turbine meter using this arrangement.

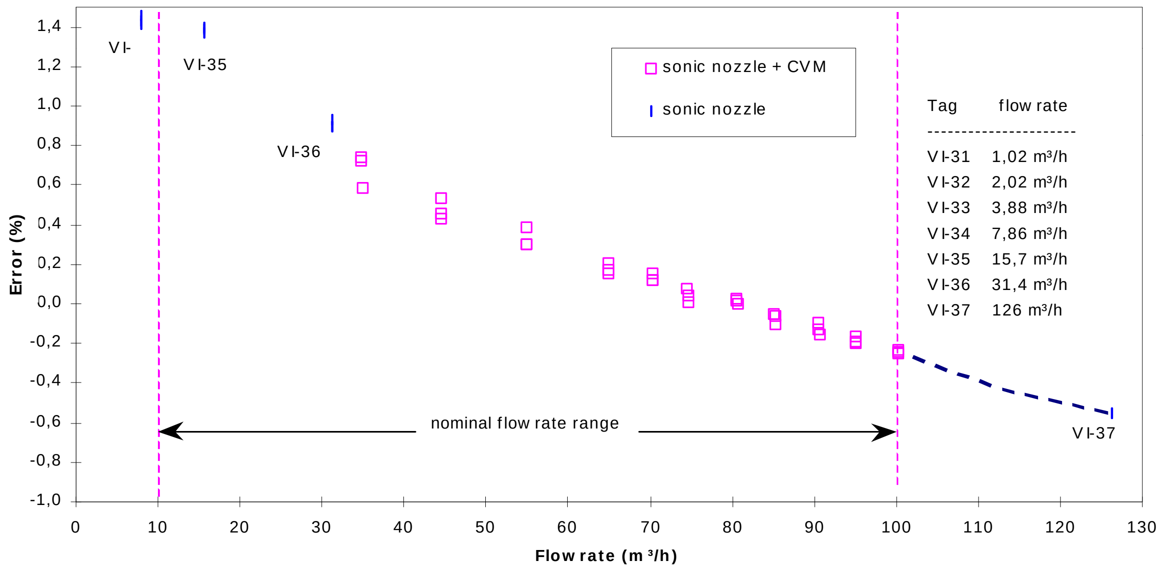


Figure 3. Calibration of a turbine meter using sonic nozzle and CVM5.3M as standards

In this case the sonic nozzles allow calibrations up to the flow rate range of the nozzle VI-36 (16 m³/h). Next nozzle available in the lab has a flow rate 26% higher than the meter under calibration. The best solution was to divide the flow between 2 working standards, as it is shown in figure 4. So the excess flow rate can be measured by the CVM.

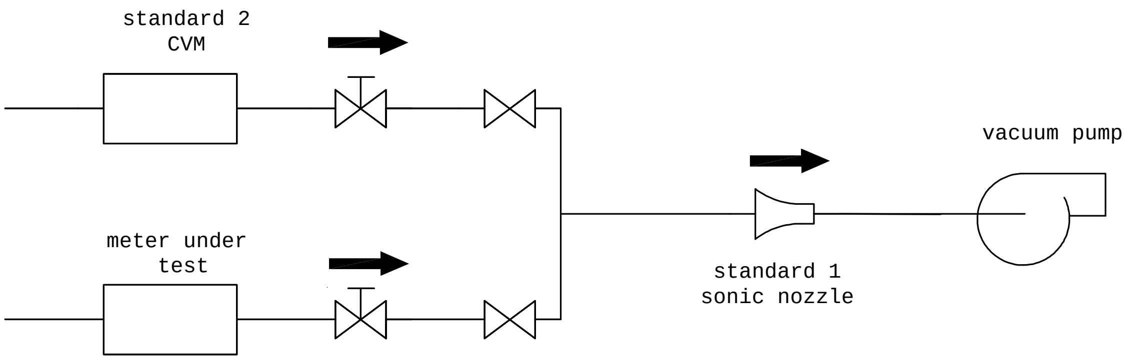


Figure 4. Scheme of the calibration of a turbine meter using the divided flow technique, with sonic nozzle and CVM.

Mass flow rate is given by the expression :

$$\dot{m}_{std1} = \dot{m}_{std2} + \dot{m}_{test} \tag{1}$$

Figure 5 shows the low flow rate laboratory with this new bench connected to the bell prover. This arrangement makes possible the operation in a wide range of flow rates, in the same facility.

1st standard sonic nozzle

TAG	Flowrate m3/h
VI-25	0,02
VI-26	0,04
VI-27	0,08
VI-28	0,17
VI-29	0,33
VI-30	0,65
VI-31	1,02

2nd standard sonic nozzle

TAG	Flowrate m3/h
VI-32	2,02
VI-33	3,88
VI-34	7,86
VI-35	15,7
VI-36	31,4
VI-37	126
VI-38	254

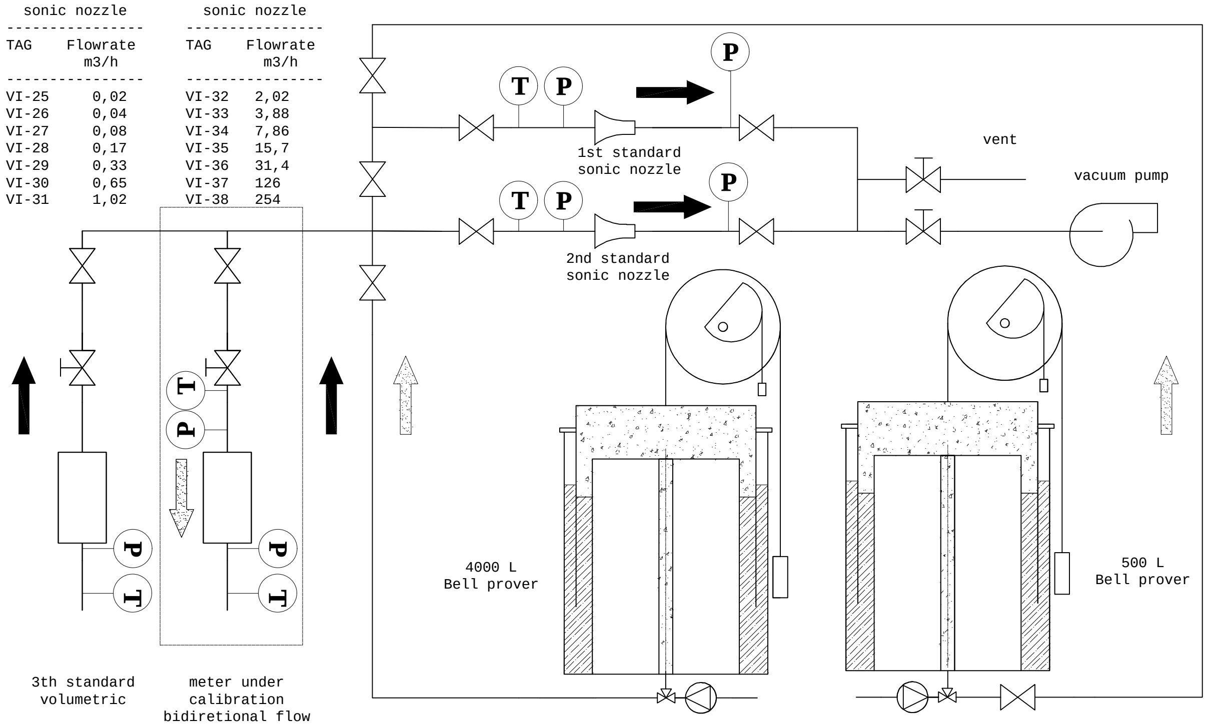
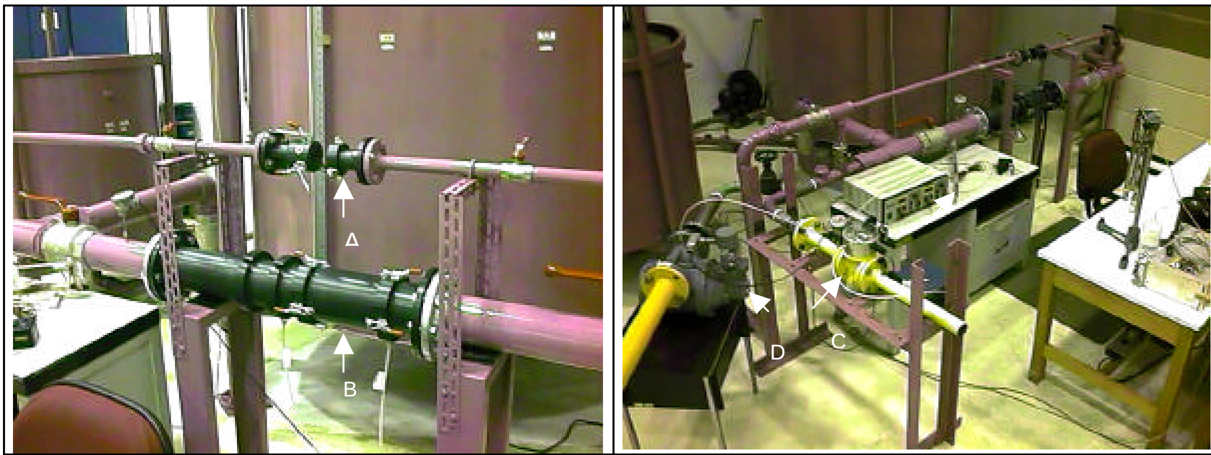


Figure 5. Scheme of the new medium range facility

The inclusion of the Bell provers will easy two basic needs:

- Calibration of the sonic nozzles
- Calibration of volumetric meters operating with the pressure given by the descending movement of the bell.

Figures bellow show pictures with details of the new facility.



A – 1st standard – sonic nozzle	C- meter under calibration
B – 2nd standard sonic nozzle	D- 3th standard - volumetric

Figure 7. Divided flow technique bench.

3 RESULTS

Other meters, with smaller range of flow rate were also calibrated at the new facility, as it is shown in the figure 8, in this figure can be seen the experimental data and the curve fit according function of error estimated.

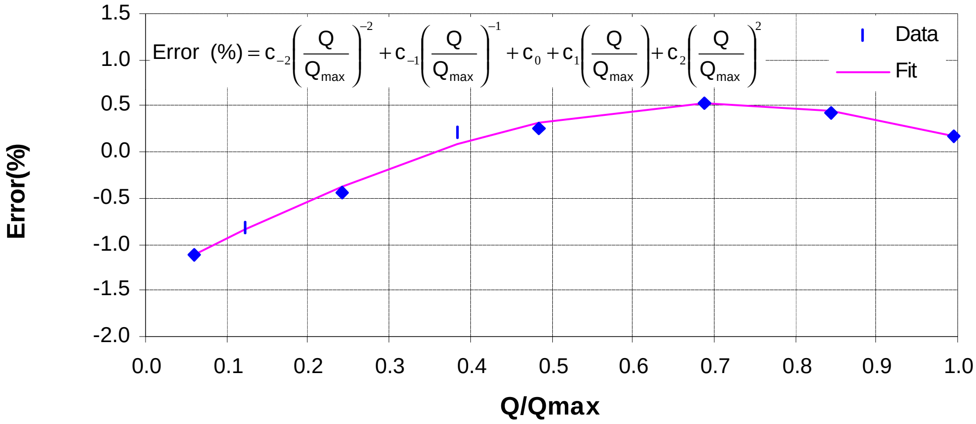


Figure 8. Calibration of a rotary piston (CVM) including curve fit.

The estimated measurement uncertainty (according to ISOGUM) of the new facility is shown in table 1, including curve fit [2].

Table 1 – Uncertainty budget

Source	Estimate	Standard uncertainty	Distribution	Sensitivity coefficient	contribution (%)	Degrees of freedom
Curve fit	0	0.06 %	rectangular	1	0.060	3
Calibration bench	0	0.13 %	normal	1	0.128	infinite
Error(Q/Q_{max})	**f(Q/Q_{max})**				**0.141**	95
k =	**2.0**				**0.188**	
Expanded uncertainty	**±0.28%**					

4 CONCLUSIONS

The results shown that the technique is applicable to calibration facilities with a low uncertainty level and that the new bench is a good device for the present needs of the Flow Laboratory, in a large flow range.

REFERENCES

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[2] Guide to expression of uncertainty in measurement. ISO international Organisation for Standardization, Geneva, 1995.

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