EFFICIENCY OF THE SMMi INSERTION FLOW CONDITIONER

Julien Cancade, Bertrand Reeb, R&D Division Gaz de France, Alfortville, France

1 Context and Introduction

Turbine meters and orifice plates are designed to operate in ideal conditions, downstream of straight pipe lengths and therefore turbine meters are calibrated in this configuration. The metering accuracy strongly depends on the flow conditions encountered at the meter inlet. Turbine meters are very sensitive to installation effects inducing flow perturbations like jet flow or swirling effects, generated by pressure regulators or pipe configuration in city gate stations. The error due to bad installation effects can reach more than 3%.

Consequently, in order to maintain a good level of accuracy, either the bad installation configuration has to be removed, or the meter has to be isolated from flow perturbations. However, the first solution is not suitable because other constraints like urbanization require a higher compactness of flow measurement systems. In addition it is not economically viable to modify the geometrical configuration of current delivery stations. So the second solution (which consists of making the meter less sensitive to bad configurations) is more suitable, and flow conditioners fulfill this goal. Flow conditioners (FCs) reduce flow perturbations like swirl or asymmetry in a much shorter pipe length than that usually necessary to a natural attenuation. Flow conditioners are more and more used on gas networks. As a proof, a certain number of FCs are quoted in international standards such as the ISO 5167 on differential pressure metering, acknowledging the efficiency of flow conditioners.

The International Organization of the Legal Metrology has a project of recommendations concerning flow measurement systems of combustible gas. This text defines three categories of users and a given level of permissible metering error for each category. The future national laws based upon these recommendations will make the requirements concerning the metering even more drastic, especially for category A meters which will be the biggest systems. It is more than probable that the use of flow conditioners will be necessary for existing delivery stations to match the new requirements. A certain number of flow conditioners are available on the market. Their efficiency but also their limits are well known. Gaz de France proposes a new version of its patented flow conditioner SMM10.

Different experimental studies using hot wire-velocimetry and LDA measurement were carried out to assess the efficiency of the conditioner SMM. These results were the subject of papers presented in another congress. In addition, validation tests have been carried out under real operating conditions, on delivery station configurations of the Gaz de France network. This poster described results obtained

2 Presentation of the SMMi

The Gaz de France Research and Development Division has developed in 1988 a fully-integrated device, the PDIM, performing the functions of pressure regulation, flow straightening, metering, network protection and filtering.

This integrated device is already being used successfully in the Gaz de France distribution network, allowing reduction of delivery station dimensions. Thus, the concept of the flow straightener used in PDIM proved to be efficient and maintenance-problem free during its utilization on the field. Therefore, five years ago, Gaz de France used this concept to develop an original flow straightener, specially designed for use in pressure reducing stations upstream of turbine meters (patent N°9803117). It is mainly composed of a perforated plate, which can be mounted against a second plate made out of a porous material as an option (Fig. 1).

The total length is then equal to one third of the nominal pipe diameter, which is very short. This conditioner can be mounted against the inlet flange of the meter, allowing the turbine meter to be mounted directly downstream of any type of pressure regulator. Its use gives the opportunity to drastically reduce the size of a station, while at the same time providing an excellent measurement accuracy.

Moreover, the density of the porous material can be adapted to various applications of the conditioner. The use or not of the porous material in addition to the perforated plate and choosing its adequate density will depend on the degree of perturbation to be dealt with and on the maximum pressure drop that can be afforded. For highly perturbed flows or very short installations, the use of a porous body may be relevant. Pressure reducing, wherever needed, may be conveniently shared between the porous body and the pressure reducer. The SMMi is designed for an insertion between flanges just upstream of the flow meter.

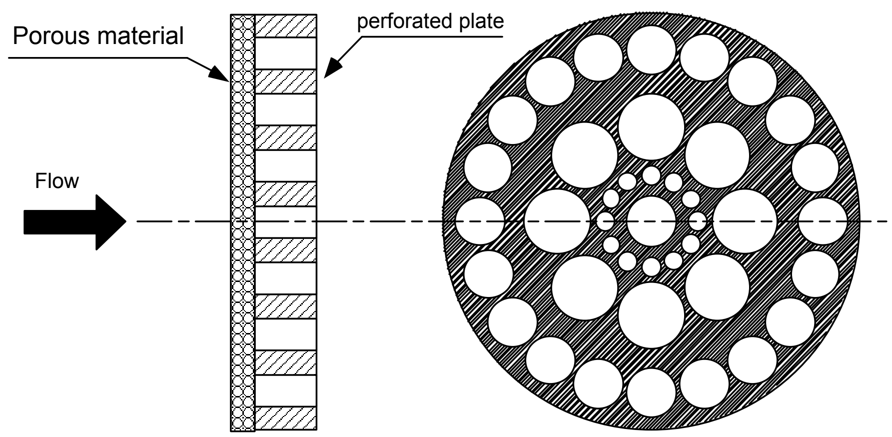


Fig. 1 : Scheme of the smm10 conditioner.

The SMMi new version (i stands for insertion) which is more compact, is designed to be inserted between the flanges just upstream of the flow meter (fig. 2). The necessary play between two flanges in order to insert the SMMi in an existing station is reduced to only one millimeter using specific spiral plate joint.

This conditioner could be installed in an existing city delivery station without any pipe work. It is also a low cost yet efficient method to dramatically improve the meter's accuracy.

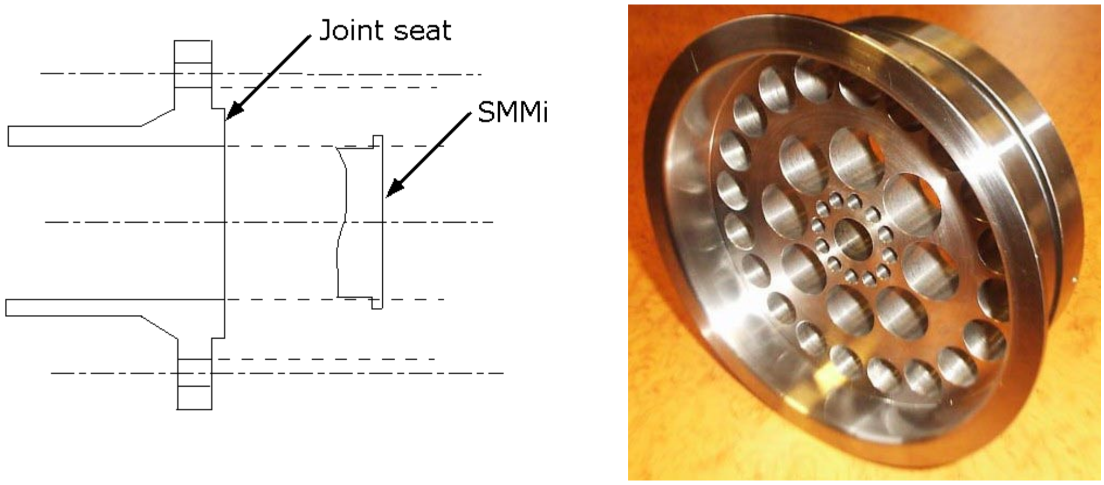


Fig. 2 : Scheme and photo of the SMMi conditioner.

Porous characteristics	
Estimated average pore diameter [mm]	0.9
Specific surface area [m^2/m^3]	1700
Thickness [mm]	10
Material	Nickel-chromium

The particularity of the SMM conditioner is the combination of a porous material with a perforated plate. The porous material removes the asymmetry of the axial velocity profile and the acoustic disturbances of the flow generated by the regulator of the delivery station. Due to its suitable design, the perforated plate removes the swirl with efficiency.

3 Test

In order to assess the efficiency of this new version, an experimental study was carried out on four geometries of delivery stations, well known for their negative impact on metering accuracy. The nominal flow rate of the meters was 1000 $m^3.h^{-1}$.

Each delivery station configuration included one pressure regulator with a pressure reduction ratio of five. The SMMi is located just upstream of the turbine flow meter. This position has been shown to produce the best result.

The reference flow rate is obtained by sonic nozzles.
Figure 3 shows the test benches of the Gaz de France facility in Alfortville that was used for the AccuLERT development study. The bench is fed with natural gas at 40 bar from the transmission network, 6 sonic nozzles mounted in parallel are operated as the reference meter of the bench, and 2 test lines can accept meters (one line can be operated while the other is being dismounted to prepare a different test).

An accuracy of 0.2% is guaranteed concerning mass flow rate determination. This bench and its operators are certified by the COFRAC (French Committee for Accreditation) for metrological tests, all sensors are traceable to national standards.

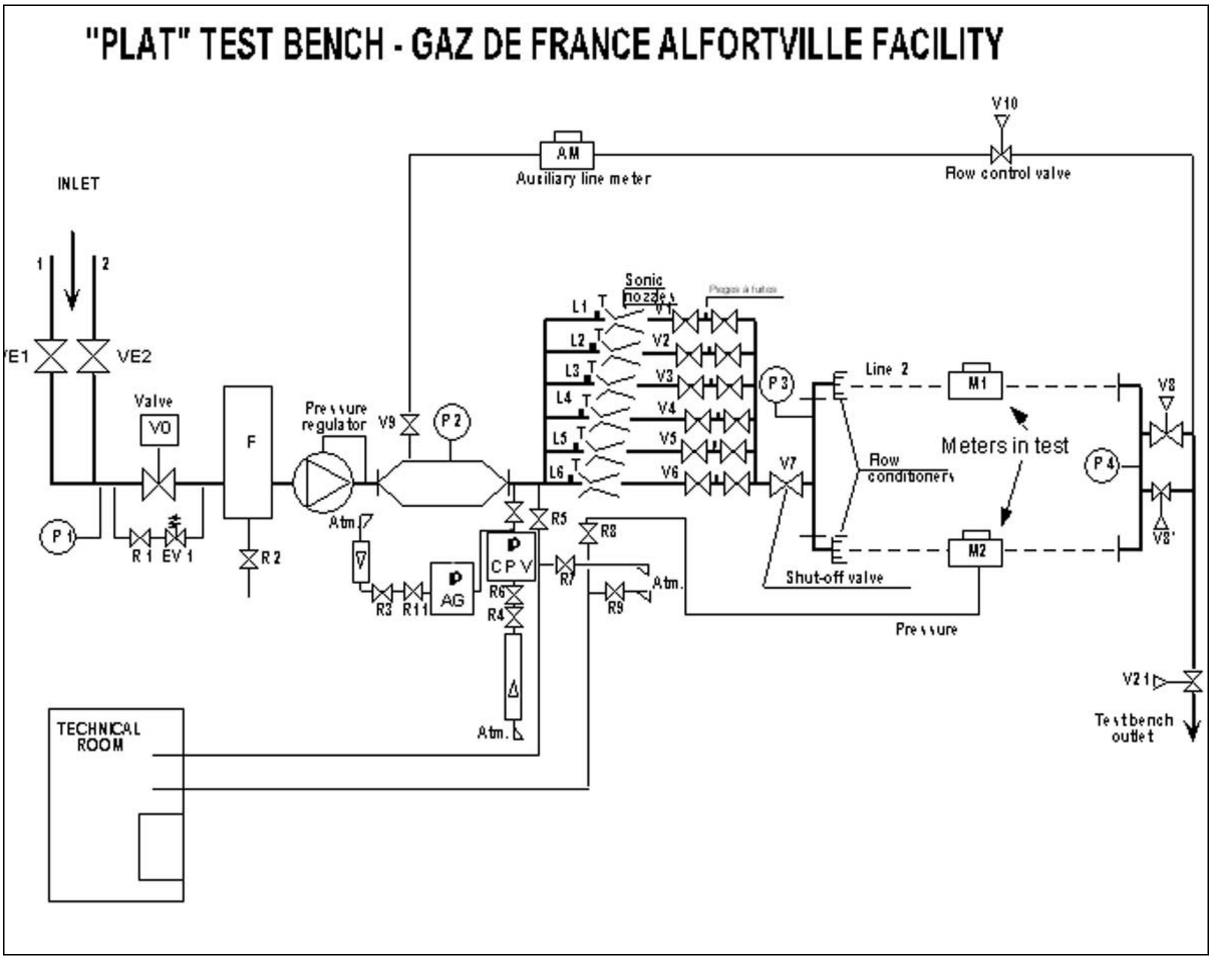
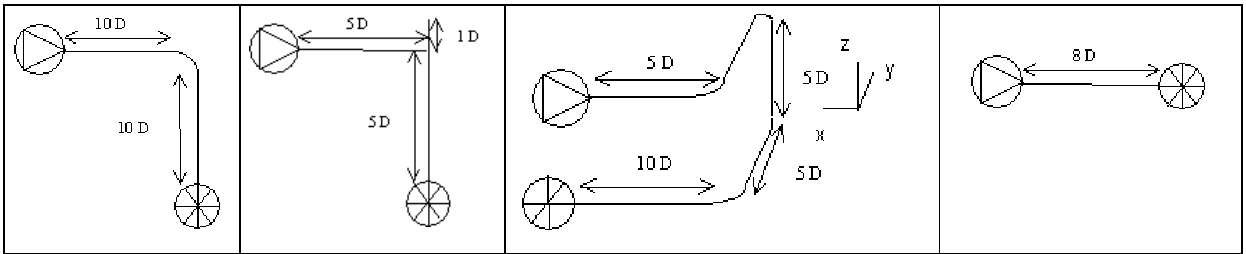


Fig 3 : configuration bench

Figure 4 shows the four geometrical configurations studied during this validation test of the SMMi under real operating conditions.



1st geometry	2nd geometry	3rd geometry	4th geometry

Fig. 4 : tested geometrical configuration

The impact of the SMMi flow conditioner on two types of flow meters (new and old generation), from two different manufacturers was tested. The new generation flow meter has an integrated perforated plate. The nominal flow rate of the meters was 1000 $m^3.h^{-1}$. Each delivery station configuration included one pressure regulator with a pressure reduction ratio of five.

Firstly, due to a reference flow rate measured by sonic nozzles located upstream of the turbine meter, each flow meter is calibrated to obtain the reference curve in baseline conditions, with a fully developed velocity profile.

Then the accuracy of the two flow meters tested in the four configurations was reproduced on a test bench. For each configuration, the two flow meters are tested without SMMi, then only with the perforated plate (simple conditioner) and then, for the third and fourth geometry, with the porous material connected to the perforated plate (compounded conditioner).
The results presented below represent , in each tested configuration, the accuracy gains on the flow rate measurement due to the SMMi conditioner. The accuracy gains is the difference between the error obtained without conditioner and the one measured with the single or the compounded SMMi.
Results will be shown and results will be discussed at the nominal flow rate accordingly to the OIML recommendations.

4 **Result**

4.1 1st geometrical configuration

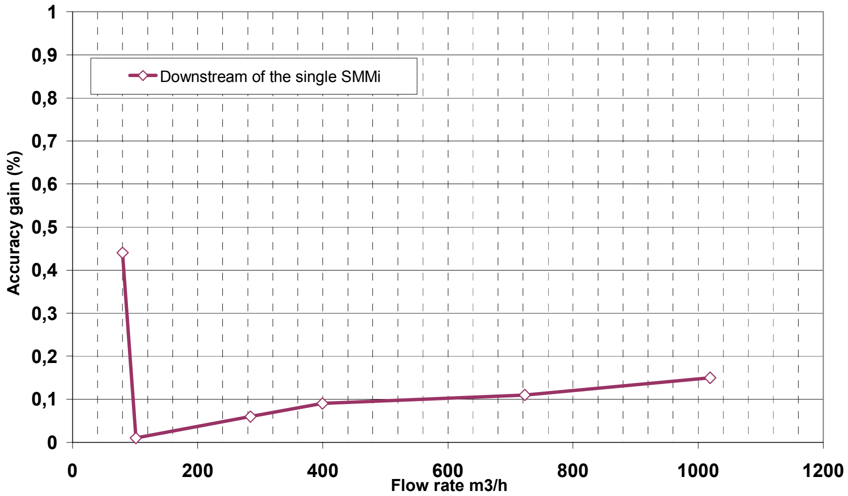


Fig. 5 : Accuracy gains due to the SMMi located upstream of new generation turbine flow meter

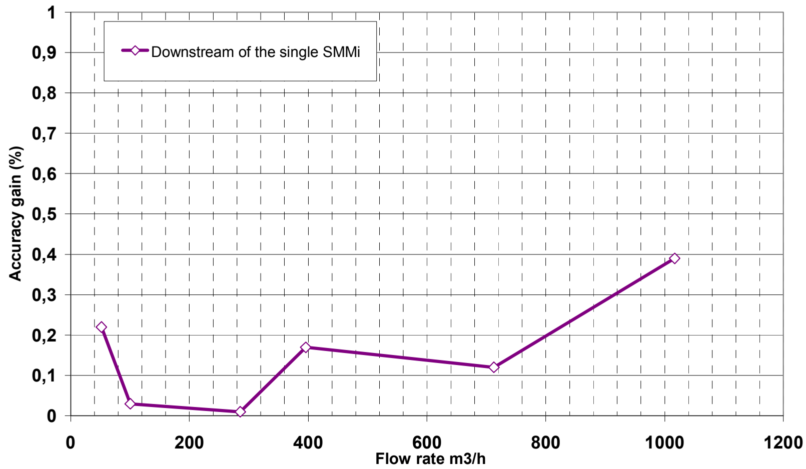


Fig. 6 : Accuracy gains due to the SMMi located upstream of old generation turbine flow meter

In this configuration without SMMi, the new generation flow meter is more efficient than the old generation meter. In fact, the error of the new generation turbine flow meter, at the nominal flow rate, is larger by 3/1000 than that of the old generation meter. Nevertheless, after the installation of the single SMMi, the error with the new and the old generation turbine flow meter are similar and is under the OIMLB level. In fact, the single SMMi in this configuration decreases the measure error of the turbine flow meter by 4/1000 for the old generation meter, and only by 2/1000 for the new generation meter.

4.2 2nd geometrical configuration

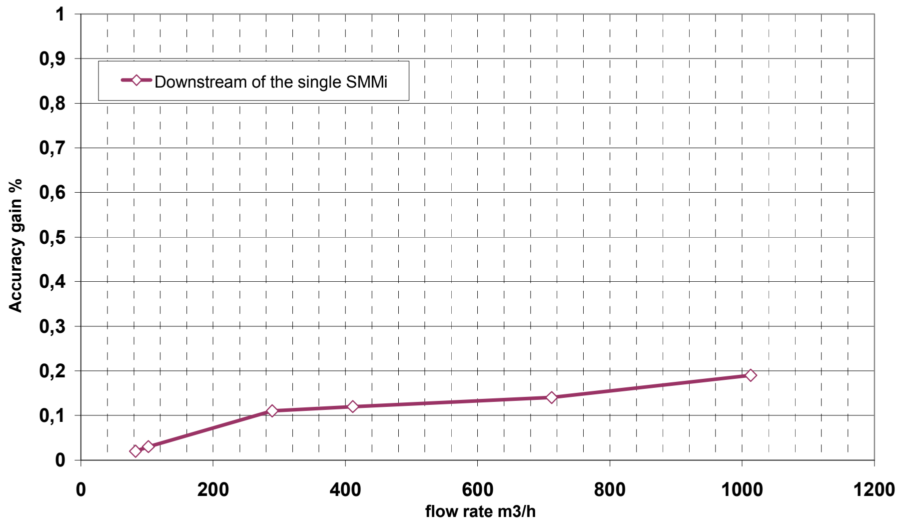


Fig. 5 : Accuracy gains due to the SMMi located upstream of new generation turbine flow meter

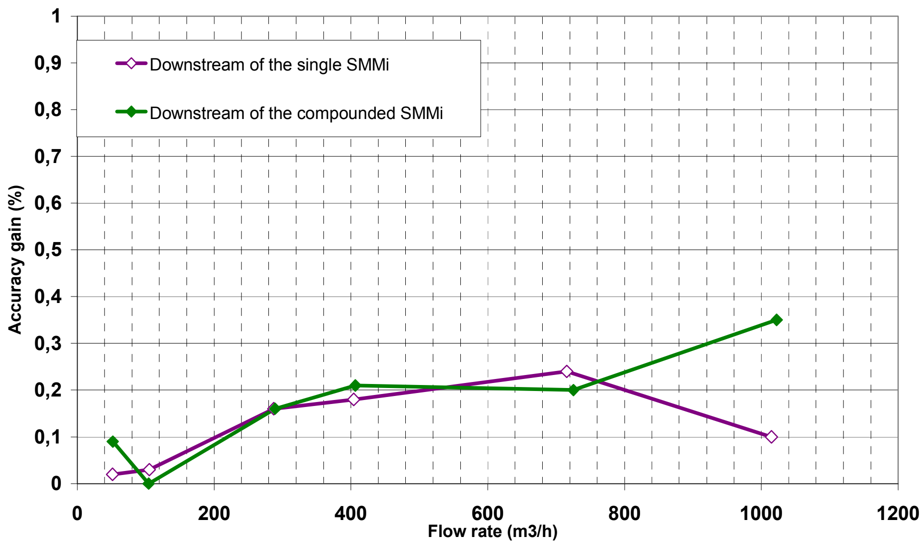


Fig. 6 : Accuracy gains due to the SMMi located upstream of old generation turbine flow meter

This configuration is less critic than the previous one. The te with short dead branch, involves a re-circulation zone, acting like a generator of turbulence which homogenizes the flow.

As in the previous configuration, the new generation turbine flow meter is more efficient than the old generation meter. In this configuration including a te, the new generation turbine flow meters measures with an error under the level of the OIMLB recommendation.

Nevertheless, the single SMMi upstream of the old generation turbine flow meter decreases the error by 1/1000 and the compounded SMMi by 4/1000. Due to the compounded SMMi, the error is under the OIMLB level.

4.3 3rd geometrical configuration

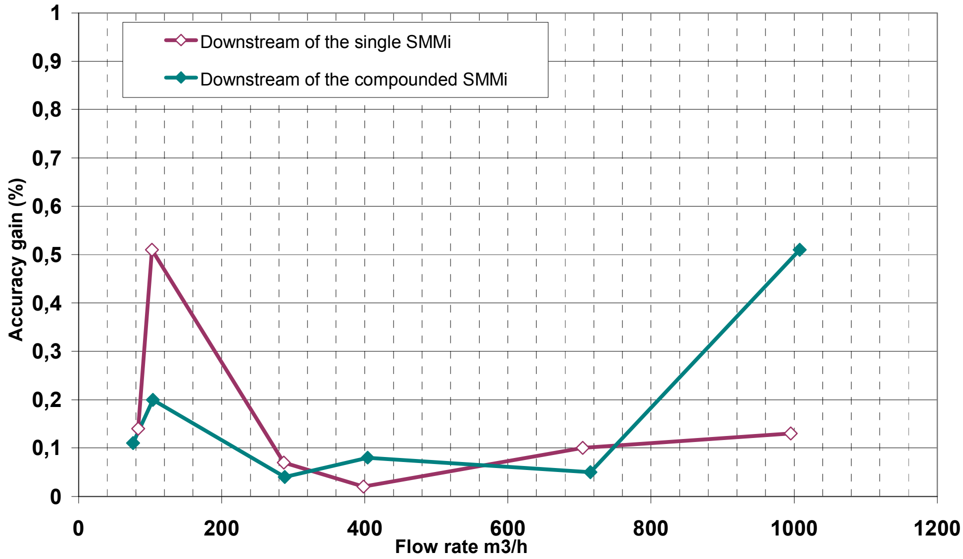


Fig. 5 : Accuracy gains due to the SMMi located upstream of new generation turbine flow meter

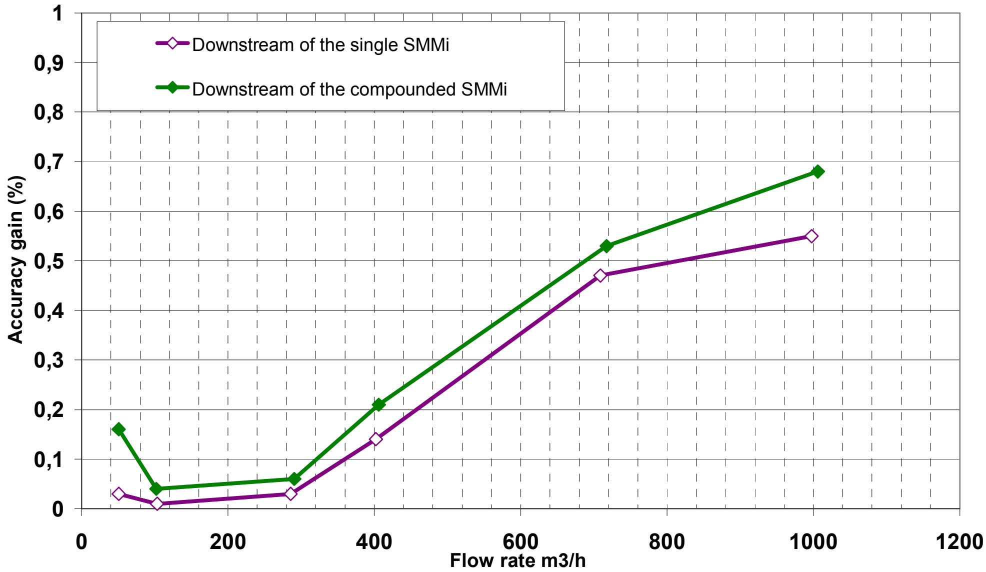


Fig. 6 : Accuracy gains due to the SMMi located upstream of old generation turbine flow meter

In contrast, the previous configuration, the efficiency of the new generation turbine flow meter is similar to the old generation model. The single SMMi decreases the error by 1/1000 for the new generation and by 6/1000 for the old generation turbine flow meter. However, the compounded SMMi decreases the error by 1/1000 for the old generation turbine flow meter and of 5/1000 for the new generation turbine flow meter.

The compounded SMMi ensures an error on the flow rate under the OIMLA level for the old generation and under the OIMLB for the new generation turbine flow meter.

4.4 4th geometrical configuration

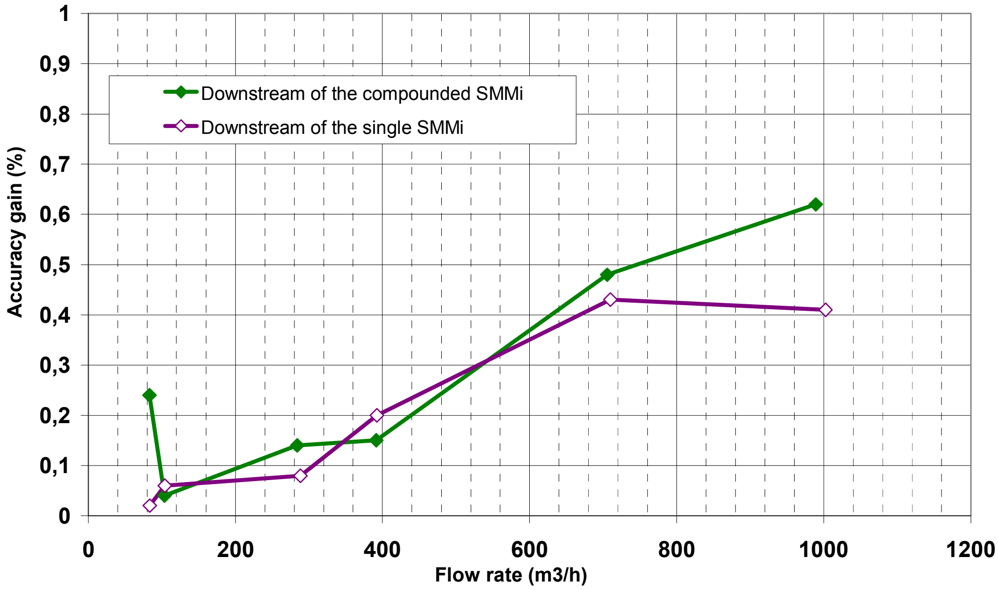


Fig. 5 : Accuracy gains due to the SMMi located upstream of new generation turbine flow meter

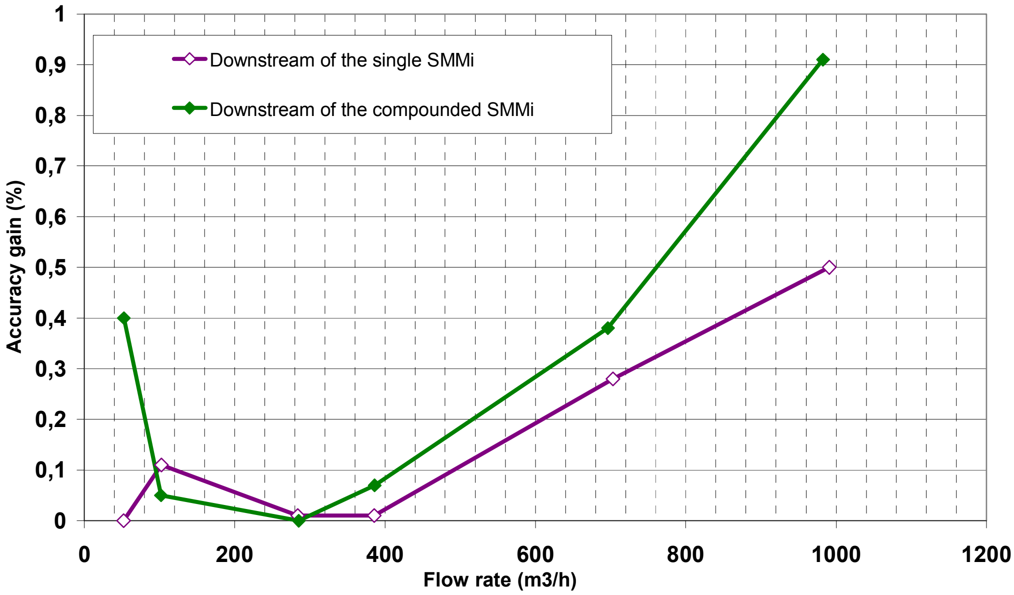


Fig. 6 : Accuracy gains due to the SMMi located upstream of old generation turbine flow meter

As in the previous configuration, the efficiency of the new generation turbine flow meter is similar to the old generation model.

The efficiency of the single SMMi is quasi-similar for the new and old generation turbine flow meter, nevertheless, the compounded SMMi is more efficient when it is linked to the old generation turbine flow meter. In this case, the error falls under the OIMLA level. The accuracy gains are substantial, decreasing the error on the flow rate measurement by 9/1000.

5 Conclusion

This study shows that the SMMi is a solution, at less cost, to meet the recommendations of the International Organization of the Legal Metrology for a delivery station. It shows the efficiency of the compounded SMMi, including a porous material, which acts like a destroyer of unsteady perturbations.
As results show, the impact of the SMMi on the flow measurement depends on the coupling of the SMMi and a type of turbine flow meter (old or new generation).

The compounded SMMi presents two drawbacks, one being the pressure drop and the other the clogging of the porous material. The porous material integrated in the compounded SMMi significantly increases the pressure drop of the device. The pressure drop coefficient goes from 1.5 for the single SMMi, to 22 for the compounded SMMi ($Cd=2*\Delta P/\rho v^2$).
The first drawback may be countered by a new adjustment of the upstream pressure. The second requires that compounded SMMi be placed in a part of the network where gas is free of particles and oil. G.D.F. continues to study a new device to overcome the problem of clogging. In addition, numerical studies will be carried out on flow conditioners, to compare different types of conditioners, including the SMMi.

References

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[2] Patent N°9803117
[4]international Standard ISO 5167-1, Measurement of fluid flow by means of pressure differencial devices