Low-Pressure Gas Flow Standard in Russian Federation:
Principles, Calibration Techniques, Intercomparisons


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Development of Low-Pressure Gas Flow Standard in Russian Federation

1967  Work on creation of reference facilities for the calibration of measuring instruments for measuring the volume and mass flow rate of low-pressure gas (air) was started

1974  VNIIR developed and approved the State Primary Standard GET 62-74 of Gas Volume Rate Units

1979  VNIIR developed and approved the State Primary Standard GET 118-79 of Gas Mass Flow Rate Units

2006  The State Primary Standard GET 118-2006 of Volume and Mass Gas Flow Rate Units was created

2007  Participation in international comparison COOMET No.219/Sk-00

2010  Participation in international comparison COOMET No.412/UA/07

2011  Participation in trilateral comparison between NIM, PTB and VNIIR
Reference test rigs:

Gravimetric

Sonic nozzles

Sonic nozzles

\[ Q = 0.0003 \ldots 10 \ 000 \ \text{m}^3/\text{h} \ (0.00036 \ldots 12 \ 000 \ \text{kg/h}) \]

\[ S_0 = 0.035 \ldots 0.05 \ % \quad \Theta_0 = 0.04 \ % \]
Schematic diagram of sonic nozzles calibration in GET 118-2006:

\[ Q_2 = Q_1 \frac{f_2}{f_1} \]
New method of sonic nozzle calibration

Laminarizer:

Schematic diagram of the reference test rig for sonic nozzles calibration:

1 – laminarizer (comparator); 2 – pressure differential sensor; 3 – pressure sensor; 4 – receiver, 5 – lower flow RSN; 6 – calibratable nozzle; 7 – higher flow RSN; 8, 9, 10 – gas valves; 11 – compressor

The volume gas flow rate of calibratable nozzle under standard conditions:

\[
Q = \Delta p \left[ \frac{Q_1}{\Delta p_1} + \frac{\Delta p - \Delta p_1}{\Delta p_2 - \Delta p_1} \left( \frac{Q_2}{\Delta p_2} - \frac{Q_1}{\Delta p_1} \right) \right]
\]

Height of flat slit channels \( h = 0.8 \) mm
Length \( L = 230 \) mm
The application of developed comparing method in GET 118 allowed:

- to calibrate the nozzles with an expanded uncertainty $U$ (at coverage factor $k=2$) 0.06…0.1%
- to calibrate nozzles with gas flow values much higher than the maximum value of the reproduction range of the original reference installation of the bell type,
- to reduce the load and wear of the expensive initial reference installation,
- to increase significantly the productivity of calibration works,
- to reduce the nomenclature of the reference nozzles.

Gorchev A.I., etc “Method for critical nozzles calibration and device for critical nozzles calibration”, Patent RU 2654934, 2018
Content of GET 118-2017:

1) initial test rig TR-1 – high-precision bell prover;

2) test rig TR-2 with sonic nozzles set;

3) highly-productive test rig TR-3 with sonic nozzles set;

4) test rig TR-4 with sonic nozzles set and reference gas meter (at gage pressure up to 1 Mpa)

5) piston prover (test rig TR-5) for reproduction gas flow rate units in ultra-low range
Initial test rig TR-1

1 – bell (in highest position), 2 - oil tank, 3 - cabinet of climate precision system, 4 – test bench, 5 - cabinet of automated control system

$U \leq 0.06\%$ at $Q=1...65$ m$^3$/h  
$U \leq 0.10\%$ at $Q=0.4...1$ and $Q=65...100$ m$^3$/h.

Schematic diagram of bell prover

Automated test rig TR-2

Module 1
\[ Q = 10...16\,000\ \text{m}^3/\text{h} \]

Measuring system includes 45 parallelly installed reference sonic nozzles of various typical sizes

Module 2
\[ Q = 1...1\,600\ \text{m}^3/\text{h} \]

Module contains 13 various reference sonic nozzles and 7 laminarizers (comparators)

\[ U \leq 0.10\% \]
Automated test rig TR-3

\[ Q = 1 \ldots 64 \text{ m}^3/\text{h} \]

8 reference sonic nozzles

2 laminarizers (comparators)

\[ U \leq 0.09 \% \]

1 – laminarizer (comparator); 2 – inlet pneumatic valve;
3 – pressure differential sensor; 4 – control unit; 5 – set of parallel mounted reference sonic nozzles;
6 – pneumatic cranes of reference sonic nozzles;
7 – receiver with calibratable nozzle inside;
8 – pneumatic crane of calibratable nozzle
Test rig TR-4 at gage pressure up to 10 MPa

\[ Q = 10 \ldots 2300 \text{ m}^3/\text{h} \]

5 reference sonic nozzles

1 reference rotary gas meter (Q \leq 400 \text{ m}^3/\text{h})

\[ U \leq 0.11 \% \]
Automated test rig TR-5

Two measuring cells:
- SL-800-10 ($Q = 0.0003...0.03 \ m^3/h$),
- SL-800-44 ($Q = 0.03...3 \ m^3/h$).

1 – parallel pipe, 2 – piston, 3 – pressure sensor, 4 – thermometer, 5 – optical sensors, 6 – bypass valve

$U \leq 0.10\%$
Conclusion

As a result of the improvement of the GET 118, the following was achieved:

- the expanded uncertainty $U$ of reproduction of volume and mass flow rate units of gas (air) at the initial test rig in the flow range from 1 to 65 m$^3$/h was reduced from 0.08% (in GET 118-2006) to 0.06%, and in general an expanded uncertainty of reproduction of volume and mass gas flow rate units in GET 118-2017 is from 0.06 to 0.11%;

- the range of reproducible gas flow rate $Q$ was significantly expanded, and now it is from 0.0003 to 16000 m$^3$/h);

- the upper value of the gage pressure of gas (air) was increased to 1 MPa in the range of gas flow rate from 10 to 2300 m$^3$/h;

- the application of the developed comparing method using laminarizers allowed: 1) to calibrate sonic nozzles with gas flow values much higher than the maximum value of the reproduction range of the initial test rig TR-1 of bell type, 2) to reduce the load and wear of the expensive initial test rig TR-1, 3) to significantly increase the productivity of calibration works.
**Conclusion**

General metrological characteristics of GET 118-2017

<table>
<thead>
<tr>
<th>Test rig</th>
<th>Parameter</th>
<th>Q, m$^3$/h</th>
<th>p, kPa</th>
<th>U, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR-1</td>
<td></td>
<td>1 – 65</td>
<td>96 – 104</td>
<td>0,06</td>
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<tr>
<td></td>
<td></td>
<td>0,4 – 1</td>
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<td></td>
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<td>65 – 100</td>
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<td>1 – 16000</td>
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<td>1 – 64</td>
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</tr>
<tr>
<td>TR-4</td>
<td></td>
<td>10 – 2300</td>
<td>up to 1100</td>
<td>0,11</td>
</tr>
<tr>
<td>TR-5</td>
<td></td>
<td>0,0003 – 3</td>
<td>96 – 104</td>
<td>0,10</td>
</tr>
</tbody>
</table>

International comparison of GET 118-2017 (VNIIR):
- Euramet project No. 1396 (2018; with PTB and CMI; Q=1…100 m$^3$/h),
- COOMET project No. 680/RU/16 (in progress; with PTB, BELGIM, IFSM, LEI; Q=20…6 500 m$^3$/h)
Thank you!

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