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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

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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

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

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Reference test rigs:

Gravimetric

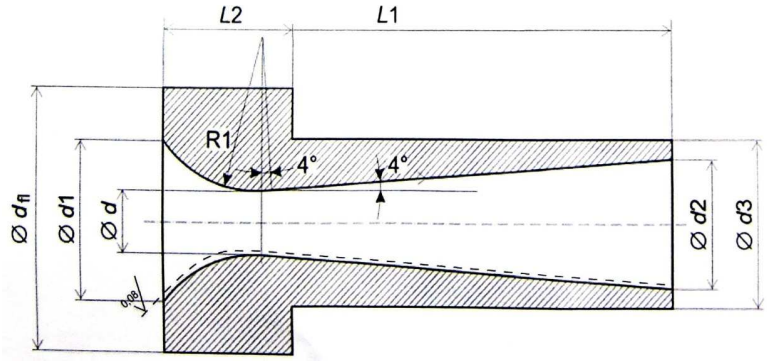
Sonic nozzles

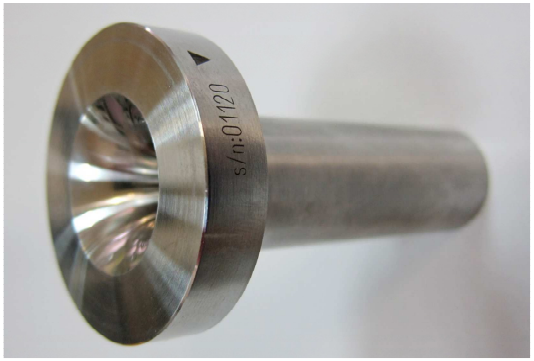
Sonic nozzles

Q = 0.0003…10 000 m^3/h (0.00036…12 000 kg/h)

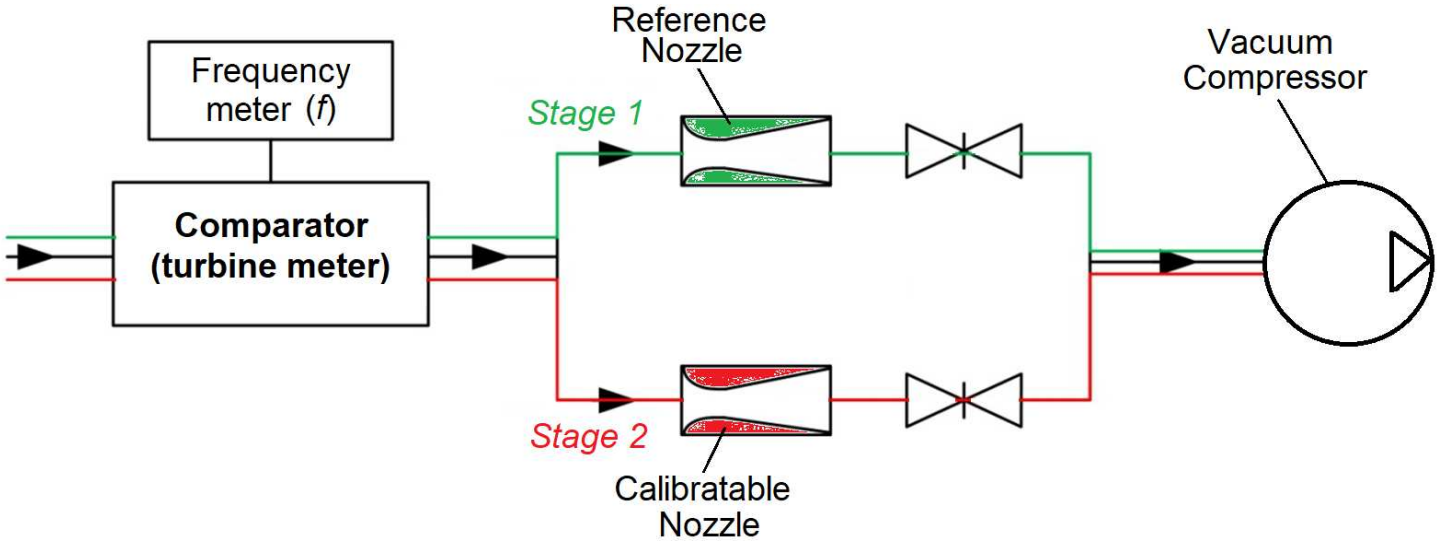
S_0 = 0.035…0.05 % Θ_0 = 0.04 %

Sonic Nozzle Calibration





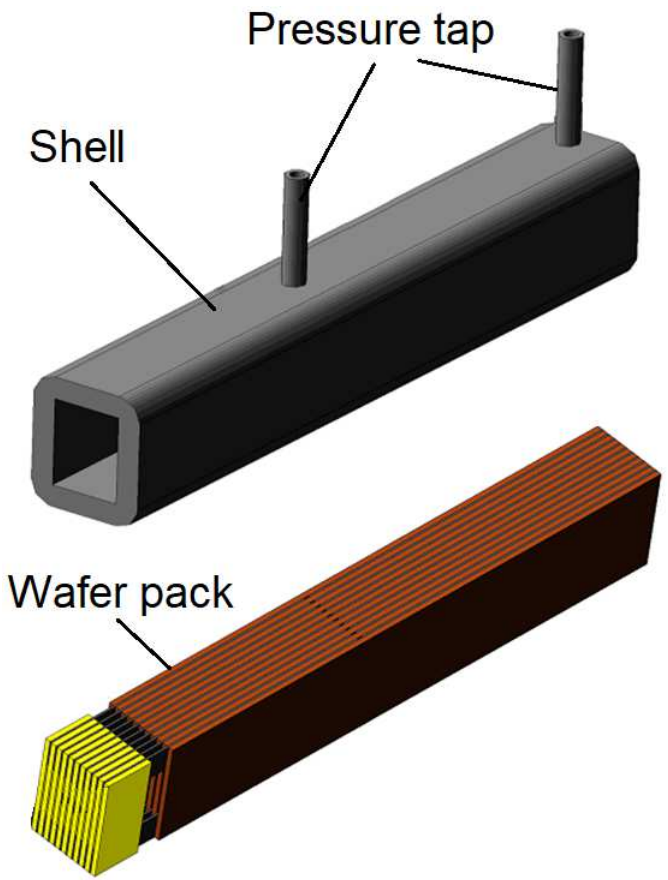
Schematic diagram of sonic nozzles calibration in GET 118-2006:



$$Q_2 = Q_1 \frac{f_2}{f_1}$$

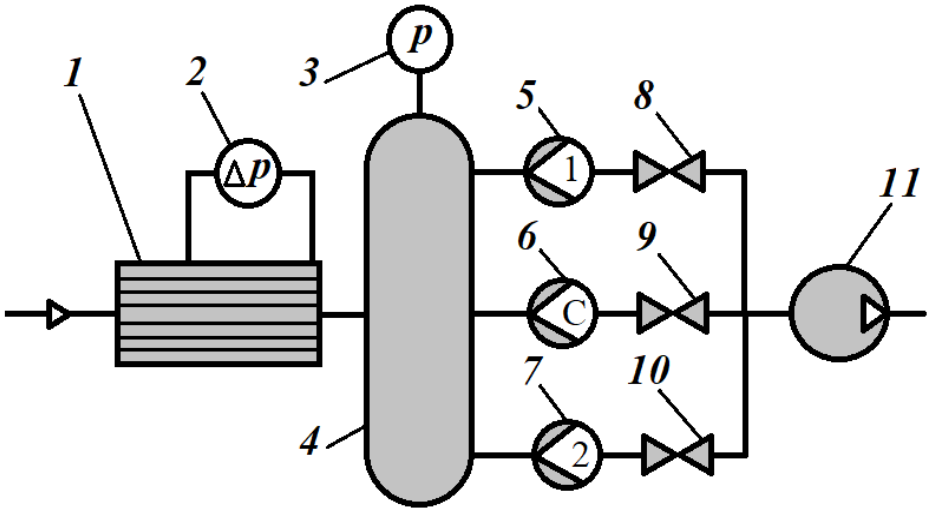
New method of sonic nozzle calibration

Laminarizer:



Height of flat slit channels h=0.8 mm
Length L=230 mm

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:

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

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New method of sonic nozzle calibration

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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

РОССИЙСКАЯ ФЕДЕРАЦИЯ

ПАТЕНТ

НА ИЗОБРЕТЕНИЕ

№ 2654934

Способ калибровки критических сопел и устройство для калибровки критических сопел

Патентообладатель: *Федеральное агентство по техническому регулированию и метрологии (Госстандарт) (RU)*

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Руководитель Федеральной службы по интеллектуальной собственности

Г.П. Ивлиев

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Improved State Primary Standard GET 118-2017 of Volume and Mass Gas Flow Rate Units

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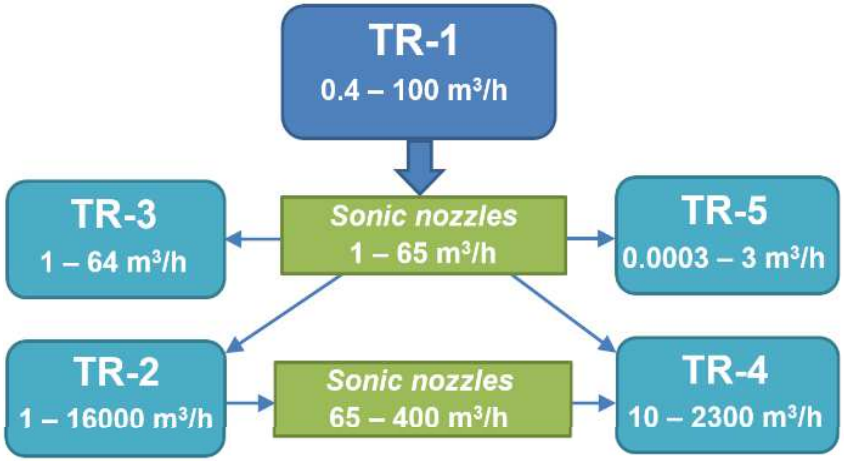
Content of GET 118-2017:

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

Diagram of the transfer of gas flow rate units in the GET 118-2017



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Initial test rig TR-1

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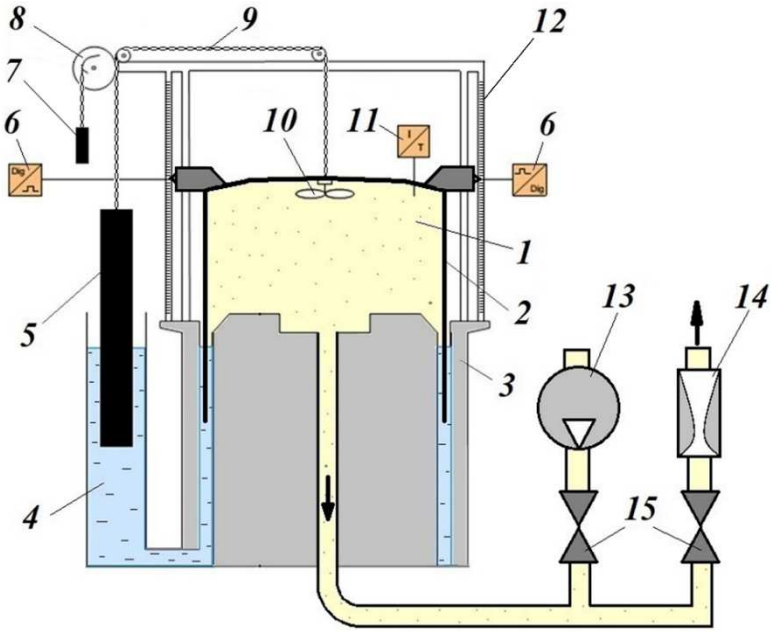
1 – bell (in highest position), 2 - oil tank, 3 - cabinet of climate precision system, 4 – test bench, 5 - cabinet of automated control system

$U \leq 0.06\%$ 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



1 – gas volume, 2 – bell, 3 – bottom tank, 4 – barrier liquid (oil), 5 – counterweight - compensator of liquid level, 6 – bell position sensor, 7 – load of buoyancy compensation, 8 – eccentric disk (Archimedean spiral), 9 – rope, 10 – fan, 11 – temperature sensor, 12 – linear displacement meter; 13 – compressor, 14 – meter under test, 15 – magnet crane

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Automated test rig TR-2

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Module 1

Q = 10...16 000 m³/h

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

Module 2

Q = 1...1 600 m³/h

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

$U \leq 0.10\%$

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Automated test rig TR-3

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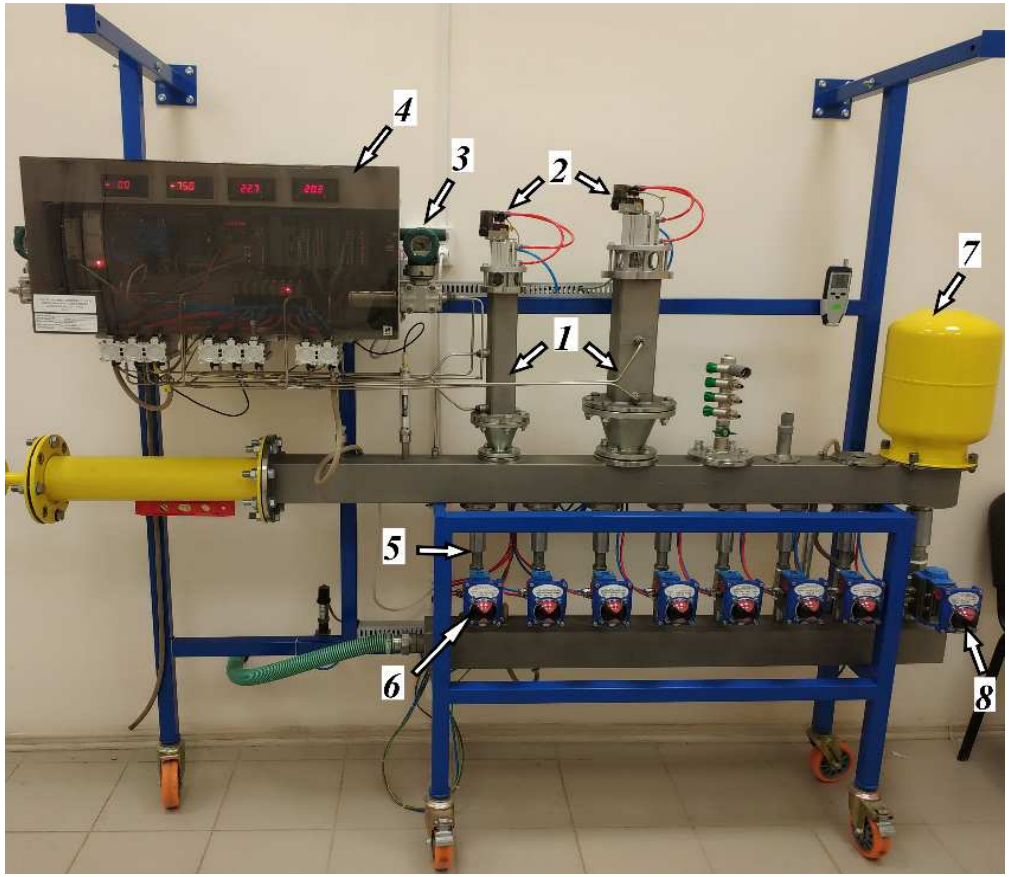


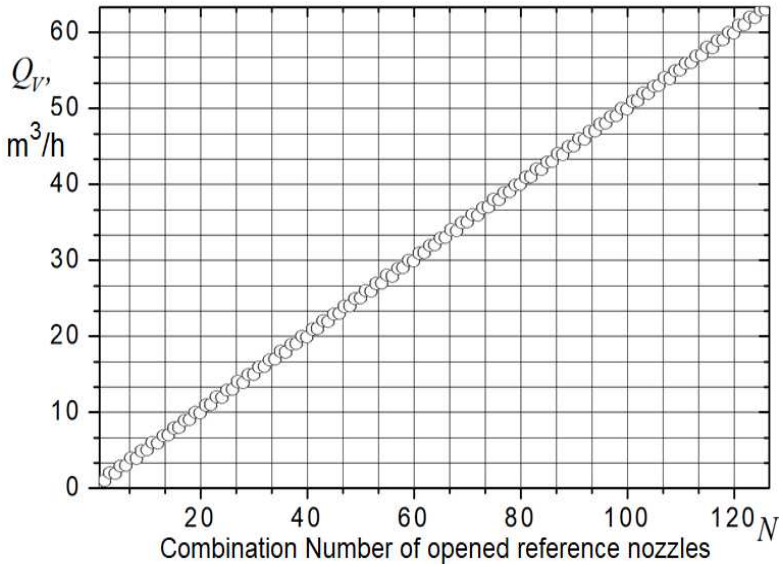
1 – laminarizer (comparator); 2 – inlet pneumatic valve;
3 – pressure differential sensor; 4 – control unit; 5 – set of parallel mounted reference sonic nozzles;
6 – pneumatic cranes of reference sonic nozzles;
7 – receiver with calibratable nozzle inside;
8 – pneumatic crane of calibratable nozzle

Q = 1…64 m³/h

8 reference sonic nozzles

2 laminarizers (comparators)

$U \leq 0.09$ %



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Test rig TR-4 at gage pressure up to 10 MPa

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Q = 10…2300 m^3/h

5 reference sonic nozzles

$U \leq 0.11$ %

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

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Automated test rig TR-5

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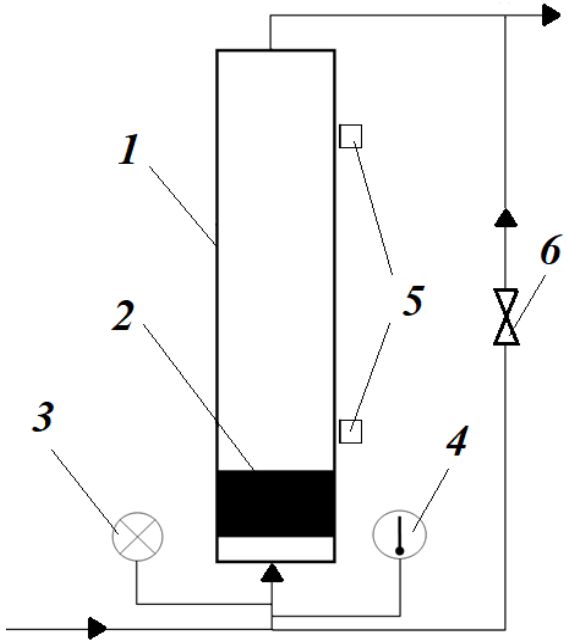

1 – parallel pipe, 2 – piston, 3 – pressure sensor, 4 – thermometer, 5 – optical sensors, 6 – bypass valve

Two measuring cells:

- SL-800-10 (Q = 0.0003…0.03 m^3/h),
- SL-800-44 (Q = 0.03…3 m^3/h).

$U \leq 0.10\%$

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

Test rig	Parameter		
	Q, m^3/h	p, kPa	U, %
TR-1	1 – 65 0,4 – 1 65 – 100	96 – 104	0,06 0,10 0,10
TR-2	1 – 16000	96 – 104	0,10
TR-3	1 – 64	96 – 104	0,09
TR-4	10 – 2300	up to 1100	0,11
TR-5	0,0003 – 3	96 – 104	0,10

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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