Approved
Chief of the Testing Laboratory "Stroilaboratoria SL"
signature Kiselyov M. M.
December, 23 2013.

Seal: Limited Company
"STROILABORATORIA SL"
Number of state register 526 006
MOSCOW

Resolution № 1
December, 19, 2013

Determination of the coefficient of thermal conductivity
of the liquid ceramic thermal coating
Bronya Classic
in compliance with specifications 2216-006-09560516-2013.

Moscow 2013.

Detailed test procedure:

1. Liquid thermal insulation Bronya is applied to one of the test section of the pipeline. Application is made by a paint brush with 0,5 mm layers and 24 hours inter-coat drying. Total thickness of layers is 1,5 $\pm$ 0,1 mm.

2. All the system is scooped with water by a pump. Start of the heat conductor circulation.

3. Heating of the heat conductor with the aid of an electric heating boiler.

4. Measurement of the temperature on the surface of the delivery and return piping with thermal insulation.

5. Measurement of the water flow rate at the test section of pipeline with the aid of the water meter, installed at the delivery piping.

6. Reading the period of time of heat transfer on the test section.

7. After a certain period of time the readings of the meter are taken.

8. Measurement of the mean temperature on the surface of the delivery and return piping with thermal insulation.

9. Decoupling of the drive.

Further, the same test is conducted with non-insulated section of the pipeline.

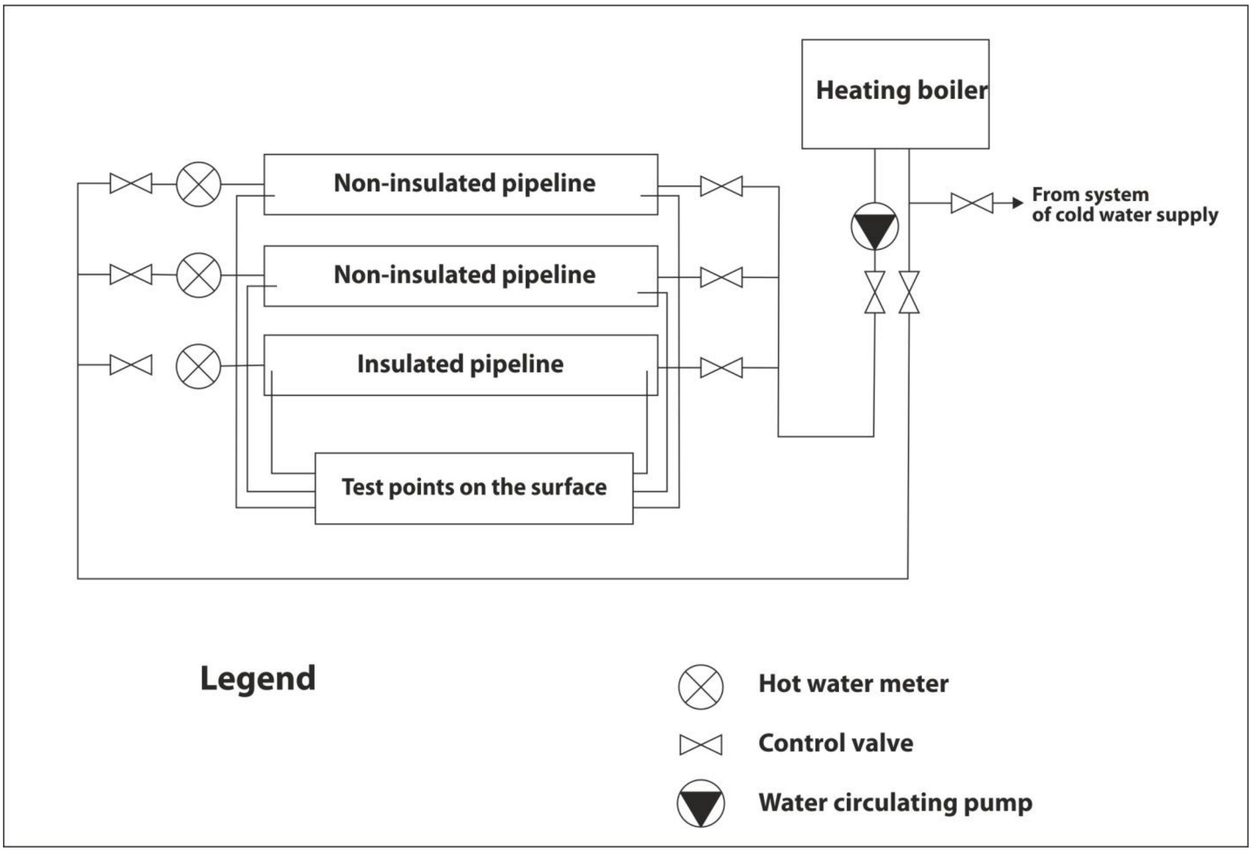

Fig. 1 – Basic scheme of the test facility

Calculation technique

The quantity of the heat given by the section of the pipeline:

$$Q = \frac{G_{вд} \cdot c_{вд} \cdot (t_г - t_{ох})}{3,6}, (1)$$

Where

Q – is the quantity of the heat given by the section of the pipeline, W;
$c_{вд}$ – water specific heat ($c_{вд}$ = 4,187 J/(kg °C));
$t_г$ - temperature on the surface of the delivery piping, °C (measured by the thermal hygrometer Elcometer 319);
$t_{ох}$ - temperature on the surface of the return piping, °C (measured by the thermal hygrometer Elcometer 319);
$G_{вд}$ – flow rate on the test section of piping, kg/h.

q - heat flow density from 1 m^2 of the test section of piping is determined by the following formula :

$$q = \frac{Q}{l \cdot \pi \cdot d}, (2)$$

where l – the length of the test section of the piping, m;
d – pipe diameter, m.

The surface heat exchange coefficient is determined by the formula:

$$\alpha_н = \frac{q_{пов}}{\tau - t_{int}}, (3)$$

where $q_{пов}$ - heat flow from 1 m^2 of the test section of piping , W/m;
τ – temperature of the surface of the thermal insulation (measured by the thermal hygrometer Elcometer 319)), °C;
t_{int} – environmental temperature inside the laboratory, °C.

Determination of the heat-conduction coefficient

The heat-conduction coefficient is determined by the formula:

$$\lambda = \frac{\delta \cdot \alpha_н \cdot (\tau - t_{int})}{t_в - \tau}, (4)$$

where δ – thickness of the liquid insulation layer Bronya, m;

$t_в$ - temperature of the non-insulated pipeline (medium value), °C.

Tabel 1

Test reading of the piping sections

Indicators'names	Non-insulated section
Mean temperature of the air inside the laboratory during the testst_{int}, °C	23,8
The surface temperature at the inlet of the test piping, °C	70,6
the surface temperature at the oulet of the test piping, °C	69,6
Temperature difference($t_г$- t_{ox}), °C	1
Temperature on the surface of the thermal insulation	35,4
Flow rate on the test section$G_{вд}$, kg/h	21,9
Quantity of generated heat from the test section$Q_{пр}$, W	25,47
Actual value of the heat flow density from1 m^{2}of the test section of piping, $q_{пр}$, W/м^2	18,77
Thickness of the insulation, mm	1,5

Thermal measurement treatment:

Insulated pipeline.

- Determination of the quantity of the heat given by the formula 1, W:

$$Q = \frac{21{,}9 \cdot 4{,}187 \cdot (70{,}9 - 69{,}9)}{3{,}6} = 25{,}47$$

- Determination of heat flow density from 1 m^2 of the test section of piping by the formula 2:, W/m^2:

$$q = \frac{25{,}47}{4 \cdot 3{,}14 \cdot 0{,}108} = 18{,}77.$$

- Determination of the surface heat exchange coefficient by the formula 3, W/m^2 °C:

$$\alpha_н = \frac{18{,}7}{35{,}4 - 23{,}8} = 1{,}61$$

- Determination of the heat-conduction coefficient by the formula 4, W/m^2 °C:

$$\lambda = \frac{0{,}0015 \cdot 1{,}61 \cdot (35{,}4 - 23{,}8)}{(70{,}6 - 35{,}4)} = 0{,}0008$$

Conclusion:

The following results of the tests conducted to determinate the coefficient of the thermal conductivity of the liquid ceramic thermal insulation Bronya (specifications 2216-006-09560516-2013) were received:

- The surface heat exchange coefficient 1,61 W/(m^2 ^oC);
- Coefficient of the heat-conduction of the thermal insulation Bronya® with such parameters of the heat transfer medium and environment is 0,0008 W/(m^2 ^oC).
-

Heat-conduction of the liquid ceramic thermal insulation of the series Bronya (specifications 2216-006-09560516-2013) declared by the manufacture equals 0,001±0,0002 W/m K. Experimental evidence totals to 0,0008 W/m K. Consequently, all the declared thermotechnical data are confirmed.

Test engineer
"Stroilaboratoria SL" testing laboratory signature Kiselyov M. M.

Representative
"NPO Bronya" Limited company signature Rigin O. B.

Annex 1

List of the testing and measuring equipment

Designation	Serial Number and date of check
Thermal hygrometer Elcometer 319	LH02620 of 18.12.2013
Cold/hot water meter, type VFK2	1009034 of 15.09.2012
Tape measure	w/n of 27.05.2013
Slide caliper ШЩ-1-200	№ 0758766 of 27.05.2013
Measuring ruler, 50 cm	w/n of 27.05.2013
Analytical balance	№ 018811 of 29.08.2013
Heating stove ES-H3040	№ GL100318 of 21.08.2013

Test engineer
"Stroilaboratoria SL" testing laboratory signature Kiselyov M. M.

Representative
"NPO Bronya" Limited company signature Rigin O. B.

Approved
Chief of the Testing Laboratory "Stroilaboratoria SL"
signature Kiselyov M. M.
December, 24 2013.

Seal: Limited Company
"STROILABORATORIA SL"
Number of state register 526 006
MOSCOW

Resolution № 2
December, 20, 2013

Determination of the coefficient of thermal conductivity
of the liquid ceramic thermal coating
Bronya Facade
in compliance with specifications 2216-006-09560516-2013.

Moscow 2013.

Detailed test procedure:

1. Liquid thermal insulation Bronya is applied to one of the test section of the pipeline. Application is made by a paint brush with 0,5 mm layers and 24 hours inter-coat drying. Total thickness of layers is 1,5 ± 0,1 mm.

2. All the system is scooped with water by a pump. Start of the heat conductor circulation.

3. Heating of the heat conductor with the aid of an electric heating boiler.

4. Measurement of the temperature on the surface of the delivery and return piping with thermal insulation.

5. Measurement of the water flow rate at the test section of pipeline with the aid of the water meter, installed at the delivery piping.

6. Reading the period of time of heat transfer on the test section.

7. After a certain period of time the readings of the meter are taken.

8. Measurement of the mean temperature on the surface of the delivery and return piping with thermal insulation.

9. Decoupling of the drive.

Further, the same test is conducted with non-insulated section of the pipeline.

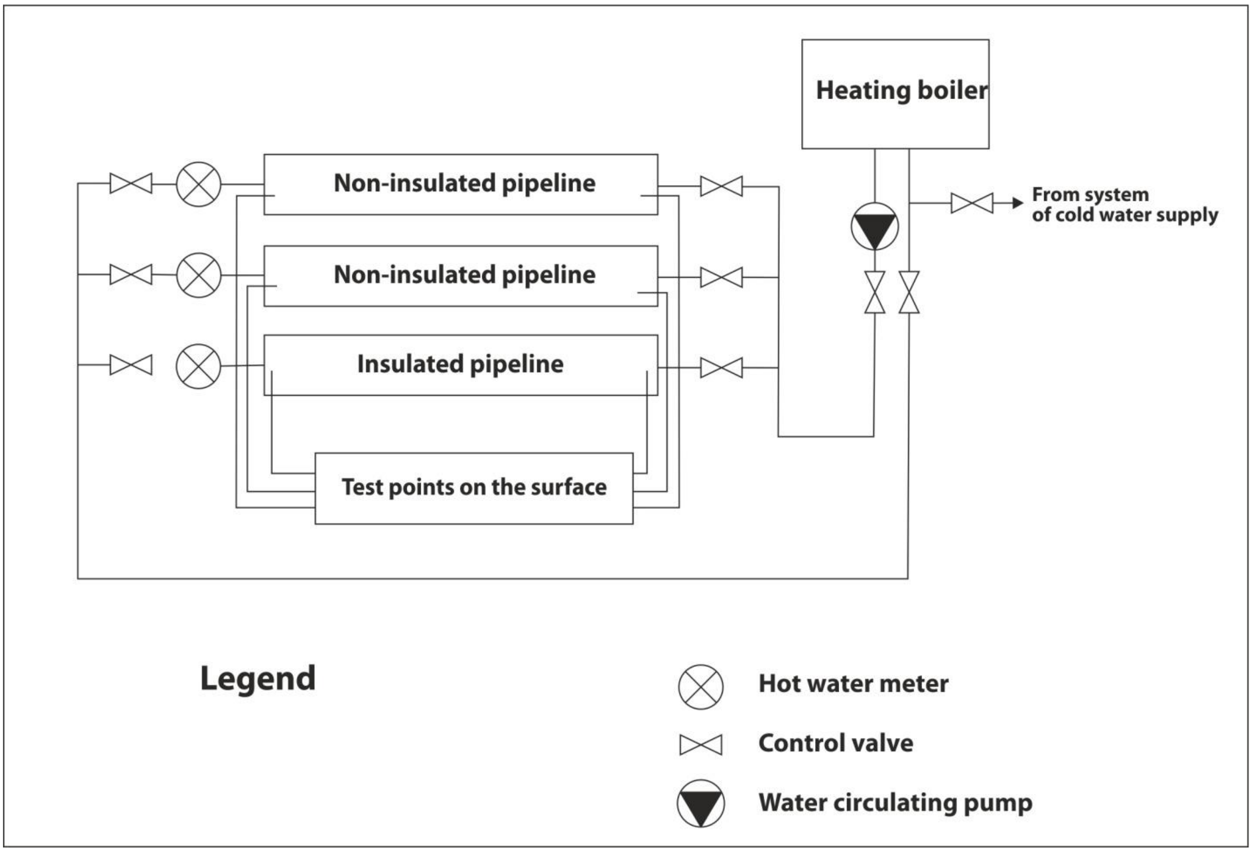

Fig. 1 – Basic scheme of the test facility

Calculation technique

The quantity of the heat given by the section of the pipeline:

$$Q = \frac{G_{вд} \cdot c_{вд} \cdot (t_г - t_{ох})}{3{,}6}, (1)$$

Where

Q – is the quantity of the heat given by the section of the pipeline, W;

$c_{вд}$ – water specific heat ($c_{вд}$ = 4,187 J/(kg ^{o}C));

$t_г$ - temperature on the surface of the delivery piping, ^{o}C (measured by the thermal hygrometer Elcometer 319);

t_{ox} - temperature on the surface of the return piping, ^{o}C (measured by the thermal hygrometer Elcometer 319);

$G_{вд}$ – flow rate on the test section of piping, kg/h.

q - heat flow density from 1 m^2 of the test section of piping is determined by the following formula :

$$q = \frac{Q}{l \cdot \pi \cdot d}, (2)$$

where l – the length of the test section of the piping, m;

d – pipe diameter, m.

The surface heat exchange coefficient is determined by the formula:

$$\alpha_н = \frac{q_{пов}}{\tau - t_{int}}, (3)$$

where $q_{пов}$ - heat flow from 1 m^2 of the test section of piping , W/m;

τ – temperature of the surface of the thermal insulation (measured by the thermal hygrometer Elcometer 319)), ^{o}C;

t_{int} – environmental temperature inside the laboratory, ^{o}C.

Determination of the heat-conduction coefficient

The heat-conduction coefficient is determined by the formula:

$$\lambda = \frac{\delta \cdot \alpha_н \cdot (\tau - t_{int})}{t_в - \tau}, (4)$$

where δ – thickness of the liquid insulation layer Bronya, m;

$t_в$ - temperature of the non-insulated pipeline (medium value), ^oC.

Tabel 1

Test reading of the piping sections

Indicators'names	Non-insulated section
Mean temperature of the air inside the laboratory during the tests t_{int}, ^oC	23,87
The surface temperature at the inlet of the test piping, ^oC	71,2
the surface temperature at the oulet of the test piping, ^oC	70,1
Temperature difference ($t_г$- t_{ox}), ^oC	1,1
Temperature on the surface of the thermal insulation	37,1
Flow rate on the test section $G_{вд}$, kg/h	21,9
Quantity of generated heat from the test section $Q_{пр}$, W	28,02
Actual value of the heat flow density from 1 $m^2$of the test section of piping, $q_{пр}$, W/$м^2$	20,64
Thickness of the insulation, mm	1,5

Thermal measurement treatment:

Insulated pipeline.

- Determination of the quantity of the heat given by the formula 1, W:

- Determination of heat flow density from 1 m^2 of the test section of piping by the formula 2:, W/m^2:

- Determination of the surface heat exchange coefficient by the formula 3, W/m^2 ^oC:

$$\alpha_н = \frac{20,64}{37,1 - 23,7} = 1,54\ Bm/(м2 \cdot {}^oC)$$

- Determination of the heat-conduction coefficient by the formula 4, W/m^2 ^oC:

Conclusion:

The following results of the tests conducted to determinate the coefficient of the thermal conductivity of the liquid ceramic thermal insulation Bronya (specifications 2216-006-09560516-2013) were received:

- The surface heat exchange coefficient 1,54W/(m^2 ^oC);
- Coefficient of the heat-conduction of the thermal insulation Bronya® with such parameters of the heat transfer medium and environment is 0,0009 W/(m^2 ^oC).
-

Heat-conduction of the liquid ceramic thermal insulation of the series Bronya (specifications 2216-006-09560516-2013) declared by the manufacture equals 0,001±0,0002 W/m K. Experimental evidence totals to 0,0009 W/m K. Consequently, all the declared thermotechnical data are confirmed.

Test engineer
"Stroilaboratoria SL" testing laboratory signature Kiselyov M. M.

Representative
"NPO Bronya" Limited company signature Rigin O. B.

Annex 1

List of the testing and measuring equipment

Designation	Serial Number and date of check
Thermal hygrometer Elcometer 319	LH02620 of 18.12.2013
Cold/hot water meter, type VFK2	1009034 of 15.09.2012
Tape measure	w/n of 27.05.2013
Slide caliper ШЩ-1-200	№ 0758766 of 27.05.2013
Measuring ruler, 50 cm	w/n of 27.05.2013
Analytical balance	№ 018811 of 29.08.2013
Heating stove ES-H3040	№ GL100318 of 21.08.2013

Test engineer
"Stroilaboratoria SL" testing laboratory signature Kiselyov M. M.

Representative
"NPO Bronya" Limited company signature Rigin O. B.

Approved
Chief of the Testing Laboratory "Stroilaboratoria SL"
signature Kiselyov M. M.
December, 25 2013.

Seal: Limited Company
"STROILABORATORIA SL"
Number of state register 526 006
MOSCOW

Resolution № 3
December, 19, 2013

Determination of the coefficient of thermal conductivity
of the liquid ceramic thermal coating
Bronya Anticor
in compliance with specifications 2216-006-09560516-2013.

Moscow 2013.

Detailed test procedure:

1. Liquid thermal insulation Bronya is applied to one of the test section of the pipeline. Application is made by a paint brush with 0,5 mm layers and 24 hours inter-coat drying. Total thickness of layers is 1,5 $\pm$ 0,1 mm.

2. All the system is scooped with water by a pump. Start of the heat conductor circulation.

3. Heating of the heat conductor with the aid of an electric heating boiler.

4. Measurement of the temperature on the surface of the delivery and return piping with thermal insulation.

5. Measurement of the water flow rate at the test section of pipeline with the aid of the water meter, installed at the delivery piping.

6. Reading the period of time of heat transfer on the test section.

7. After a certain period of time the readings of the meter are taken.

8. Measurement of the mean temperature on the surface of the delivery and return piping with thermal insulation.

9. Decoupling of the drive.

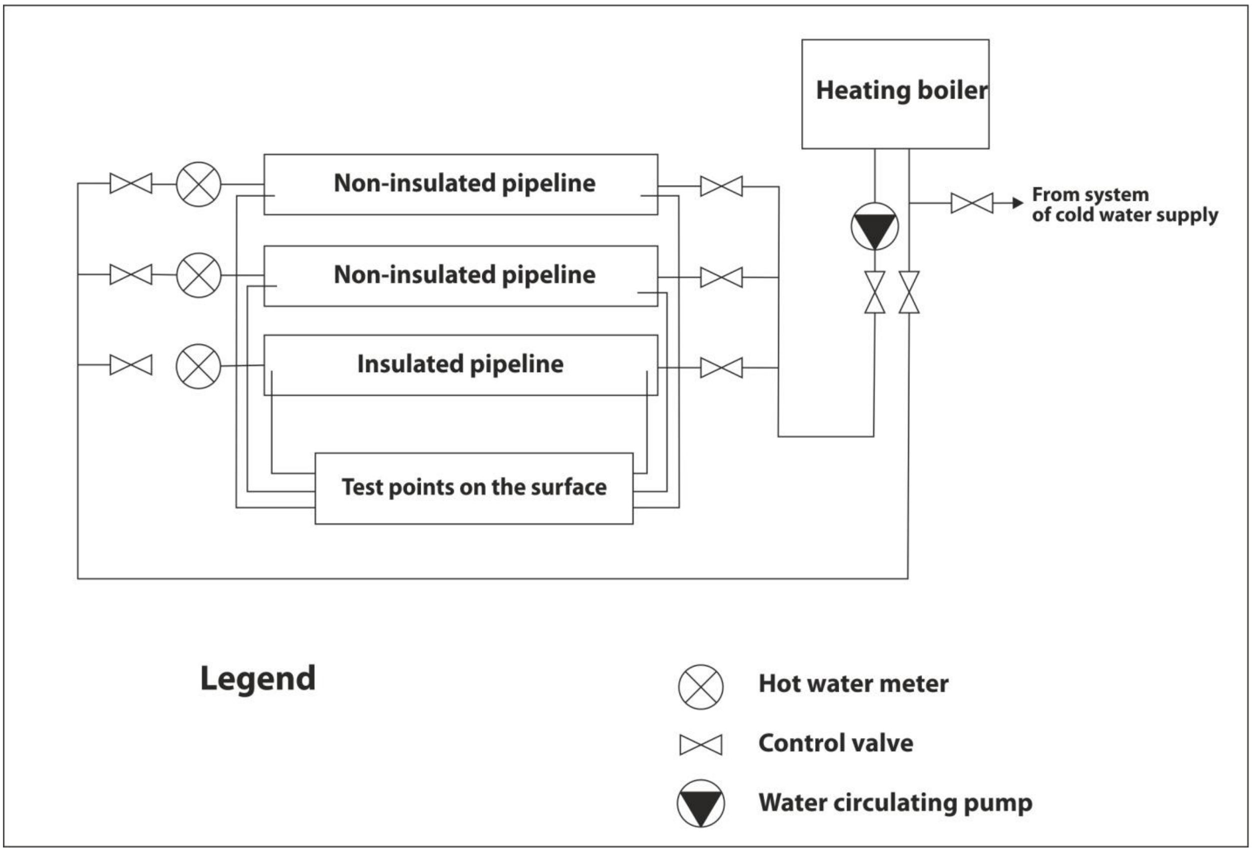

Fig. 1 – Basic scheme of the test facility

Calculation technique

The quantity of the heat given by the section of the pipeline:

$$Q = \frac{G_{вд} \cdot c_{вд} \cdot (t_г - t_{ох})}{3,6}, (1)$$

Where

Q – is the quantity of the heat given by the section of the pipeline, W;

$c_{вд}$ – water specific heat ($c_{вд}$ = 4,187 J/(kg °C));

$t_г$ - temperature on the surface of the delivery piping, °C (measured by the thermal hygrometer Elcometer 319);

t_{ox} - temperature on the surface of the return piping, °C (measured by the thermal hygrometer Elcometer 319);

$G_{вд}$ – flow rate on the test section of piping, kg/h.

q - heat flow density from 1 m^2 of the test section of piping is determined by the following formula :

$$q = \frac{Q}{l \cdot \pi \cdot d}, (2)$$

where l – the length of the test section of the piping, m;

d – pipe diameter, m.

The surface heat exchange coefficient is determined by the formula:

$$\alpha_н = \frac{q_{пов}}{\tau - t_{\text{int}}}, (3)$$

where $q_{пов}$ - heat flow from 1 m^2 of the test section of piping , W/m;

τ – temperature of the surface of the thermal insulation (measured by the thermal hygrometer Elcometer 319)), °C;

t_{int} – environmental temperature inside the laboratory, °C.

Determination of the heat-conduction coefficient

The heat-conduction coefficient is determined by the formula:

$$\lambda = \frac{\delta \cdot \alpha_н \cdot (\tau - t_{\text{int}})}{t_в - \tau}, (4)$$

where δ – thickness of the liquid insulation layer Bronya, m;

$t_в$ - temperature of the non-insulated pipeline (medium value), °C.

Tabel 1

Test reading of the piping sections

Indicators'names	Non-insulated section
Mean temperature of the air inside the laboratory during the tests t_{int}, °C	20,3
The surface temperature at the inlet of the test piping, °C	68,3
the surface temperature at the oulet of the test piping, °C	67
Temperature difference ($t_г$- $t_{ох}$), °C	1,3
Temperature on the surface of the thermal insulation	38,6
Flow rate on the test section $G_{вд}$, kg/h	21,9
Quantity of generated heat from the test section $Q_{пр}$, W	33,11
Actual value of the heat flow density from 1 m^{2}of the test section of piping, $q_{пр}$, W/м^2	24,4
Thickness of the insulation, mm	1,4

Thermal measurement treatment:

Insulated pipeline.

- Determination of the quantity of the heat given by the formula 1, W:

- Determination of heat flow density from 1 m^2 of the test section of piping by the formula 2:, W/m^2:

- Determination of the surface heat exchange coefficient by the formula 3, W/m^2 °C:

$$\alpha_и = \frac{18,7}{35,4 - 23,8} = 1,61$$

- Determination of the heat-conduction coefficient by the formula 4, W/m^2 °C:

Conclusion:

The following results of the tests conducted to determinate the coefficient of the thermal conductivity of the liquid ceramic thermal insulation Bronya (specifications 2216-006-09560516-2013) were received:

- The surface heat exchange coefficient 1,33 W/(m^2 ^oC);
- Coefficient of the heat-conduction of the thermal insulation Bronya® with such parameters of the heat transfer medium and environment is 0,0012 W/(m^2 ^oC).
-

Heat-conduction of the liquid ceramic thermal insulation of the series Bronya (specifications 2216-006-09560516-2013) declared by the manufacture equals 0,001±0,0002 W/m K. Experimental evidence totals to 0,0012 W/m K. Consequently, all the declared thermotechnical data are confirmed.

Test engineer
"Stroilaboratoria SL" testing laboratory signature Kiselyov M. M.

Representative
"NPO Bronya" Limited company signature Rigin O. B.

Annex 1

List of the testing and measuring equipment

Designation	Serial Number and date of check
Thermal hygrometer Elcometer 319	LH02620 of 18.12.2013
Cold/hot water meter, type VFK2	1009034 of 15.09.2012
Tape measure	w/n of 27.05.2013
Slide caliper ШЩ-1-200	№ 0758766 of 27.05.2013
Measuring ruler, 50 cm	w/n of 27.05.2013
Analytical balance	№ 018811 of 29.08.2013
Heating stove ES-H3040	№ GL100318 of 21.08.2013

Test engineer
"Stroilaboratoria SL" testing laboratory signature Kiselyov M. M.

Representative
"NPO Bronya" Limited company signature Rigin O. B.

Approved
Chief of the Testing Laboratory "Stroilaboratoria SL"
signature Kiselyov M. M.
December, 26 2013.

Seal: Limited Company
"STROILABORATORIA SL"
Number of state register 526 006
MOSCOW

Resolution № 4
December, 20, 2013

Determination of the coefficient of thermal conductivity
of the liquid ceramic thermal coating
Bronya Winter
in compliance with specifications 2216-006-09560516-2013.

Moscow 2013.

Detailed test procedure:

1. Liquid thermal insulation Bronya is applied to one of the test section of the pipeline. Application is made by a paint brush with 0,5 mm layers and 24 hours inter-coat drying. Total thickness of layers is 1,5 $\pm$ 0,1 mm.

2. All the system is scooped with water by a pump. Start of the heat conductor circulation.

3. Heating of the heat conductor with the aid of an electric heating boiler.

4. Measurement of the temperature on the surface of the delivery and return piping with thermal insulation.

5. Measurement of the water flow rate at the test section of pipeline with the aid of the water meter, installed at the delivery piping.

6. Reading the period of time of heat transfer on the test section.

7. After a certain period of time the readings of the meter are taken.

8. Measurement of the mean temperature on the surface of the delivery and return piping with thermal insulation.

9. Decoupling of the drive.

Further, the same test is conducted with non-insulated section of the pipeline.

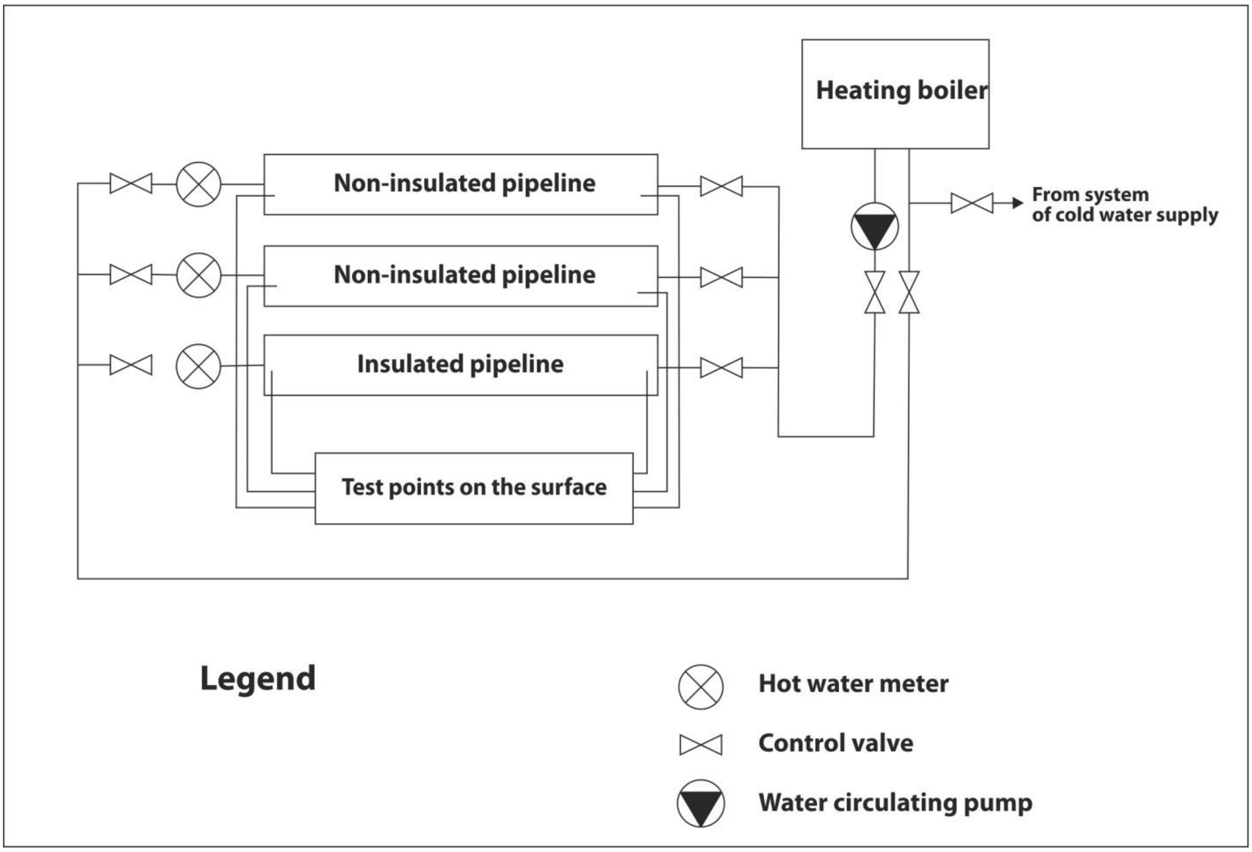

Fig. 1 – Basic scheme of the test facility

Calculation technique

The quantity of the heat given by the section of the pipeline:

$$Q = \frac{G_{вд} \cdot c_{вд} \cdot (t_г - t_{ox})}{3,6}, (1)$$

Where

Q – is the quantity of the heat given by the section of the pipeline, W;
$c_{вд}$ – water specific heat ($c_{вд}$ = 4,187 J/(kg ^oC));
$t_г$ - temperature on the surface of the delivery piping, ^oC (measured by the thermal hygrometer Elcometer 319);
t_{ox} - temperature on the surface of the return piping, ^oC (measured by the thermal hygrometer Elcometer 319);
$G_{вд}$ – flow rate on the test section of piping, kg/h.

q - heat flow density from 1 m^2 of the test section of piping is determined by the following formula :

$$q = \frac{Q}{l \cdot \pi \cdot d}, (2)$$

where l – the length of the test section of the piping, m;
d – pipe diameter, m.

The surface heat exchange coefficient is determined by the formula:

$$\alpha_н = \frac{q_{пов}}{\tau - t_{int}}, (3)$$

where $q_{пов}$ - heat flow from 1 m^2 of the test section of piping , W/m;
τ – temperature of the surface of the thermal insulation (measured by the thermal hygrometer Elcometer 319)), ^oC;
t_{int} – environmental temperature inside the laboratory, ^oC.

Determination of the heat-conduction coefficient

The heat-conduction coefficient is determined by the formula:

$$\lambda = \frac{\delta \cdot \alpha_н \cdot (\tau - t_{int})}{t_в - \tau}, (4)$$

where δ – thickness of the liquid insulation layer Bronya, m;

$t_в$ - temperature of the non-insulated pipeline (medium value), °C.

Tabel 1

Test reading of the piping sections

Indicators'names	Non-insulated section
Mean temperature of the air inside the laboratory during the tests t_{int}, °C	23,4
The surface temperature at the inlet of the test piping, °C	68,4
the surface temperature at the oulet of the test piping, °C	67,1
Temperature difference ($t_г$- t_{ox}), °C	1,3
Temperature on the surface of the thermal insulation	35,4
Flow rate on the test section $G_{вд}$, kg/h	21,9
Quantity of generated heat from the test section $Q_{пр}$, W	33,11
Actual value of the heat flow density from 1 m^{2}of the test section of piping, $q_{пр}$, W/м^2	24,4
Thickness of the insulation, mm	1,6

Thermal measurement treatment:

<u>Insulated pipeline</u>.

- Determination of the quantity of the heat given by the formula 1, W:

- Determination of heat flow density from 1 m^2 of the test section of piping by the formula 2:, W/m^2:

- Determination of the surface heat exchange coefficient by the formula 3, W/m^2 °C:

- Determination of the heat-conduction coefficient by the formula 4, W/m^2 °C:

Conclusion:

The following results of the tests conducted to determinate the coefficient of the thermal conductivity of the liquid ceramic thermal insulation Bronya (specifications 2216-006-09560516-2013) were received:

- The surface heat exchange coefficient 2,03 W/(m^2 °C);
- Coefficient of the heat-conduction of the thermal insulation Bronya® with such parameters of the heat transfer medium and environment is 0,0011 W/(m^2 °C).

•

Heat-conduction of the liquid ceramic thermal insulation of the series Bronya (specifications 2216-006-09560516-2013) declared by the manufacture equals 0,001±0,0002 W/m K. Experimental evidence totals to 0,0011 W/m K. Consequently, all the declared thermotechnical data are confirmed.

Test engineer
"Stroilaboratoria SL" testing laboratory signature Kiselyov M. M.

Representative
"NPO Bronya" Limited company signature Rigin O. B.

Annex 1

List of the testing and measuring equipment

Designation	**Serial Number and date of check**
Thermal hygrometer Elcometer 319	LH02620 of 18.12.2013
Cold/hot water meter, type VFK2	1009034 of 15.09.2012
Tape measure	w/n of 27.05.2013
Slide caliper ШЩ-1-200	№ 0758766 of 27.05.2013
Measuring ruler, 50 cm	w/n of 27.05.2013
Analytical balance	№ 018811 of 29.08.2013
Heating stove ES-H3040	№ GL100318 of 21.08.2013

Test engineer
"Stroilaboratoria SL" testing laboratory signature Kiselyov M. M.

Representative
"NPO Bronya" Limited company signature Rigin O. B.