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Technical report
Determination of actual heat insulation properties of Bronya Classic liquid ceramic heat insulation upon the results of tests conducted at JSC “Gazpromneft-MNPZ”

The Test program (see Appendix 4) was developed for pilot testing of Bronya Classic liquid ceramic heat insulation according to item 2 of the Protocol of October 25, 2013 (see Appendix 3) of working session on the system of temperature testing of the materials supplied by LLC “GC “NST”.
Sections of heat exchangers pack of “Teplotsentr” plant were chosen for pilot application of Bronya Classic liquid ceramic heat insulation according to item 1 of the Protocol and item 3.1 of the Program.
Test goals according to item 1 of the Program were as follows:

1. Determination of actual heat insulation and operational properties of liquid ceramic heat insulation delivered by LLC “GC “NST” and comparison of the results with the declared specification.
2. Determination of possibility to use the liquid ceramic heat insulation delivered by LLC “GC “NST” to JSC “Gazpromneft” Oil processing factory:

According to item 3.2 representatives of JSC “Gazpromneft-MNPZ”:

- provided representatives of LLC “GC “NST” with the access to the object;
- provided safety of elevated jobs;
- arranged a place for storage of inventory and liquid ceramic heat insulation on the territory of JSC “Gazpromneft-MNPZ”;
- provided the involved personnel with the protective means to protect the places to be treated against atmospheric condensations during the works.

Surface of the objects was prepared by the representatives of LLC “GC “NST” for application of liquid ceramic heat insulation according to item 4.1.

The works on application were done according to the schedule stated in item 7 of the Program.

On November 11, 2013 control surface temperature measurements using three methods according to items 5.1 and 5.2 were made:

1. Flir i5 thermal imaging camera;
2. Flir i5 thermal imaging camera with preliminary surface coating with liquid ceramic heat insulation using paper-based masking tape;
3. Elcometer 319 dew point meter.

Several measurement variants were used due to radio transparency of the liquid ceramic heat insulation (according to the information from LLC “GC “NST” (item 5.2 of the Program)).
The results of control measurements of surface temperature were fixed in Acceptance certificate (Appendix 5).

Upon the test results, heat conductivity ratio was calculated and its comparison with the value of 0,001 W/m* ^{0}C as specified by the manufacturer was made in order to confirm the declared properties if Bronya Classic liquid ceramic heat insulation.
The results of heat conductivity ratio calculation according with three variants of temperature measurement were fixed in Table 1.
The following data were obtained during tests on application of Bronya Classic liquid ceramic heat insulation on the elements of heat exchanger No.7 of the unit belonging to JSC “Gazpromneft-MNPZ” (Appendix 4):
Coating was homogenous in the measurement points;
No pealing as of the inspection date detected;
The material was not damaged at the exposure of temperatures of up to 165 ^{0}C.
Average coefficient of heat conductivity of Bronya Classic liquid ceramic heat insulation obtained in the course of the experiment was as follows:
λ= 0.0040 W/m* ^{0}C (Flir i5 thermal imaging camera + tape);
λ= 0.0054 W/m* ^{0}C (Flir i5 thermal imaging camera).
The above results were connected with radio transparency of liquid ceramic heat insulation and could not be used for the analysis. This fact was described in Appendix 1 in more details.
λ= 0,0013 W/m* ^{0}C (Elcometer 319).
Conclusions

1. Average heat conductivity of Bronya Classic liquid ceramic heat insulation calculated on the basis of data obtained in the result of tests with application of Elcometer 319 indications was 0,0013 W/m* ^{0}C. Deviation from the declared value of 0,001 W/m* ^{0}C was 30% that is allowable taking into consideration the test method inaccuracy. With reference to the above the declared thermal and technical properties of the material were confirmed.

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General director of LLC “GC “NST” (*Signature*) I.E.Zhuravleva

Appendix 1

Substantiation of measuring results

Surface temperature measuring was made using 3 methods:

1. Flir i5 pyrometer;
2. Elcometer 319;
3. Tactile test.

When making measuring with Flir i5 pyrometer, a discrepancy with indications of Elcometer 319 contact thermometer from 9 to 50% was found out. That fact could be explained as follows: liquid heat insulation really has specific properties, for example, when it is applied to a surface with the temperature exceeding 100°C, in case of the coating thickness is about one millimeter, the surface temperature measuring of “liquid heat insulation” by means of an optical pyrometer or thermal imaging camera indicates that the surface temperature decreases a little, remains unchanged or exceeds 100 degrees; at the same time water (for example, in the form of drops) being on the surface does not boil; simultaneously unexpectedly slow melting of ice pieces being on the surface of the “liquid heat insulation” is observed.

The above features specific for photon crystals in case of microspheres with the dimensions of 20-50 μm like microspheres contained in “liquid ceramic heat insulation” confirm that liquid ceramic heat insulation is radio transparent. When using pyrometer of thermal imaging cameras having operational wave length from 7 to 14 μm, which includes the energetic maximum of ceramic microsphere irradiation, the wave interference is observed; due to that fact, the device indicates the temperature which is 1,5 – 2-fold higher than the actual one.

The above is confirmed as follows:

1. Covering of liquid ceramic heat insulation with paper-based masking tape with the heat conductivity coefficient of 0.14 W/m*^{0}C. Taking into consideration the value of the heat conductivity coefficient and minor material thickness (125 μm), it should not significantly influence the surface temperature of liquid ceramic heat insulation; however we can see the discrepancy from 5 to 20 %.

Let’s calculate the thickness of the painter’s tape required for such significant influence to the surface temperature in order to confirm the above data.
The values of measuring made on November 8, 2013 in point 12 will be taken as initial data.
According to Flir i5 indications, the surface temperature of liquid ceramic heat insulation is 92°C, surface temperature of liquid ceramic heat insulation + paper-based masking tape is 82°C. We know the paper heat conductivity and emission coefficient and can calculate the thickness required for temperature decrease in 10°C as follows:

δ = λ*(t lchi – t tape)α o * (t tape – t a) = 0.14 * (92-82)5*(82-20) = 4.516*10 – 3 m

where:
δ = thickness of the paper-based masking tape;
α o = coefficient of heat emission from the outer surface of the paper-based masking tape;
t tape = surface temperature of the paper-based masking tape
t a = ambient air temperature at the moment of measurement, °C;
t пов = surface temperature of liquid ceramic heat insulation, °C.

Taking into consideration the results of the above calculation, thickness of the paper-based masking tape required for a 10°C decrease in the surface temperature must be not less than 4.5

mm. As the average thickness of the paper-based masking tape is 125 μm, we can conclude that Flir i5 pyrometer indications can not be correct and used for the proof of liquid ceramic heat insulation effectiveness.

2. The results of the tactile test for determination of the surface temperature and indications of Elcometer 319 contact device disprove Flir i5 pyrometer indications once more.

Elcometer 319 indications, °C	Tactile sensations (without any discomfort), min
Up to 45 °C	Infinite time
Up to 50 °C	More than 5 minutes
Up to 55 °C	2 minutes maximum
Up to 60 °C	1 minute maximum

Elcometer 319 indications are proved with the tactile test results that confirm the correctness of the obtained data.