About standards for hot water heating

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Abstract. This article examines the existing legislative features of hot water supply, sanitary-epidemiological and hygienic requirements, as well as temperature standards for the quality of hot water. Practice shows that the standard for heating cold water, in contrast to the standard for heating, is universally underestimated. A feature of domestic hot water supply systems that significantly affects the efficiency of their operation is the high value of the circulation flow in the heat balance. At constant circulation and hot water temperature in the range from 60°C to 70°C, the value of the actual specific heat consumption for TPP can be more than 0.1 Gcal/m³. In sparsely populated homes, neighborhoods, and where some of the residents have switched to independent gas or electric water heating, this value is even higher. In order to determine the actual coefficients for heating cold water to provide utilities for hot water and comparison with the approved standard for heating, affect the distribution of losses in heat supply and hot water, conducted a study of the modes of operation of intrahouse systems of a number of apartment houses in the heating system of the city of Ulyanovsk. Based on the results of technical measures, the values of the actual coefficients for cold water heating were determined, ways to reduce excess heat consumption for cold water heating were proposed, and the technical feasibility of their implementation was determined.

Currently, the consumption in hot water supply systems is calculated using standard values of the thermal energy expenditure used for heating the cold water [1]. When applying this calculation method it is meant that the utility charge for the hot water supply will be determined individually for each consumer depending on the consumption mode of the hot water. However, since these standard values have been introduced, experts cannot stop arguing about the correctness of using this very payment determination method of the utility charge for the hot water supply (HWS).

The standard value is the value calculated with the wide range of assumptions discounting real consumption modes in HWS systems [2]. So, hot and cold water temperatures are embarked as constant ones. The circulatory consumption in HWS system is considered using the added coefficient which maximum value, as the studies show, does not consider the actual loss value [3, 4]. As a result, introduced assumptions have the significant influence on the exhaustiveness and the accuracy of actual thermal energy expenditure metering in HWS systems.

Table 1 shows the comparative analysis of the standard value of the thermal energy expenditure for heating the cold water in various regions of Russia. As can be seen in Table 1, calculated values slightly but differ in various regions.
Table 1. The approved standard value of the thermal energy expenditure for heating the cold water in various regions of Russia

| Type of hot water supply systems, design features of apartment buildings | Standard value of the thermal energy expenditure for heating the cold water for the provision of public services for hot water supply, Gcal/m³ |
|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
|                                                                        | with external pipeline hot water supply | without external pipeline hot water supply |
| Ulyanovsk oblast                                                       |                                                |                                            |
| With insulated risers and equipped towel driers                        | 0.062                                           | 0.060                                      |
| With insulated risers and without equipped towel driers                | 0.057                                           | 0.055                                      |
| With non-insulated risers and equipped towel driers                    | 0.067                                           | 0.065                                      |
| With non-insulated risers and without equipped towel driers            | 0.062                                           | 0.060                                      |
| Tver oblast                                                            |                                                |                                            |
| With insulated risers and equipped towel driers                        | 0.06271                                          | 0.06020                                    |
| With insulated risers and without equipped towel driers                | 0.05769                                          | 0.05518                                    |
| With non-insulated risers and equipped towel driers                    | 0.06773                                          | 0.06522                                    |
| With non-insulated risers and without equipped towel driers            | 0.06271                                          | 0.06020                                    |
| Krasnoyarsk region                                                     |                                                |                                            |
| With insulated risers and equipped towel driers                        | 0.0635                                           | 0.0610                                     |
| With insulated risers and without equipped towel driers                | 0.0584                                           | 0.0559                                     |
| With non-insulated risers and equipped towel driers                    | 0.0686                                           | 0.0661                                     |
| With non-insulated risers and without equipped towel driers            | 0.0635                                           | 0.0610                                     |

As evidenced by the study and the analysis of working modes of hot water supply systems, the standard value of the thermal energy expenditure for heating is under-recorded everywhere. When maintaining the circulation and the temperature of the hot water within the range from 60°C to 70°C, the actual specific heat consumption for HWS can exceed the value of 0.1 Gcal/m³. This value is even higher in sparsely inhabited buildings, quarters and also where a part of tenants switched to individual gas or electric heating of water.

To review the balance between the actual thermal energy expenditure for heating the cold water to provide the utility of the hot water supply and the approved standard value (the standard value for heating) having the influence on the loss distribution in the general heat and hot water supply system, the range of domestic hot water supply systems was studied in Ulyanovsk city. Working modes of HWS systems with the limited circulatory consumption by installed orifice gages with uniform cross-section are compared with working modes of HWS systems by maintaining set values of the water temperature in circulatory lines via installing thermostatic valves.

Arrangements were made during the period from 20.07.2018 to 17.10.2018 in dwelling buildings joined with two central heat supply stations (CHSS) of Ulyanovsk municipal unitary enterprise (UMUE) «City heat service» with the following characteristics:

- CHSS «Locomotive depot»: the double-tube heat supply system, 3 dwelling buildings are joined, HWS systems are circulatory, water risers are with towel driers, the connected load of HWS is 0.82 Gcal/hour;
- CHSS «Ulyanovsk factory of heavy machines (UZTS) 1a»: the four- and double-tube heat supply system, 11 dwelling buildings are joined, HWS systems are circulatory in 8 buildings,
Water risers are with towel driers, HWS systems without circulation are in 3 buildings, the connected load of HWS is 5.68 Gcal/hour.

Information was collected, studied and the work of consumers, joined with CHSS, was analyzed during the period from 20.07.2018 to 07.08.2018. The current condition of HWS systems was recorded, measures related to the working mode optimization were made, the availability of orifice gages in circulatory lines of HWS and their correspondence with the calculation were checked.

Mean values of working parameters of the HWS system from considered CHSS before making technical measures are shown in Table 2. As can be seen in Table 2, the actual consumption in HWS systems can exceed calculated values more than twofold.

Table 2. The mean values of working parameters of HWS system from considered CHSS before making technical measures

| Address | Standard value of the thermal energy expenditure for heating, Gcal/m³ | Actual thermal energy for heating, Gcal/m³ | Water temperature in the supply pipeline HWS T₃, °C | Water temperature in the circulation pipeline HWS T₄, °C | Water consumption in the supply pipeline HWS, M₃, t/h | Water consumption in the circulation pipeline HWS, M₄, t/h |
|---------|-------------------------------------------------|------------------------------------------|----------------------------------------|-------------------------------------------------|------------------------------------------|------------------------------------------|
| Kirova st., 50 | 0.067 | 0.075 | 61.97 | 58.37 | 3.82 | 3.46 |
| Kirova st., 52 | 0.067 | 0.068 | 61.08 | 57.07 | 3.87 | 3.4 |
| Zheleznodorozhnaya st., 45 | 0.067 | 0.125 | 61.23 | 52.92 | 2.15 | 1.95 |
| CHSS «Locomotive depot» | | | | | | |
| Efremova st., 37 | 0.067 | 0.128 | 66.33 | 51.38 | 2.78 | 2.23 |
| Efremova st., 46 | 0.067 | 0.099 | 64.01 | 52.24 | 1.85 | 1.37 |
| Stankostroitele y st., 6 | 0.067 | 0.121 | 65.4 | 54.96 | 5.88 | 4.91 |
| Stankostroitele y st., 8 | 0.067 | 0.148 | 63.84 | 54.16 | 3.45 | 3.09 |
| Stankostroitele y st., 10 | 0.067 | 0.122 | 65.58 | 52.26 | 2.28 | 1.84 |
| Stankostroitele y st., 12 | 0.067 | 0.151 | 65.24 | 53.37 | 3.12 | 2.74 |
| Stankostroitele y st., 14 | 0.067 | 0.147 | 67.61 | 55.02 | 2.9 | 2.5 |
| Stankostroitele y st., 22 | 0.067 | 0.112 | 62.37 | 51.87 | 1.69 | 1.4 |
| Stankostroitele y st., 16 | 0.062 | 0.071 | 67.56 | 59.7 | 1.16 | 0.38 |
| Stankostroitele y st., 18 | 0.062 | 0.077 | 66.56 | 45.55 | 1.13 | 0.36 |
| Stankostroitele y st., 20 | 0.062 | 0.072 | 66.92 | 57.72 | 2.6 | 1.35 |

To balance the actual specific heat consumption with the reference value, during the period from 12.09.2018 to 18.09.2018 the diameter of orifice gages installed in HWS circulatory lines of thermal energy consumers from CHSS «Locomotive depot» was reduced. When working modes were corrected and the circulatory expenditure was reduced, the mean expenditure actual value of the
thermal energy for heating was 0.058 Gcal/m³. However, the defect in the quality of the HWS was recorded. The temperature of the heat-transfer medium at entry points into buildings was less than 55°C. It is obvious that the limitation of the circulatory expenditure using orifice gages does not allow providing the consumption in HWS systems in accordance with standard values.

To increase the turndown, thermostatic valves with improved resistance were installed in HWS circulatory lines instead of orifice gages. After thermostatic valves were installed in all buildings, actual expenditures of the hot water were reduced. We did not succeed in reducing the specific heat consumption in HWS systems of buildings 50 and 52 located in Kirova street. We succeeded in reducing the actual value of the coefficient for heating but we did not succeed in balancing it with standard values without any losses in the quality of the HWS because of engineering features of the building 45 located in Zheleznodorozhnaya street (with respect to the project the increased area for towel driers was provided).

Mean values of HWS system parameters during the period from 08.10.2018 to 10.10.2018 after installing thermostatic valves are listed in Table 3. When thermostatic valves were installed, actual expenditures of the hot water and actual values of the specific heat consumption for heating were reduced in all buildings of CHSS «UZTS 1a». We succeeded in balancing the actual heat consumption with standard values only in the building 16 located in Stankostroiteley street. Mean values of HWS system parameters during the period from 04.10.2018 to 17.10.2018 after installing thermostatic valves are listed in Table 3.

| Address                        | Standard value of the thermal energy expenditure for heating, Gcal/m³ | Actual thermal energy for heating, Gcal/m³ | Water temperature in the supply pipeline HWS T₃, °C | Water temperature in the circulation pipeline HWS T₄, °C | Water consumption in the supply pipeline HWS, M₃, t/h | Water consumption in the circulation pipeline HWS, M₄, t/h |
|--------------------------------|------------------------------------------------------------------|------------------------------------------|---------------------------------------------|------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| CHSS «Locomotive depot»        |                                                                  |                                          |                                             |                                                    |                                                  |                                                  |
| Kirova st., 50                 | 0.067                                                           | 0.076                                    | 60.83                                       | 57.33                                           | 2.66                                            | 2.35                                            |
| Kirova st., 52                 | 0.067                                                           | 0.074                                    | 60.7                                        | 52.37                                           | 1.88                                            | 1.4                                             |
| Zheleznodorozhnaya st., 45     | 0.067                                                           | 0.108                                    | 61.05                                       | 52.07                                           | 2.06                                            | 1.8                                             |
| CHSS «UZTS 1a»                |                                                                  |                                          |                                             |                                                    |                                                  |                                                  |
| Efremova st., 37               | 0.067                                                           | 0.105                                    | 63.52                                       | 50.33                                           | 3.65                                            | 2.93                                            |
| Efremova st., 46               | 0.067                                                           | 0.077                                    | 62.29                                       | 52.44                                           | 2.27                                            | 1.65                                            |
| Stankostroiteley st., 6        | 0.067                                                           | 0.087                                    | 62.65                                       | 49.58                                           | 4.98                                            | 3.65                                            |
| Stankostroiteley st., 8        | 0.067                                                           | 0.105                                    | 60.45                                       | 51.78                                           | 3.84                                            | 3.33                                            |
| Stankostroiteley st., 10       | 0.067                                                           | 0.094                                    | 62.08                                       | 52.55                                           | 3.52                                            | 2.9                                             |
| Stankostroiteley st., 12       | 0.067                                                           | 0.108                                    | 61.68                                       | 50.53                                           | 3.4                                             | 2.85                                            |
| Stankostroiteley st., 14       | 0.067                                                           | 0.119                                    | 63.7                                        | 51.51                                           | 3.28                                            | 2.77                                            |
| Stankostroiteley st., 22       | 0.067                                                           | 0.101                                    | 61.2                                        | 52.59                                           | 2.69                                            | 2.31                                            |
| Stankostroiteley st., 16       | 0.062                                                           | 0.056                                    | 65.46                                       | 61.98                                           | 2.27                                            | 1.23                                            |
| Stankostroiteley st., 18       | 0.062                                                           | 0.065                                    | 65.05                                       | 57.11                                           | 2.59                                            | 1.61                                            |
| Stankostroiteley st., 20       | 0.062                                                           | 0.067                                    | 65.22                                       | 59.46                                           | 4.52                                            | 3.18                                            |
The dynamic pattern of values of the specific heat consumption before and after making technical measures in dwelling buildings joined with CHSS can be seen in Figure 1, 2.

**Figure 1.** The dynamic pattern of values of the specific heat consumption in HWS systems from CHSS «Locomotive depot»: 1 – Zheleznodorozhnaya street, 45; 2 – Kirova street, 52; 3 – Kirova street, 50; 4 – standard value of the thermal energy expenditure for heating 0.067 Gcal/m³.
Figure 2. The dynamic pattern of values of the specific heat consumption in HWS systems from CHSS «UZTS 1a»: 1 – Stankostroiteley street, 14; 2 – Efremova street, 37; 3 – Stankostroiteley street, 12; 4 – Stankostroiteley street, 8; 5 – Stankostroiteley street, 22; 6 – Stankostroiteley street, 10; 7 – Stankostroiteley street, 6; 8 – Efremova street, 46; 9 – standard value of the thermal energy expenditure for heating 0.067 Gcal/m³; 10 – Stankostroiteley street, 20; 11 – standard value of the thermal energy expenditure for heating 0.062 Gcal/m³; 12 – Stankostroiteley street, 18; 13 – Stankostroiteley street, 16.

Based on the results of made technical measures in dwelling buildings, the following results were obtained:

1. Before making the abovementioned technical measures the actual consumption in hot water supply systems significantly outweighed (more than twofold) the approved expenditure standard value of the thermal energy used for heating of the cold water for the HWS utility.

2. There is no technical capability to balance the actual consumption in HWS systems with the approved standard value of 0.067 Gcal/m³ without any losses in quality of the hot water supply of the end consumer. The minimum achieved specific value of the thermal energy expenditure in dwelling buildings with towel driers was 0.074 Gcal/m³. The further reduction of the coefficient for heating leads to the loss in quality of the supplied heat-transfer medium. The reason of this nonconformity are engineering features of HWS systems when the thermal energy from the internal HWS system is used for heating bathrooms notwithstanding the time of day and the temperature of the air outside.

3. The hot water consumption mode yields major influence on the specific thermal energy expenditure. During hours of the maximum water draw-off in circulatory systems, the specific thermal energy expenditure value is reduced up to 0.054 Gcal/m³. During hours of the minimum water draw-off (the night time) in circulatory systems, the specific thermal energy expenditure value is increased up to 0.14-0.20 Gcal/m³. In HWS systems without circulation, the influence of the heat-transfer medium amount drawn off on the actual thermal energy expenditure is not so significant in comparison with circulatory ones. During hours of maximum and minimum draw-off, the value of the coefficient for heating ranges from 0.053 to 0.081 Gcal/m³. It is obvious that the greater effect can be achieved by using dynamic regulation methods taking into consideration the irregularity of working modes of HWS systems [3, 5].

4. In the dwelling building 16 located in Stankostroiteley street which is not equipped with towel driers we succeeded in balancing the actual specific thermal energy expenditure with the approved standard value of 0.062 Gcal/m³ without any losses in how water supply quality of the end consumer only after installing thermostatic valves.

5. Made technical measures related to limiting the circulatory consumption or maintaining the set temperature value of the circulatory water do not allow the full balancing the actual specific thermal energy expenditure with standard values without undermining quality parameters [6]. It may be assumed that when decreasing the lower limit of the authorized temperature regulation range of the hot water, for example, by 55 °C, the efficiency of such technical measures will be higher and will not influence the sanitary reliability of HWS systems even without applying any corrective measures.

Conclusions

1. The calculated standard value of the thermal energy for heating the cold water fails to meet real working conditions of HWS systems. The imbalance of the standard value is conditioned by the necessity to carry the higher temperature of the hot water in the heat supply system for providing quality standard values to consumers and for maintaining the excessive circulatory expenditure to compensate losses of thermal energy during periods of minimum water draw-off.

2. Known and widely used statistical regulation methods by limiting the circulatory expenditure via orifice gages or by limiting the temperature of the circulatory water do not produce the full effect and can lead to the violation of current quality norms of the hot water.
3. It is advisable to legislatively enlarge the possible temperature regulation range of the hot water for improving the efficiency of applied regulation methods. The short-term decrease of temperature of the hot water by 55 °C will not influence the sanitary reliability of hot water supply systems.

4. It is possible to boost the working efficiency of HWS systems by using dynamic regulation methods of the expenditure and the temperature of the circulatory water taking into consideration the daily and the weekly unevenness in their working mode.

References

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