CALCULATION OF HEAT LOSS THROUGH THE PIPES OF THE INTERIOR CENTRAL HEATING SYSTEM

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Received: 15.09.2015 / Accepted: 10.10.2015 / Revised: 24.10.2015 / Available online: 15.12.2015

DOI: 10.1515/jaes-2015-0018

KEY WORDS: central heating, residential buildings, thermal energy, energy audit

ABSTRACT:

The article presents aspects related to the calculation of heat loss through the pipes of the interior central heating system. The purpose of the article is to detail the local heat losses in case of central heating systems. Based on the conclusions of the article, we propose the modification of the calculation methodology related to the building energy audit.

1. INTRODUCTION

1.1. Context

As climate is changing and fossil fuel deposits are constantly diminishing, lowering energy consumption has become an important objective of the European Union states, including Romania. In order to achieve this goal, a series of legislative measures have been developed, their target being to limit energy consumption (Ionescu, 2011).

Buildings are responsible for 40-45 % of the total energy consumption in Europe and China (and for about 30-40 % worldwide) (Day, 2009).

It is well known that a major objective of all states is to decrease the energy consumption in order to protect the natural resources, and directly related to this aspect, to decrease the CO₂ emissions in the atmosphere. These are also the objectives set in Directive no. 2010/31/UE on the energetic performance of buildings. This directive was transposed into the Romanian legislation in Law no. 372/2005 (Constantinescu, 2008), (Law 372, 2005).

1.2. General Considerations

The thermal calculation of the pipe networks represents a calculation related to the heat transfer between two fluids, separated by a wall. The purpose of the thermal calculation is either to determine the necessary width in order to satisfy certain imposed requirements (regulated values imposed to heat and temperature losses or certain values of the temperature at the surface of the thermal insulation), or to determine the heat and temperature losses for a certain thermal insulation (Athanasovici, 1981).

This paper represents a continuation of the study conducted by the author (Giurca, 2006, 2009; Naghiu, 2014) in the field of energetic audit.

1.3. The purpose presented in the article

The article presents aspects related to the calculation of heat loss through the pipes of the interior central heating system.

The purpose of the article is to detail the local heat losses in case of central heating systems.

1.4. The added value of the present article

Based on the conclusions of the article, we propose the modification of the calculation methodology related to the building energy audit.

2. MATERIALS AND METHODS

2.1. Calculation of total heat losses of a pipe

The total amount of heat that a pipe loses in the environment is determined with the formulas:

$$Q_h = q \cdot L + \sum Q_{loc} \quad (1)$$

or

$$Q_h = q_{ech} \cdot L_e = q_{ech} \cdot (k \cdot L + l) \quad (2)$$

where:

Q_h = stands for the pipe's heat loss;
 q = unitary heat losses of a thermally insulated pipe;
 L = length of the pipe, in m;
 $\sum Q_{loc}$ = local heat losses;
 q_{ech} = equivalent thermal flow;
 L_e = equivalent pipe length, in m;
 k = coefficient taking into account supplementary heat losses through the pipe's supporting elements (see table no. 1);
 l = length of the thermally insulated pipe, equaling the heat losses through the closing elements and through the pipe's joints, in m (Carabogdan, 1986).

2.2. Key Determining heat losses through the related elements

When referring to heat losses of a pipe system one must take into account not only the losses that correspond to the pipes, but also those corresponding to the related elements (valves, fittings, bases that are not insulated, etc.). In order to be able to take into account the related elements, one must consider an equivalent length (Mc 001/2, 2006).

2.2.1. Determining the supplementary heat losses through the supporting elements of the pipe

Supplementary heat losses through the supporting elements of the pipe are represented as percentages

of the linear heat losses, and those respective values are presented in a table (see table no. 1).

Pipe supported by	K coefficient for	
	pipes in enclosed rooms	pipes in open air
hanging	1.10	1.15
propping	1.15	1.20

Table 1. Values of the K coefficient for determining heat losses through the supporting elements of the pipes (Athanasovici, 1981; Carabogdan, 1986)

2.2.2. Determining heat losses through the valves' body, including through the joining flanges

For losses through valves' bodies, including the flanges, the equivalent length taken into account depends on the thermal insulation degree. This value shall be added to the length of the pipes (Mc 001/2, 2006).

Further on, we shall present the data related to the way of determining heat losses through the valves' body, including through the joining flanges, according to the Romanian legislation in force, as well as in accordance with the specialized papers published in Romania, Germany, Belgium or France.

In table no. 2 we presented the equivalent length for the casings, in accordance with the Romanian calculation methodology, namely Mc 001/2-2006- Part II.

Valves also including the attachment flanges	Equivalent length [m] ND ≤ 100 mm	Equivalent length [m] ND ≥ 100 mm
	mm	
not insulated	4.0	6.0
insulated	1.5	2.5

Table 2. Equivalent length for casings (Mc 001/2, 2006)

In table no. 3 we presented the length of the thermally insulated pipe which represents the heat losses through the closing and joining elements, according to the Romanian specialized papers.

Element		Pipes in enclosed rooms		Pipes in open air	
		t = 100 °C	t = 400 °C	t = 100 °C	t = 400 °C
Casings	Di = 100 mm	2.3	4.8	4.5	6.2
	Di = 500 mm	3.0	7.5	5.5	8.5
Joints through flanges		1 – 1.5			

Table 3. Values of the "l" coefficient, the length of the thermally insulated pipe which represents the heat losses through the closing and joining elements, in m (Athanasovici, 1981; Carabogdan, 1986)

According to the Romanian specialized papers (Voinescu, 1964), the “I” coefficient for the pipes located in enclosed rooms is the following:

- flange thermally not insulated, 3 m;
- flange thermally insulated, 0.5 m;
- cock or valve thermally not insulated, 5-7 m;
- cock or valve thermally insulated, 3 m.

In table no. 4 we presented the equivalent length corresponding to valves and flanges thermally not insulated, according to the specialized papers from Germany.

Name	ND	Water temperature	
		50 °C	100 °C
Valves	25	0.5 m	1.0 m
	100	1.2 m	2.5 m
	300	3.0 m	6.0 m
Flanges	25	0.2 m	0.4 m
	100	0.5 m	1.0 m
	300	1.5 m	3.0 m

Table 4. Thermally equivalent lengths of the valves and flanges thermally not insulated, in equivalent meters of pipe (Recknagel, 1996; Energie+, nd.b.)

And in table no. 5 we presented the equivalent pipe length corresponding to heat losses through valves and flanges, according to the specialized papers from Belgium.

Name	Equivalent pipe length - m -
Valves not insulated	1.7
Insulated valves (6 cm of padding)	0.17
Pair of flanges not insulated	0.9
Pair of flanges not insulated (6 cm of padding)	0.06

Table 5. Equivalent pipe length for heat losses through valves and flanges (source: AIB, cited in paper (Energie+, nd.a.)

If the value of the “I” coefficient is not determined, the values of the “K” coefficient shall be increased with 0.05 (Carabogdan, 1986).

Heat losses through pipes may be represented directly as values, and therefore in table no. 6 we presented these values in accordance with the French specialized papers.

In table no. 7 we presented the values corresponding to heat losses through valves, according to the Belgian scholarly literature.

ND	Threaded valve	Ball threaded valve	2-way cock with flange	3-way cock with flange
mm	W/ °C	W/ °C	W/ °C	W/ °C
20	0.12	0.11		
32	0.17	0.18	1.65	
40				2.59
50	0.25	0.32	2.37	
65		0.59	3.46	3.63
100			4.27	5.71

Table 6. Heat loss values recommended for a temperature difference of one degree between the thermal agent and the air (COSTIC, nd)

Inner diameter	Outside diameter	Not-insulated valve	Insulated valve	Savings
toli	mm	W/m ²	W/m ²	W/m ²
½	21	48	17	31
1	33	88	31	57
1 ½	48	124	43	81
2	60	158	55	103
3	89	226	79	147
4	114	292	102	190
5	140	358	125	233
6	169	420	147	273

Table 7. Heat losses through valves (Simon, 2010)

In Figure 1-4 we presented the heat losses through valves, as presented by the French association COSTIC in the paper (COSTIC, nd).

Figure 1. Nomogram for determining heat losses through threaded valve

Figure 2. Nomogram for determining heat losses through ball valves

Figure 3. Nomogram for determining heat losses through flanged ball valves

Figure 4. Nomogram for determining heat losses through 3 way flanged valves

3. CASE STUDY, RESULTS AND DISCUSSION

3.1. Case Study

Further on, we are presenting a case study concerning the heat losses that occur in case of an interior central heating system of a block of flats located in Bucharest and administered by the Owners' Association.

The building has a parallelepiped shape, consists of 2 sections, each of these sections being composed of an underground floor, a first floor and 3 floors. In plan, the building's dimensions are 34.90 m x 13.00 m, with a total built surface of 1814.88 m².

The block has 24 flats, namely 3 flats on each floor that is 12 flats on each section (Mc 001/4, 2009).

Hypotheses:

- the number of yearly heating hours is of 5736 hours/year;
- the average temperature of the heating agent is of 70 °C;
- the average temperature of the underground floor is of 8.73 °C;
- the average interior temperature is of 20 °C;
- the pipes located in the underground floor are thermally insulated;
- the pipes located in the apartments are not thermally insulated.

3.2. Results

Based on the above hypotheses and based on the calculation methodology, we made the calculations using the following bibliography in order to determine the heat losses through the valves:

- Romanian legislation;

- specialized papers from Belgium;
- specialized papers from France.

Steps pipe heat loss calculation are shown in Figure 5.

Figure 5. Steps calculation of heat loss through pipes

The results of the calculations are synthetically presented in table no. 8, table no. 9, table no. 10 and table no. 11.

Pipe destination	di	Unitary heat losses of a thermally insulated pipe, q	L	Total linear heat loss	Number of valves	l	Equivalent pipe length for heat losses through valves	Total loss of local heat	Total loss of heat
	m	kWh/m an	m	kWh/an	pcs.	m/pcs.	m	kWh/an	kWh/an
Distribution pipeline	0.04	76.849	206.28	15,852	6	3	18	1,383	17,236
Columns	0.025	51.828	254.4	13,185	48	3	144	7,463	20,648
Connecting pipes to radiators	0.015	58.145	960	55,819	64	6	384	22,328	78,146
Total			1,420.68	84,856	118		546	31,174	116,030

Table 8. Calculation of heat loss through pipes according to literature in Romania

Pipe destination	di	Unitary heat losses of a thermally insulated pipe, q	L	Total linear heat loss	Number of valves	l	Equivalent pipe length for heat losses through valves	Total loss of local heat	Total loss of heat
	m	kWh/m an	m	kWh/an	pcs.	m/pcs.	m	kWh/an	kWh/an
Distribution pipeline	0.04	76.849	206.28	15,852	6	0.17	1.02	78	15,931
Columns	0.025	51.828	254.4	13,185	48	0.17	8.16	423	13,608
Connecting pipes to radiators	0.015	58.145	960	55,819	64	1.7	108.8	6,326	62,145
Total			1,420.68	84,856	118	2.04	117.98	6,827	91,684

Table 9. Calculation of heat loss through pipes according to literature in Belgium

Pipe destination	di	Unitary heat losses of a thermally insulated pipe, q	L	Total linear heat loss	Number of valves	l	ΔT	tH	Total loss of local heat	Total loss of heat
	m	kWh/m an	m	kWh/an	pcs.	W/ °C	K	h/year	kWh/an	kWh/an
Distribution pipeline	0.04	76.849	206.28	15,852	6	0.32	61.27	5,736	675	16,527
Columns	0.025	51.828	254.4	13,185	48	0.18	50	5,736	2,478	15,663
Connecting pipes to radiators	0.015	58.145	960	55,819	64	0.11	50	5,736	2,019	57,838
Total			1,420.68	84,856	118				5,172	90,028

Table 10. Calculation of heat loss through pipes according to literature in France

Method	Total linear heat loss	Total loss of local heat	Total loss of heat	Linear losses weight	Local losses weight
	kWh/an	kWh/an	kWh/an	%	%
Romania	84,856	31,174	116,030	73.1%	26.9%
Belgium	84,856	6,827	91,684	92.6%	7.4%
France	84,856	5,172	90,028	94.3%	5.7%

Table 11. Values of heat losses

where:

d_i represents the inner diameter of the pipe, in m;
 Δt - temperature difference between the thermal agent and the air, in K;
 t_H - the annual number of hours of heating, h/year.

The results obtained are also presented graphically (figure 6 and figure 7).

Figure 6. Values of heat losses

Figure 7. Weight of heat losses

3.3. Discussion

From the facts presented above, it results that:

- local heat losses range between 5.7...26.9 % from total heat losses;

- the values obtained for the local heat losses may differ, depending on the bibliography used when making the calculations.

4. CONCLUSIONS

a) Conclusions derived from the article:

- The use of the calculation method presented above allows us to calculate more precisely the heat losses through valves, depending on the constructive type of the valve used and depending on the temperature difference between the thermal agent and the air.

- We notice that using different bibliographic sources may lead to obtaining different local heat losses, for the same interior central heating system.

- Considering that the local heat losses may have significant values, we recommend that in the preliminary calculations, one should supplement the local heat losses. According to the recommendations of the Romanian specialized papers, in case of interior heating systems, the heat losses through:

- pipe supporting elements represent about 10-15 % of the linear heat losses;
- closing elements and pipe joints represent about 5 % of the linear heat losses.

b) Contribution of the present work synthesis:

- The article presents aspects related to the calculation of heat loss through the pipes of the interior central heating system.

- The purpose of the article is to detail the local heat losses in case of central heating systems.

c) The possibility of practical use of the study results:

- The conclusions of this study are useful both for the specialists who want to obtain the energy auditor license for buildings as well as for elaborating energy audit projects for buildings.

d) Outlook:

- Based on the conclusions of the article, we propose the modification of the calculation methodology related to the building energy audit.

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