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MAIN ISSUES OF RESERVATION IN HEAT SUPPLY SYSTEMS

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ANNOTATION:

The following article considers the issue of heat provision and reliable operation of heat supply systems that can be ensured by the reservation of heat sources and heating networks.

Keywords: reliability, heat source, reservation, heating main, heat humidity.

INTRODUCTION:

Due to a number of both remote in time and current reasons, the situation in centralized heat supply is characterized by an unsatisfactory technical level and low economic efficiency of systems, worn-out equipment, insufficient reliability of heat supply and the level of comfort in buildings, and large losses of heat energy.

The most unreliable link in heat supply systems are heating networks, especially when they are laid underground. In addition, the structure of heating networks in large systems does not correspond to their scale.

The development of heat supply systems for settlements is carried out on the basis of the development of heat supply schemes. At the same time, a mandatory decision-making criterion should be the provision of the necessary sanitary and hygienic conditions and requirements for the reliability of heat supply to each of the consumers "through redundancy and achieving uninterrupted operation of heat sources, heating networks and the system as a whole."

First, the sectioning of the main heat pipelines with a sufficient number of marking devices; secondly, reservation of the throughput of heat pipelines for feeding emergency sections through other sections. It is shown that full redundancy of the transmission capacity of the main heat pipelines with sectioning provides almost 100% reduction in emergency damage [1].

The methodology is intended for calculating reliability indicators in heating networks of district heating systems when developing heat supply schemes in order to select solutions that provide regulatory requirements for the reliability of heat supply to consumers based on redundancy of heating networks.

A pipeline system of an arbitrary given configuration with known indicators of the reliability of the corresponding elements under fairly general conditions is considered.

In this regard, when developing heat supply schemes and heating network projects, it is recommended to proceed from the following fundamental principles:

- Ensuring redundancy of the heat source by installing two or more units on it;
- The probability of an accident on only one main heating main during the period under consideration;
- Admissibility of short-term disconnection from heating networks of the majority of consumers (subscribers) with accelerated repair work considering the thermal stability of buildings.
- Laying from a heat source of two or more head heating mains, interconnected by backup jumpers (looping heating networks);
- Laying of reserve bridges between heating networks of two or more heat sources (looping around heating areas);

- Laying of two reserve heat pipelines to subscribers;
- Reducing the length of the section between the sectioning valves;

Long-term disruption of heat supply can lead to catastrophic consequences, which imposes restrictions on the permissible time for eliminating failures. This time can be increased by reserving the heating network, which allows maintaining a certain reduced level of heat supply to consumers (with a slight decrease in air temperature in buildings) during the elimination of accidents and excludes their possible catastrophic development.

Along with increasing the reliability of structures, heat pipelines and equipment, redundancy of the heating network is the main way to ensure the required level of reliability of heat supply, which forms the time reserve of consumers, which is the time (and frequency) of reducing the air temperature in the building to the normalized, minimum permissible value.[2]

Providing for a given time the required modes and permissible parameters in the premises is the most important task of heat supply systems, which is ensured by backing up heat sources and heating networks. When considering the issue of reservation of heating networks, it is necessary to take into account that it leads to an additional increase in capital costs and therefore should be minimized.

The general provisions for the reservation of heat supply systems, developed on the basis of these principles, are given in Building regulations (Building regulations 2.04-07-99) and are of a recommendatory nature.

In order to reduce capital costs for heat sources and heating networks, consumers, based on the reservation condition, are divided into three categories.

The first category are the consumers who do not allow interruptions in the supply of the estimated amount of heat and reduce the air temperature in the premises. These consumers include: hospitals, maternity and preschool institutions with round-the-clock stay of children, art galleries and special production sites. With appropriate justification, other consumers can also be assigned to the first category. From the above list it follows that the objects of the first category include buildings from which it is difficult to evacuate people, as well as buildings that require maintaining the exact thermal and humidity parameters of the room.

The second category includes the consumers who allow a decrease in temperature in heated premises for the period of accident elimination: residential and public buildings - up to +12°C; industrial buildings - up to +8°C.

The third category refers to the rest of the consumers.

Heat source redundancy:

According to the provisions of Building regulations 2.04-07-99, the reservation of heat sources for the main equipment is ensured by the following condition for the selection of boilers: in the event of failure of the most powerful boiler, the performance of the remaining boilers must provide coverage, depending on the design temperature of the outside air, from 78 to 91% of the design load for heating and ventilation for consumers of the 2nd and 3rd categories and 100% of the calculated load of consumers of the 1st category. If possible, it is allowed to turn off the hot water supply system. The boiler room must be provided with a standard reserve of emergency fuel. The power supply to the boiler house with a capacity of more than 10 Gcal/h should actually correspond to the first category. Under these conditions, the construction of two heat sources for a settlement is not a mandatory requirement and is justified by technical and economic considerations [2].

Heating mains reservation:

The long-term practice of heat networks operation has shown that the probability of interruption in the supply of heat energy as a result of an accident to consumers during the heating period is extremely low. Moreover, this probability decreases with an increase in the diameter of the heat pipes. Therefore, the probability of a simultaneous accident on two different head heating mains connected to the same heat source is practically zero. Based on this, to ensure reliable heat supply, it is enough to reserve two adjacent heating mains between each other.

Vitality of the heat supply system:

The concept of survivability is understood as the ability of the heat supply system to maintain its performance under emergency and extreme conditions associated with a drop in the outside air temperature below the design temperature for heating [2]. The main condition for the survivability of the heat supply system is to prevent the freezing of network water, leading to the cessation of its circulation. In this regard, during the period of emergency situations, a minimum supply of heat energy to the building systems should be ensured to maintain a water temperature of more than +3 ° C in attics, entrances and basements [3].

In accordance with this, the projects should develop measures to ensure the survivability of elements of heat supply systems located in areas of possible exposure to negative temperatures, including:

- Organization of local circulation of network and circulating water in heating networks and heat-consuming systems of buildings;
- Heating of heating networks and heat-consuming systems of buildings during the period of repair and restoration work;
- If necessary, descent followed by filling with network and circulation water of heat-consuming systems of buildings on time and after completion of repair and restoration work.

Disconnection of consumers for the period of repair work:

Since each building has a certain thermal stability, the drop in the indoor air temperature in the premises (for example, from a comfortable approximately +20°C to the minimum allowable +8°C - +12°C) is observed for several hours, which allows for a short-term disconnection of subscribers from heating networks for restoration work. The cooling rate of buildings depends on the design of the building itself and the weather conditions of the area, i.e. the lower the design temperature for heating, the higher the rate of temperature drop in the premises. In this regard, as the design temperature for heating decreases, the conditions for the reservation of heating networks become more stringent.

The period of repair work increases with an increase in the diameter of the heat pipelines and the length of the disconnected sections of the heating network, which is associated with the drain and filling of heat pipelines. At the same time, an accident in overhead heating networks is detected and eliminated much faster than with underground duct laying. It is also faster to detect the place of the accident with channelless laying of heat pipes in polyurethane foam insulation with a remote operational monitoring system. On the other hand, the probability of an accident decreases noticeably with a decrease in the length and an increase in the diameter and thickness of the walls of heat pipes [4]

Based on the foregoing, in the provisions of Building regulations 2.04-07-99, the reservation of heating networks is assumed optional for the following cases:

- If consumers have a local backup heat source;

- For sections of overhead laying less than 5 km long (with appropriate justification, the distance can be increased);
- For heat pipelines laid in tunnels and passageways;
- For heating networks with a diameter of 250 mm and less (in the absence of consumers of the 1st category).

At the same time, for consumers of the 1st category, depending on the situation, it is compulsory to reserve a local emergency heat source or heat networks from two heat sources, or heat networks from two outlets of one heat source.

It is allowed not to make redundancy of transit heat pipelines from the warm-electric central to the external peak boiler houses, if their performance provides, depending on the design temperature of the outside air, coverage from 78 to 91% of the design load for heating and ventilation for consumers of the 2nd and 3rd categories and 100 % of the estimated load of consumers of the 1st category.

For other cases, it is necessary to consider the issue of redundancy of heating networks, with consideration of specific situation that has been developed in a given site, as well as the capabilities of the operating organization.

Basic provisions for the reservation of heating networks:

In emergency situations, it is important to take into account the provisions set forth in Building regulations 2.04.07-99 [5], that the heat supply system and heating networks must provide the minimum allowable amount of heat at the design temperature for heating t_p = -10 ^{0}C and below. At the same time, there is no data on the need to reserve heating networks at a design temperature for heating above t_p = -10 ^{0}C. However, the actual design practice has shown that these provisions are contradictory and, in many cases, impracticable.

For example, when developing heat supply schemes for areas with a high design temperature for heating (t_p = -3 ÷ -5^{0}C), in some cases, an unjustified looping of heating networks and an increase in the diameters of emergency bulkheads are performed. The above requirements are especially difficult to fulfill for intra-quarter heating networks of small diameter and remote objects with a load from 20 to 50 Gcal/h, i.e. for heat pipelines 2Du300 ÷ 400 mm. The most difficult problems arise during the reconstruction of existing systems, in which the level of redundancy does not correspond to the provisions of Building regulations 2.04.07.99[5].

The most complex problems arise during the reconstruction of existing systems, in which the level of redundancy does not correspond to the provisions of Building regulations 2.04.07.99 [5]. For example, if a new residential area with a heat load of 30 Gcal/h is connected to the existing dead-end heat pipe 2Du500 mm, to fulfill the conditions given in Table. 1, it is necessary to:

- Make redundancy of the existing heat pipe 2Du500 mm by laying an additional heat pipe 2Du300 mm and more;
- Lay a circular heat pipe 2Du300 mm around the block;
- Make a tie-in of each subscriber input between two sectional valves on the circular heating main 2Du300 mm.

Table 1. Reserve supply of heat energy to subscribers in emergency situations in% of the estimated amount

Conditional diameter of heat pipes, mm	Estimated outside air temperature for heating, ^{0}C				
	-10^{0}C	-20^{0}C	-30^{0}C	-40^{0}C	-50^{0}C
300	32	50	60	59	64
400	41	56	65	63	68
500	49	63	70	69	73
600	52	68	73	73	76
700	59	70	76	75	78
800-1000	66	75	80	79	82
1200-1400	71	79	83	82	85

Table 2. Reserve supply of heat energy to subscribers in emergency situations in % of the estimated amount.

Conditional diameter of heat pipes, mm	Estimated outside air temperature for heating, ^{0}C					
	-10^{0}C and higher	-10^{0}C up to -20^{0}C	-20^{0}C up to -30^{0}C	-30^{0}C up to -40^{0}C	-40^{0}C up to -50^{0}C	Below 50^{0}C
300	-	-	-	-	50	60
400	-	-	-	50	60	70
500	-	-	50	60	70	80
600	-	50	60	70	80	85
700 и более	50	60	70	80	85	90

As a result, capital costs increase by 2-3 times in comparison with the option of inserting a dead-end distributing heat pipe 2Du300 mm. An alternative to this solution is the use of measures aimed at reducing the period of repair and restoration work by reducing the length of the sections between the sectioning valves [4].

In this regard, it is recommended as minimum requirements to comply with the more realistic conditions given in Building regulations 2.04.07.99 [1], on the basis of which most of the country's heating networks are designed. The minimum amount of reserve heat supply in emergency situations in % of the calculated one is given in Table 2, which is developed on the basis of the provisions of Building regulations 2.04.07.99. At the same time, short-length dead-end sections limited by sectioning valves are permissible for large-diameter heat pipelines. The last issue for closed and open heat supply systems is discussed in detail in the relevant works.

When developing heat supply schemes and heating networks, it is recommended at the first stage to use the conditions given in Table 2, and in the course of coordinating the schemes (at the request of customers and operating organizations) to tighten the reservation conditions up to the provisions given in Table 1. This approach allows to optimize technical solutions and reduce capital costs for the reservation of heating networks.

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