USE OF THERMAL IMAGING METHOD OF CONTROL FOR INSPECTION OF BUILDING STRUCTURES FOR TIGHTNESS

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Abstract

In any industry related to the construction of buildings and structures we have heard about the need to assess the technical condition of various objects to assess and analyze the risks associated with the possible collapse of buildings (structures), loss of life and high costs to eliminate these consequences. Since many objects fail over time, and in general to determine the wear and tear and the possible term of further safe operation, it is necessary to conduct a technical survey. The article describes the principle of operation of thermal imaging devices for determining the reliability of building structures in residential premises, and also raises problems, the solution of which can simplify the use of thermal imaging devices in the inspection of buildings and structures and reduce the economic costs of damage compensation in case of timely detection and elimination of any defects.

Keywords: thermal imager, thermal imaging device, reliability of building structures, risk analysis, building collapse, economic costs, inspection of buildings and structures, hidden defects, energy audit, temperature, energy, air leakage

I. Introduction

In the Russian Federation, the construction industry is developing quite rapidly, and new buildings and structures are constantly being constructed. Companies that build and monitor the safe operation of various facilities are obliged to assess and determine the category of the technical condition of buildings and structures, which assesses the current state of the object under study, its operational properties, including the condition of the foundation soils, based on a comparison of the actual values of the parameters under study with the values of the same parameters established by the project or regulatory document.

II. Methods

During the inspection and assessment of the technical condition of buildings and structures we mainly fix only visible defects, but quite often, many different damages in the building structures of buildings and structures are hidden and directly affect the load-bearing capacity of objects. For the fastest detection of any damage, especially hidden damage, where the integrity of structural elements has been violated, namely cracks, cavities, etc. in closed building structures, thermal imaging methods of control of buildings and structures are used [1]. Such methods involve the use of devices called thermal imaging cameras. This device is based on non-contact and remote scanning of various structural elements of buildings and structures, and is used to visually determine and evaluate the thermal insulation characteristics of a building or room in real time [2]. Thermal imagers differ from each other by their technical characteristics, such as matrix parameters, ergonomics parameters, range of infrared radiation capture. Such devices are used in various spheres of human activity, for example, in medicine, veterinary medicine, engineering, housing and utilities, firefighting, etc. This article deals with the application of thermal imaging in the field of construction and examines the inspection of window glazing with the help of a thermal imaging device Testo 875 2i (Figure. 1).

Figure 1: *General view of the device - Testo 875 2i thermal imager [1].*

The thermal imaging method is used to observe the temperature distribution of the surface being inspected, which is displayed as a color picture where different colors correspond to different temperatures [2]. There is a temperature difference between the interior and exterior surfaces, and with the help of different colors on the thermal imager screen it is possible to identify defects where there is an increased heat loss due to the violation of thermal insulation [3].

Thermal imaging devices began to be used due to the fact that in 2009 came into force the federal law № 261 "On energy saving and energy efficiency" [4], and the subsequent introduction of thermal imaging devices in the field of energy saving and energy efficiency [4], and the subsequent order of the Ministry of Energy of the Russian Federation № 182 "On approval of requirements to the energy passport, compiled on the basis of the results of mandatory energy inspection" [5].

Thanks to the use of thermal imaging technology for inspection of the technical condition of structural elements of buildings and structures, it becomes possible to detect hidden defects at the early stages of their development, which makes it possible to prevent the transition of structural elements from "workable" technical condition to "limited-workable" or even "emergency" [6].

If we consider only the sphere of construction and architecture, it is possible with the help of thermal imaging devices:

- detect hidden defects in building structures [7];
- visualize energy loss [7];
- detect missing or deformed insulation layers;
- locate air leaks;

- detect mold, rotten or poorly insulated areas;
- identify temperature bridges;
- locate moisture penetration in flat roofs;
- find irregularities in piping and heating risers;
- find faults in electrical supply lines.

We have carried out energy audit of the installed double-glazed windows to determine their quality and tightness in the apartment of a residential building located in the Moscow region, Balashikha, Balashikha, Prospekt Lenina, 73 (Fig.2). Conducting an energy audit in the house is necessary to check the technical characteristics of the residential premises, its energy efficiency and cost-effectiveness. The main purpose of the survey is to identify the causes of high costs for electricity, gas, heat and water, as well as to determine possible ways to reduce energy consumption [8,9].

Figure 2: *Schematic of the location of the object under study*

The research was conducted using the following methods:

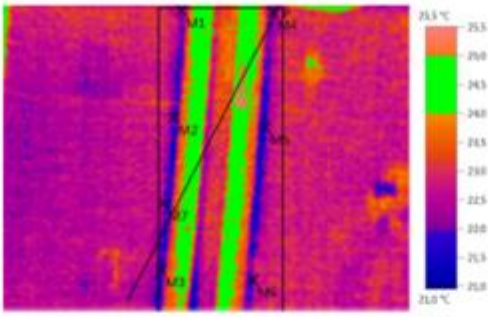
- method of comparison, comparison of the data of submitted documents and normative acts;
- analysis of normative and technical sources.
- carrying out thermal imaging inspection.

Thermal inspection of window structures of a residential building

Firm	**Regional Center for Forensic Expertise** **Balashikha, Prospekt Lenina, 73**	**Customer**	**Pyatainina E.V.** **Balashikha, Meshchery str. 4, kv.13**
Controller			

Instrument **Testo 875-2i** **Serial № 60342865**

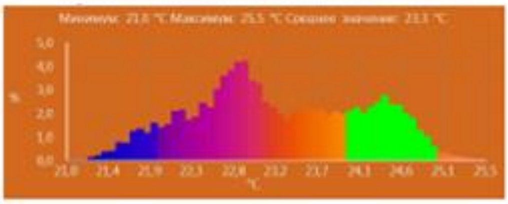
Order



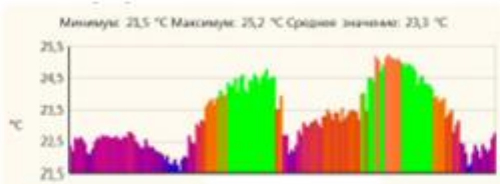
Graphical data	**Date**	**09/07/2023**	**Radiation coefficient**	**0,95**
	Time	**8:37:56**	**Reflective temperature [°C]**	**22,0**
	File	**IV-001.BMT**		

Image selection

Measured objects	t, [°C]	Radiation	Reflective t, [°C]	Remarks
Measuring point 1	22,3	0,95	22	-
Measuring point 2	21,7	0,95	22	-
Measuring point 3	21,6	0,95	22	-
Measuring point 4	22,1	0,95	22	-
Measuring point 5	21,6	0,95	22	-
Measuring point 6	21,8	0,95	22	-
Measuring point 7	22,2	0,95	22	-



Histagram



Profile line

Figure 3: *Analysis of the conducted thermal imaging inspection of the apartment window units*

Thermal inspection of window structures of a residential building

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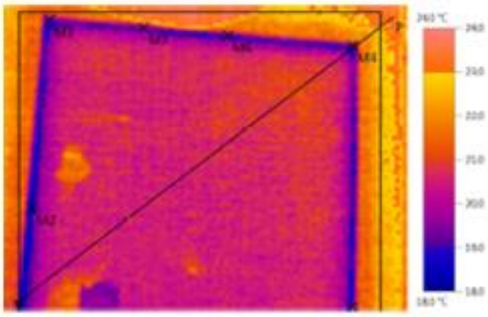
Instrument **Testo 875-2i** **Serial № 60342865**

Order



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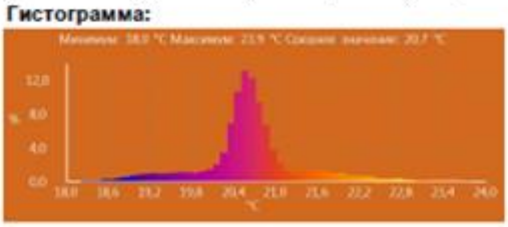
	Time	**8:38:32**	**Reflective temperature [°C]**	**22,0**
	File	**IV-00110.BMT**		

Image selection

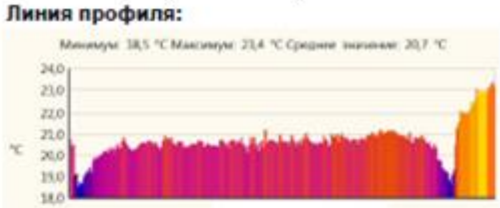
Measured objects	t, [°C]	Radiation	Reflective t, [°C]	Remarks
Measuring point 1	19,3	0,95	22	-
Measuring point 2	18,4	0,95	22	-
Measuring point 3	18,9	0,95	22	-
Measuring point 4	19,2	0,95	22	-
Measuring point 5	19,0	0,95	22	-
Measuring point 6	19,3	0,95	22	-
Measuring point 7	19,6	0,95	22	-

Гистограмма:



Histagram

Линия профиля:



Profile line

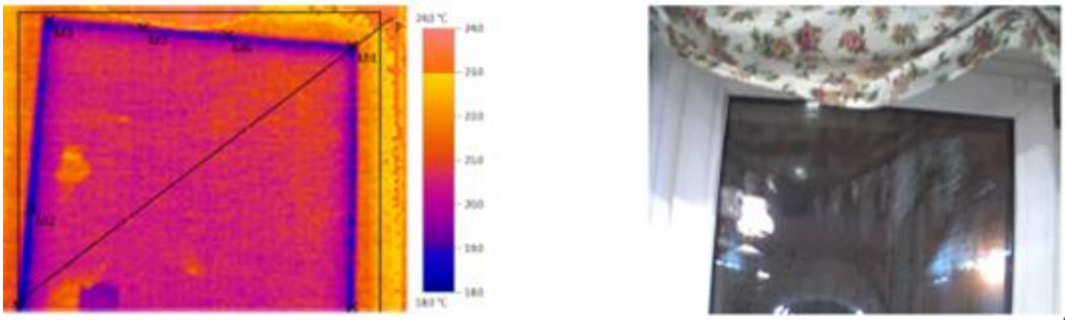
Figure 4: *Analysis of the conducted thermal imaging inspection of the balcony door of the apartment*

Thermal inspection of window structures of a residential building

Firm	**Regional Center for Forensic Expertise** **Balashikha, Prospekt Lenina, 73**	**Customer**	**Pyatainina E.V.** **Balashikha, Meshchery str. 4, kv.13**
Controller			

Instrument **Testo 875-2i** **Serial № 60342865**

Order



Graphical data	**09/07/2023** **8:39:32** **IV-00114.BMT**	**Radiation coefficient** **Reflective temperature [°C]**	**0,95** **22,0**

Image selection

Measured objects	t, [°C]	Radiation	Reflective t, [°C]	Remarks
Measuring point 1	18,0	0,95	22	-
Measuring point 2	18,3	0,95	22	-
Measuring point 3	18,2	0,95	22	-
Measuring point 4	18,5	0,95	22	-
Measuring point 5	18,4	0,95	22	-
Measuring point 6	18,2	0,95	22	-

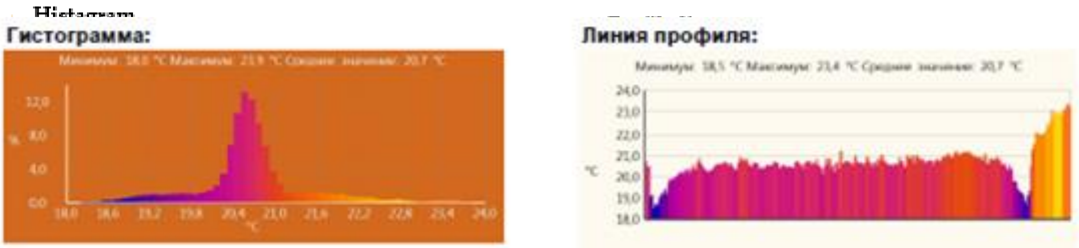


Figure 5: *Analysis of the conducted thermal imaging inspection of the apartment window units*

III. Results

According to the results of the data obtained by taking thermal imaging and instrumental parameters of window structures, the following conclusions were obtained:

- the presence of voids (under the sill) was revealed;
- defects in filling the installation gaps during the construction of joints;
- thermal imaging inspection revealed air leakage both from the inside of the premises and from the outside;
- traces of condensation and mold formation on the slopes were revealed.

The reason of occurrence of available defects and shortcomings is low quality of manufacture of products and their installation. Translucent structures made of PVC profile installed in the apartment do not meet the basic requirement for windows of any design (tightness), it is not possible to use them for their intended purpose (operation) [10].

IV. Discussion

In conclusion, it can be concluded that non-destructive thermal imaging methods are an indispensable tool for locating hidden defects in structural elements of buildings and structures, because they can be effective even in areas inaccessible for other diagnostic methods, and they help to identify the causes of high costs for electricity, gas, heat and water, as well as to identify possible ways to reduce energy consumption.

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