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Studying Fire Hazard of Premises of a Mobile Communications Base Station

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Abstract. The need to study the fire hazard of typical premises of a mobile communications base station was substantiated, in particular, regarding the feasibility of equipping it with an automatic (self-contained) fire-fighting system. Criteria for assessing the fire hazard of a mobile communications base station were developed. It was experimentally established that the greatest fire hazard in the premises of a mobile communications base station was related to the following devices: Alarm Box switching panel, input and distribution board, internal air conditioner unit and 12 V 100 A#2 batteries. Moreover, the latter two ones contribute to the spread of fire inside the premises. During the ignition of the 12 V 100 A#2 batteries, it was established that the surface of the outer wall further heated to a temperature of 80 °C, which did not exceed the critical one. Thus, the fire did not spread beyond the premises. It was established that equipping the premises of a mobile communications base station with a fire-fighting system in order to prevent the fire spreading beyond its boundaries was unreasonable.

Introduction

Recently, leading mobile operators have increasingly been arising issues on the feasibility of ensuring fire safety of mobile communications base stations from the economic view-point. In particular, the greatest attention is paid to the feasibility of providing such premises with automatic fire-fighting systems. After all, the latter being used for their intended purpose, the losses arising from a fire caused by burning telecommunications and electrical equipment are many times less than the costs associated with the purchase and maintenance of automatic fire-fighting systems. Because of this, there arose a need to study the fire hazard of mobile communications base stations, in particular, the features of the fire spread inside the premises of a mobile communications base station and the likelihood of its spread beyond the boundaries of such the premises. All this should be considered taking into consideration the fact that ensuring fire safety of mobile communications base station premises is a decisive factor for protecting both the electrical and telecommunications equipment of such a station and surrounding facilities, which in turn should take into account the importance of maintaining the uninterrupted operation of critical infrastructure facilities.

Analysis of the recent studies and publications

Many scientists have been involved in researching the fire safety of mobile communications base stations. Thus, papers [1, 2] considered protection of critical infrastructure facilities, including mobile communications base stations, from forest fires. At the same time, the impact of possible fires involving such stations on the surrounding environment was not studied. In paper [3], a set of measures for preventing fires in computer rooms was developed. However, the issue of the feasibility of fighting fires in such premises and the specific features of the fire spread in them was not considered. Paper [4] examines the impact of aerosol coming from an automatic or self-contained fire-fighting system on telecommunications or electrotechnical equipment of a mobile communications base station and the damages that occur when such systems, including faulty ones, operate. However, the fire hazard arising in the absence of such fire-fighting systems has not been studied. The features and prospects of providing the premises of mobile communications base stations with automatic and self-contained fire-fighting systems are shown in paper [5]; however, specifics regarding the feasibility of fire protection of such premises are not determined. It is worth noting that according to [6] the premises of mobile communications base stations and transponders located in separate special buildings and structures intended for the placement of telecommunication and electrotechnical equipment of the mobile communications base station only shall be equipped with self-contained fire-fighting systems for local use. At the same time, [7] stipulates that mobile communications switching centres (BSC/MSC) shall be equipped with fire detection systems, and in case that the design capacity of their equipment exceeds 12 kW, these shall be provided with automatic fire-fighting systems. In this regard, a certain conflict additionally arises in the regulatory framework.

Therefore, appropriate scientific research into the fire hazard of mobile communications base station premises in the context of the economic crisis is timely and relevant.

Formulation of the research goals

The purpose of this work is to study the behaviour of telecommunication and electrotechnical equipment in a mobile communications base station premises in the event of a fire and the possibility of its spread beyond the boundaries of such the premises in the absence of an automatic (self-contained) fire-fighting system.

The objects of the research are the process of flame spreading the through telecommunication and electrotechnical equipment of a mobile communications base station and the temperature influence of a fire in the base station premises on the surface temperature of its external walls.

The subject of the research is the effect of flame on the condition of telecommunications and electrotechnical equipment of a mobile communications base station and the high-temperature effect of a fire inside the base station on the surface temperature of its external walls.

To achieve the goal, it is necessary to solve the following tasks:

– Conduct a fire hazard analysis of the premises of a mobile communications base station;

– Establish experimentally the value of the heating temperature of certain telecommunications and electrotechnical equipment inside the premises of a container-type mobile communications base station when exposed to flame as well as the possibility of flame spreading from one element of equipment to another one;

– Establish experimentally the value of the heating temperature of the surface of the external walls of a container-type mobile communications base station in the event of a temperature effect of a fire inside the base station premises as well as the possibility of flame spreading beyond the boundaries of such the premises.

Presentation of the main research material

The study is conducted using a typical mobile communications base station container having a tambour and main premises to house telecommunications equipment. The main premises have internal dimensions of 2,500 mm × 2,200 mm × 2,450 mm, and the tambour is dimensioned 1,070 mm × 2,200 mm × 2,450 mm. The external and internal metal doors of the container are fire resistant. The thermal insulation is fabricated of non-combustible materials. The container floor is made of wooden boards on wooden logs (all treated with flame retardants) and covered with linoleum. The general view of the container executed of panels of black steel sheets is shown in Fig. 1.

Fig. 1. General view of a typical mobile communications base station container.

The analysis of the telecommunications and electrotechnical equipment of the mobile communications base station premises conducted allowed us to identify its components that can pose the greatest fire hazard and are subject to investigation, more particularly:

– Elements of the control unit of the PSS SHZh power supply cabinet;

– 12V 100 A#2 batteries of the PSS SHZh power supply cabinet;

– Elements of the system module, power supply module and 19” RAN19cabinet extension board;

– Rack elements of the SPP transmission systems;

– Alarm Box switching panel;

– Heater (600 W);

– Indoor air conditioner unit;

– Power cable for guaranteed uninterrupted power supply of a mobile communications base station;

– Input board.

The layout of the container-type mobile communications base station premises with equipment placement and dimensions is shown in Fig. 2.

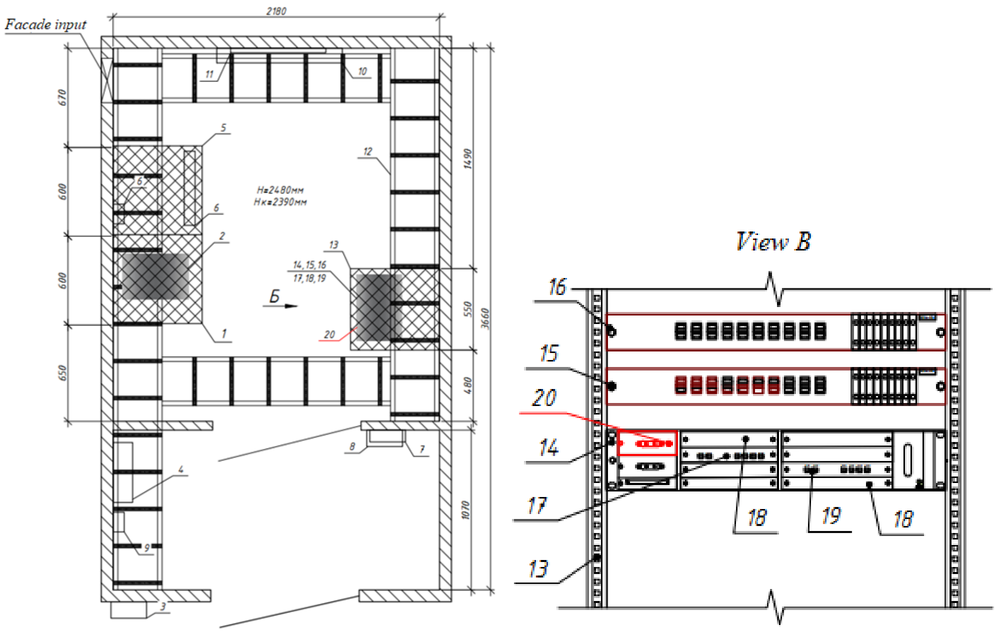


Fig. 2. Layout of equipment in a container type mobile communications base station: 1 – SHZh; 2 – batteries; 3 – metering panel; 4 – distribution switchboard; 5 – transmission system rack; 6 – Alarm Box panel; 7 – fire detection alarm panel; 8 – self-contained fire-fighting system control panel; 9 – grounding block; 10 – air conditioner; 11 – heater; 12 – cable rack; 13 – RAN19 rack; 14 – system module; 15, 16 – power supply module; 17, 18, 19, 20 – extension board.

Based on the analysis of regulatory documents [6–10], we proposed assessing the fire hazard of a mobile communications base station based upon the following criteria:

1) Duration of self-supported burning not exceeding 30 s;
2) Heating temperature of any elements not exceeding 70 °C;
3) Separation of any particles capable of ignition;
4) Flame spreading from one element to other ones;
5) Flame or fire spreading beyond the container structure (the critical surface temperature of the outer wall is assumed to be 250 °C);
6) Presence of any soot on the surfaces of the electrical equipment.

Temperature monitoring was carried out using chromel-alumel thermocouples of the TKhA type on certain elements of telecommunications and electrical equipment in the premises of the mobile communications base station at the following points:

– T1: PSS SHZh power supply cabinet (upper compartment);
– T2: 12V 100 A#2 batteries of the SHZh power supply cabinet (upper compartment);
– T3: Above the elements of the system module, power supply module and 19” RAN19 cabinet extension board;
– T4: On the floor at the midpoint between the 19” RAN19 cabinet and the PSS SHZh power supply cabinet;
– T5: Above the rack elements of the SPP transmission systems;
– T6: On the Alarm Box switchboard;
– T7: Above the heater (600 W);
– T8: Above the air conditioner indoor unit;
– T9: On the cable routing box;
– T10: On the input and distribution switchboard;
– T11 – T14: At the central points of the surfaces of the walls of the container of the mobile communications base station.

The layout of thermocouples for measuring temperature at the monitoring points of the mobile communications base station is shown in Fig. 3.

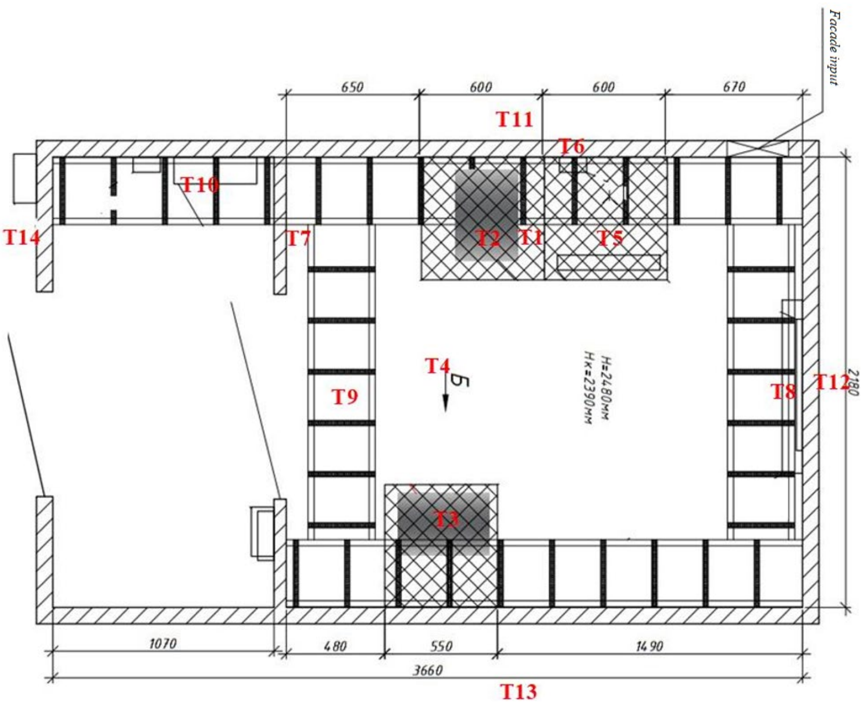
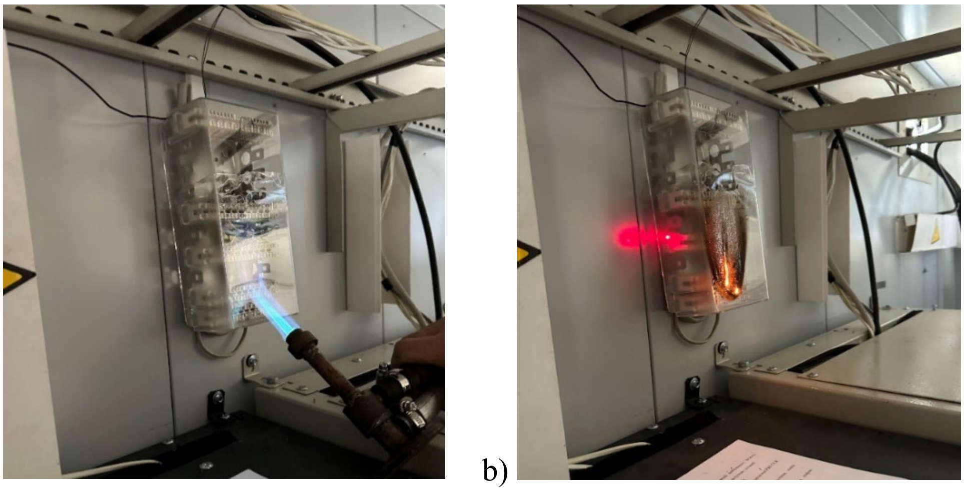


Fig. 3. Layout of thermocouples at monitoring points of the mobile communications base station.

The studies were conducted according to the procedure specified in [11]. The essence of the procedure lied in the application of a test flame to certain elements of telecommunication and electrotechnical equipment of the mobile communications base station premises using a 1 kW burner for 30 s according to the procedure provided in [10], removal of the burner, and recording the temperature values at the monitoring points measured with thermocouples and a thermal imager. Having processed the results of the experimental studies, it is purposeful to highlight the most significant experiments from the fire hazard viewpoint. These were the ones No 4, No. 7, No. 8 and No 9.

Experiment No. 4: Application of the test flame to the Alarm Box switchboard of the mobile communications base station the location shown in Fig. 4 a).

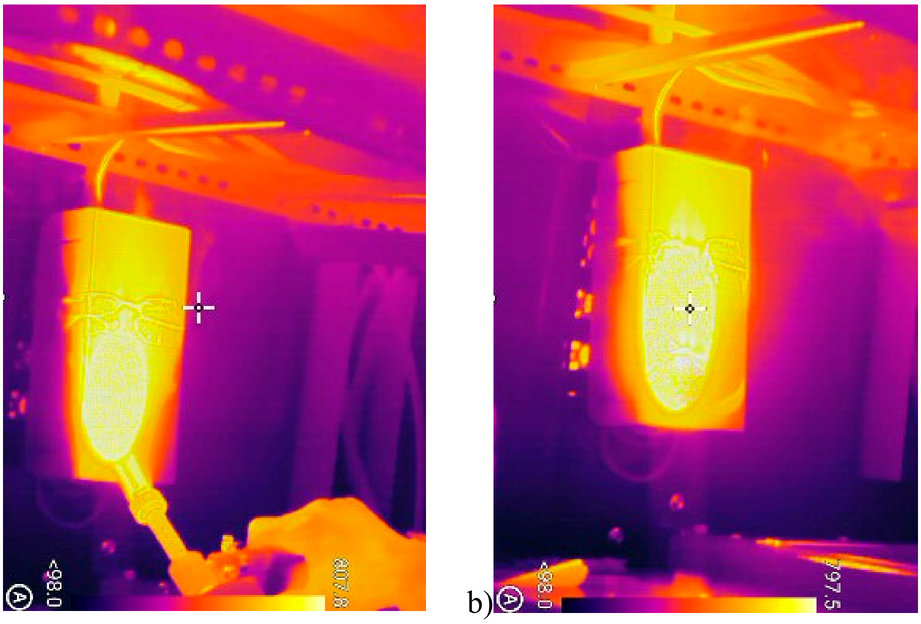
After the burner removal (Fig, 4 b)), self-supported burning and formation of visible volatile combustion products (smoke) were observed for 13 s.



a) b)

Fig. 4. Experiment No. 4 on applying the test flame to the Alarm Box switchboard of a mobile communications base station: a) applying the test flame application of to the Alarm Box switchboard; b) reaction to fire of the Alarm Box switchboard

The temperature distributions at the Alarm Box switchboard are shown in Fig. 5.



a) b)

Fig. 5. Temperature distributions at the Alarm Box switchboard: a) temperature distributions during the burner application; b) temperature distributions after the burner removal.

The temperature dependences on time at the monitoring points of the mobile communications base station derived during experiment No. 4 are presented in the form of graphs in Fig. 6.

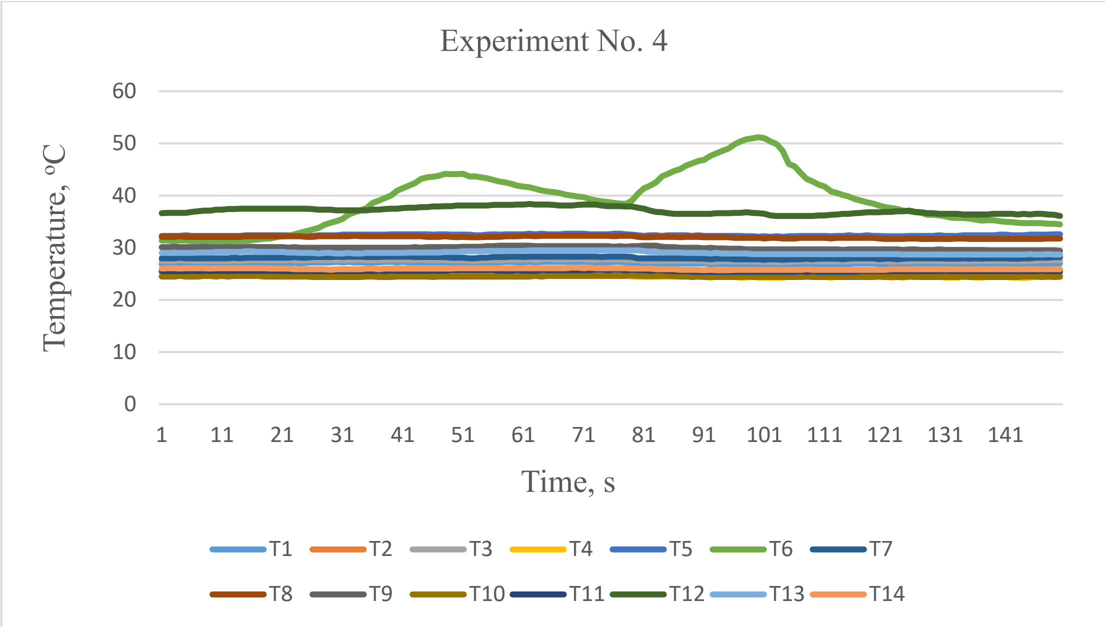


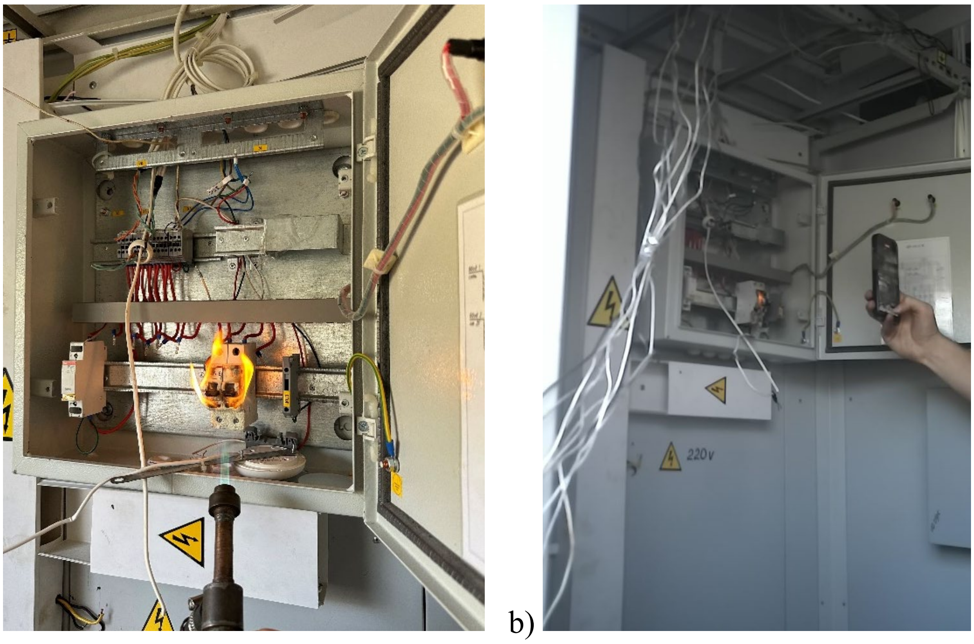
Fig. 6. Temperature vs. time dependences at the monitoring points of the mobile communications base station derived during experiment No. 4.

Thus, the graphs in Figure 6 show that the maximum temperature values of the elements of the mobile communications base station did not exceed the limit value of 70 ºC. The Alarm Box switchboard of the mobile communications base station did not contribute to the spreading of the flame beyond its casing. At that:

– Duration of the self-supported burning was 13 s which did not exceed 30 s;
– Heating temperature of any elements did not exceed 70 °C;
– Separation of any particles capable of ignition did not take place;
– Flame spreading from one element to other ones did not occur;
– Flame or fire spreading beyond the container structure was not observed;
– Upon cessation of the burning process, there was some soot on the surface of the electrical equipment having been exposed to fire.

Experiment No 7: Application of the test flame to the input and distribution board of the mobile communications base station as shown in Fig. 7 a).

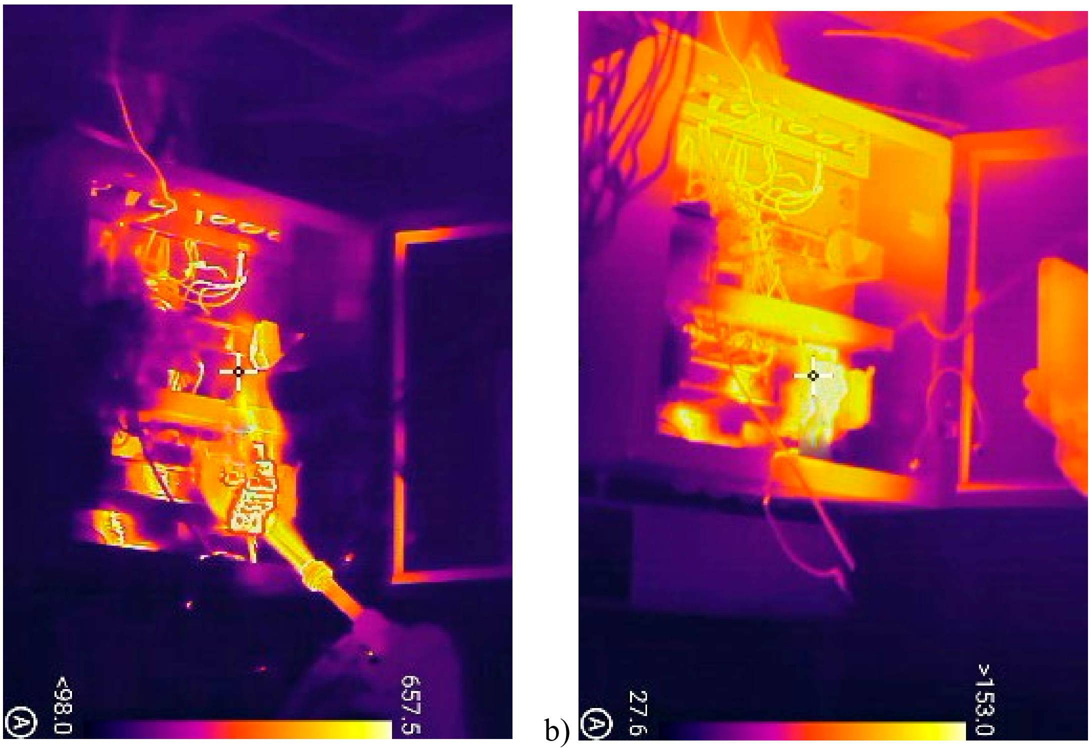
After the burner was removed (Fig. 7 b)), self-supported burning and formation of visible volatile combustion products (smoke) were observed for 1 min 25 s. It is worth noting the fact that the flame combustion was not supported by the circuit breaker housing, but it was supported directly by the mode switch (on/off), which was obviously fabricated of some combustible material. In this regard, the fire hazard of the input and distribution board increases significantly, and being fully equipped with circuit breakers it can become a source of fire spreading inside the premises of the mobile communications base station.



a) b)

Fig. 7. Experiment No. 7 on applying the test flame to the input board of a mobile communications base station: a) place of application of the test flame to the input board; b) reaction to fire of the input board.

The temperature distributions at the input board during its burning are shown in Fig. 8.



a) b)

Fig. 8. Temperature distributions at the input board: a) temperature distributions during the burner application; b) temperature distributions after the burner removal.

The temperature dependences on time at the monitoring points of the mobile communications base station derived during experiment No. 7 are presented in the form of graphs in Fig. 9.

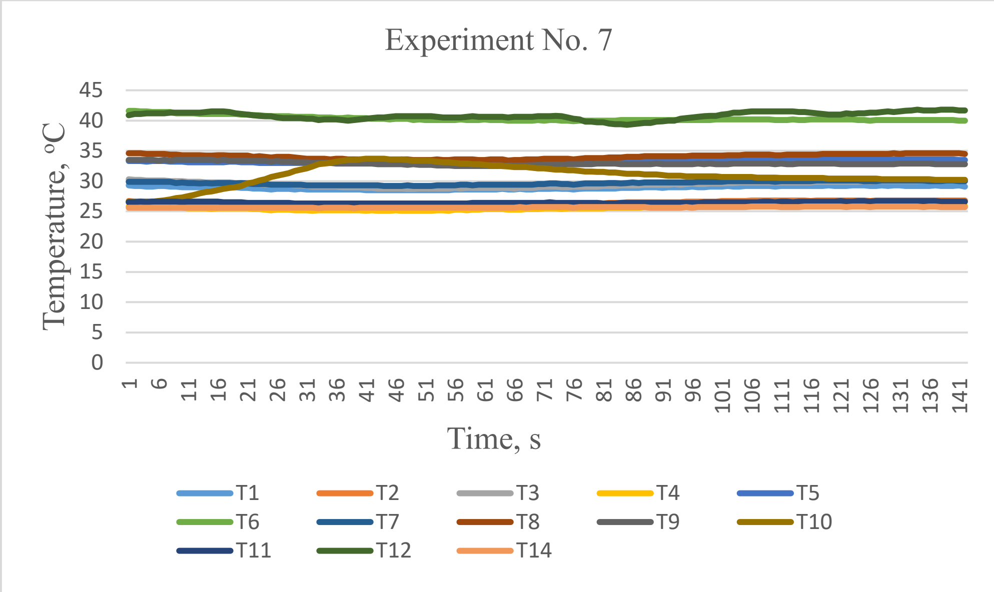


Fig. 9. Temperature vs. time dependences at the monitoring points of the mobile communications base station derived during experiment No. 7.

Thus, the graphs in Figure 9 show that the maximum temperature values of the elements of the mobile communications base station did not exceed the limit value of 70 ºC. The input and distribution board of the mobile communications base station did not contribute to the flame spreading beyond its housing. At that:

– Duration of the self-supported burning was 1 min 25 s which did exceed established limit value of 30 s;

– Heating temperature of any elements did not exceed 70 °C;

– Separation of some particles capable of ignition did take place; nevertheless, their ignition did not occur;

– Flame spreading from one element to other ones did not occur;

– Flame or fire spreading beyond the container structure was not observed;

– Upon cessation of the burning process, there was some soot on the surface of the electrical equipment having been exposed to fire.

Experiment No. 8: Application of the test flame to the air conditioner indoor unit of the mobile communications base station was done as specified by [9] technique.

After the burner was removed, self-supported burning and formation of visible volatile combustion products (smoke) were observed for 2 min 8 s. During this experiment, it was decided to use a fire extinguishing device. This is due to the fact that the flame was spreading intensively across the housing of the air conditioner indoor unit and this would later lead to the complete destruction of the housing as well as damage to the electrical wiring and lamps inside the premises of the mobile communications base station. The main fire hazard in the premises of the base station is the battery pack. Therefore, a decision was made to conduct a full experiment No. 9.

Experiment No. 9: Application of the test flame to the 12V 100 A#2 batteries of the PSS SHZh power supply cabinet of the mobile communications base station as per Fig. 10 a).

After the burner was removed (Fig. 10 b)), self-supported burning and formation of visible volatile combustion products (smoke) were observed for 13 min.

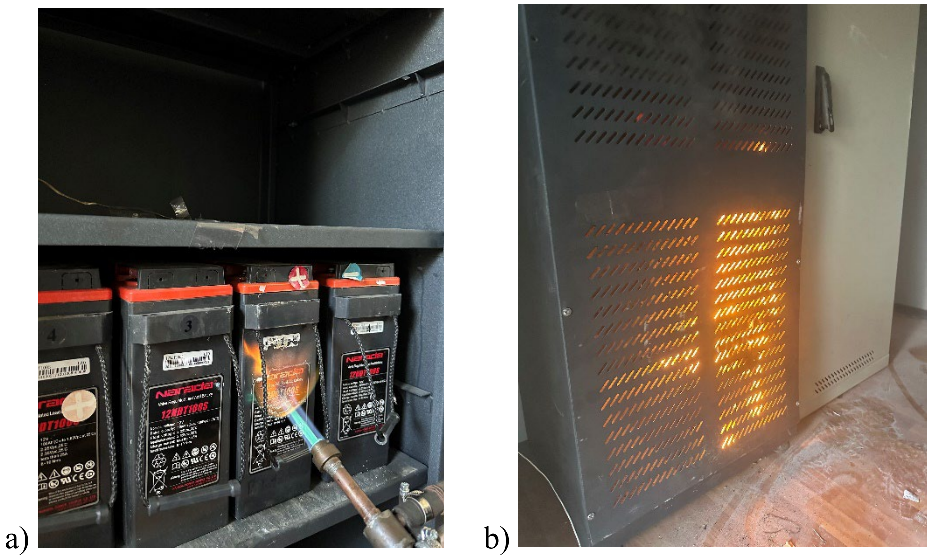


Fig. 10. Experiment No. 9 on applying the test flame to the 12V 100 A#2 batteries of the PSS SHZh power supply cabinet: a) place of application of the test flame to the 12V 100 A#2 batteries of the PSS SHZh power supply cabinet; b) reaction to fire of the 12V 100 A#2 batteries of the PSS SHZh power supply cabinet.

The temperature distributions at the 12V 100 A#2 batteries of the PSS SHZh power supply cabinet are shown in Fig. 11.

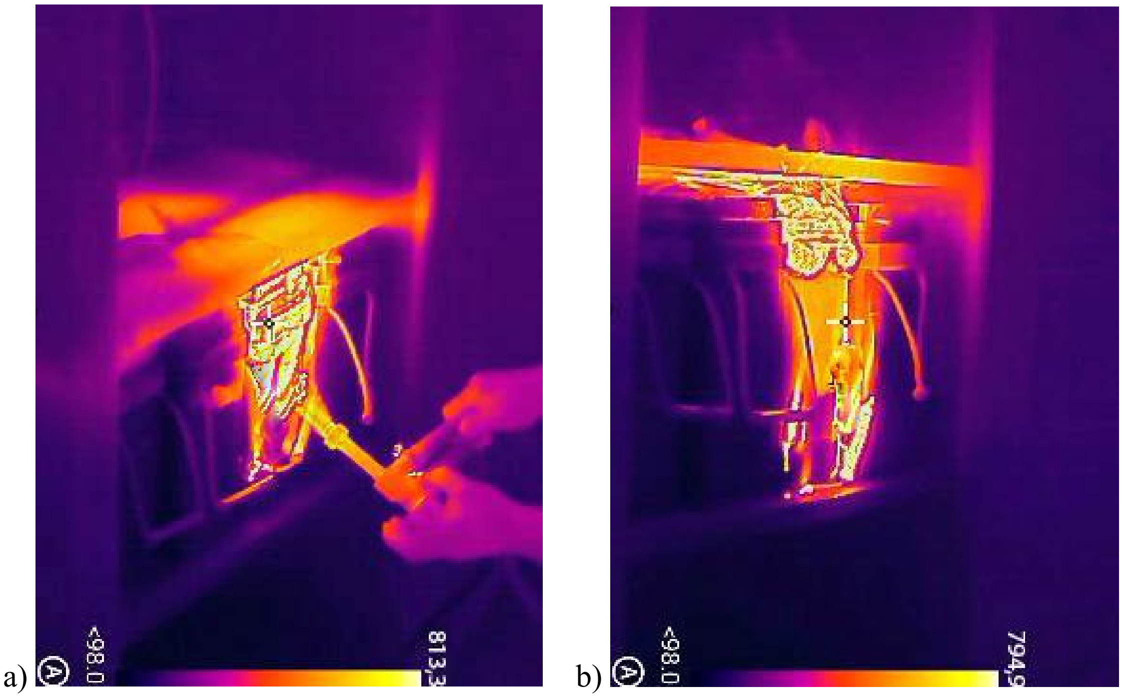


Fig. 11. Temperature distributions at the 12V 100 A#2 batteries of the PSS SHZh power supply cabinet: a) temperature distributions during the burner application; b) temperature distributions after the burner removal.

The temperature dependences on time at the monitoring points of the mobile communications base station derived during experiment No. 9 are presented in the form of graphs in Fig. 12.

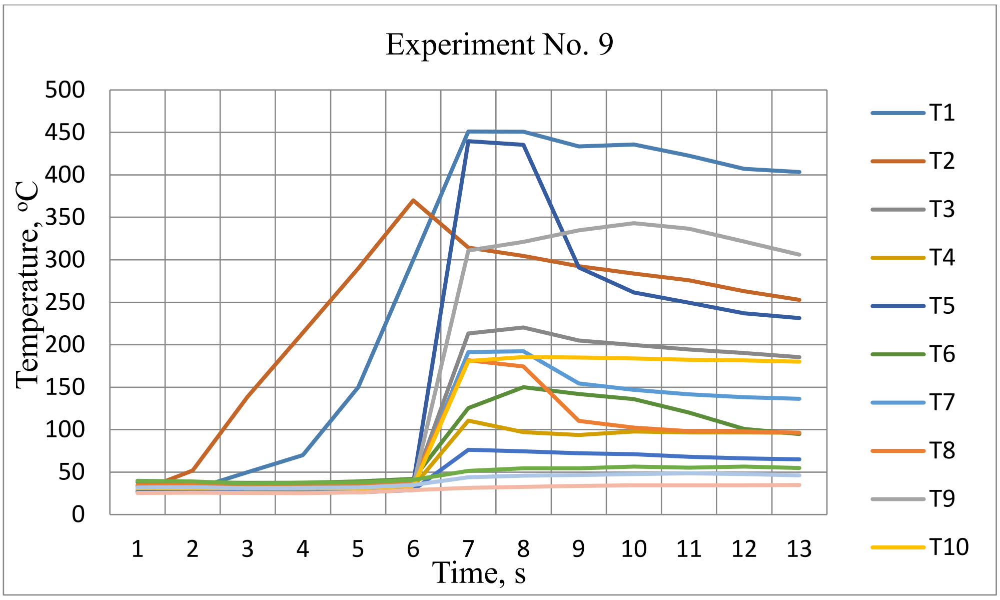


Fig. 12. Temperature vs. time dependences at the monitoring points of the mobile communications base station derived during experiment No. 9.

The graphs in Fig. 12 show that the maximum temperature values of the elements of the mobile communications base station exceeded the limit value of 70 °C. 9 min after the start of the research, there was a decrease in the temperature of the elements of the premises of the mobile communications base station which is associated with the burnout of the fire load.

After the smoke was exhausted and the container cooled, an external inspection was conducted (Fig. 13), which revealed:

– The unit of the air conditioner was damaged by the temperature effects of the fire and was hanging on by the power cable and refrigerant tubes; refrigerant from was leaking from the latter;

– Damage and sagging of the electrical wiring system inside the premises of the mobile communications base station;

– Thermal deformation of lighting fixtures and fire detectors;

– Soot deposition (which can contain corrosive combustion products) on the surfaces of the base station elements, its sources of guaranteed uninterrupted power supply, other elements, as well as on the surfaces of the container.

Fig. 13. Condition of the premises of the mobile communications base station caused by ignition of the 12V 100 A#2 batteries of the PSS SHZh power supply cabinet.

After opening the PSS SHZh power supply cabinet, the 12V 100 A#2 batteries looked as shown in Fig. 14.

Fig. 14. Condition of the 12V 100 A#2 batteries of the PSS SHZh power supply cabinet upon completion of experiment No. 9.

The overall temperature distribution in the mobile communications base station container during experiment No. 9 is shown in Fig. 15.

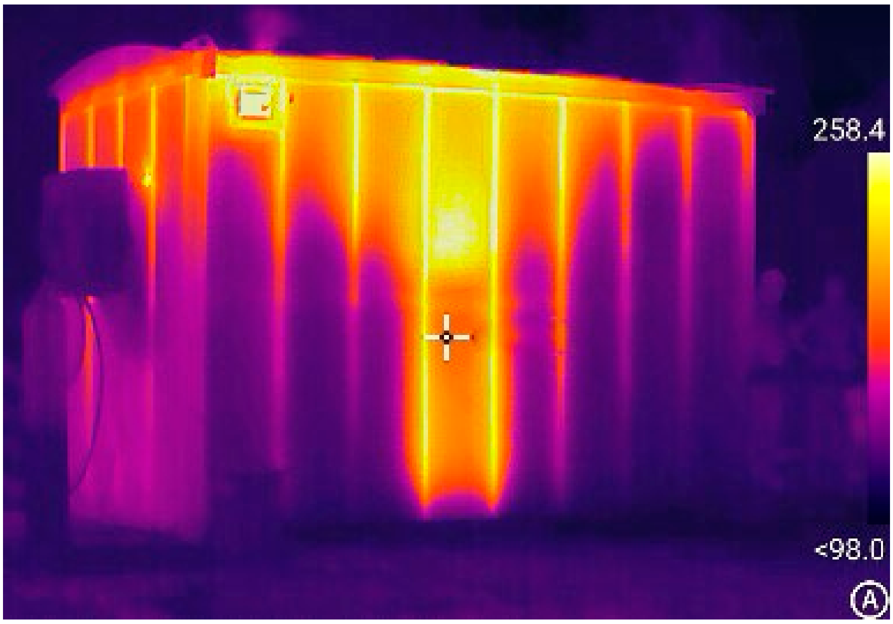


Fig. 15. Temperature distribution at the mobile communications base station during experiment No. 9.

Thus, burning of 12V 100 A#2 batteries of the PSS SHZh power supply cabinet of the mobile communications base station contributed to the flame spreading beyond the PSS SHZh power supply cabinet. At that:

– Duration of the self-supported burning was 13 min which did exceed established limit value of 30 s;

– Heating temperature of the elements did exceed 70 °C;

– Separation of some particles capable of ignition did take place, and this caused further ignition;

– Flame spreading from one element to other ones did occur;

– Floor ignition was not observed;

– Flame or fire spreading beyond the container structure did not take place; at that maximum surface temperature of the container external wall was ca. 80 °C which did not exceed the critical value of 250 °C;

– Upon cessation of the burning process, there was some soot on the surface of the electrical equipment having been exposed to fire;

– A large amount of volatile combustion products have formed; these have settled on the surface of electrical equipment and can be dangerous in terms of corrosive damage to this equipment.

Conclusion

1. Based upon the analysis of appropriate scientific literature and regulatory documents, it was found that the issue of fire hazard studying has not been studied sufficiently, and in addition, there existed a collision in the regulatory framework regarding the need to equip the premises of mobile communications base stations with automatic (self-contained) fire-fighting systems.

2. Telecommunication and electrotechnical equipment installed in the premises of mobile communications base stations being the most hazardous from the view-point of fire occurrence was revealed. A number of criteria for assessing the fire safety of such the premises were proposed. Some experimental studies were conducted in accordance with the previously developed program and methodology; it was found that the greatest fire hazard in the premises of the mobile communications base station was related to the following items: Alarm Box switchboard, input and distribution board, indoor air conditioner unit and 12V 100 A#2 batteries. Moreover, the last two contribute to the spreading of fire inside the premises.

3. According to the results of the experiment related to the ignition and subsequent burning of 12V 100 A#2 batteries, it was established that the fire spread throughout the premises of the mobile communications base station occurred with subsequent heating of the surface of the outer wall to a temperature of 80 °C, which did not exceed the critical one. Thus, the fire did not spread beyond the premises.

4. In the event of a fire in a typical mobile communications base station premises containing a list of equipment having been studied in the work, installation of an automatic (self-contained) fire-fighting system for such the premises in order to prevent fire from spreading beyond its boundaries is unreasonable.

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