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The Effect of Additives to the Primary Material of a Current-Carrying Conductor on the Heating Temperature of an Electrical Wire

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Abstract. The work investigates the effect of additives to the primary material of a current-carrying conductor on the heating temperature of an electrical wire, exemplified by a single-core aluminium wire with single-layer polyvinyl chloride insulation. It establishes the dependencies between the wire's heating temperature and its operating time under load currents that are lower, close to, and higher than the permissible levels set by regulations. The effect of chromium, vanadium, and titanium additives to the primary material of a current-carrying conductor on the wire's heating temperature during operation is also evaluated. Even small amounts of additives (less than 0.1 %) to the primary material of a current-carrying conductor can affect the heating temperature of the loaded wire. Chromium additives have the most effect, while titanium additives have the least effect. The study demonstrates that during operation, a loaded electrical wire heats the least if the primary material of its current-carrying conductor has none of the additives considered in the article.

1 Introduction

The Russian invasion of Ukraine has made the issue of ensuring fire and environmental safety at industrial and infrastructure facilities particularly urgent. Damage to chemical, oil refining, and energy facilities poses a risk of hazardous radioactive and chemical substance releases into the environment, along with the potential outbreak of fires of varying scales.

To reduce the effects of atmospheric and environmental pollution, algorithms are being used to identify hazardous factors [1], and various methods are being employed to predict the scale of pollution [2, 3]. For efficient monitoring of these hazardous conditions, remote sensing tools are being proposed to analyze the composition and concentration of harmful substances [4]. Additionally, to enhance the protection of facilities against fire, research is being carried out into the fire resistance of steel and reinforced concrete constructions [5, 6]. The potential use of silicate coatings is also being explored [7].

In today's conditions, special attention is being given to the functioning of the power supply system as a whole, and to the cable infrastructure as one of its key components. Ensuring the fire safety of cable products is one of the priority areas.

Cables and wires heat up under heavy current loads. The temperature can reach a level high enough to ignite the insulation, which may cause a fire [8–11]. Therefore, in practice, it's important to determine the temperature that a cable product will reach by the time the protective device activates in response to the fire hazard. Thus, determining the heating temperature of cable products during operation is a crucial task for ensuring fire safety.

When assessing the fire hazard of electrical wires, the primary physical characteristic of the metal in a current-carrying conductor is its electrical conductivity. The current-carrying conductor materials of wires must also meet other requirements dictated by the specifics of their operating conditions. To enhance properties such as corrosion resistance, mechanical strength, and heat