Determination of fire behavior of polymer cable materials and mathematical modeling of highly-filled halogen-free compound burning

Mikhail **SHUVALOV** (1), Mikhail **KAMENSKIY** (1), Aleksandr **KRYUCHKOV** (1),
Tatiana **STEPANOVA** (1), Andrey **FRIK** (1), Dmitry **SAVIN** (1)

1 VNIIKP, Moscow, Russia, shuvalov@vniikp.ru

Due to adverse combination of combustible cable polymer materials and ignition sources occurring under emergency operation conditions the cables become fire-hazardous objects. Moreover, taking into consideration that branched cable grids are not only bearers of fire risks but also channels along which fire can propagate in buildings and constructions, the improvement of cable fire safety characteristics is important problem at present.

The required level of fire safety of cable products is achieved mainly by using special highly-filled polymer materials. The behavior of a cable exposed to fire is determined by the material characteristics which have to be measured under controlled conditions simulating the effect of external thermal flow and flame and similar to the conditions of cable burning in fire. Such conditions are simulated while testing materials in a Cone Calorimeter. This instrument is used to measure the entire set of fire characteristics of a material, as well as to register the dynamic variations of measured parameters.

A comparative study of the fire parameters was carried out on a number of halogen-free materials that are used in fire performance cable constructions intended for various applications. The recommendations for choosing proper compounds to make insulation, filling and sheath and to design flame retardant cables are based on the results of the performed analysis.

The study results suggest that in designing cables, particularly cables insulated with cross-linked polyethylene which is the most combustible insulating material, it is essential to select filling and sheathing materials that have the lowest peak values of heat release rate and the longest periods of time it takes for these peak values to be achieved. Critical ratios of these values to ensure the compliance with the flame retardancy requirements for cable laid in bunches were revealed. The adequacy of the suggested approach to the selection of polymer materials at the stage of cable design is proved by the cable specimen test results.

A mathematical model was developed for the physical and chemical processes going on in a non charing halogen-free polymer material under exposure to flame. The model makes allowance for the transient heating of the material and the thermal decomposition of its basic components which is accompanied by a reduction of mass and thickness of the polymer part of the specimen.

Thermal analysis methods were used for experimental determination of the thermal decomposition kinetic parameters of halogen-free polymer materials (activation energy, rate constant for different stages of pyrolysis, thermal effect, etc.) which are required for mathematical modeling.

The simulation results are in satisfactory agreement with the cone-calorimetric experiments data.

The described approach to the mathematical modeling of the burning processes of halogen-free materials can be further used to investigate the combustion behavior of flame retardant cable products.