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NUMERICAL EVALUATION OF WIND SPEED INFLUENCE ON ACCIDENT TOXIC SPILL CONSEQUENCES SCALES

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Abstract – This study aims to evaluate numerically the influence of wind speed on scales of environmental harmful consequences caused by accidentally spilled toxic liquid evaporated from the surface of a free-form outlined spill spot. A coupled problem of the gas-dynamic movement of a toxic air-mixture cloud in the surface layer of the atmosphere under the influence of wind and a negative toxic inhalation impact on a human in an accident zone is solved by means of mathematical modelling and computer experiment. Physical processes of toxic liquid evaporation from the spill spot, formation of a mixture of toxic gas with the incoming air, and further dispersion of a hazardous gaseous chemical in the atmosphere under various wind speed conditions are investigated. A three-dimensional non-stationary mathematical model of the turbulent movement of a gas-air mixture is used for obtaining distribution of relative mass concentration of toxic gas impurities in time and space. The model takes into account the complex terrain, compressibility of the gas flow, three-dimensional and non-stationary nature of actual physical processes, different toxic properties of chemical substances, and arbitrary contour shape of the toxic spill spot. A probabilistic harmful impact model based on using a modernized probit analysis method is used to obtain fields of the conditional probability of a fatal human injury resulting from toxic gas inhalation. This model extracts relative mass concentration of toxic gas that could cause negative impact on humans at any control point during calculation time step exposition, collects integral toxic dose values from the multicomponent gas mixture dynamics model, calculates a value of the probit function for the corresponding toxic inhalation dose dangerous factor, and automatically assesses the human fatal injury conditional probability using partial cubic Hermitian spline. This technique allows environmental safety experts assessing the scale of considered type technogenic accident consequences numerically depending on wind speed conditions and elaborating the means to mitigate them to acceptable levels.

Keywords – *Accidental toxic spill; evaporation rate; gas-air mixture flow; hazardous area; inhalation toxic dose; lethal probability; mass concentration; numerical methods for solving partial differential equations; probit function; time of exposure; toxic gas*