Self-ignition of pressurized hydrogen released into open space through gradually rupturing diaphragm

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The study demonstrates 2D numerical modeling of gaseous hydrogen release under high pressure into atmosphere through circular hole with gradually rupturing diaphragm. The cases of release with different initial hydrogen pressures, up to 700 atm, different hole radii, 2 to 20 mm, as well as different diaphragm rupture times are considered. The characteristic flow structure is obtained, which enabled to reveal that the development of self-ignition kernel occur on the side surface of hydrogen flow, but not on its central part, as in the case of release with instantaneous diaphragm rupture. The limits of self-ignition are obtained by varying diaphragm rupture time (or rate) and initial hydrogen pressure for different hole radii. The significant convergence of limits in terms "rupture rate – hydrogen pressure" is revealed, when using sufficiently small hole radii, 10 mm. A criterion for self-ignition based on characteristic time scales is discussed. The obtained results could be useful for setup of laboratory experiments as well as evaluation of risks of hydrogen self-ignition during accidental depressurization of hydrogen storage systems or hydrogen pumping from the high-pressure vessel into the combustion chamber.

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