Progress in hydrogen safety

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Lecture introduces the fundamentals of the hydrogen safety engineering (HSE), i.e. application of scientific and engineering principles to the protection of life, property and environment. The overview of main physical phenomena is given: non-reacting hydrogen steady jets; unsteady blowdown of hydrogen from storage tank; spontaneous ignition; jet fires; and large-scale hydrogen-air deflagrations. The similarity law of Chen and Rodi for concentration decay in free jets is validated for the first time for highly underexpanded hydrogen jets, which parameters are calculated accounting for non-ideal behaviour of hydrogen by the Abel-Noble equation. A novel engineering correlation for jet fire flame length in the full range of conditions, and the nomogram for determination of hydrogen jet flame length by only real nozzle diameter and storage pressure are presented. The nomogram is a simple engineering tool convenient for use by hydrogen safety engineers and other stakeholders. The multi-phenomena turbulent burning velocity model for large eddy simulation of hydrogen-air deflagrations is described and its application to reproduce large-scale deflagrations in closed, semi-confined, and the open environment is demonstrated.