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High pressurized CO_2 release CFD calculations from onshore pipeline leakages

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Emissions from high pressurized pipelines can be determined on the basis of hydrodynamical and thermophysical calculations of the escaped fluid. If a rupture occurs when CO_2 is onshore transported in liquid form there will be initially a large pressure drop in the pipeline, the pressure will fall until the liquid becomes a mixture of saturated vapor/liquid. In the vicinity of the rupture, liquid CO_2 will escape and immediately vaporize and expand, some of the liquid will desublimate into dry ice, which will precipitate onto the ground [1, 2]. The period of time taken for a large amount of carbon dioxide to be discharged would be short. Initially CO_2 will escape by pushing the overlying soil upwards at an explosion-like speed. After the pressure in the pipe fell the flow profile of the escaping gas will almost be as described for gaseous material transport. The expansion of carbon dioxide will occur at sonic speed and will continue to do so until the pressure ratio between the CO_2 and the ambient air is lower than about 1.9 [3]. As a result of the expansion also the temperature of the escaping gas will fall drastically and a cloud of cold gas will form which is then dispersed and slowly mixed with ambient air. The rate of emptying the pipeline is controlled by the pipe cross-section area and the speed of the escaping gas, or by the pressure difference between the pipeline and the atmosphere. Therefore the mass flow will be largest immediately after the accident with an exponential decay in time.

In this study a two-phase model is applied to a high pressurized pipeline through which liquid carbon dioxide flows. A leakage is considered to be at different positions along the pipeline and the release pressure is calculated over several parameter ranges. It is also intended to characterize from hydrodynamical point of view the dispersion of released CO_2 in the ambient medium by means of CFD simulations which includes multiphase flow treatment. For that a turbulent two-phase CFD model is used to analyze the influence of the jet release pressure and leakage dimension on the harmful gaseous CO_2 concentration distances.

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