Etude de la dynamique et des conséquences d'une fuite massive d'air comprimé depuis un réservoir de stockage immergé

Doctorant·e
DEBERNE CAMILLE

Direction de thèse
BLAISOT JEAN-BERNARD (Directeur·trice de thèse)
BRANDLE DE MOTTA JORGE CESAR (Co-encadrant·e de thèse)
RENOULT MARIE-CHARLOTTE (Co-encadrant·e de thèse)

Date de la soutenance
18/03/2025 à 14:00

Lieu de la soutenance
CORIA, Avenue de l'Université, 76801 Saint-Étienne-du-Rouvray

Rapporteurs de la thèse
FOX RODNEY O. Université d'État de l'Iowa, Etats-Unis
OBLIGADO MARTIN École Centrale de Lille

Membres du jurys
BLAISOT JEAN-BERNARD, , URN - Université de Rouen Normandie
BRANDLE DE MOTTA JORGE CESAR, , URN - Université de Rouen Normandie
CHARTON SOPHIE, , CEA Marcoule
FOX RODNEY O., , Université d'État de l'Iowa, Etats-Unis
JOSSERAND CHRISTOPHE, , École Polytechnique, Palaiseau
NEU THIBAULT, , SEGULA Engineering
OBLIGADO MARTIN, , École Centrale de Lille
RENOULT MARIE-CHARLOTTE, , INSA Rouen Normandie

Abstract
The recent development of new submerged energy storage technologies, such as UnderWater Compressed Air Energy Storage (UWCAES) systems, necessitates risk analysis studies to address potential accidents that may arise due to the significant mechanical constraints of the seawater environment. For example, a rupture in the riser connecting the energy conversion platform to the underwater storage tanks could result in a substantial release of air at a great depth into the seawater, which would rapidly ascend to the surface due to buoyancy. In this work, a methodology is proposed to describe this incident scenario and predict its impacts. Since the governing mechanisms vary during the rise, distinct zones are identified where the airflow exhibits different characteristics. Various tools are used to accurately model the airflow in each zone, with special attention given to the bubble plume to provide both a macroscopic and microscopic description. First, a mathematical model is developed to predict the mass flow rate of compressed air from a massive leak in a submerged storage tank, as well as its discharge time. Second, the dynamics of isolated rising air bubbles in initially quiescent water are investigated through direct numerical simulation of the two-phase Navier-Stokes equations using the in-house code \textit{Archer}. Subsequently, the entire bubble plume is modeled by means of a computational approach based on the population balance modeling framework. Lastly, the established methodology is applied to a realistic case to highlight the key findings.