GAS AGENT RELEASE SIMULATIONS USING CFD

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***Abstract*– The answer to chemical and biological attacks relies on the ability to monitor and detect the presence of an agent. The aim of this study is to verify the efficacy of a subway smoke extraction system that contains a toxic gas contamination area. A Brazilian subway station located in Rio de Janeiro was selected as a model scenario. Three case studies were examined that activated the SES in exhaustion and ventilation modes. The visualization of the velocity fields and toxic gas concentration profiles showed that when the SES was activated in the extraction mode, it took a few minutes for all of the gas to be taken into the galleries. When the SES was activated in the ventilation mode, the contaminated air was directly disposed into the atmosphere. Therefore, our results show that CFD can be used to propose a contingency plan using the subways' ventilation equipment.**

***Keywords*– CFD, dispersion, chemical defense.**

I. INTRODUCTION

The new world order has enlarged the political, economic and military powers of the hegemonic nations. In addition, strong nationalisms and fundamentalisms have been rising, resulting in international terrorist actions around the world, such as suicide attacks using airplanes in New York and Washington and bomb explosions in Madrid and London. These events reveal that the national defense question is not only the concern of specialized groups, but is becoming a relevant matter to all citizens. Therefore, the scientific community must consider the security of the civilian population and work to find solutions to terrorist attacks.

In particular, the answer to chemical and biological attacks requires the ability to monitor and detect the presence of agents (Fitch *et al*., 2003), to restrict the affected area and to identify the people exposed to the agent. This must be done prior to the decontamination of people, equipment and construction.

In fact, new and sophisticated techniques of chemical and biological defense (CB) have been developed (Shenoi, 2003; Bhalla and Warheit, 2004). The sensitivity, automation and reliability of detection systems and agent identification methods have improved. Several dispersion models and simulations of chemical warfare have been carried out (Scorpio *et al*., 2003), which has facilitated the process of sensor positioning, in addition to other improvements.

Computational fluid dynamics (CFD) is a powerful tool that can be used to simulate chemical and biological attacks, which can occur in a variety of situations ranging from indoor scenarios (Fitch *et al*., 2003; Zhao *et al*., 2004) to attacks on continents. Indoor environmental studies investigate heating, ventilation, and air conditioning (HVAC) issues and do not demand massive computation.

There are some studies that the validation is not possible. They are just the defense and hazardous studies. It can be cited Kukkonen *et al*. (2001), Scorpio *et al*. (2003) and Zhao *et al*. (2004). In the first article, the atmospheric dispersion of Sarin was carried out. In the second, the authors studied the release of a bio-agent in a room. And in the third, the authors determined a ventilation strategy to defend indoor environment against contamination by a contaminant source.

The aim of this work is to use CFD tools to simulate a toxic gas release event in a Brazilian subway station located in Afonso Pena's station in Rio de Janeiro. To reach this objective, the simulation work was divided into three main parts: *i*) establish subway station geometries and boundary conditions; *ii*) choose a satisfactory turbulence model to model the airflow; and *iii*) choose an optimal grid for the finite volume algorithm. For the first part, the data on the station's geometry were collected *in loco* in addition to the information on the ventilation/exhaustion systems located in the adjacent train tunnels. In order to select satisfactory fluid dynamics conditions, experiments were conducted using LVEL and κ-ε turbulence models. The chosen grid was structured and non-uniform so it would be possible to compute the more detailed fields near the release area and around obstacles. Finally, the analysis of the resulting data was made by visualizing the velocity fields and the toxic gas concentration profiles. The present study is a CFD simulation and further experimental analysis should be performed.

II. FUNDAMETALS

A. Contingency Plan

A terrorist attack can be treated like a disaster event, thus one may assume that the procedures used to deal with both types of situations are similar. Risk analysis indicates that a contingency plan should be composed of four phases: notification, first-response, characterization and restoration (decontamination and remediation) (Fitch *et al*., 2003; Raber *et al*., 2002).

The first necessary condition prior to forming a decision-making framework is the ability to detect a chemical or biological agent. After that, notification is possible. The first-response phase is composed of emergency actions that public health departments must carry out. Finally, the characterization and restoration phases include dispersion modeling and simulation of warfare contamination agents. This can include flow fields and