Chemical Security Analysis Center – Ammonia Safety and Training Institute Cooperative Research and Development

Science and Technology

COOPERATIVE RESEARCH AND DEVELOPMENT BACKGROUND

Anhydrous ammonia is produced and transported across the nation to be used for fertilizer, as a refrigerant, and as a feedstock for making explosives and pharmaceuticals. There is increasing interest in utilizing anhydrous ammonia as an alternative zero-carbon emission energy source. Transport of this toxic industrial chemical occurs via pressurized pipelines, rail cars, highway tanker trucks, nurse tanks, and refrigerated barges. Given the current volume in production, transport, and storage coupled with projected increased demand of ammonia as an alternative fuel, the impact to public health and safety from an accidental or intentional large-scale release of this chemical must be well-characterized.

According to the National Response Center data archive, small-scale ammonia releases resulting in hospitalizations and fatalities occur more frequently at the end of the agriculture and refrigeration ammonia supply chain. Major accidental releases periodically occur although not regularly in the U.S. While there has been no reported terrorist attack on the chemical supply chain, concerns for use of ammonia to inflict mass casualties do exist because of **widespread availability of bulk volumes of ammonia in population-dense areas coupled with ammonia toxicity**.

The Department of Homeland Security (DHS) Science and Technology Directorate's Chemical Security Analysis Center (CSAC) is the nation's only federal studies, analysis, and knowledge management center for assessing the threats and hazards associated with an accidental or intentional large-scale chemical event or chemical terrorism event in the U.S. CSAC applies atmospheric transport and dispersion (ATD) models for purposes of chemical release consequence modeling.

CSAC entered a Cooperative Research and Development Agreement (CRADA) with the Ammonia Safety and Training Institute (ASTI) in July 2022 under the authority of the U.S. Federal Technology Transfer Act of 1986. ASTI is a 501(c)(3) non-profit organization dedicated to making ammonia the most safely managed chemical in the world. ASTI focuses its training on improving emergency response.

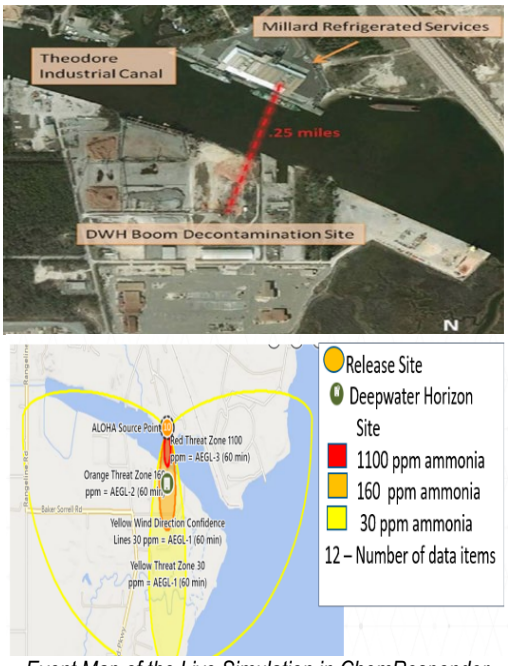
Under this CRADA (21-CSAC-001), the parties collaborated on two specific activities, working at the intersection of ATD modeling and emergency response:

- The Application of the ChemResponder Software Tool During Incident Response
- Improving Response in Water Proximate Situations

The goal of the collaboration was to use modeling to improve emergency response and conversely to allow emergency response needs to drive improved modeling and model development.

KEY FINDINGS FROM THE APPLICATION OF CHEMRESPONDER DURING INCIDENT RESPONSE

Having a Common Operating Picture (COP) is critical for execution of emergency response Concepts of Operation (CONOPS). ChemResponder is a Federal Emergency Management Agency (FEMA)-developed COP platform, which is made available to state, local, territorial, and tribal responders to help in emergency planning. ChemResponder includes the capability to visualize chemical plumes and to input chemical and meteorological data. Under this CRADA, the possible use of ChemResponder during an actual ammonia large scale release incident was examined.



Event Map of the Live Simulation in ChemResponder

The CRADA partners researched all available information on the 2010 ammonia release from the Millard Refrigerated Services Corporation, Theodore, AL, to include information on the location of downwind casualties, the severity of the injuries, and the local meteorological conditions at the time of the release. Using event recreation, CSAC simulated the release with ChemResponder, employing the pre-planned ammonia response CONOPS. ChemResponder was used to provide an on-going situational status and present plume modeling results. The response improvement was then measured. **It was shown that use of ChemResponder with this CONOPS can result in the shortening of the time required to reach a shelter-in-place decision and to notify people in the area.**

This simulation was subsequently utilized in a tabletop exercise (TTX) based on the Millard incident. A group of responders and emergency management officials attending a crisis communications workshop supported by ASTI were enlisted to take part in the TTX. The purpose of the TTX was to evaluate the appropriateness of the simulation with respect to the emergency response decisions made in the simulation. **Activities that would be necessary in the deployment of ChemResponder to make it useful during a large-scale chemical release incident were identified.**

This work applies to other tools designed to provide responders with a COP. FEMA participated in the TTX and received the TTX findings and simulation results.

MAJOR OUTCOMES FROM RESEARCH ON IMPROVING RESPONSE IN WATER PROXIMATE SITUATIONS

Most U.S. ammonia production occurs along its coastlines. Large quantities of ammonia are imported or exported from U.S. ports. Ammonia production with the associated storage and handling at U.S. ports is expected to increase dramatically as ammonia is adopted as a non-carbon fuel alternative.

While the transport and dispersion of ammonia in dry conditions is well understood, this is not the case when humid conditions exist or in situations where water bodies influence plume dynamics. **The CRADA sought to better understand the burgeoning ammonia energy picture with its significant water proximate presence, examine ATD aspects of large-scale ammonia releases in water proximate environments, and identify emergency response implications in water proximate situations.**

ASTI-facilitated forums were held during which industry experts shared plans to support anticipated application of ammonia as an alternate energy source. This included conversation with both domestic and foreign organizations involved in ammonia production and transport.

The planned increase in ammonia production at locations near major U.S. Gulf Coast ports was evidenced as was the planning for U.S. ammonia export from these ports. Therefore, **the consideration of ammonia in both filling and fueling as a source of increased ammonia release risk was explored**.

A worldwide historical review was conducted of major ammonia releases that occurred near water bodies with a focus on incidents at ports. Incidents were researched to obtain details, such as the meteorological conditions that existed at the time of the release such that plumes of the events could be constructed. Each event was studied to ascertain what might be learned about ammonia transport and reactivity in the atmosphere when the ammonia plume traveled over or alongside water bodies.

Ammonia release at Puerto Mejillones, Chile

Based on the examination of large-scale ammonia incidents in water proximate situations, CSAC assessed the handling of these situations by widely used ATD models such as Areal Locations of Hazardous Atmospheres (ALOHA) and Hazard Prediction & Assessment Capability (HPAC) and identified knowledge gaps.

To complete the CRADA work, ASTI created a reference document that captures information relevant to conducting emergency response in water proximate situations. It describes the application of expedient emergency response methodology and presents research findings. Its goal is to better prepare responders for operations in water proximate conditions.