Transportation Security Administration

Improving Consequence Analysis for Large TIH Releases

16th Conference on Air Pollution Meteorology

Jan 19, 2010

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Risk = Threat x Vulnerability x Consequence

- Tank Car Vulnerability
- Understanding Consequence of a Catastrophic TIH Release
- Reducing Consequences by Increasing Emergency Response Preparedness
- Reducing Consequences by Improving Regulations

Understanding and Reducing TIH Rail Tank Car Vulnerability TSA – DHS Projects

- TIH Material Tank Car Threat Assessment Project – FBI, TSA, DHS S&T, DOD, DOT
- Tank Car Vulnerability Assessment Project – TSA, DHS S&T, FBI, FRA, DOD
- Rail Car and Stationary Storage Tank Mitigation Technology Integration Project - (.50 caliber AP and small IED) – IP, S&T, TSA, TSL, DOD
- Industry Programs:
  - DOW/UP/UTC Next Generation Tank Car
  - Advanced Tank Car Collaborative Research Program – ACC, AAR, CI TFI, RSI

Consequence Modeling

Are the current transport and diffusion models adequate?

- Evidence against the models is circumstantial, not scientific
- Primary evidence is the low number of deaths
- Differences between accidents and model results could arise at any step in the modeling process, not just T&D
- There have been no large Chlorine Tests applicable to this problem
- Recent mid-scale (1 ton) tests have highlighted the unknowns but don't provide a clear direction for future testing

The TSA Technical Approach

- Assemble a team of experts across a range of specialties
- Seek out established experts skeptical of current approach
- Develop relationships with key organizations
- Glean all of the available data from accidental releases
- Identify the key data and modeling gaps
- Develop a series of hypothesis that are useful and plausible
- Lead a testing effort to support/refute the hypothesis
- Document and disseminate the results

Current TSA Focus Areas

Understanding DELAYED Dispersion from the Release Site

t=0 t=5 min t=30 min t= 60 min

Typical: t=0 20% vapor/ 80% liquid

Empty Time = 1 -10 min

Tank Full → Tank Empty

Analyze Evaporation, Droplets, Rainout as a function of time

Set Initial Conditions

- Lading, Air Temperatures
- Hole Size & Configuration
- Release amt (60 tons)
- Release type (impeded)
- Ambient winds (H, M, L)
- Terrain & obstructions at release site

Areas of Study

IF

Fast Evaporation Vapor Cloud

- Wind (H, M, L)
- Reactivity Importance
- Impact of structures and barriers
- Sun impact
- Toxicity

Mist Cloud Low Rainout

- Wind ability to move mist cloud
- Mist cloud persistence
- Reactivity Importance
- Impact of gravity on cloud movement
- Impact of structures, barriers, low areas
- Sun impact

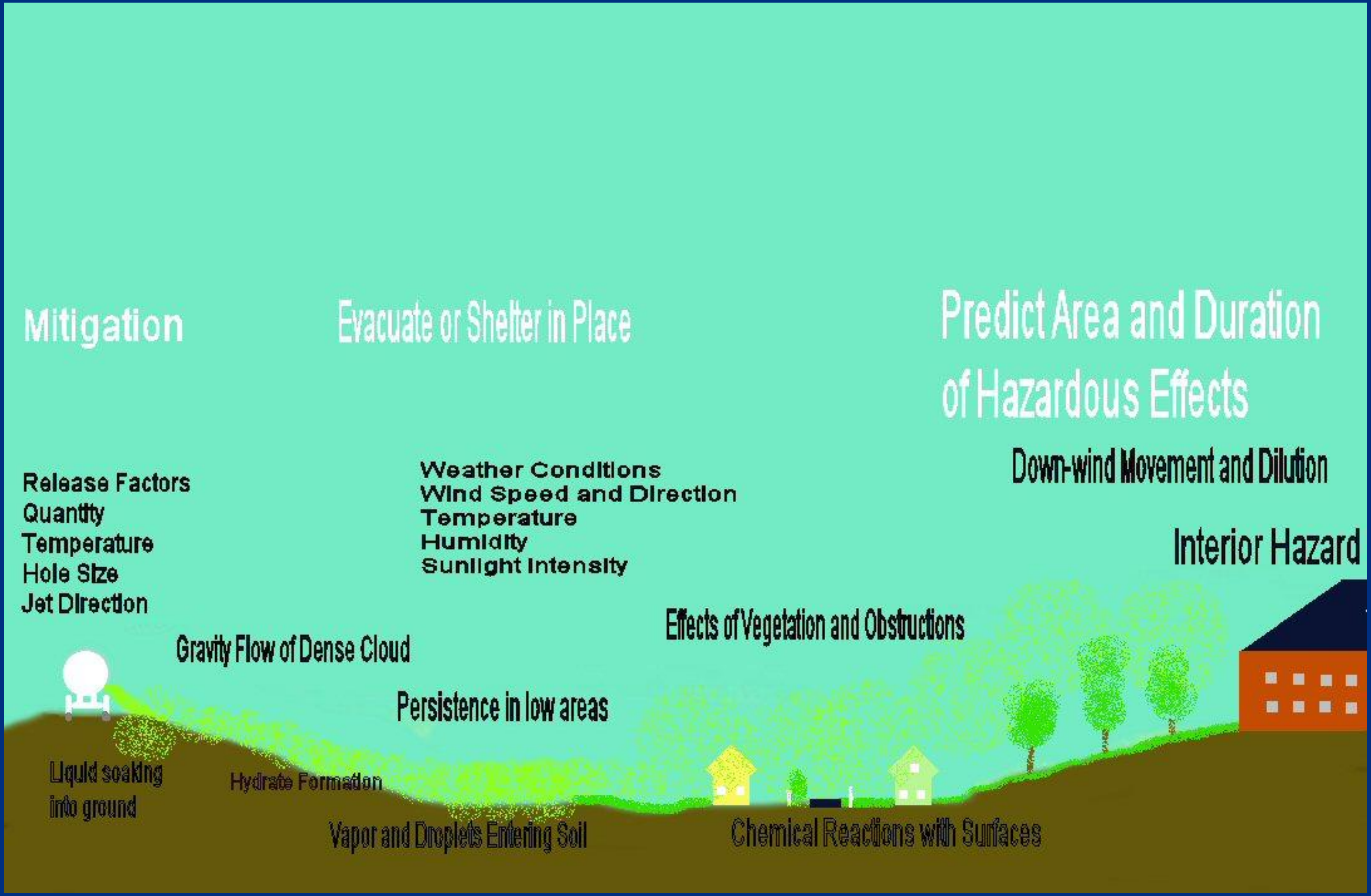
Mist Cloud High Rainout

- All above
- Amount of rainout
- Evaporation of rainout

Liquid Pooling

- Evaporation of pool

Overview of Problem Space



DHS S&T CSAC - Modeling of Large Scale Toxic Inhalation Hazard Transport Releases

Source Terms

- Mass Flow/Empty Rate
- Very Low Wind Speeds
- Stable Stratification
- Mist Cloud Over Source
- Jet Direction
- Impingement
- Air Entrainment
- Droplet Size/Rainout
- Pool Formation

Removal Mechanisms

- Chemical Reactions
  - Vegetation
  - Ground/Soil
  - Water
  - Building Materials
  - Atmospheric
- Soil Absorption
- Water Submersion
- Photolysis (+ rxn)

Other

- Toxicity
- Breaching Conditions
- Transport Temperature
- Physical Barriers
- Terrain Effects
- Transition: SEM T&D
- Targeted Accident Data

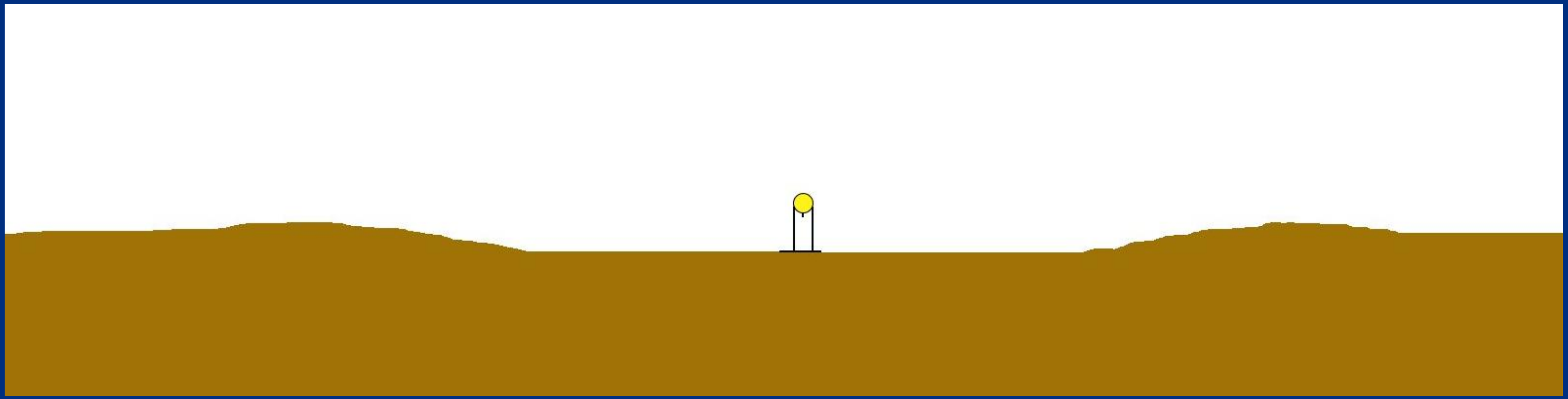
Observations and Hypotheses

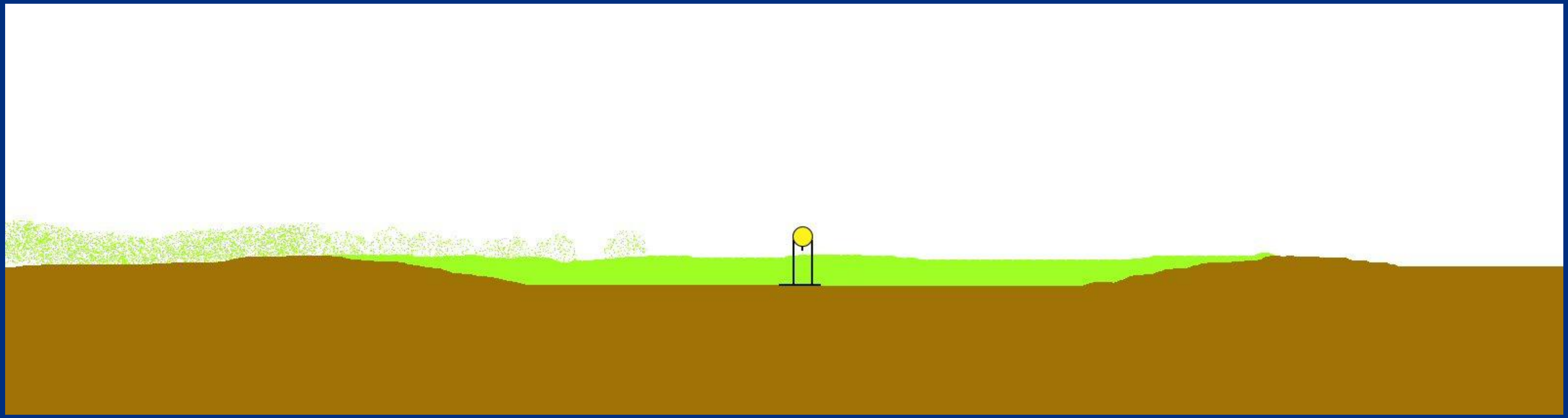
- Lethal effects are in the near field (~500 meters)
- Chlorine vapor and aerosols are dense and initially flow with gravity
- Dispersion models use source terms which are not valid for large release of liquid chlorine
- Large releases, due to slow kinetics of heat absorption, form stable source blankets that persist for minutes to hours
- Each release of a large amount of liquid chlorine is unique and dependent on chlorine temperature, topography, environmental conditions such as temperature, humidity, solar radiation, etc
- No single general scenario will apply, but a "perfect storm" is possible, and the possibility could be enhanced by careful selection of attack site.

April 2010 DPG Field Test

- Improved understanding of 2-phase dense gas source term
  - Attempt to reproduce large-scale phenomena at a reduced scale
    - Restrict cloud spread with embankment
    - Release in low-wind low-turbulence conditions
  - Observations and measurements of Dense Gas /Aerosol cloud
    - Attempt to measure conditions inside cloud
    - Measure evolution and dispersion down-wind
  - Evaluation of detection and sampling systems
    - Preparation for follow-on tests
- Comparison of 2 TIH materials
  - Chlorine
    - 4 Releases, 2 Tons each
  - Anhydrous Ammonia
    - 4 Releases, 2 Tons each

Proposed Test Release Configuration





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Testable Results of Impounded Release

- Mist is very dense, 8 to 17 times more dense than air (samplers)
- Mist will flow due to gravity (cameras)
- Mist will pool in low areas (cameras, detectors)
- Mist keeps a very high Chlorine concentration in contact with the ground for long periods. (surface plates)
- Mist temperature below b.p. of Chlorine, -34C (Thermocouples)
- Mist is very stratified and shallow (cameras, samplers)
- Vapor generated by ground heat will cause turbulence within the cloud, mixing it (in-pool anemometers)
- Cold vapor layer will form on top of mist, reducing vertical entrainment (samplers, cameras)
- Air movement over the mist will carry off vapor and provide additional spreading force (cameras, detectors, stand-off)
- Mist acts as a reservoir of released material, buffering and localizing the effects (detectors, stand-off)

Emergency Preparedness

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Emergency Response to Catastrophic TIH Material Release – Identified Gaps

- Inadequate understanding by First Responders of the TIH cloud behavior and impact
- Insufficient community outreach
- Inadequate catastrophic release emergency response procedures
- Insufficient emergency response equipment
- Insufficient knowledge by the local emergency response officials of the locations and movements of TIH tank cars
- Insufficient coordination with local public health officials

Participants in Emergency Preparedness Effort

- TSA – Jack Aherne
- DOT FRA – Bill Schoonover
- DOT PHMSA – Tonya Schreiber
- DHS Emergency Services Sector – Colleen Mall
- City of Chicago – Haz Mat Chief Dan O'Connell
- City of Chicago OEMC -
- Illinois MABA – Chief Jay Reardon
- International Association of Fire Chiefs – Chief Tim Butters
- FEMA
- DHS IP

Next Steps

- Monitor test preparation and conduct
- Coordinate activities of other organizations
- Disseminate and analyze test data
- Develop plans for follow-on testing

TSA - Jack Aherne – Project Lead

Northrop Grumman - Curtis Schuhmacher - Technical Lead

DHS Chemical Security Analysis Center (CSAC) – Dr. Shannon Fox; Dr. Steve Chesler

Homeland Security Institute – Dr. Joe Chang

University of Arkansas - Dr. Tom Spicer

Naval Surface Warfare Center, Dahlgren - Tim Bauer

Center for Toxicology and Environmental Health (CTEH) - Dyron Hamlin

Hanna Consultants – Dr. Steve Hanna

Dow Chemical - Kay Koslan

Johns Hopkins Applied Physics Lab – Dr. Dave Lawrence

National Center for Medical Intelligence (NCMI) – Dr. John Cockayne

University of Cambridge/MIT – Dr. Rex Britter

Metcorps - Dr. Bruce Hicks

U.S. Army NGIC, Charlottesville, VA – Dr. Rick Babarsky

Institute for Defense Analyses (IDA) –Dr. Kimberly Papadantonakis; Dr. Jeff Urban

Argonne National Labs – Dr. Dave Brown (NAERG)

Hazard Analysis Consulting - Dr. Ron Koopman

Defense Threat Reduction Agency (DTRA) - Rick Fry

Naval Research Laboratory – Dr. Jay Boris