

# **HAZARD ANALYSIS**

## **Toxic Industrial Chemicals**

### **IDENTIFICATION AND MODELING**

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June 18, 2002

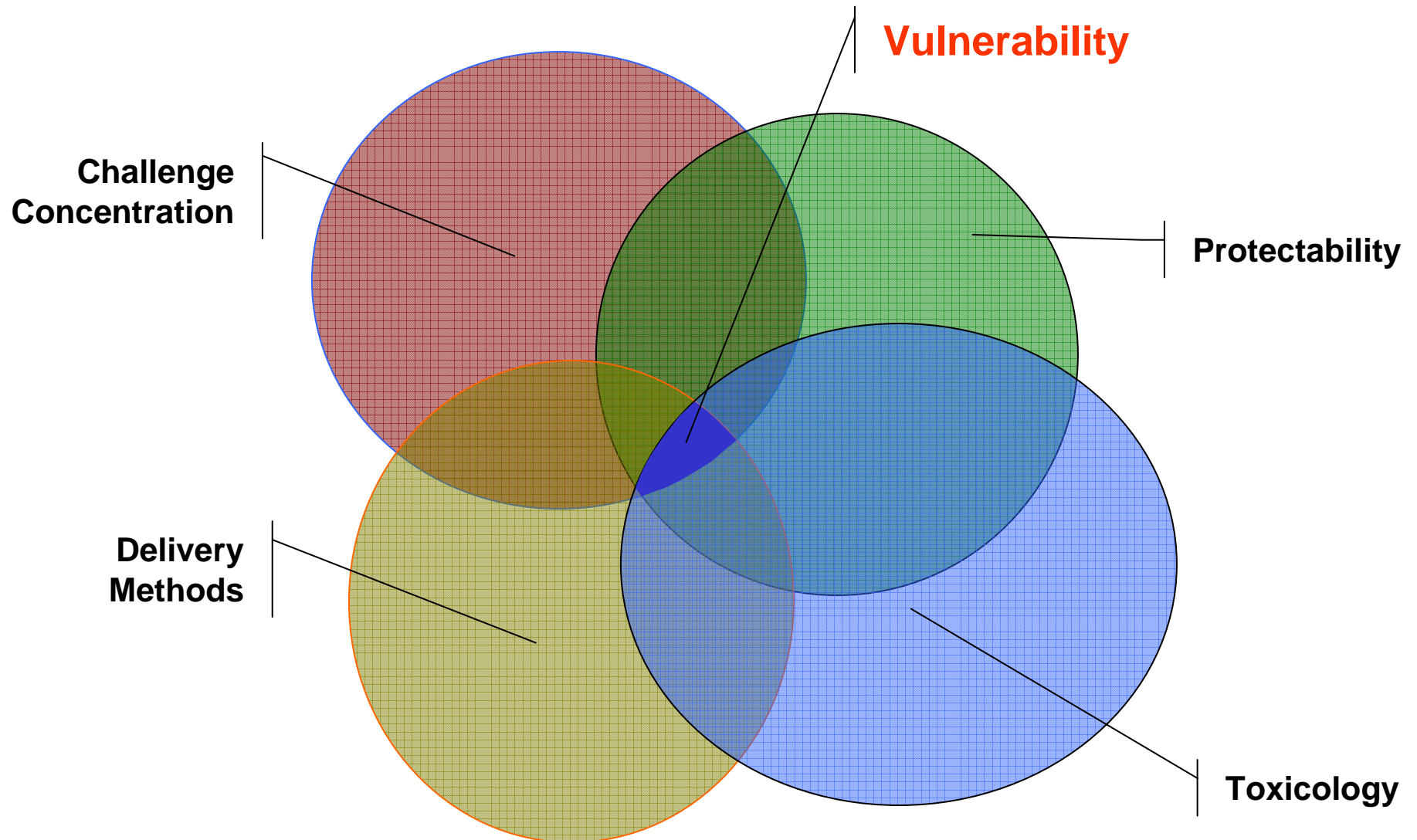
# OVERVIEW

- Objectives and Purpose
- Warm Zone Strategy
- Proposed Assessment Methodology
- Model Estimations
- Data Needs
- Discussion
- Conclusions

# OVERVIEW

- Purpose
- Vulnerability Assessment
- Chemicals of Interest
- Scenarios
- Hot Zone Modeling
- Vapor Concentration-Time Profiles
- Conclusions

# Vulnerability Assessment



# **TOXICOLOGY**

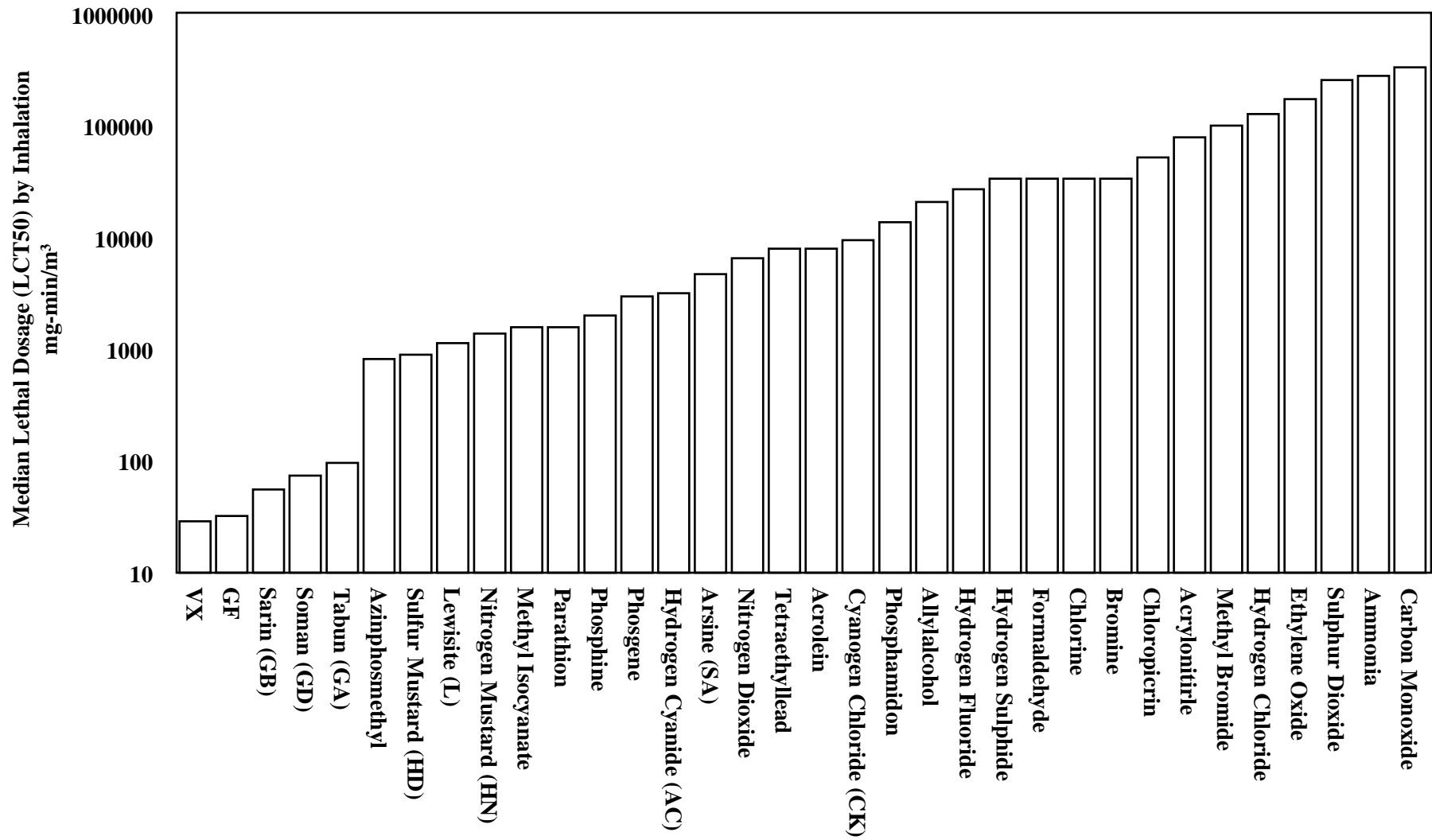
**What is it?**

**How Much is there?**

**How long are you exposed?**

**What routes of entry?**

# Relative Inhalation Toxicities



# CWA Physical Properties

Chemical Name	Mole Wt. (g/mole)	VP (mm Hg @ 20 °C)	Volatility (g/m <sup>3</sup> )
Sarin (GB)	140.1	2.1	16
Soman (GD)	182.18	0.40	3.9
Sulfur Mustard (HD)	159.08	0.072	0.63
Cyanogen Chloride (CK)	61.47	~880	~2945

# NIOSH List of Respirable TIC

- Ammonia
- Cyclohexane
- Carbon Tetrachloride
- Cyanogen Chloride
- Ethylene Oxide
- Formaldehyde
- Hydrogen Cyanide
- Hydrogen Sulfide
- Nitrogen Dioxide
- Phosgene
- Phosphine
- Sulfur Dioxide



# Physical Properties

Chemical Name	Mole Wt. (g/mole)	VP (mm Hg @ 21.1 °C)	Volatility (g/m <sup>3</sup> )
Ammonia	17.03	6660.8	6200
Cyclohexane	84.16	~100	~458
Carbon Tetrachloride	153.82	~95	~796
Cyanogen Chloride	61.47	~880	~2945
Ethylene Oxide	44.05	~1100	~2640
Formaldehyde	30.03	>760	>1250

# Physical Properties

Chemical Name	Mole Wt. (g/mole)	VP (mm Hg @ 21.1 °C)	Volatility (g/m <sup>3</sup> )
Hydrogen Cyanide	27.03	~650	~1000
Hydrogen Sulfide	34.08	13792	25688
Nitrogen Dioxide	46.01	760	1810
Phosgene	98.92	1313	6568
Phosphine	34	~30650	57000
Sulfur Dioxide	64.07	2539	8515

# **DELIVERY METHODS**

**Spill**

**Spray**

**Explosive**

**Pressurized Cylinders**

# **Challenge Concentration**

**Venue**

**Location of Casualties**

**Amount and type of Hazard**

# Venues Considered

- Large Meeting Room
- Auditorium/Theater
- Office Building
- Airport Concourse
- Shopping Mall Store
- Shopping Mall Food Court

# TIC ASSUMPTIONS

- Mass function of container size and type
- Rate of Mass release – dependent on method of dissemination
- Compressed gas discharge rates dependent on TIC, pressure, temperature, valve size, etc.

# TIC ASSUMPTIONS

- Choke Flow Equations
- Ventilation kinetics  
drastically influence vapor  
TIC concentrations
- Heavy gas not factored in  
these initial calculations.

# INDOOR SCENARIO COMPLEXITIES

- Building Structure
- Compartmentalization
- Ventilation Characteristics
- Source Type and Location
- Remediation Techniques



## VENUES

INDOOR (Reference)	IDENTIFICATION	INCIDENT SITE L-W-H (ft <sup>3</sup> )	VENTILATION NEEDS	TOTAL VOLUME (ft <sup>3</sup> )	HVAC SERVICED ROOMS
1	Meeting room 1 (MR1)	51-68-11	15% OA* 3500 cfm	38,148	1
	Meeting room 2 (MR2)	51-68-11	15% OA 25,000 cfm total	160,000	4
2	Auditorium/theater 1 (A1)	130-84-40	15% OA 3640 cfm	436,800	1
3	Office Building 1 (OB1)	50-6-8.5 (Hallway)	15% OA 63,500 cfm total	75,000	12 different room sizes
5	Office Building 2 (OB2)	10-10-10	20% OA 120 cfm	20,000	20
4	Airport Concourse (AC)	160-128-33	5% OA 9,100 cfm	389,120 HVAC off	1
5	Shopping Mall Store1 (SM1)	30-100-10	25% OA 3000 cfm	30,000	1
2	Shopping Mall Food Court (SMFC)	100-50-20	25% OA 3300 cfm	100,000	1

\* = Outside Air

## SOURCE DESCRIPTIONS

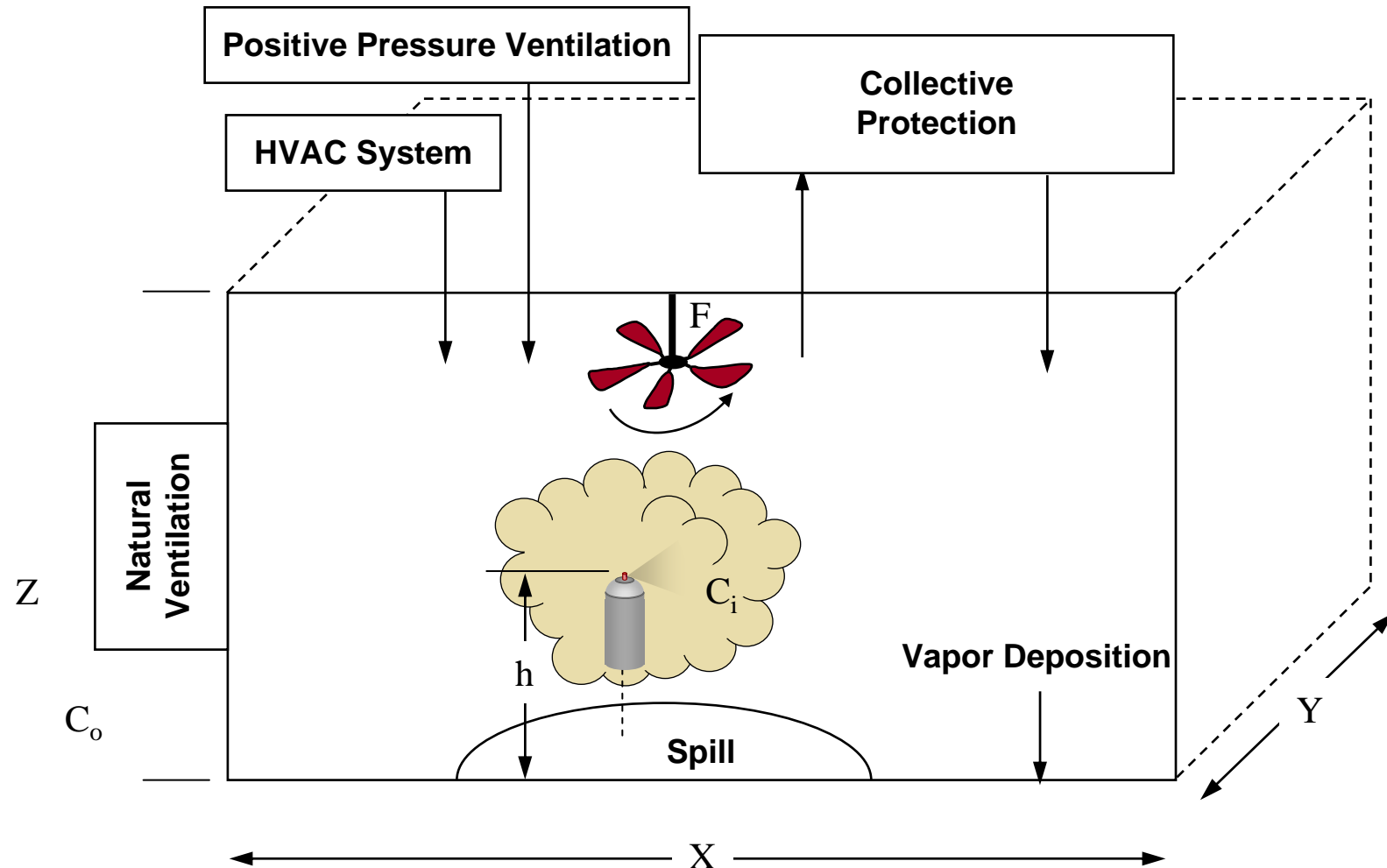
INDOOR VENUE	IDENTIFICATION	AMOUNT	METHOD	RELEASE TIME (SEC)	WHERE	PLACEMENT
MR1	BOTTLE	1 LITER	SPILL	1	FLOOR	CENTER
“	“	1 LITER	EXPLOSIVE	1	FLOOR	CENTER
“	“	1 LITER	SPRAY	120	1 FT- FLOOR	CENTER
MR2	BOTTLE	1 LITER	SPILL	1	HVAC	RM 1 DUCT
“	“	1 LITER	EXPLOSIVE	1	HVAC	RM 1 DUCT
“	“	1 LITER	SPRAY	120	HVAC	RM 1 DUCT
A1	“	1 LITER	SPILL	1	FLOOR	CENTER
“	“	1 LITER	EXPLOSIVE	1	FLOOR	CENTER
“	“	1 LITER	SPRAY	120	HVAC	DUCT
“	“	4 LITERS	EXPLOSIVE	1	FLOOR	CENTER
OB1	BOTTLE	0.5 LITER	SPRAY	3000	CORRIDOR	CENTER
“	“	0.5 LITER	SPRAY	600	CORRIDOR	CENTER
“	“	0.5 LITER	SPRAY	600	HVAC	AHU *
OB2	BOTTLE	1 LITER	EXPLOSIVE	1	ROOM 1	CENTER
“	“	1 LITER	SPRAY	600	ROOM 1 1 FT-FLOOR	CENTER
AC	KNAPSACK	25 LBS	EXPLOSIVE	1	FLOOR	CENTER
“	“	25 LBS	SPRAY	600	FLOOR	CENTER
“	PULL LUGGAGE	50 LBS	EXPLOSIVE	1	FLOOR	CENTER
“	LUGGAGE CART	200 LBS	EXPLOSIVE	1	FLOOR	CENTER
SM1	BOTTLE	1 LITER	EXPLOSIVE	1	FLOOR	CENTER
“	“	2 LITERS	EXPLOSIVE	1	FLOOR	CENTER
“	“	5 LITERS	EXPLOSIVE	1	FLOOR	CENTER
“	“	10 LITERS	EXPLOSIVE	1	FLOOR	CENTER
SMFC	BOTTLE	1 LITER	EXPLOSIVE	1	FLOOR	CENTER
“	“	2 LITERS	EXPLOSIVE	1	FLOOR	CENTER
“	“	5 LITERS	EXPLOSIVE	1	FLOOR	CENTER
“	“	10 LITERS	EXPLOSIVE	1	FLOOR	CENTER
“	“	25 LBS	EXPLOSIVE	1	FLOOR	CENTER
“	“	25 LBS	SPRAY	600	FLOOR	CENTER

\* = AIR HANDLING UNIT

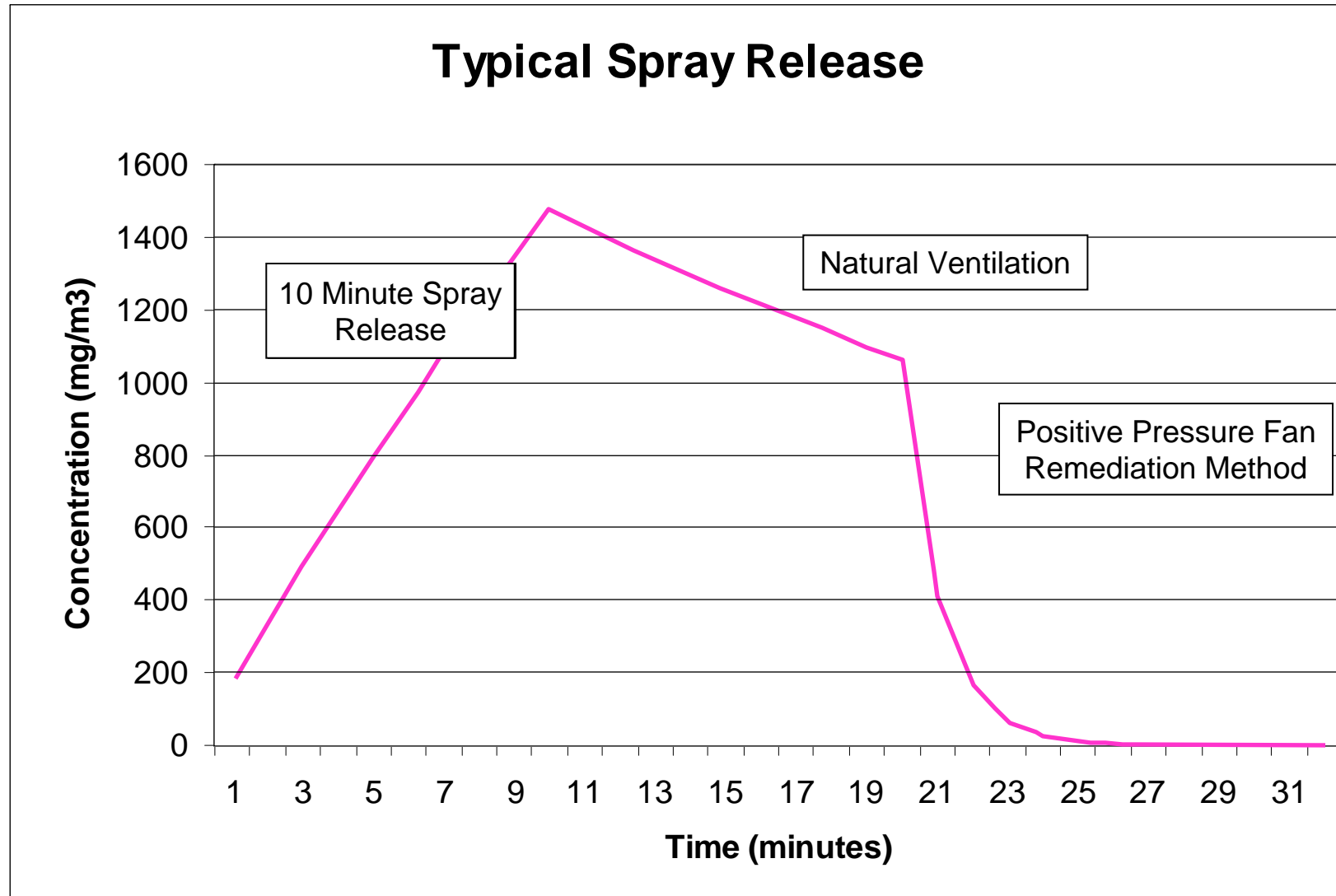
# Source Descriptions

<u>Container</u>	<u>Method</u>	<u>Amount</u>
Gas Cylinder	Pressure Valve	150 lbs
Gas Cylinder	Pressure Valve	100 lbs
Gas Cylinder	Pressure Valve	20 lbs
Bottle	Spray	25 lbs
Bottle	Explosive	50 lbs
Bottle	Spill	200 lbs

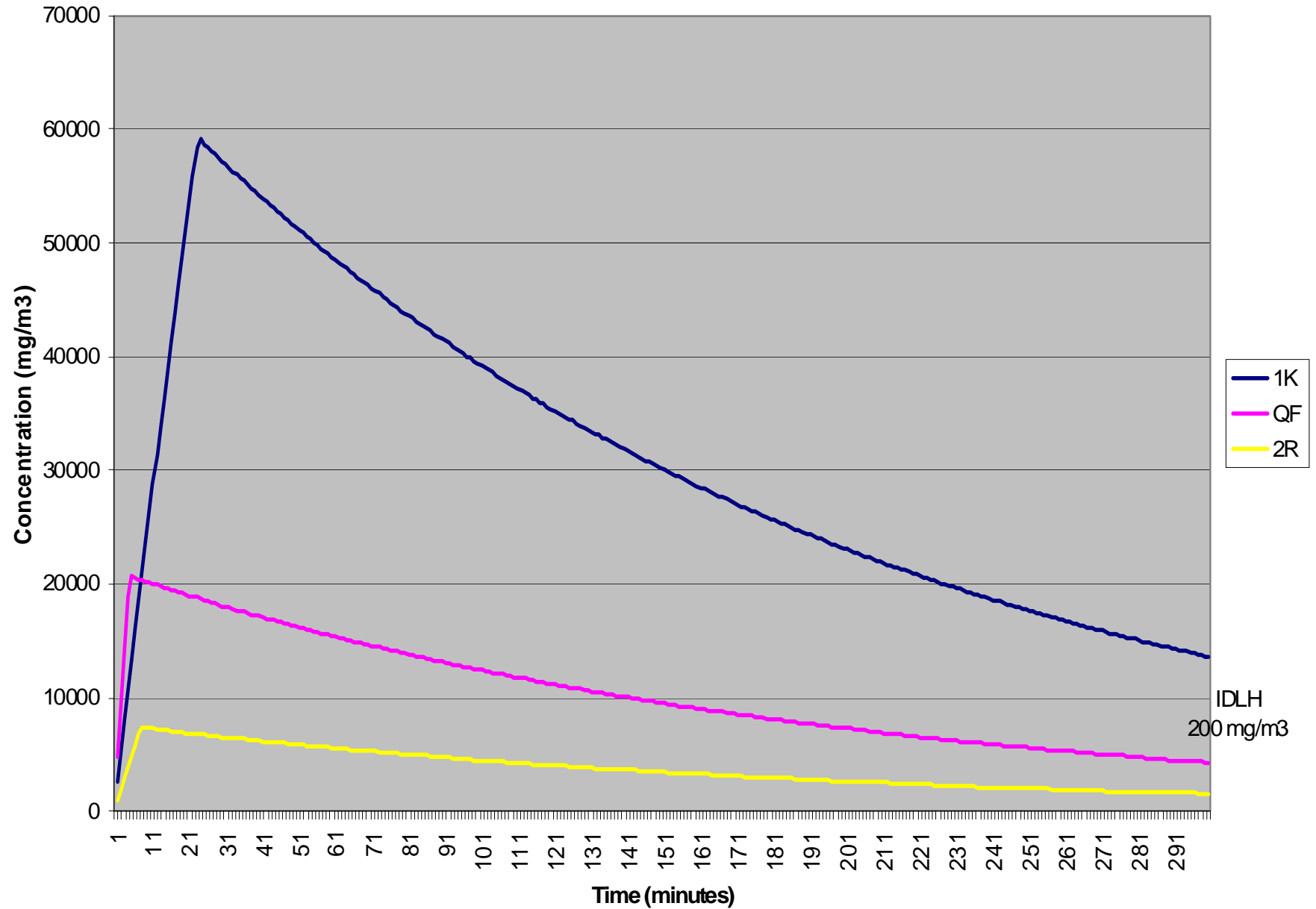
# Ventilation Kinetics



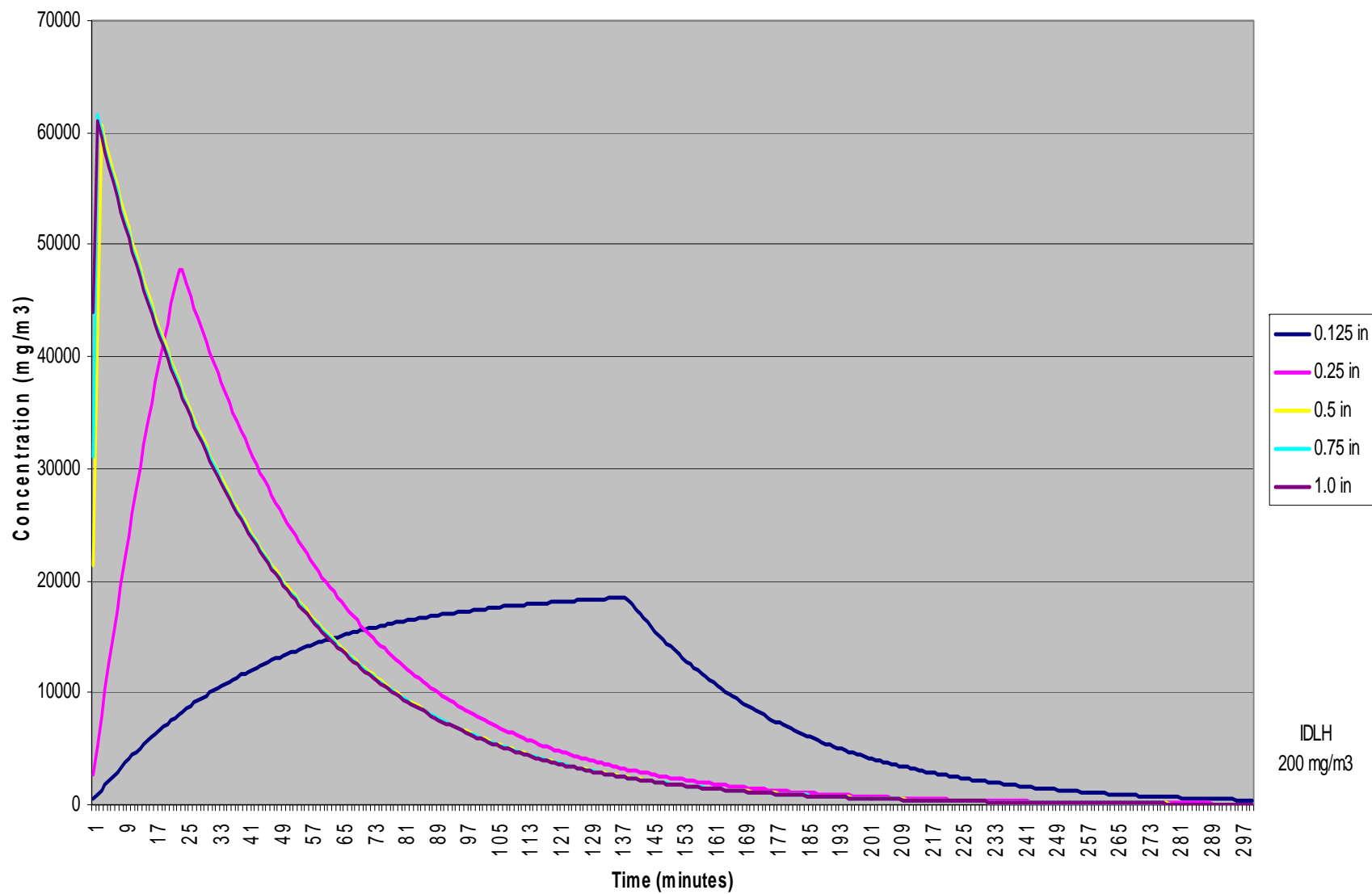
# Concentration Profile



Ammonia Gas Cylinder - 0.25 in Opening  
Meeting Room 1 - no HVAC



# Ammonia Gas Cylinder 1K Meeting Room 1



**PROTECTABILITY**



# RESPIRATOR USES

- Escape Hood Respirator (EHR)
  - Atmosphere > IDLH
  - 15 Minute Protection
- Self-Contained Breathing Apparatus (SCBA)
  - Hot Zone, Unknowns, >IDLH
  - Limited to Air Supply Bottle
- Air-Purifying Respirator (APR)
  - Atmosphere < IDLH
  - Lengthy Protection Duration

# OPERATIONAL USES

## AIR PURIFYING RESPIRATORS

- Protection Zone Security
- Personal Decontamination Corridors
- Transportation of Exposed Personnel
- Medical Services Treatment Centers
- Area Clean-up and Facilities Restoration

# CONCLUSIONS

- Vulnerability Assessment Factors Involve:
  - Toxicology
  - Delivery Methods
  - Challenge Concentration
  - Protectability
- Terrorist's Intent Not Prescribed
- Toxicities of TIC and CWA Span Orders of Magnitude in Values
- Challenge Levels are Venue Specific
- Test Standards Dependent on Respirator Uses