Public Meeting

Explosion at Bayer CropScience, LP Institute, West Virginia
August 28, 2008

Meeting Agenda

• Investigation Team Presentation
• Board Questions and Answers
• Panel Presentations
• Public Comment
• Board Closing Statement

Panelists

• Sterling Lewis, State Fire Marshal
• Dale Petry, Kanawha Putnam County Emergency Management Director
• Nick Crosby, Vice President, Site Leader
• Michael J. Flynn, Director, Occupational Safety and Health Apprenticeship, International Association of Machinists
• Dennis Hendershot, Chemical Process Safety Expert
• Maya Nye, People Concerned About MIC

Investigation Team

• John Vorderbrueggen, PE Investigations Supervisor
• Francisco Altamirano, CFEI
• Johnnie Banks, CFEI
• Catherine Corliss, PE
• Lucy Sciallo, GSP
Investigation Team Presentation

• Facility and unit overview
• Incident summary
  – Emergency response
  – Fatalities and injuries
• Facility and offsite damage
• Properties of chemicals involved
• Preliminary findings
• Path forward

Facility Overview

• U.S. government 1943-1947
  Rubber manufacturing
• Union Carbide 1947-1986
• Rhone-Poulenc 1986-2000
• Aventis 2000-2002
• Bayer CropScience, LP 2002-present

Facility Overview

• Multi-tenant facility
• Shared feedstocks
• FMC and Adisseo operated by Bayer

Facility Overview

• Bayer CropScience, AG
  – 17,800 employees, 120 countries
  – U.S. headquarters – Research Triangle Park, NC
  – Institute, WV
    • ~520 employees
    • Three manufacturing centers
      • East Carbamoylation
      • West Carbamoylation
      • Rhodimet

Embargoed until 10:00 am EDT Thursday April 23, 2009
Process Description

- 1983 Methomyl/Larvin unit in service
- Summer 07 - Larvin unit control system upgraded
- Summer 08 - Methomyl unit
  - Control system upgraded
  - New residue treater installed

Explosion epicenter

Embargoed until 10:00 am EDT Thursday April 23, 2009
Methomyl Process Description

- Methomyl unit restart activities began Thursday, August 21
  - Restart after extended outage
  - First time use of control system on Methomyl unit
  - Beginning of an extended production run to meet a new international demand
Incident Summary

- Methomyl production started Wednesday, August 27
  - Adjusting to the new control system displays and computer input method
  - Focusing on upstream equipment performance startup issues
  - Continuing with controls tuning and process troubleshooting

Incident Summary

- Thursday 5:00 am – residue treater
  - Level indicator read 0% full
  - Temperature was 40°C (104°F)
  - Safeguards were bypassed
  - Flasher bottoms feed valve was opened

- 6:25 pm
  - Liquid level was 49%
  - Temperature was 63°C (145°F)
  - Recirculation pump was started

Incident Summary

10:20 pm
- Residue treater level was 58% full
- Temperature 140°C (284°F) and climbing
- Pressure unexpectedly increasing

Residue Treater Pressure and Temperature History

- Pressure (psig)
- Temperature

Operating temperature

10:20 pm – Pressure rapidly increasing
Incident Summary

10:25 pm
- Outside operator was asked to check residue treater vent
- Second outside operator was asked to assist

10:35 pm
- Residue treater relief valves opened
- Residue treater ruptured
  - ~2500 gallons Methomyl-solvent liquid was suddenly released
  - Fire erupted in unit
  - Solvent piping, vent headers, and other process equipment were damaged
Preliminary Findings

- Residue treater feed control bypassed
  - Minimum temperature safety interlock
  - Minimum recirculation flow operational interlock
  - Feed valve in “manual” mode

Residue Treater Pressure and Temperature History

- Instrument failed at 10:35 pm – vessel ruptured, temperature uncontrollably increasing
- Flow of Methomyl solvent-mixture to residue treater began around 5 am
- Residue treater recirculation began around 6 pm
Preliminary Findings

- Sudden, uncontrolled exothermic decomposition of Methomyl
  - Methomyl concentration >> 20% in residue treater
  - Relief system sized for < 1.0% concentration
  - Residue treater ruptured
  - Solvent and Methomyl lines severed and contents ignited

Emergency Response, Consequences, and Community Impact

Johnnie Banks, CFEI

Emergency Response

1 min (10:36)
- A local citizen reported an explosion to Metro911
- Tyler Mountain fire department alarm sounded
- Bayer gate guard attempted to call Metro911

4 min (10:39)
- Metro911 called Bayer main gate

7 min (10:42)
- Kanawha County Sheriff ordered Route 25 closed
- Metro911 called main gate
- Bayer requested ambulance for burn victim

10 min (10:45)
- Bayer EOC activated; Crew A and B ring-down
- Institute VFD arrived at main gate
Emergency Response

14 min (10:49) Nitro and Dunbar PD closed I-64
15 min (10:50) Institute Fire Chief tells Metro911 that Bayer Incident Commander reported no dangerous chemicals released
24 min (10:59) Bayer notified Metro911, WV State University, WV Rehabilitation Center, and Reagent Chemicals

Emergency Response

25 min (11:00) St. Albans FD planning a Shelter-in-Place (SIP)
44 min (11:19) Metro911 –
   – Announced SIP in area around Bayer
   – Started reverse 911 ring-down notification
49 min (11:24) Bayer recommended to Metro911 issue SIP in St. Albans and Nitro

Emergency Response

59 min (11:34) Kanawha Putnam County Emergency Management Director activated the County Emergency Alert System
   – SIP west of Charleston to Putnam County line
2 hr 2 min (12:37) Bayer reported incident to the National Response Center
Emergency Response

3 hr 5 min (1:40) Bayer spokesperson held news conference
  – Fire continuing but contained
3 hr 30 min (2:05) Metro911 cancelled SIP
3 hr 40 min (2:15) Bayer reported fire out
6 hr 15 min (5:50) Bayer reported all clear except Larvin unit

Consequences

• Fatalities
  – Outside operator fatality at the scene
  – Second outside operator seriously burned; died 41 days later at burn center

Consequences

• Injuries
  – Chemical exposure symptoms reported
    • Five Tyler Mountain volunteer firefighters
    • Two Norfolk Southern employees
    • One Institute volunteer firefighter
  – Friday hospital emergency room treatment
    • One Institute volunteer firefighter

Overpressure Damage

• On site
  – New residue treater vessel destroyed
  – Process equipment destroyed
  – Moderate overpressure damage to control room and nearby structures
Residue Treater Vessel

Overpressure Damage

- Off site businesses and homes
  - Window breakage
  - Minor structural damage

Windows broken

Ceiling and wall cracks at private residence
Emergency Response Findings

- PPE for hot-zone responders
  - Use of SCBA or respirators was not clearly conveyed to outside responders
  - Outside responders not decontaminated onsite

- Incident command and coordination
  - Bayer incident command did not use unified command structure
  - Multiple EOCs established

Emergency Response Findings

- Shelter-In-Place decision process complicated by lack of information

- Communications
  - BCS-Metro911-County EOC
    - Gate guard followed Bayer emergency communications procedures
    - Metro911 experienced high call volume
    - Commendable performance
Possible Toxic Consequences from Chemicals Involved in the Incident

Lucy Sciallo

Possible Consequences

- Methomyl toxicity
- Methyl Isocyanate toxicity
- Potential releases

Methomyl Exposure Symptoms

- Nervous system disruption
- Acute Symptoms
  - Blurred vision, pinpoint pupils
  - Tremors, muscle twitching
  - Nausea, abdominal pain
  - Respiratory arrest, coma, death
- Chronic Symptoms
  - Liver damage
  - Anemia
  - Nervous system damage

Was Methomyl Released?

- Solvent-Methomyl solution sprayed from residue treater, broken pipes and equipment
  - Some decomposed
  - Some burned in the fire
  - Some remained on ground and nearby equipment
  - Some might have been carried in the air
Methomyl Thermal Decomposition

- Hazardous Chemicals
  - Acetonitrile
  - Dimethyl Disulfide
  - Hydrogen Cyanide
  - Oxides of Nitrogen and Sulfur
  - Methyl Thiocyanate
  - Methyl Isocyanate

Methyl Isocyanate Properties

- Highly reactive with water
- Highly flammable
- Relative vapor/air mixture density is 1.4
- Immediately Dangerous to Life and Health (IDLH) concentration: 3 parts per million (ppm)
- Boiling point: 39 C (102 F)

Possible sources of an MIC release

- Bayer reported MIC supply piping and equipment was not broken
- Methomyl/Larvin unit vent systems were heavily damaged
- MIC might be a product of Methomyl decomposition
Chemical Release Monitoring

- Methomyl/Larvin unit MIC monitors were not operational
- Perimeter air monitors are still being investigated

Methyl Isocyanate Symptoms

- Acute
  - Eye irritation, ocular damage
  - Respiratory distress
  - Pulmonary edema
  - Skin irritation, chemical burns
  - Nausea, abdominal pain
  - Coma, Death
- Chronic
  - Lung damage
  - Blindness

Chemical Properties

<table>
<thead>
<tr>
<th>Chemical</th>
<th>IDLH</th>
<th>Odor Threshold</th>
<th>Odor Characteristics</th>
<th>RMP (Toxic)</th>
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</thead>
<tbody>
<tr>
<td>Methyl Isocyanate</td>
<td>3 ppm</td>
<td>2 ppm</td>
<td>sharp, strong odor</td>
<td>Yes</td>
</tr>
<tr>
<td>Methomyl</td>
<td>-----</td>
<td>-----</td>
<td>sulfur-like odor</td>
<td>----</td>
</tr>
<tr>
<td>Phosgene</td>
<td>2 ppm</td>
<td>0.4 ppm</td>
<td>hay or grass odor</td>
<td>Yes</td>
</tr>
<tr>
<td>Chlorine</td>
<td>10 ppm</td>
<td>0.002 ppm</td>
<td>characteristic odor</td>
<td>Yes</td>
</tr>
<tr>
<td>Ammonia</td>
<td>300 ppm</td>
<td>5 ppm</td>
<td>characteristic odor</td>
<td>Yes</td>
</tr>
<tr>
<td>Methyl Isobutyl Ketone</td>
<td>500 ppm</td>
<td>0.3 - 0.7 ppm</td>
<td>sweet odor</td>
<td>----</td>
</tr>
</tbody>
</table>

Methyl Isocyanate, Environmental Protection Agency Risk Management Program, and Institute, WV

John Vorderbrueggen, PE
MIC Handling in U.S.

- EPA Risk Management Program reporting requirement
  - MIC Threshold Quantity = 10,000 lbs
- Bayer is the only U.S. facility with MIC inventory in excess of threshold quantity

Bayer Risk Management Plan - MIC

- Worst Case Scenario
  - 200,000 pounds of liquid released from a tank
  - 300,912 people affected within 25 mile radius
- Alternative Scenario
  - 125 pounds of gas leaked from a pipe
  - 58 people affected within 0.4 miles prevailing downwind direction

Methyl Isocyanate Issues

- MIC on-site inventory
- MIC Day Tank siting
  - Proximity to explosion epicenter
  - Adequacy of safeguards to prevent / mitigate toxic release
- Alternative to MIC storage
  - Produce → Use

MIC Handling

- MIC production
  - Stored underground
  - 200,000 pounds in single largest vessel
  - Pumped to production units daily
    - Jacketed piping (pipe-in-a-pipe)
    - Leak detection in jacket space
    - Pipe drained / nitrogen purged after use
    - Unit ends and mid-run isolation valves
**Methomyl / Larvin MIC Day Tank**

- Stainless steel pressure vessel
- 8 feet diameter
- 19 feet tall
- 75 psig maximum pressure
- ~37,000 pounds maximum fill
- ~13,800 pounds at time of explosion
**MIC Day Tank**
- Refrigerated and insulated
- Redundant pressure, temperature, and level instruments
- Area air monitors and alarms
- Emergency dump tank
- Concrete liquid containment wall
- Blast blanket debris shield

**MIC Day Tank Blast Blanket**
- Installed 1982
- 1994 - Top section added above vessel
  - Installed larger wire rope diameter
- 2008 - Replaced all sections
  - Larger wire rope diameter

**MIC Day Tank**
Blast blanket and support structure

**Methomyl / Larvin Debris**
MIC Storage Issues

- Centralized production vs. local produce and use
  - Reduces storage inventory
  - Might require more locations to handle phosgene
  - Might eliminate phosgene

MIC Storage Issues

- Continuous produce and use
  - DuPont implemented in LaPorte, TX facility in August 1985
    - Eliminated need to transport MIC via rail
  - DuPont patent awarded 1987

Unit Operations from a PSM / RMP Perspective

Catherine Corliss, PE

Unit Startup Issues

- Equipment
- Man-Machine interface
- Fatigue
- Procedures

Covered by OSHA Process Safety Management and EPA Risk Management Program
Equipment Startup Problems
- MIBK/Hexane column
  - Valve missing on column
  - Some controls in manual
- Process Controls
  - Adjustments ongoing and incomplete
- Only one centrifuge operating
  - MOM Unit operated at low flow rate

Personnel Challenges
- New Siemens control system for Methomyl
  - New computer display screens
  - User interface changed
  - Process measures changed
- Fatigue
  - Very high overtime levels
  - 12 hour shifts with few days off

Procedure Problems
- Operating procedure inadequate
  - Not updated for Siemens control system
  - Methomyl sampling inadequate
- Residue Treater
  - Minimum operating temperature could not be achieved at startup
  - Work-around used – bypass safety interlock

OSHA – Process Safety Management (PSM)
EPA – Risk Management Program (RMP)
- Coverage
- Intent
- Focus
PSM and RMP Deficiencies

• Process Hazards Analysis
  – Identify, evaluate, and control the hazards involved in a process
  – Requires that
    • Recommendations are resolved in a timely manner and
    • Resolutions are documented
• Operating Procedures

PSM and RMP Deficiencies

• Pre-startup Safety Reviews
  – Require operating procedures to be in place and adequate before startup
• Management of Change
  – Written procedure to manage change in technology and equipment
  – Requires operators to be trained in the change prior to startup

PSM and RMP Deficiencies

• Action items follow-up for
  – Process Hazard Analysis
  – Incident Investigation
  – Compliance Audits
• Require
  – Action items to be promptly addressed and resolved
  – Resolution of items to be documented

Investigation Path Forward

• Identify additional documentation needed
• Conduct follow-up interviews with site personnel and emergency response community
• Continue collecting information on community impact
• Acquire missing Methomyl/Larvin unit security camera and MIC monitors’ data

April 23, 2009
www.csb.gov
Investigation Path Forward

• Review design documents associated with MIC operations
• Run air model scenarios
• Test chemical samples
• Develop report and recommendations
• Prepare for final public meeting

Board Questions

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Public Comments

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