U.S. Chemical Safety and Hazard Investigation Board

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Public Meeting

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

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Meeting Agenda

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

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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

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Investigation Team

- John Vorderbrueggen, PE Investigations Supervisor
- Francisco Altamirano, CFEI
- Johnnie Banks, CFEI
- Catherine Corliss, PE
- Lucy Sciallo, GSP

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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

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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

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

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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


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Methomyl / Larvin Unit
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Explosion epicenter
100 ft
April 23, 2009
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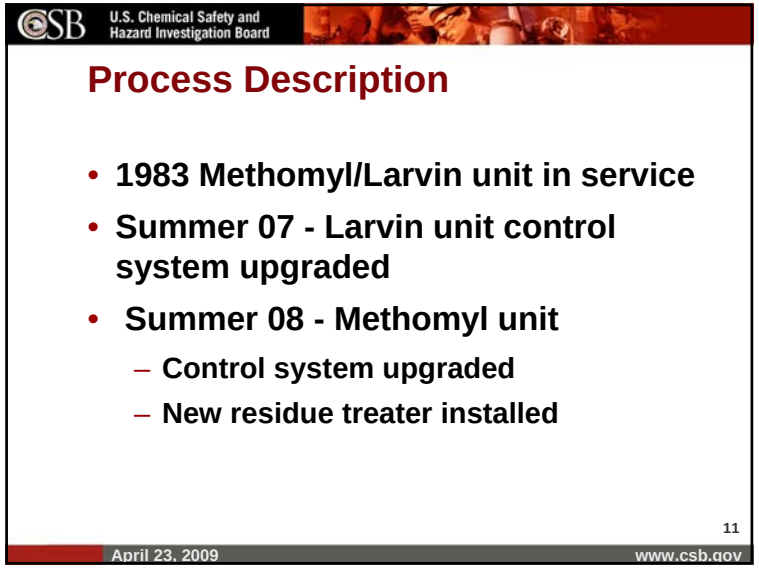
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Process Description
• 1983 Methomyl/Larvin unit in service
• Summer 07 - Larvin unit control system upgraded
• Summer 08 - Methomyl unit
– Control system upgraded
– New residue treater installed
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Old Residue Treater
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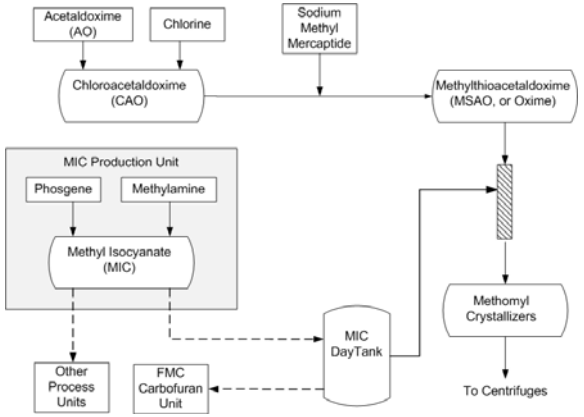
Methomyl Process Description



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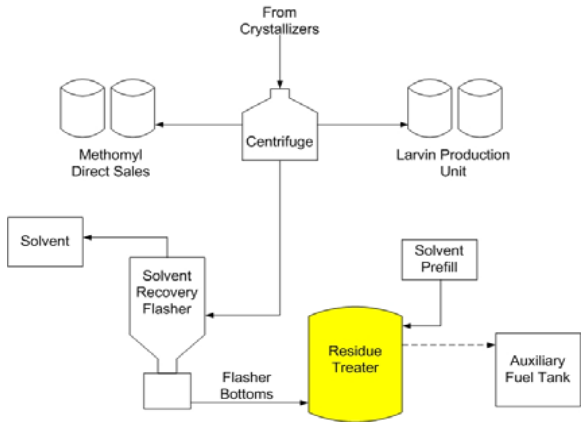
Methomyl Process Description



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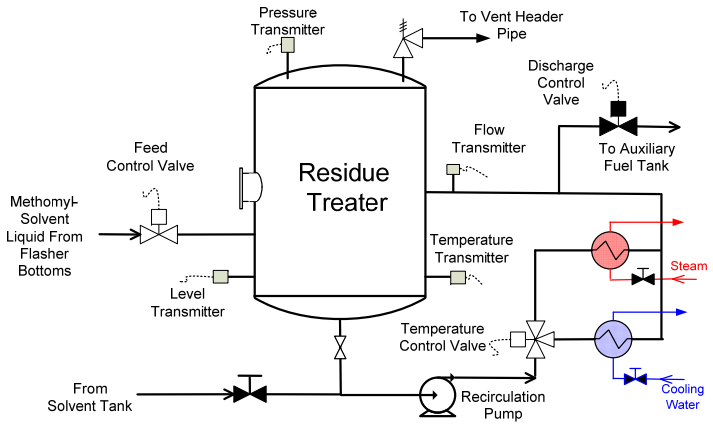

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Incident Summary

- **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**

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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**

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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**

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Incident Summary

10:20 pm

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

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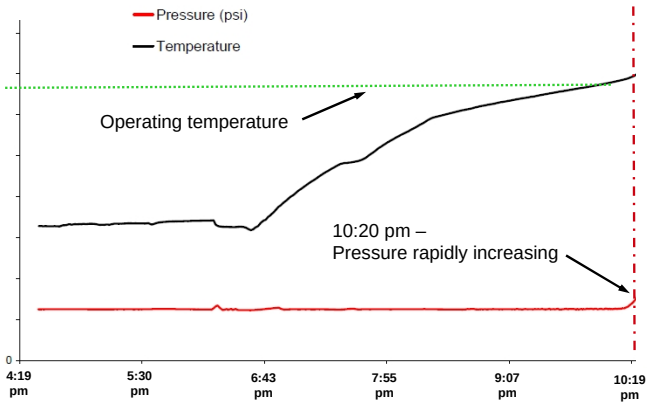
Residue Treater Pressure and Temperature History



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Incident Summary

10:25 pm

- Outside operator was asked to check residue treater vent
- Second outside operator was asked to assist

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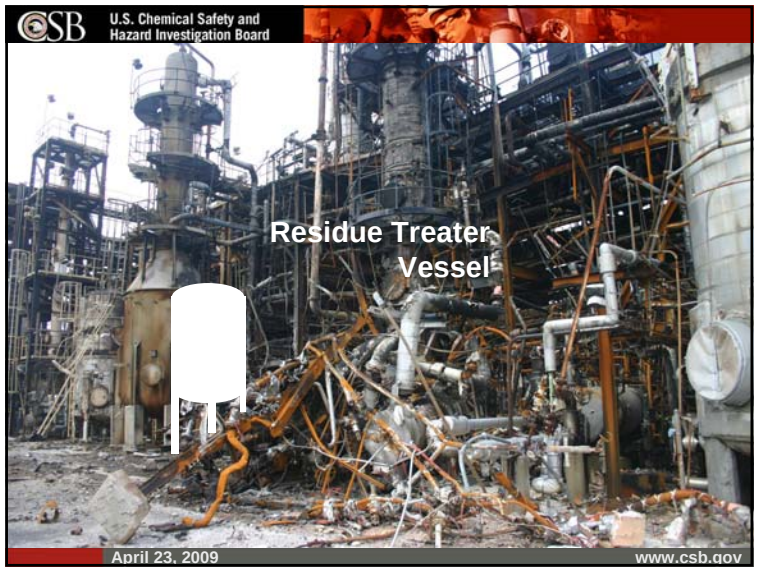
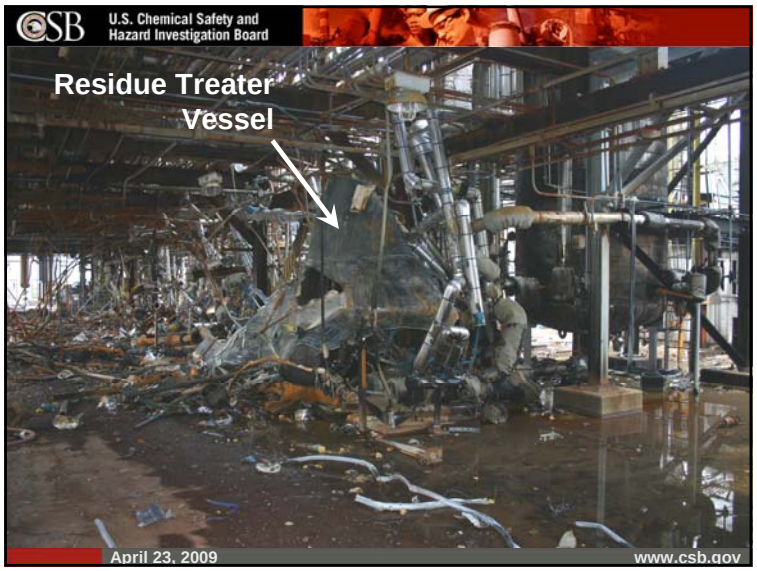
Incident Summary

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





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Preliminary Findings

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

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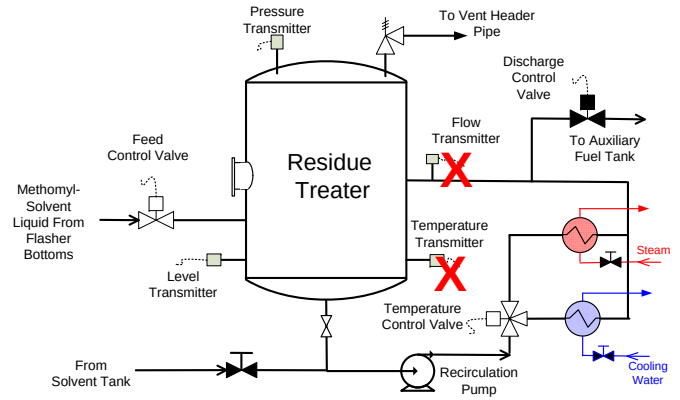

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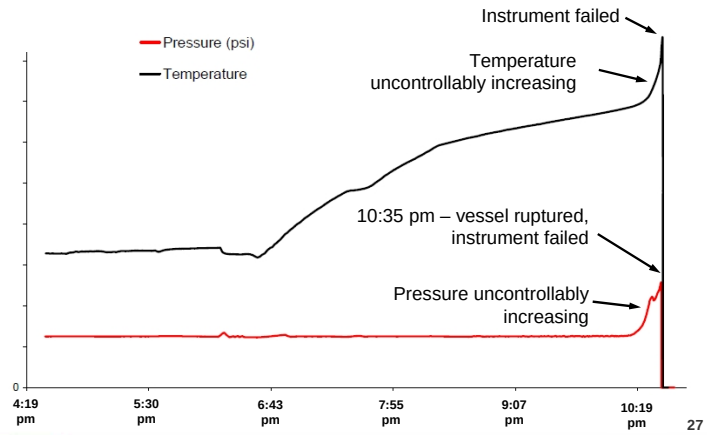
Residue Treater Pressure and Temperature History



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Preliminary Findings

- **Residue treater not pre-filled with solvent**
- **Solvent not pre-heated to minimum operating temperature**
- **Flow of Methomyl solvent-mixture to residue treater began around 5 am**
- **Residue treater recirculation began around 6 pm**

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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

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Emergency Response, Consequences, and Community Impact

Johnnie Banks, CFEI

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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

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Emergency Response

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

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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

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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

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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

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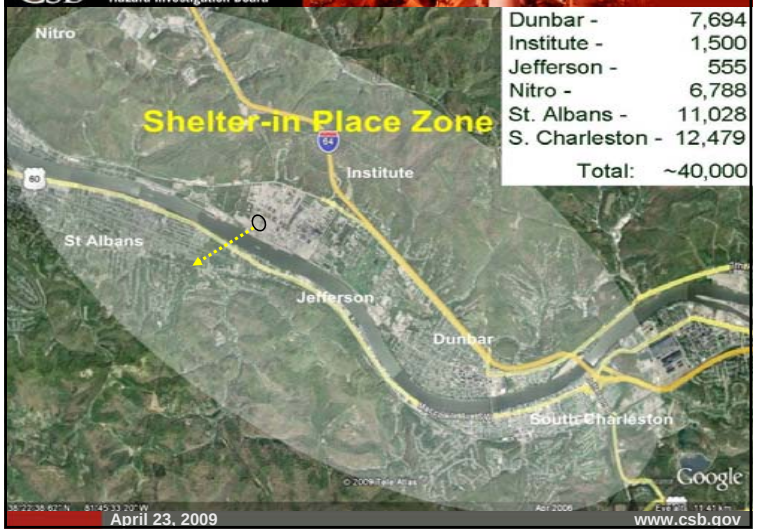

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Embargoed until 10:00 am EDT Thursday April 23, 2009

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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

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Consequences

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

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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**

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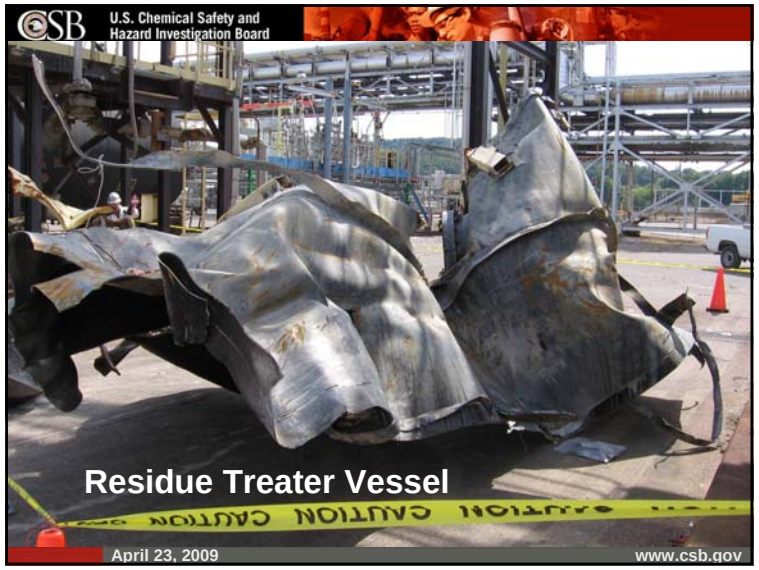
Overpressure Damage

- **On site**
  - **New residue treater vessel destroyed**
  - **Process equipment destroyed**
  - **Moderate overpressure damage to control room and nearby structures**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Residue Treater Vessel
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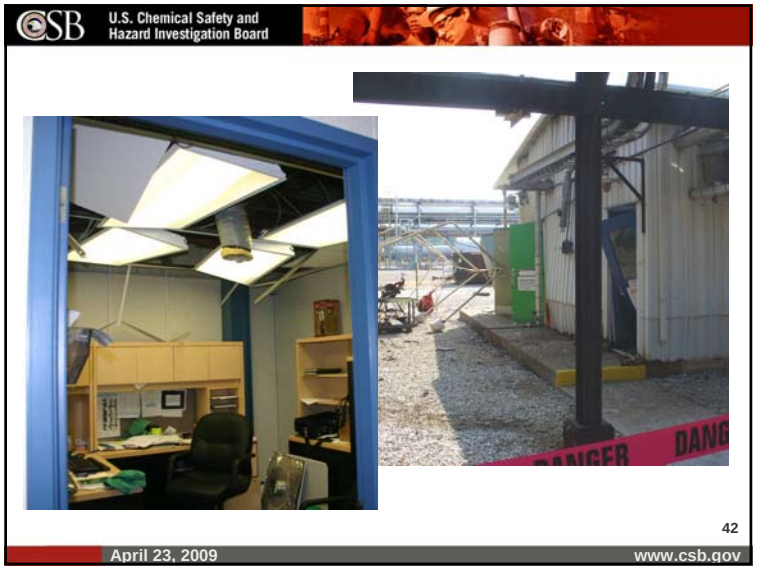
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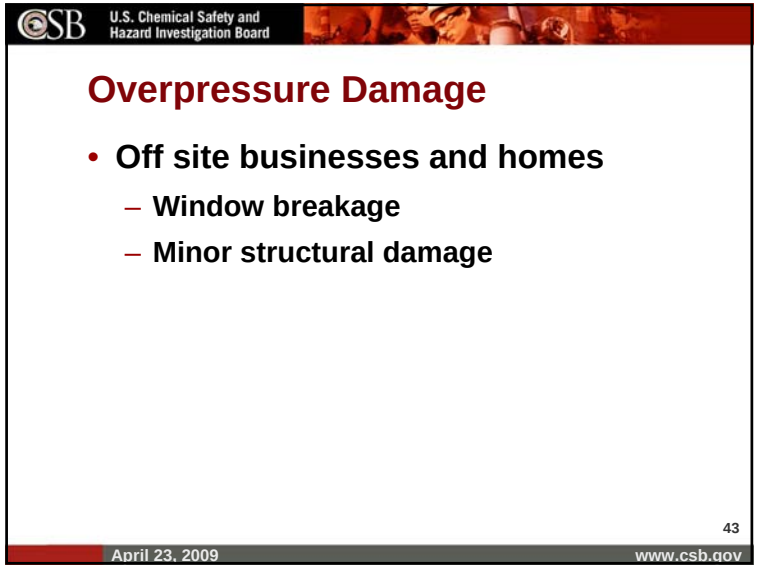
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Overpressure Damage
• Off site businesses and homes
– Window breakage
– Minor structural damage
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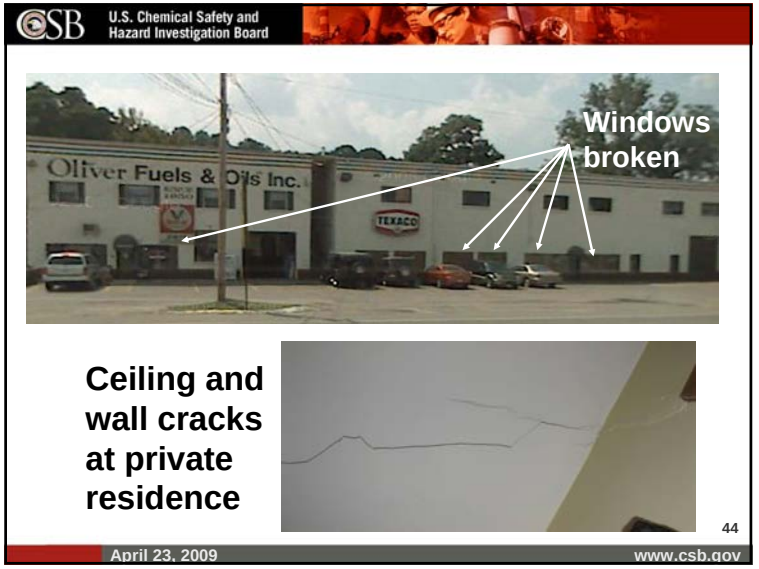
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Windows broken
Ceiling and wall cracks at private residence
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6.5 Miles from MOM Unit
REPORTED PROPERTY DAMAGE
Poca
Nitro
Methomyl Unit
St Albans
Dunbar
South Charleston
Tornado
Charleston
7.25 Miles from MOM Unit
Google
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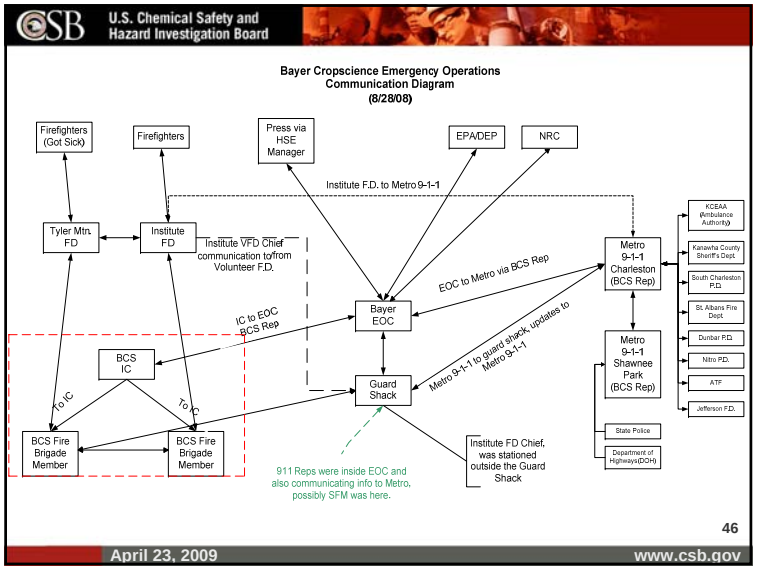
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Bayer Cropscience Emergency Operations Communication Diagram (8/28/08)
Firefighters (Got Sick)
Firefighters
Press via HSE Manager
EPA/DEP
NRC
Institute F.D. to Metro 9-1-1
Tyler Mtn. FD
Institute FD
Institute VFD Chief communication to/from Volunteer F.D.
EOC to Metro via BCS Rep
IC to EOC BCS Rep
Bayer EOC
Metro 9-1-1 Charleston (BCS Rep)
Metro 9-1-1 Shawnee Park (BCS Rep)
BCS IC
Metro 9-1-1 to guard shack, updates to Metro 9-1-1
Guard Shack
To IC
To IC
BCS Fire Brigade Member
BCS Fire Brigade Member
911 Reps were inside EOC and also communicating info to Metro, possibly SFM was here.
Institute FD Chief, was stationed outside the Guard Shack
KCBAA (Ambulance Authority)
Kanawha County Sheriff's Dept.
South Charleston P.D.
St. Albans Fire Dept.
Dunbar P.D.
Nitro P.D.
ATF
Jefferson F.D.
State Police
Department of Highways (DOH)
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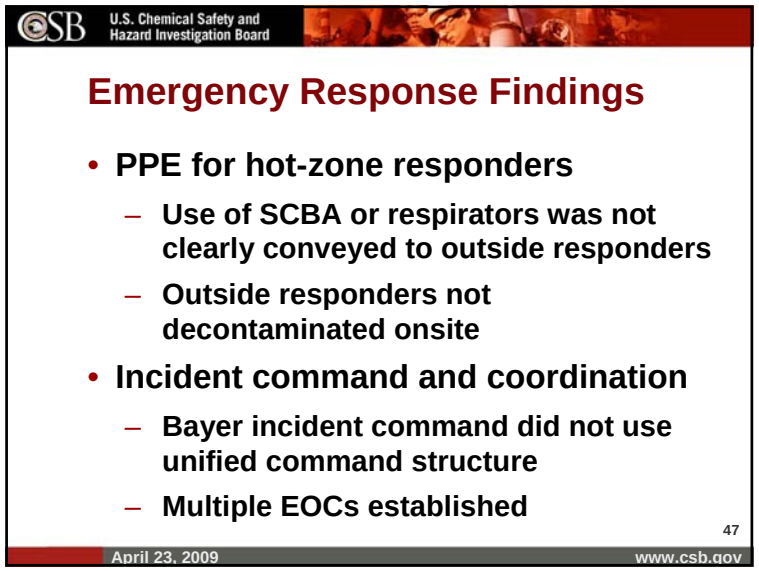
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Emergency Response Findings
• PPE for hot-zone responders
– Use of SCBA or respirators was not clearly conveyed to outside responders
– Outside responders not decontaminated onsite
• Incident command and coordination
– Bayer incident command did not use unified command structure
– Multiple EOCs established
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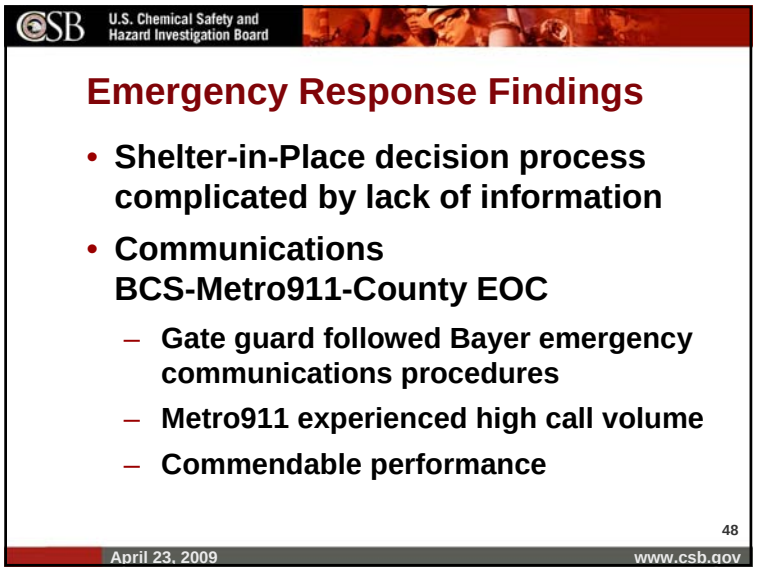
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Emergency Response Findings
• Shelter-in-Place decision process complicated by lack of information
• Communications BCS-Metro911-County EOC
– Gate guard followed Bayer emergency communications procedures
– Metro911 experienced high call volume
– Commendable performance
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Possible Toxic Consequences from Chemicals Involved in the Incident

Lucy Sciallo

U.S. Chemical Safety and Hazard Investigation Board

Possible Consequences

- **Methomyl toxicity**
- **Methyl Isocyanate toxicity**
- **Potential releases**

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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**

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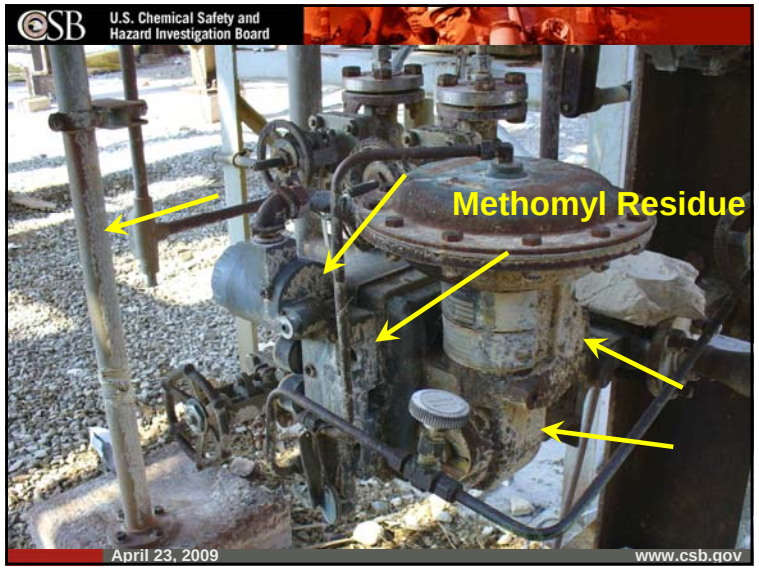
Was Methomyl Released?

- **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**



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Methomyl Thermal Decomposition

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

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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)

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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

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Chemical Release Monitoring

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

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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

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Chemical Properties

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

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

John Vorderbrueggen, PE

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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 (Source: EPA RMP Worst Case Scenario)
  - 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

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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

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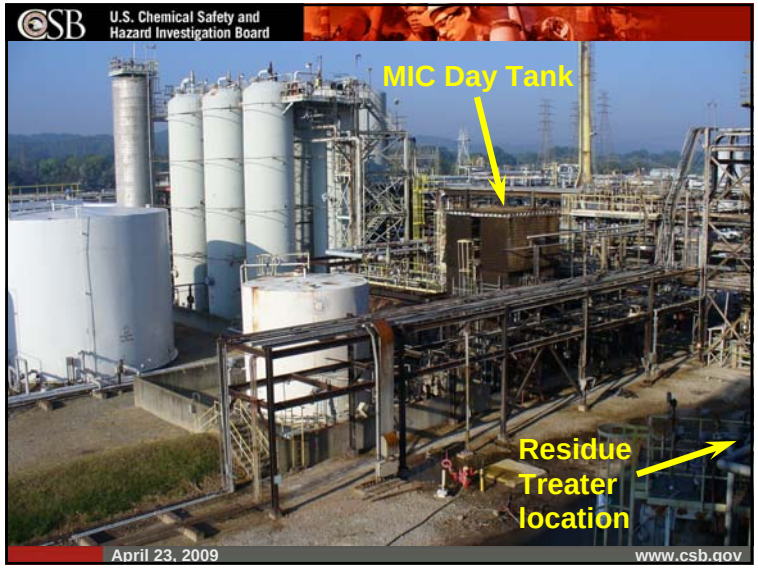

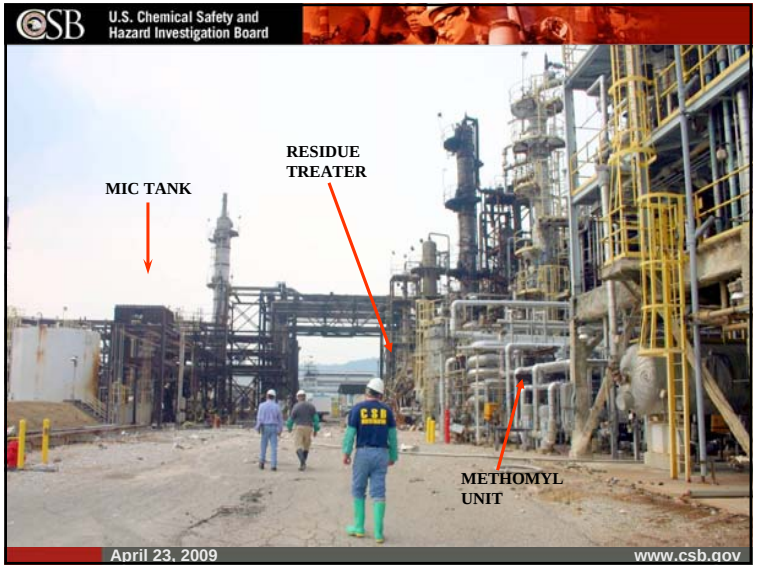

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MIC Day Tank

- 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

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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

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MIC Day Tank

Blast blanket and support structure

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Methomyl / Larvin Debris

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MIC Storage Issues

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

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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

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Unit Operations from a PSM / RMP Perspective

Catherine Corliss, PE

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Unit Startup Issues

- Equipment
- Man-Machine interface
- Fatigue
- Procedures

Covered by OSHA Process Safety Management and EPA Risk Management Program

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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

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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

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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

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OSHA – Process Safety Management (PSM)

EPA – Risk Management Program (RMP)

- Coverage
- Intent
- Focus

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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

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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

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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

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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

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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

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Board Questions

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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

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Public Comments


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