

# ENGR 399

- **Open the in-class quiz now...** today, quiz questions will be distributed throughout the lecture. Quiz access code = pasta
- Asynchronous assignment 3 is posted, and is due by Sunday midnight. There are three options... do ONLY ONE of the three options
- Dr. Torres will have "Three in-person Thurs classes in lieu of Async 6 Option C". The classes will Feb 13, 20, 27; you would need to attend all three classes (and complete in-class assignments) to get full credit.

## Criterion for ABET accreditation



Ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

Knowledge base re engineering & society

- Safety (management of change, inherently safe design; normalization of deviance, etc)
- Intellectual property (patents, copyright)

important  
skillset



Proficiency working with primary sources  
(particularly science/engineering journals)



Moral and Ethical Reasoning

Diversity and Commonality

Global Perspectives

Understand technical aspects for  
deeper insight into societal impact

fulfills 3 requirements  
in CWRU new GER



differentiates  
from  
humanities  
course

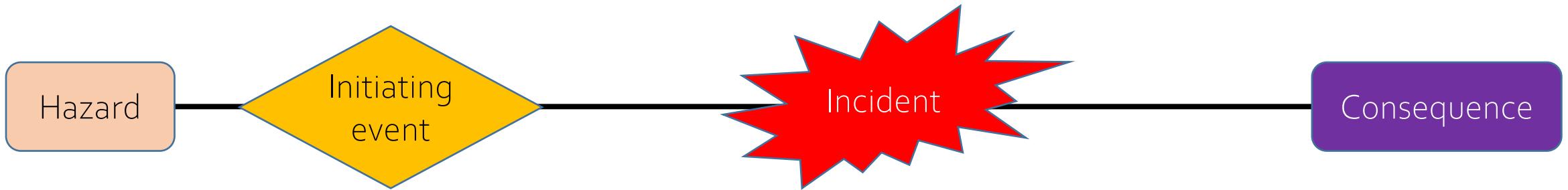
I believe these topics are inherently interwoven, and not "artificially thrown together"

I intentionally aim to tie content to personal experiences, and encourage you all to do the same!

# This lecture... what we will cover

1. What is a "hazard"?
2. Safety controls: Preventive vs mitigative, engineering vs administrative, passive vs active
3. Is objectivity in engineering a realistic expectation?

# Analysis of a safety incident

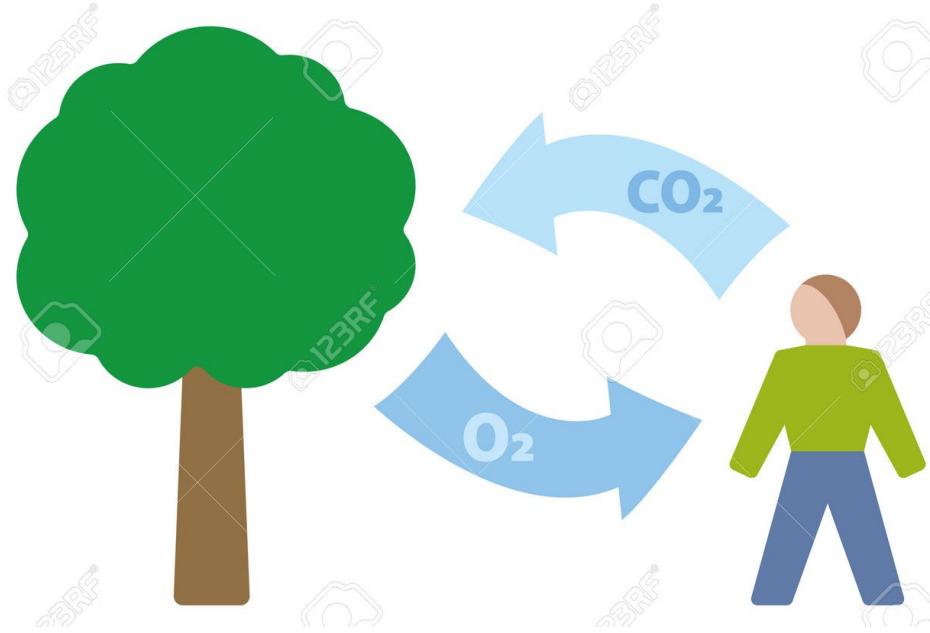


Hazard: A chemical or physical condition that has the potential for causing harm

Factors that can make something a hazard:

- Inherent properties of material (toxic, corrosive, flammable, asphyxiate, etc.)
- Conditions (temperature, pressure)
- Size of system
- Surroundings (eg, if confined)

Is water a hazard?



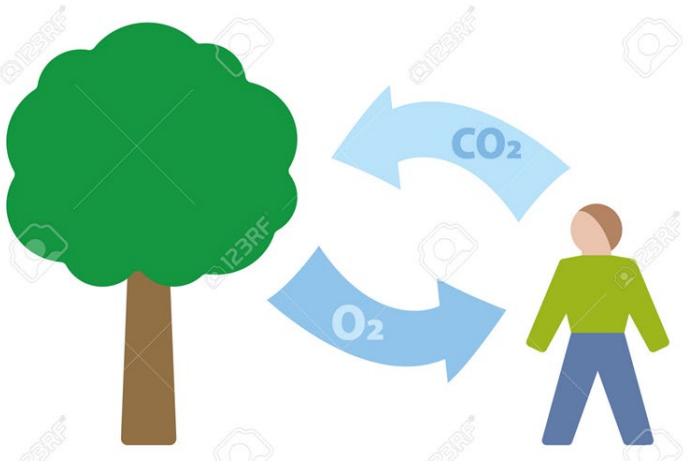
Are O<sub>2</sub> and CO<sub>2</sub> hazards?

Are these materials hazards even if you don't ingest them?



Is water a hazard?





Are O<sub>2</sub> and  
CO<sub>2</sub> hazards?

Why is O<sub>2</sub> a hazard here?

- Combustion rxn: C<sub>n</sub>H<sub>2n</sub> + 1.5n O<sub>2</sub> → n CO<sub>2</sub> + n H<sub>2</sub>O
- 100% O<sub>2</sub> ... lots of O<sub>2</sub> for rxn... explosive!

**The Detroit News**  
SERVING MICHIGAN SINCE 1873

## Boy, 5, dies in Troy hyperbaric chamber explosion

just a  
week ago

hyperbaric oxygen chamber ...  
medical treatment with 100% O<sub>2</sub>



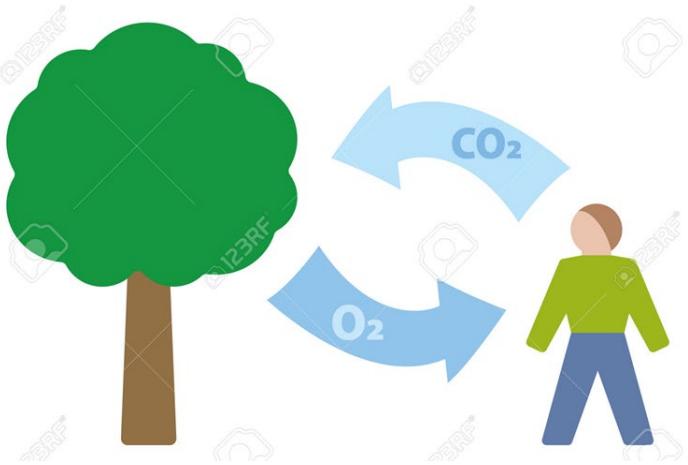
Charles E. Ramirez

The Detroit News

Published 11:07 a.m. ET Jan. 31, 2025 | Updated 12:05 p.m. ET Feb. 1, 2025



Troy — Authorities are trying to determine what caused a hyperbaric oxygen chamber at a Troy medical facility to explode on Friday morning, killing a 5-year-old boy who was inside.



Are O<sub>2</sub> and  
CO<sub>2</sub> hazards?

Why is CO<sub>2</sub> a hazard here?

- fermentation rxn: C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> → 2C<sub>2</sub>H<sub>5</sub>OH + 2CO<sub>2</sub>
- CO<sub>2</sub> (MW=44) heavier than O<sub>2</sub> (MW=32)...  
...CO<sub>2</sub> displaces O<sub>2</sub>, thus asphyxiation hazard

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## Winemaker dies in Italy while trying to save colleague who fainted in wine vat

By Barbie Latza Nadeau, CNN

⌚ 2 minute read · Updated 1:06 PM EDT, Sat September 16, 2023

"According to the fire brigade, the man in his forties was trying to save his colleague who had fainted from carbon dioxide fumes while carrying out maintenance work.

The two men were working in a processing tank that had just been emptied of wine for bottling when they were overcome by fumes from the fermentation process."

# The context...



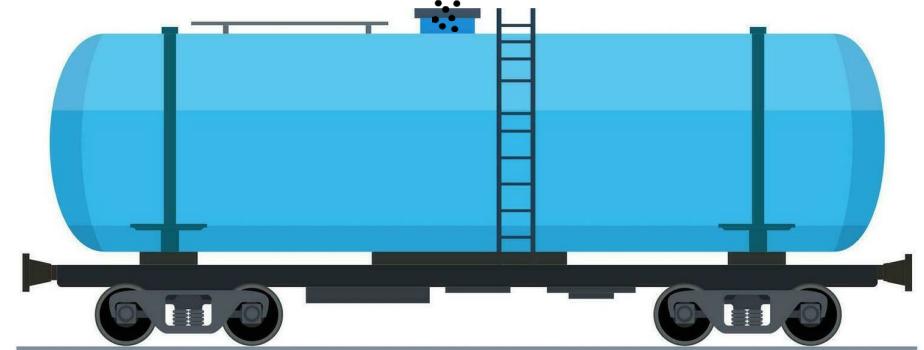
The company's produces these asphalt pellets... sold to tire companies where they are used as "homogenizing agents" to help mix different types of polymers

Note that asphalt is what roads are made out of



Asphalt dust is created during the manufacturing of the pellets

A worker sweeps up the dust and puts it in a "super sack"



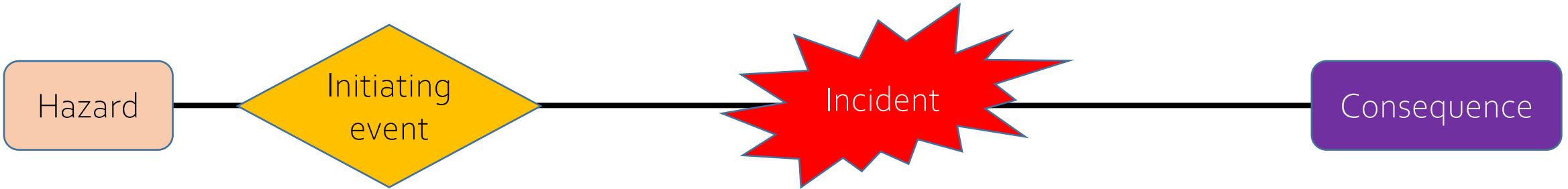
When super sack is filled with dust, it is brought to a heated railcar to be melted

The worker stands on top of the railcar and empties dust from super sack into railcar

As expert witness, I was asked to address:

- (a) was the material being transferred a flammable and/or explosive hazardous substance?
- (b) did ordinary operating conditions lead to electrostatic discharges that ignited the material?
- (c) were the supervisors in charge of the activities aware of these dangers prior to this incident?
- (d) did the supervisors **deliberately misrepresent** the hazardous nature of the material?

# Consider the asphalt pellet processing explosion



What is the hazard?

What is the initiating event?

# Imperial Sugar Company Dust Explosion and Fire

[Home](#) | [Investigation Details](#) Print

## Accident Description

**Accident:** Imperial Sugar Company Dust Explosion and Fire

**Location:** Location: Port Wentworth, GA

**Accident Occurred On:** 02/07/2008 | **Final Report Released On:** 09/24/2009

**Accident Type:** Combustible Dust Explosion and Fire

**Investigation Status:** The CSB's final report was released at a public meeting in Savannah, GA on September 24, 2009.

On February 7, 2008, a huge explosion and fire occurred at the Imperial Sugar refinery northwest of Savannah, Georgia, causing 14 deaths and injuring 38 others, including 14 with serious and life-threatening burns. The explosion was fueled by massive accumulations of combustible sugar dust throughout the packaging building.

*"14 deaths... explosion fueled by sugar dust"*



# Can these materials be explosive?

Dust clouds composed of these materials are explosive!

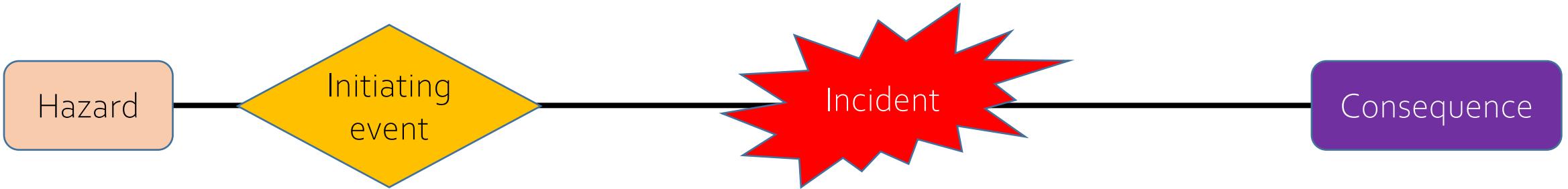


Asphalt... what roads are made of



- These are all made of carbon... mostly  $C_nH_{2n}$
- Thus they are combustible ... combustion rxn:  $C_nH_{2n} + 1.5n O_2 \rightarrow n CO_2 + n H_2O$
- In the form of tiny particles (dust) dispersed in air... lots of material in contact with  $O_2$  ... explosive!

# Consider the asphalt pellet processing explosion

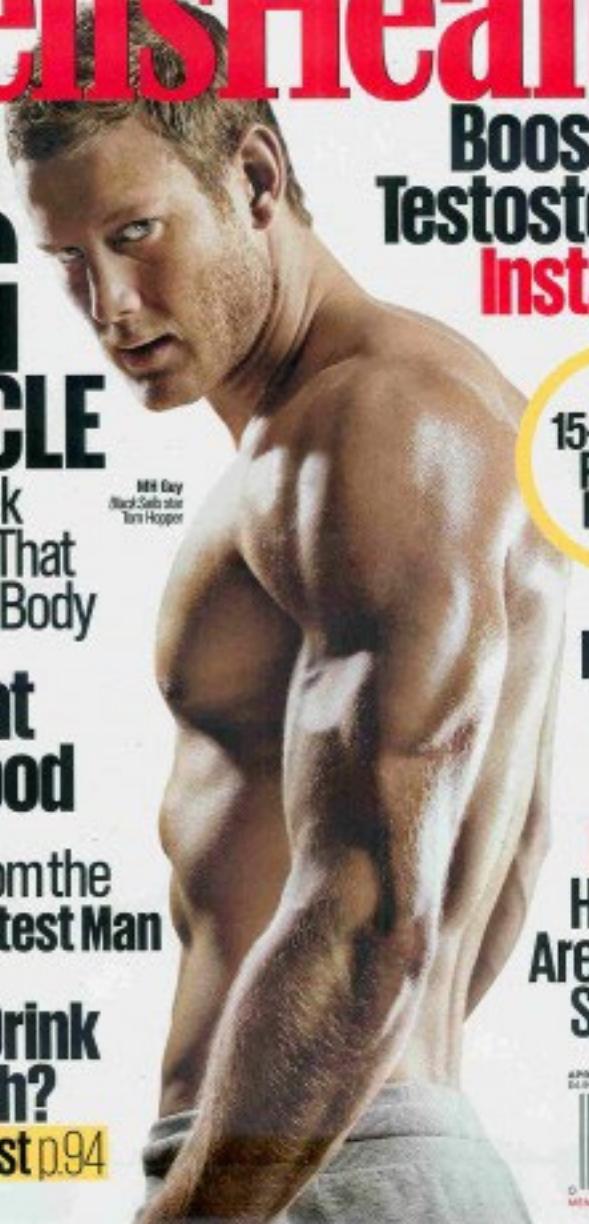


What is the hazard?      Combustible dust

What is the initiating event?

TONS OF USEFUL STUFF

# Men's Health



**Build BIG MUSCLE**  
The 8-Week Challenge That Made This Body

**Fight Fat With Food**  
Secrets from the World's Fittest Man

**Do You Drink Too Much?**  
Take Our Test p.94

**Boost Your Testosterone Instantly!**

**Eight 15-Minute Power Meals** PAGE 53

**Prevent a Heart Attack**

**Divorce How Men Are Getting Screwed**

MH Guy  
Black Salsas star  
Tom Hopper

APRIL 2016  
BALANCE DISPLAY UNIT, APRIL 2016  
043  
0 71858 02737  
MEN'S HEALTH.COM

April, 2016

Page 31



STYLE HACK

## Defuse Static Cling

Fight this laundry-day hassle with these simple science tricks.

The force that makes clothes stick together out of the dryer is due to an "unbalanced electron load" between two materials. That's how Daniel Lacks, Ph.D., explained it to us, and he should know: Lacks teaches chemical engineering at Case Western Reserve University. Your goal: Balance those charges. Here are two easy ways to make sure you're rocking a smartly ironed shirt.

### With Lotion

Rub lotion into your hands and glide them over your clothes as you take them out of the dryer. Or wet your hands and rub them over the stuck areas.

### With Metal

Attach a safety pin to your clothes before drying. Or run a wire hanger over any spots that seem bunched or clingy after you've gotten dressed.

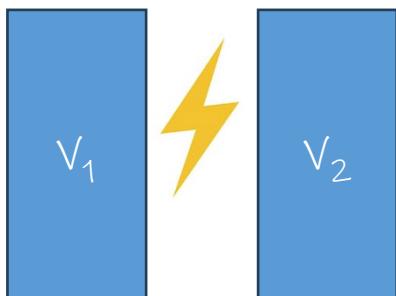


Triboelectric charging:

Electrical voltage develops on a surface when it rubs against another surface

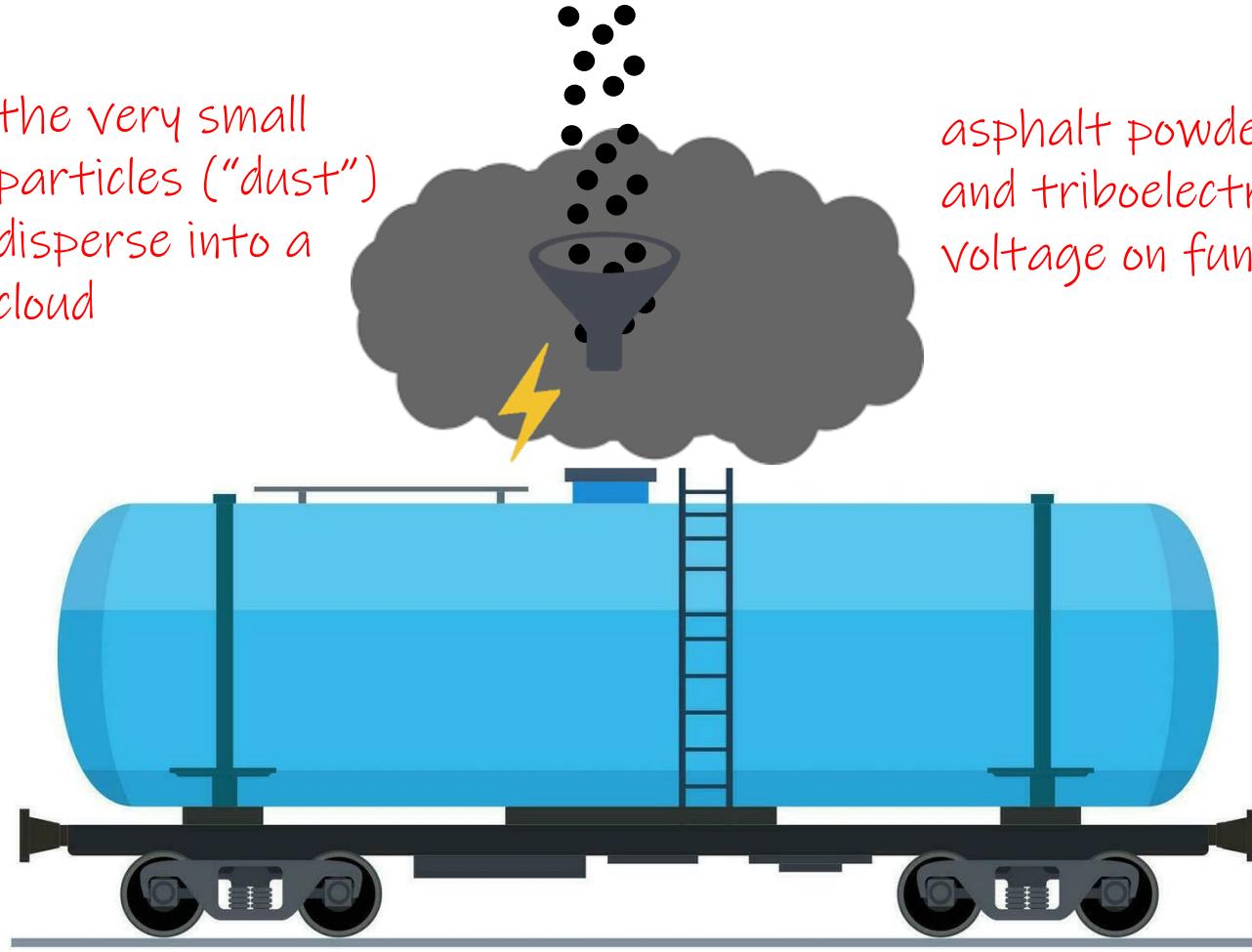
Electrical discharge (spark):

If two close surfaces have sufficiently different voltages, sparks can occur

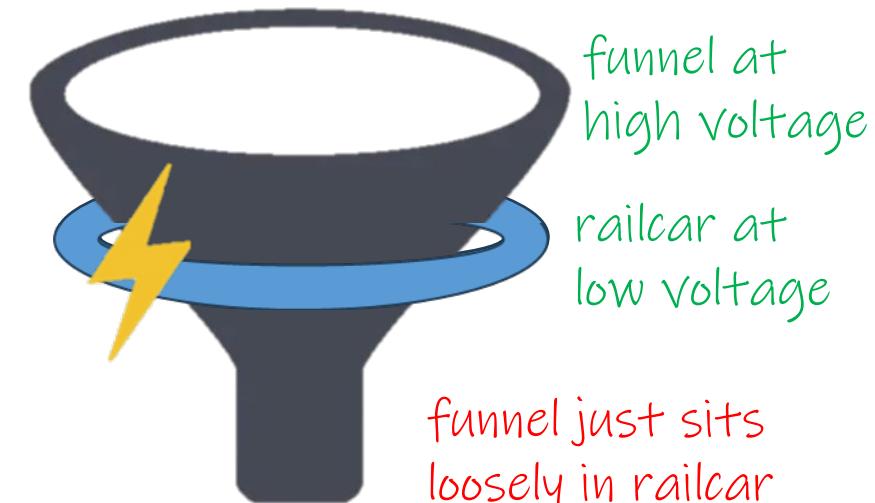


Spark if  $|v_2 - v_1| > \delta_{th}$

the very small particles ("dust") disperse into a cloud



asphalt powder rubs against funnel, and triboelectric charging increasing voltage on funnel (but not on railcar)



funnel at high voltage  
railcar at low voltage  
funnel just sits loosely in railcar

the voltage difference between the funnel and the railcar causes a spark ... the spark ignites the combustible dust!

The result...



WORK DEATHS, INJURIES PROMPT CALLS FOR CHANGE

47°

11:07

wkyc.com

And recall a key question for me as the expert witness:  
Did the supervisors **deliberately misrepresent** the hazardous  
nature of the material?

# Three questions ...

- (1) What are the challenges to being an objective expert witness?
- (2) To what extent should expert witnesses *even try to be* objective?
- (3) What exactly does it mean to be objective? Is perfect objectivity possible to attain?

# What are challenges to being an objective expert witness?

- You're getting paid for your testimony, which gives you a pecuniary (financial) incentive to help your side win. The more your testimony helps the case, the longer they might keep you on the job.
- There's a certain pull to being on a "team." Others on the team—the lawyers, plaintiff, or defendant—are counting on you to help them win the case. You might even develop personal relationships with members of the team, which could further enhance (or exacerbate!) this effect.
- You may truly come to believe that the side employing you deserves justice

Part of this is an expectation that you will present your findings with a high degree of *certainty*.

*However...*



Scientific certainty is never attainable!

No scientific theory is 100% certain, because no empirical claim can ever be known with 100% certainty

Consider the white and black swans!

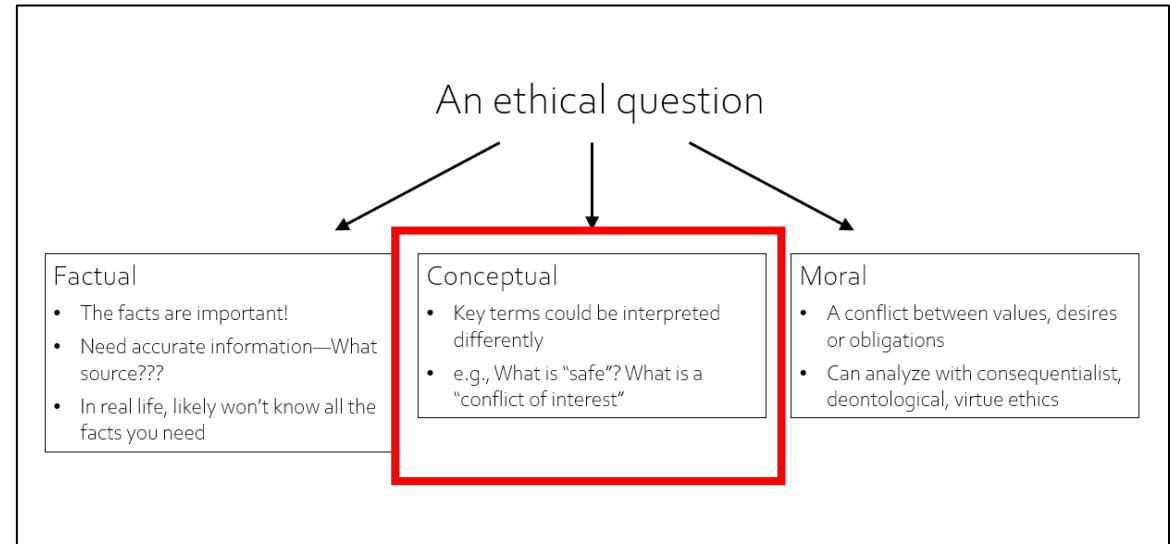


Do you have a moral obligation to be clear about uncertainty as an expert witness?  
What if the lawyer who hired you tells you strong and confident answers are needed  
for their client to receive justice?

# Open for interpretation ...

A key claim made by the plaintiff's lawyers was the company supervisors *deliberately misrepresented* the hazards of asphalt-pellet dust...

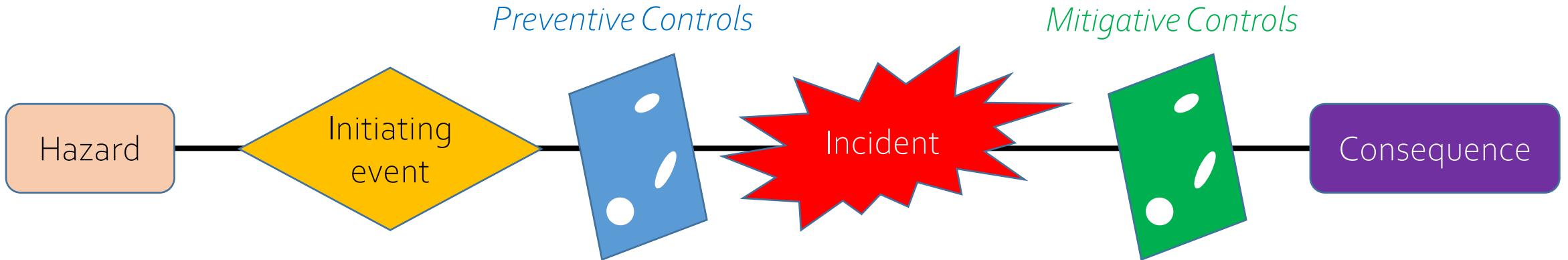
*... but what exactly does "deliberately misrepresented" mean?*



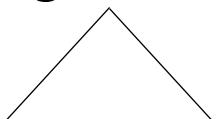
- Imagine being an expert witness for the plaintiff. How would you interpret "deliberately misrepresented"?
- Now imagine being an expert witness for the defendant. Would your interpretation change?
- Do you think it's morally okay to interpret such concepts differently depending on which side you're helping to represent? May this even be morally required?

Q1: Do you think the role of an expert witness should be to provide knowledge objectively or in support of their side's client on their quest for justice? Include in your answer either the issue of certainty or the issue of interpretation of a concept.

# Controls to enhance safety



engineering vs administrative



passive vs active

always "on":  
e.g., fences, railings,  
splash-guards,

only work in "on mode":  
e.g., sensor/alarm systems

change behavior:  
e.g., "do not enter" signs,  
do not work alone rules,  
required safety training

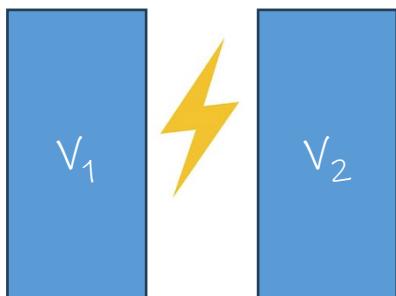


### Triboelectric charging:

Electrical voltage develops on a surface when it rubs against another surface

### Electrical discharge (spark):

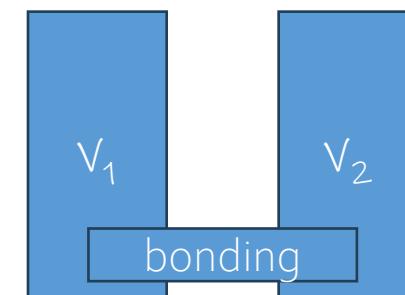
If two close surfaces have sufficiently different voltages, sparks can occur



Spark if  $|V_2 - V_1| > \delta_{th}$

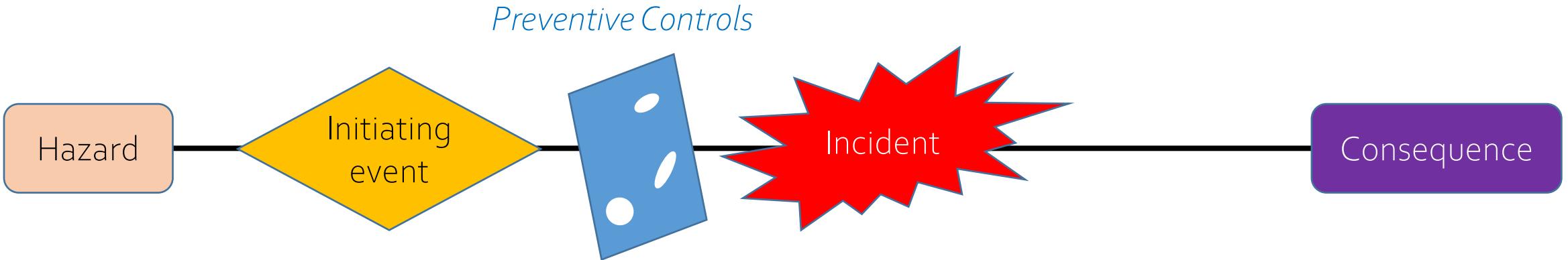
### Safety control:

Electrical bonding: Low resistance connection between the two surfaces



bonding makes  $V_2 = V_1$   
... thus no sparks!

# Consider the asphalt pellet processing explosion



What is the hazard? **Combustible dust**

What is the initiating event? **Spark from triboelectrically charged funnel**

What is a safety control? **Electrical bonding of funnel to railcar**

Is it preventive or mitigative?

Is it an active or passive control?

# OSHA® QUICK CARD™

## Permit-Required Confined Spaces



A confined space has limited openings for entry or exit, is large enough for entering and working, and is not designed for continuous worker occupancy. Confined spaces include underground vaults, tanks, storage bins, manholes, pits, silos, underground utility vaults and pipelines. See 29 CFR 1910.146.

Permit-required confined spaces are confined spaces that:

- May contain a hazardous or potentially hazardous atmosphere.
- May contain a material which can engulf an entrant.
- May contain walls that converge inward or floors that slope downward and taper into a smaller area which could trap or asphyxiate an entrant.
- May contain other serious physical hazards such as unguarded machines or exposed live wires.
- Must be identified by the employer who must inform exposed employees of the existence and location of such spaces and their hazards.

*"A confined space has limited openings for entry and exit, is large enough for entering and working, and is not designed for continuous worker occupancy"*

*"Maintain contact at all times with a trained attendant either visually, via phone, or by two-way radio"*

### What to Do

- Do not enter permit-required confined spaces without being trained and without having a permit to enter.
- Review, understand and follow employer's procedures before entering permit-required confined spaces and know how and when to exit.
- Before entry, identify any physical hazards.
- Before and during entry, test and monitor for oxygen content, flammability, toxicity or explosive hazards as necessary.
- Use employer's fall protection, rescue, air-monitoring, ventilation, lighting and communication equipment according to entry procedures.
- Maintain contact at all times with a trained attendant either visually, via phone, or by two-way radio. This monitoring system enables the attendant and entry supervisor to order you to evacuate and to alert appropriately trained rescue personnel to rescue entrants when needed.

You have a right to a safe workplace.

If you have questions about workplace safety and health, call OSHA.

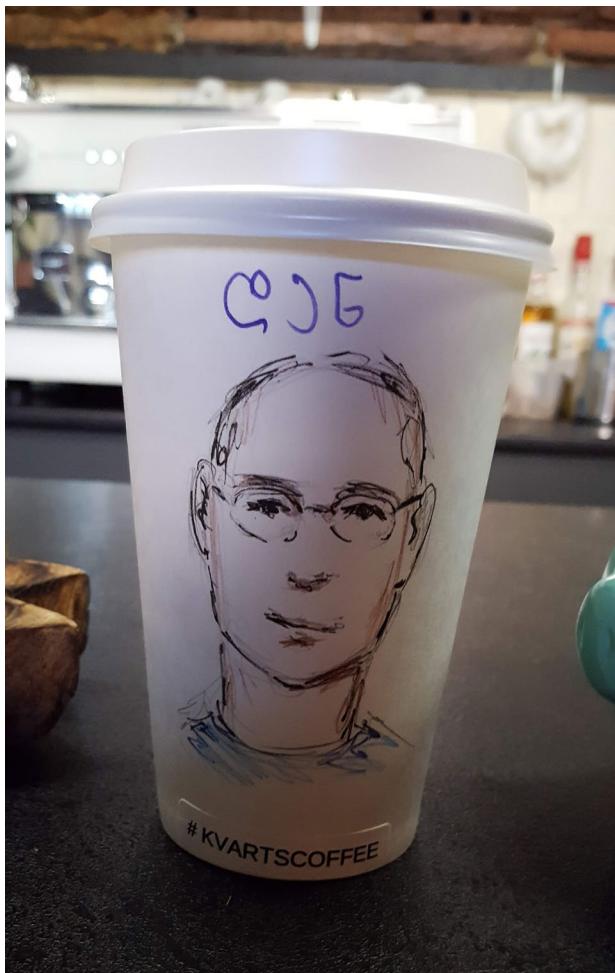
It's confidential. We can help!



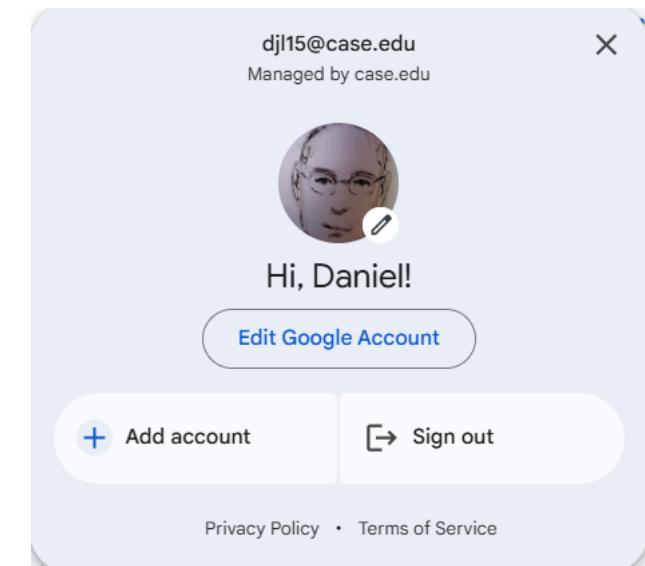
For more information:

**OSHA®**  
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My confined space story comes from the place that has this cool coffee shop!



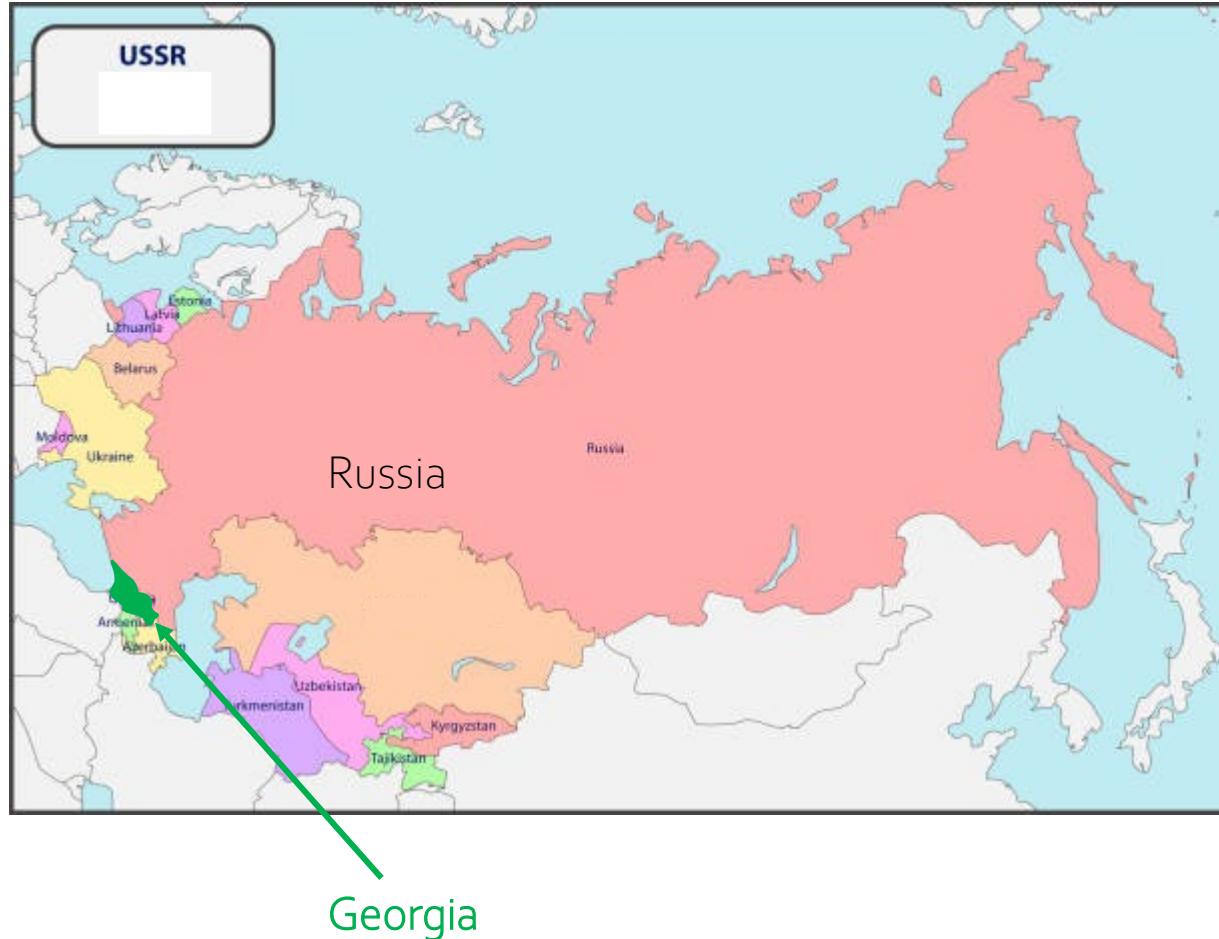
I now use this as my google picture!



and this REALLY amazing food ... Khachapuri!



# Union of Soviet Socialist Republics (USSR): 1922-1991



The Russian Empire was overthrown in 1917. After a few years of civil war, the USSR was formed in 1922

The USSR was dominated by Russia, but included 14 other republics including Kazakhstan, Uzbekistan, Turkmenistan... and Ukraine... **and Georgia**

The USSR broke up in 1991, and the republics became independent countries

# Early Neolithic wine of Georgia in the South Caucasus

Patrick McGovern<sup>a,1</sup>, Mindia Jalabadze<sup>b</sup>, Stephen Batiuk<sup>c</sup>, Michael P. Callahan<sup>d</sup>, Karen E. Smith<sup>d</sup>, Gretchen R. Hall<sup>a</sup>, Eliso Kvavadze<sup>b</sup>, David Maghradze<sup>e</sup>, Nana Rusishvili<sup>b</sup>, Laurent Bouby<sup>f</sup>, Osvaldo Failla<sup>g</sup>, Gabriele Cola<sup>g</sup>, Luigi Manari<sup>g,h</sup>, Elisabetta Boaretto<sup>i</sup>, Roberto Bacilieri<sup>j</sup>, Patrice This<sup>j</sup>, Nathan Wales<sup>k</sup>, and David Lordkipanidze<sup>b,1</sup>

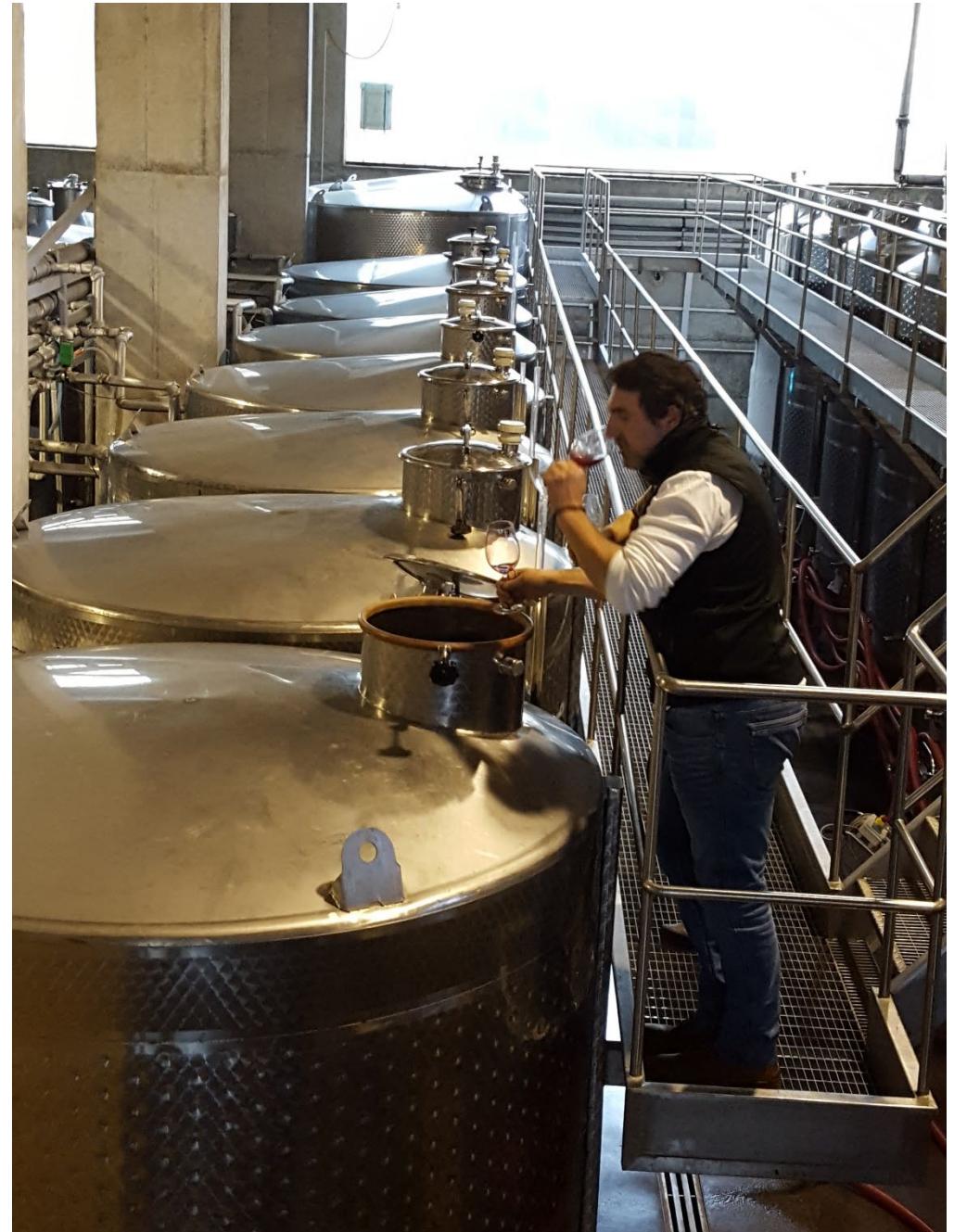
<sup>a</sup>Biomolecular Archaeology Project, University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, PA 19104; <sup>b</sup>Georgian National Museum, Tbilisi 0159, Georgia; <sup>c</sup>Department of Near and Middle Eastern Civilizations, University of Toronto, Toronto, ON, Canada MSS 1A1; <sup>d</sup>Department of Chemistry and Biochemistry, Boise State University, Boise, ID 83725; <sup>e</sup>Scientific Research Center of Agriculture, Tbilisi 0159, Georgia; <sup>f</sup>Institut des Sciences de l'Evolution, University of Montpellier, 34090 Montpellier, France; <sup>g</sup>Department of Agricultural and Environmental Sciences, Università degli studi di Milano, 20122 Milan, Italy; <sup>h</sup>Lombardy Museum of Agricultural History, 26866 Sant'Angelo Lodigiano, Italy; <sup>i</sup>Dangoor Research Accelerator Mass Spectrometer (D-REAMS) Laboratory, Weizmann Institute of Science, Rehovot 7610001, Israel; <sup>j</sup>Institut National de la Recherche Agronomique—Centre de Coopération Internationale en Recherche Agronomique pour le Développement—Centre International d'Études Supérieures en Sciences Agronomiques, UMR Amélioration Génétique et Adaptation des Plantes, 1334, 34398 Montpellier, France; and <sup>k</sup>Centre for GeoGenetics, Natural History Museum of Denmark, University of Copenhagen, 1350 Copenhagen, Denmark

**Chemical analyses of ancient organic compounds absorbed into the pottery fabrics from sites in Georgia in the South Caucasus region, dating to the early Neolithic period (ca. 6,000–5,000 BC), provide the earliest biomolecular archaeological evidence for grape wine and viniculture from the Near East, at ca. 6,000–5,800 BC.**

Georgia is the birthplace  
of European wine!



This was a work trip  
... I really shouldn't be  
complaining about  
my job!



# Traditional Georgian wine made in a qvevri

Do you see any safety issues here?



This is a Qvevri

The qvevri is buried underground

qvevri cleaned between batches... someone climbs in and scrubs

## Why is CO<sub>2</sub> a hazard here?



- CO<sub>2</sub> (MW=44) heavier than O<sub>2</sub> (MW=32)...  
...CO<sub>2</sub> displaces O<sub>2</sub>, thus asphyxiation hazard

"Maintain contact at all times with a trained attendant either visually, via phone, or by two-way radio"

### What to Do

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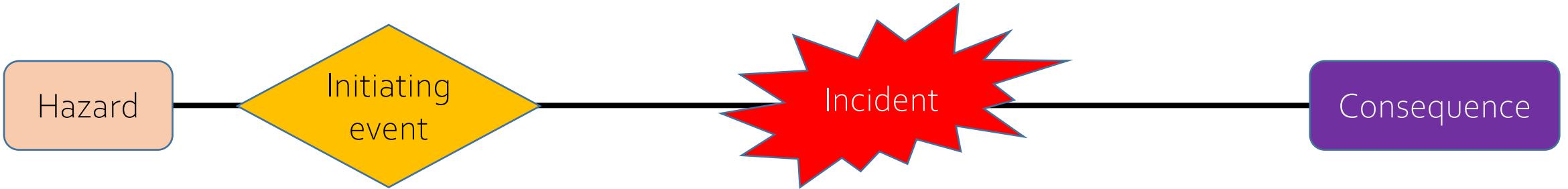
OSHA 3214-07FR 2013

On my winery tour I learned that the ancient Georgians were aware of this issue and had a solution:

The qvevri cleaner would sing while working. The singing is a "sensor" for worker unconsciousness.

If the singing stops, it means the worker is unconscious and colleagues would remove them from the qvevri before situation becomes fatal.

## Q2: For the qvevri cleaning process



Q2: For the qvevri cleaning process:

What is the hazard?

What is the initiating event?

What is the safety control, and is it preventative or mitigative?

# Our next story...











"The Bhopal gas tragedy occurred on Dec. 3, 1984. Forty years later, this incident is still recognized as history's worst industrial disaster.

The exact number of fatalities will never be known, but it is estimated that 5,000 people died within 48 hours and up to 20,000 deaths can be related to the lingering effects of the toxic gas release.

In addition, the toxic chemical release resulted in almost 500,000 injuries and massive destruction of animal life and vegetation."

## Supreme Court nixes government plea for Rs 7,400 crore additional damages for Bhopal gas disaster

Amit Anand Choudhary / TNN / Mar 15, 2023, 02:07 IST



NEW DELHI: The Supreme Court on Tuesday dismissed the Centre's plea filed in 2010 seeking an additional compensation of Rs 7,400 crore from Union Carbide Corporation (UCC) for the victims of 1984 [Bhopal gas tragedy](#).

[Bringing down the curtains on legal proceedings that continued for almost four decades](#), a five-judge constitution bench of Justices Sanjay Kishan Kaul, Sanjiv Khanna, Abhay S Oka, Vikram Nath and J K Maheshwari rejected the curative petition — the last resort in court proceedings — filed by the Centre for compensation above the amount of \$470 million (around Rs 750 crore) paid by the US company in 1989 towards full and final settlement covering all litigations, claims and liabilities arising out of the industrial disaster that claimed 5,295 lives.

Legal proceedings  
still going almost  
40 years later!



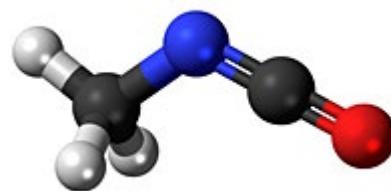
The plant was owned and operated by  
**Union Carbide India, Ltd (UCIL)**

- Founded in 1934
- 50.9% owned by Union Carbide Corporation (USA)
- 49.1% owned by investors in India, including the Indian government

# The disaster involved a precursor in Sevin production

							
<a href="#">📍 Pick up today</a>		<a href="#">📍 Pick up today</a>	<a href="#">📍 Pick up today</a>				
Sevin Insect Killer Outdoo...	GARDENTECH SEVIN...	Sevin Garden Insect Killer...	Sevin Ready-to-Use Trigg...	Garden Tech Sevin Bug...	Sevin Insect Killer Dust 1 l...	32 oz. Insect Killer Ready ...	Sevin Lawn Insecticide...
\$19.44	\$16.74	\$6.46	\$10.48	\$24.99	\$8.99	\$8.40	\$40.74
Walmart	Amazon.com	Walmart	Walmart	Nature Hills ...	Whitehead In...	Home Depot	DoMyOwn.com
★★★★★ (359)	30-day returns	★★★★★ (721)	★★★★★ (1k+)	Get it by 2...	Get it by 2...	★★★★★ (497)	Free shipping
"Effective" · "Easy to use" · "Long..."	SEVIN · Bug Killer	"Effective" · "Easy to use" · "Long..."	"Effective" · "Easy to use"	Bug Killer · Garden · Outdoor	Insect Killer · Ant · Lawn · Outdoor	Insect Killer	Insecticide

*The precursor is Methyl Isocyanate (MIC):  $CH_3NCO$*



# Methyl Isocyanate

1 of 5	<a href="#">View All</a>
<b>Pictogram(s)</b>	 Flammable    Corrosive    Acute Toxic    Irritant    Health Hazard
<b>Signal</b>	<u>Danger</u>
<b>GHS Hazard Statements</b>	H225 (94.4%): Highly Flammable liquid and vapor [ <u>Danger</u> Flammable liquids] H301 (100%): Toxic if swallowed [ <u>Danger</u> Acute toxicity, oral] H311 (100%): Toxic in contact with skin [ <u>Danger</u> Acute toxicity, dermal] H315 (100%): Causes skin irritation [ <u>Warning</u> SK] H317 (100%): May cause an allergic skin reaction H318 (100%): Causes serious eye damage [ <u>Danger</u> Serious eye damage/eye irritation] H330 (100%): Fatal if inhaled [ <u>Danger</u> Acute toxicity, inhalation] H334 (100%): May cause allergy or asthma symptoms or breathing difficulties if inhaled [ <u>Danger</u> Sensitization, respiratory]

Fatal if inhaled! Serious eye damage!

### 3.1 Physical Description

It's a liquid that boils at 39 °C (about 100 °F)



Methyl isocyanate appears as a colorless low-boiling liquid (b.p. 39 °C) that is denser than water. Flash point is less than 20 °F. Very toxic by inhalation. Can be absorbed through the skin. Has a sharp odor, but the sense of smell cannot be relied upon to warn of

### 3.8 Vapor Density

About twice as heavy as air (EPA, 1998) (Relative to Air)

The vapor won't "float away"... it stays near the ground!



### 6.7 Fire Hazards

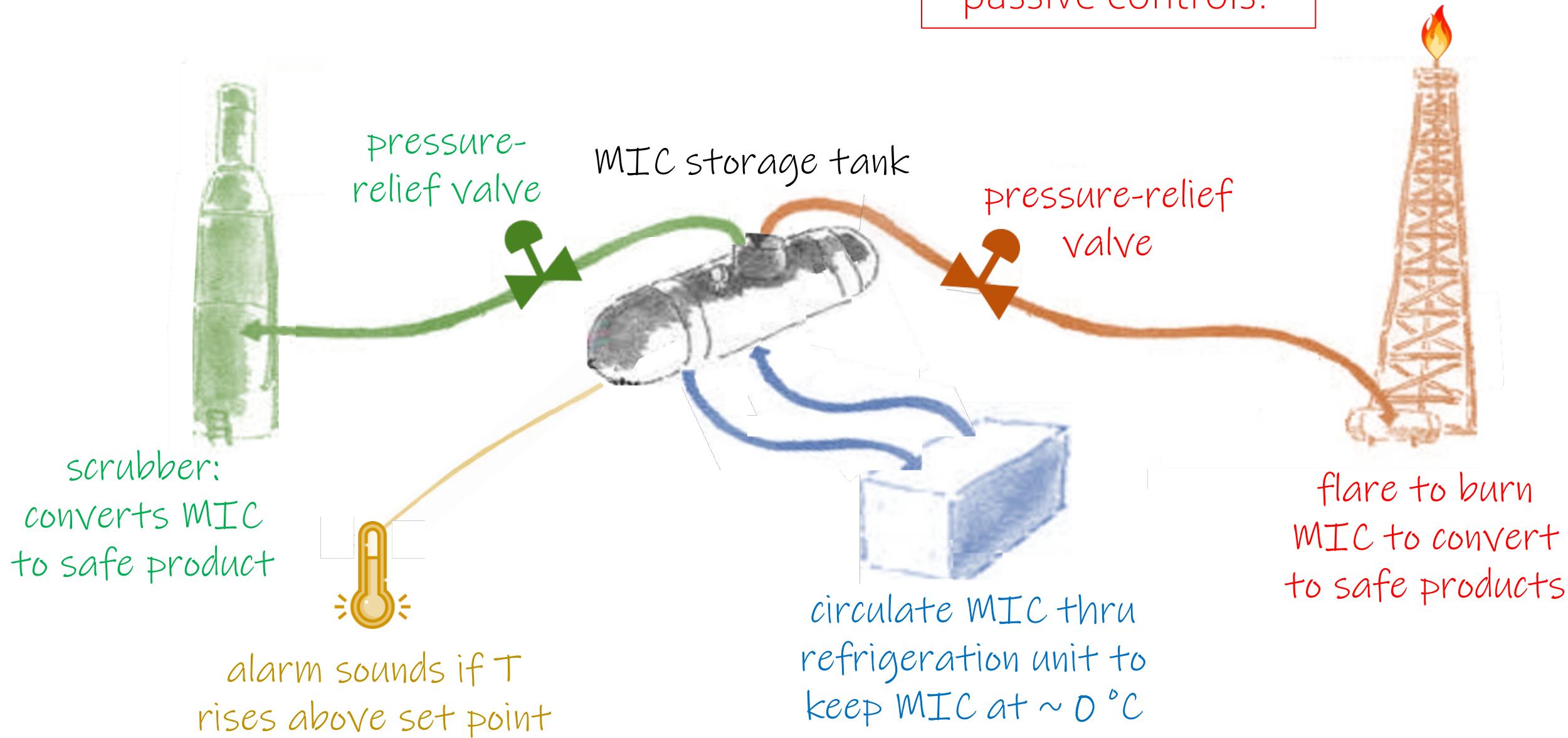
Reacts violently with water. Extremely flammable: may be ignited by heat, sparks or flames. Vapors may travel to a source of ignition and flash back. Container or sewer runoff to sewer may create oxides. Avoid water, acids, alkali, and polymerization may occur. Methyl isocyanate reacts with sodium methoxide, triphenylarsine a gummy, resinous polymer. These reactions are exothermic, producing about 540 Btu per pound of MIC. Heat produced in these reactions may result in pressure build up and rupturing of tanks. (EPA, 1998)

Reaction with water is exothermic, creates the heat to boil the liquid (39 °C)... a small volume of liquid makes a large volume of vapor... if confined, this makes a high pressure... which can rupture tanks!



# Safety systems in place for MIC

Are these active or passive controls?



**BHOPAL METHYL ISOCYANATE INCIDENT  
INVESTIGATION TEAM  
REPORT**

**MARCH, 1985**

**UNION CARBIDE CORPORATION  
DANBURY, CONNECTICUT**

**One to two thousand pounds of water entered the tank.** Although entry from vent headers (RVVH, PVH) cannot be ruled out at this time, direct introduction of water through the vent or other piping has a higher probability for occurrence because it does not require the simultaneous leakage through a series of reportedly closed valves. The chemistry, described in Section 5.0, indicates that the large amount of water and higher-than-normal levels of chloroform were necessary to obtain the particular mix of significant residue components found in the core samples. The large amount of water was necessary to generate the heat needed to initiate and accelerate the subsequent reactions. The temperature of MIC in Tank 610 before the incident was at 15 to 20°C as compared to the requirement of about 0°C. The lower temperature would have retarded the reaction rates and considerably extended the time available for corrective action. The refrigeration system provided to cool the MIC in the storage tanks had been made non-operational in June, 1984.

The reaction of water with MIC led to an increase in pressure due to evolution of carbon dioxide as well as an increase in temperature due to the exothermicity. The higher pressure, 10 psig, noticed at 11:00 PM on December 2 is believed to be due to this phenomenon. The increase in temperature was not signaled by the tank high-temperature alarm since it had not been reset to a temperature above the storage temperature. The nitrogen escape route discussed in Section 5.5 would have allowed carbon dioxide and MIC vapor to flow to the VGS. Since the VGS was not in service prior to the incident, this would explain the untraceable MIC leak reported in the MIC unit at 11:00 PM. Although the pressure in the tank could not be increased by nitrogen addition in earlier attempts, it increased at this time due to the far higher rates of carbon dioxide evolution.

"One to two thousand pounds of water entered the tank"  
(it was never determined how/why... mistake during cleaning? sabotage?)

"The refrigeration system provided to cool the MIC in the storage tank had been made non-operational in June, 1984"

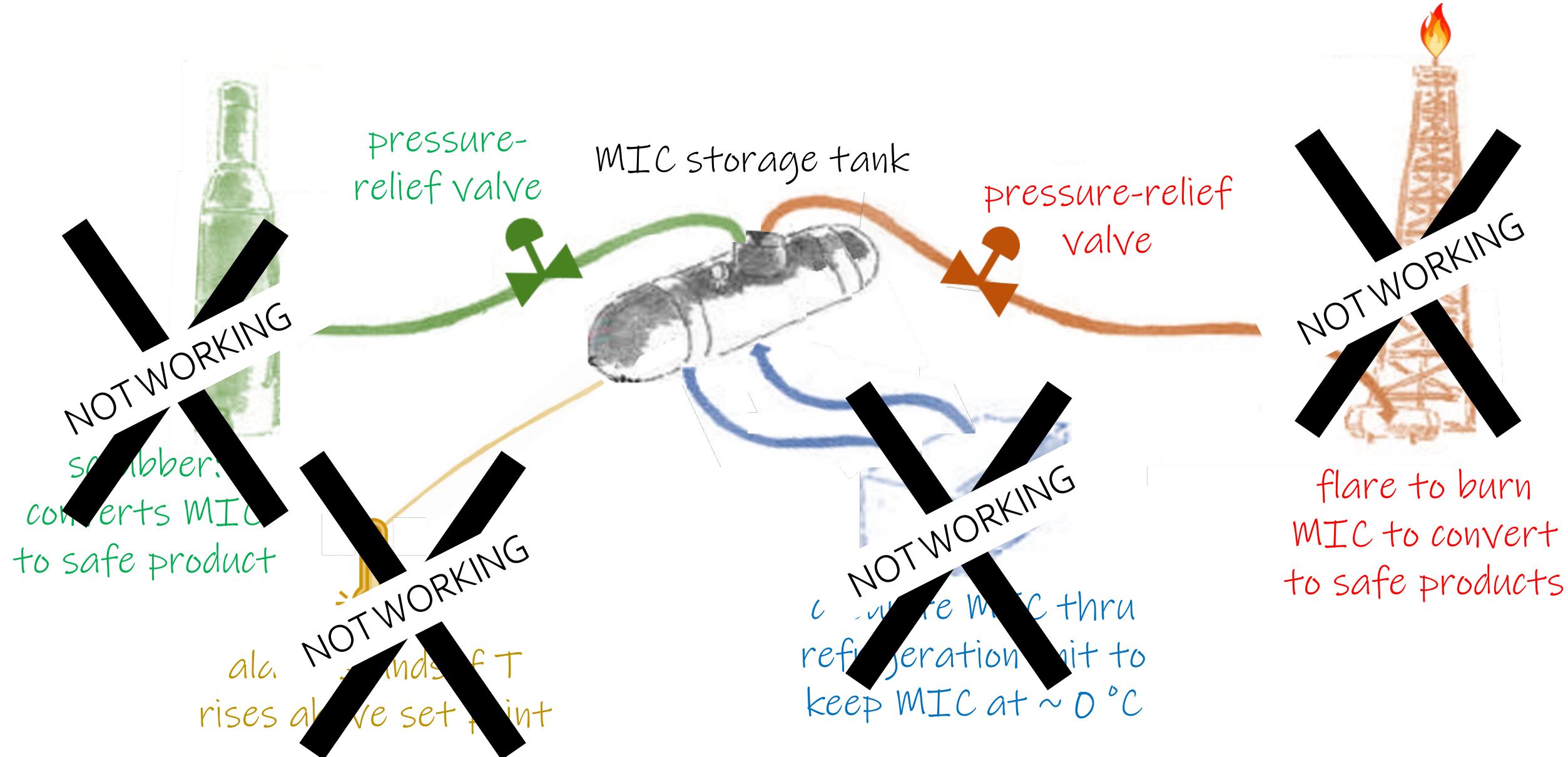
"The increase in temperature was not signaled by the tank high-temperature alarm since it had not been reset to a temperature above the storage temperature"

At 12:15 AM on Monday, December 3, the field operator reported a MIC release in the MIC process area. The control room operator looked at the tank pressure again. The reading was 30 psig and rapidly rising. Within moments the pressure was beyond 55 psig (top of scale). He called his supervisor and ran outside to the tank. He heard rumbling sounds from Tank 610, a screeching noise from the safety valve, and felt heat radiating. As he ran back to the control room, he heard the cracking of the concrete over the tank. As soon as he returned to the control room, he turned the switch to activate the VGS. The VGS had been removed from an operating mode to a standby mode on October 23, 1984, after the MIC unit was shut down with a total MIC inventory of 183,000 pounds in Tanks 610 and 611. The return to an operating mode was dependent upon the operator being alerted to a problem and taking prompt action to activate the circulating pump. The flow meter did not indicate that caustic circulation had been started. The operator did not go into the unit to check the pump and verify a flow. Prior to the incident, the flare had been removed from service for maintenance work and was not operating at the time of the incident.

"The Vapor Gas Scrubber had been removed from operating mode to a standby mode on October 23, 1984"

"Prior to the incident, the flare had been removed from service for maintenance work and was not operating at the time of the incident"

# Safety systems in place for MIC



Q3: What is “normalization of deviance” and why is it relevant to the Bhopal disaster?

"All the News  
That's Fit to Print"

# The New York Times

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35 CENTS

## NEAR DEPARTURE, RUSSIANS EXPECT WORST FOR KABUL

### LOOTING BY AFGHAN ARMY

Guerrillas Reported Massing  
Around Capital and a City  
in the Eastern Region

By BILL KELLER

Special to The New York Times

MOSCOW, Feb. 14 — In the final hours of the Soviet military withdrawal from Afghanistan, the Soviet Union seemed braced today for a rapid deterioration of the military situation it is leaving behind.

A Soviet newspaper said that some Afghan Army units had begun looting the strongholds left in their control and then abandoning them to the guerrillas.

And a Soviet Foreign Ministry spokesman said 30,000 guerrillas had massed around Kabul, the Afghan capital, and 15,000 more around the eastern city of Jalalabad, preparing for a quick offensive as the Russians leave the country.

Reuters reported from Kabul that the last Soviet troops guarding the



Associated Press

Secretary of State James A. Baker 3d, right, being greeted yesterday at

## LATIN PRESIDENTS ANNOUNCE ACCORD ON CONTRA BASES

### HONDURAS TO SHUT SITES

For Their Part, Nicaraguans  
Agree to Free Rebels and  
Hold Open Elections

By LINDSEY GRUSON

Special to The New York Times

TESORO BEACH, El Salvador, Feb. 14 — The presidents of five Central American countries announced an agreement today under which contra bases in Honduras would be closed in return for open elections in Nicaragua.

The accord was read aloud by President José Napoléon Duarte of El Salvador at the end of a two-day summit meeting here. It calls for a plan to be drawn up within 90 days for dismantling the rebel bases in Honduras and for relocating the thousands of contras and their families to third countries.

As part of the accord, Nicaragua agreed to free most of the 3,300 contras and former National Guardsmen now in prison. About 1,700 guardsmen are to be released almost immediately, and

## BHOPAL PAYMENTS BY UNION CARBIDE SET AT \$470 MILLION

### Bhopal Aftermath: 4-Year Struggle

**THE ACCIDENT** Methyl isocyanate, a toxic chemical, leaked from a pesticide plant, Dec. 3, 1984.

**CASUALTIES** More than 3,500 dead, 200,000 injured. Lung and psychological problems persist.

**COSTS** Indian Government has spent \$70 million for relief and rehabilitation.

**CLAIMS** India sought \$3.3 billion on behalf of 500,000 claimants, charging poor maintenance and design flaws at the plant.

**SETTLEMENT** \$470 million, to be paid by Union Carbide to India before March 31.

### BLAME IS NOT FIXED

Top Indian Court Drops  
All Criminal Charges  
Filed on Toxic Leak

By SANJOY HAZARIKA

Special to The New York Times

NEW DELHI, Feb. 14 — Ending a legal battle over compensation for victims of the world's most deadly industrial disaster, the Indian Supreme Court today ordered the Union Carbide Corporation to pay \$470 million in damages for the toxic gas leak at Bhopal.

In a telephone interview, a Union Carbide spokesman, Robert Berzok, said the company accepted today's ruling. Since the Supreme Court is India's highest court, the decision cannot be appealed.

More than 3,500 people were killed

### Late Edition

New York: Today, drizzle, rain, patchy fog. High 51-55. Tonight, rain or drizzle, some dense fog. Low 42-46. Tomorrow, scattered light rain. High 42-47. Yesterday: High 55, low 41. Details, page B8.

# THE WALL STREET JOURNAL.

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## Court Convicts Seven in Bhopal Gas Leak

By Tripti Lahiri

Updated June 8, 2010 12:01 am ET

26 years later!

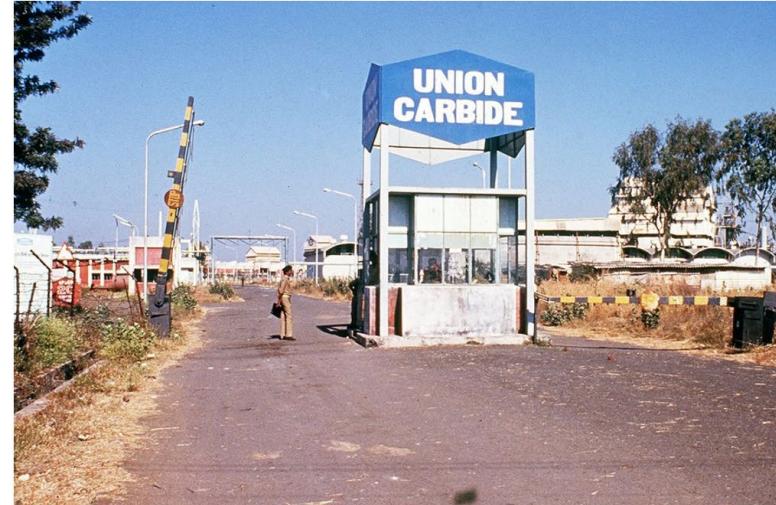


Gift unlocked article

NEW DELHI—A district court in Bhopal found seven former Union Carbide India Ltd. officials guilty of "causing death by negligence" in the gas leak there 25 years ago, the first verdict in the only Indian criminal case against the company related to the disaster.

The defendants were found guilty of failing to prevent the leak at a Union Carbide pesticide plant, sentenced to two years in prison and fined 100,000 rupees (\$2,130), India's Central Bureau of Investigation said.

What is the ethical responsibility of engineers at Union Carbide (USA)?



The plant was owned and operated by Union Carbide India, Ltd (UCIL)

- Founded in 1934
- 50.9% owned by Union Carbide Corporation (USA)
- 49.1% owned by investors in India, including the Indian government

what really were the roles, interactions and responsibilities of Union Carbide (USA)?

An ethical question

Factual

- The facts are important!
- Need accurate information—What source???
- In real life, likely won't know all the facts you need

Conceptual

- Key terms could be interpreted differently
- e.g., What is "safe"? What is a "conflict of interest"

Moral

- A conflict between values, desires or obligations
- Can analyze with consequentialist, deontological, virtue ethics

**634 F. Supp. 842 (1986)**

We can get find out some of the relevant facts from this judicial opinion, which was in regard to whether legal proceedings should be held in the US (vs India)

(It was determined that the legal proceedings should not be held in the US)

**In re UNION CARBIDE CORPORATION GAS PLANT DISASTER AT BHOPAL, INDIA IN DECEMBER, 1984.**

Misc. No. 21-38 (JFK).

**United States District Court, S.D. New York.**

May 12, 1986.

As Amended June 10, 1986.

\***843** Robins, Zelle, Larson & Kaplan, Minneapolis, Michael V. Ciresi, Bruce A. Finzen, Roberta B. Walburn, D.S. Sastri of counsel. Barrett, Smith, Schapiro, Simon & Armstrong, New York City, Gerald A. Novack, of counsel, for the Union of India.

Waite, Schneider, Bayless & Chesley Co., L.P.A., Cincinnati, Ohio, Stanley M. Chesley, Phillip B. Allen, Jan Levien, of counsel, Bailey & Broder, New York City, F. Lee Bailey, Michael C. Zwal, of counsel, for individual plaintiffs.

Hoffinger, Friedland, Dobrish, Bernfeld & Hasen, New York City, Jack S. Hoffinger, of counsel, Liaison Counsel.

Kelley Drye & Warren, New York City, Bud G. Holman, William A. Krohley, Lisa E. Cleary, of counsel, for defendant.

Christic Institute, Washington, D.C., Rob Hager, Shelley D. Hayes, of counsel, for Amicus Curiae.

**\*844 OPINION and ORDER**

KEENAN, District Judge:

# Union Carbide (USA) asserts

**Overall :** the Bhopal plant had "almost no contact" with the United States

**Management:** the Bhopal plant was managed and operated entirely by Indian nationals employed by UCIL, and the last American employed by UCIL left in 1982

**Safety audits:** Union Carbide (USA) conducted only three safety audits (in 1979, 1980 and 1982) out of the thousands of safety audits at Bhopal

**Response to prior accidents:** UCIL had responsibility for remedying issues that led to previous accidents and Union Carbide (USA) didn't make any safety recommendations in these situations

**Personnel training:** Only 40 UCIL employees were trained in the US, while the remainder of the over 1,000 employees were trained exclusively in Bhopal

**Plant design:** Union Carbide (USA)'s provided general process designs only, and UCIL was responsible to "detail design, erect and commission the plant"

Q4: Do you believe any engineers working for Union Carbide (USA) carry an ethical responsibility for the Bhopal disaster? Provide a brief explanation for your answer that takes into account the relationship between Union Carbide and UCIL.