



Industrial Explosions

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I AM THE FIRST RESPONDER!??**



NASA WSTF



Introduction

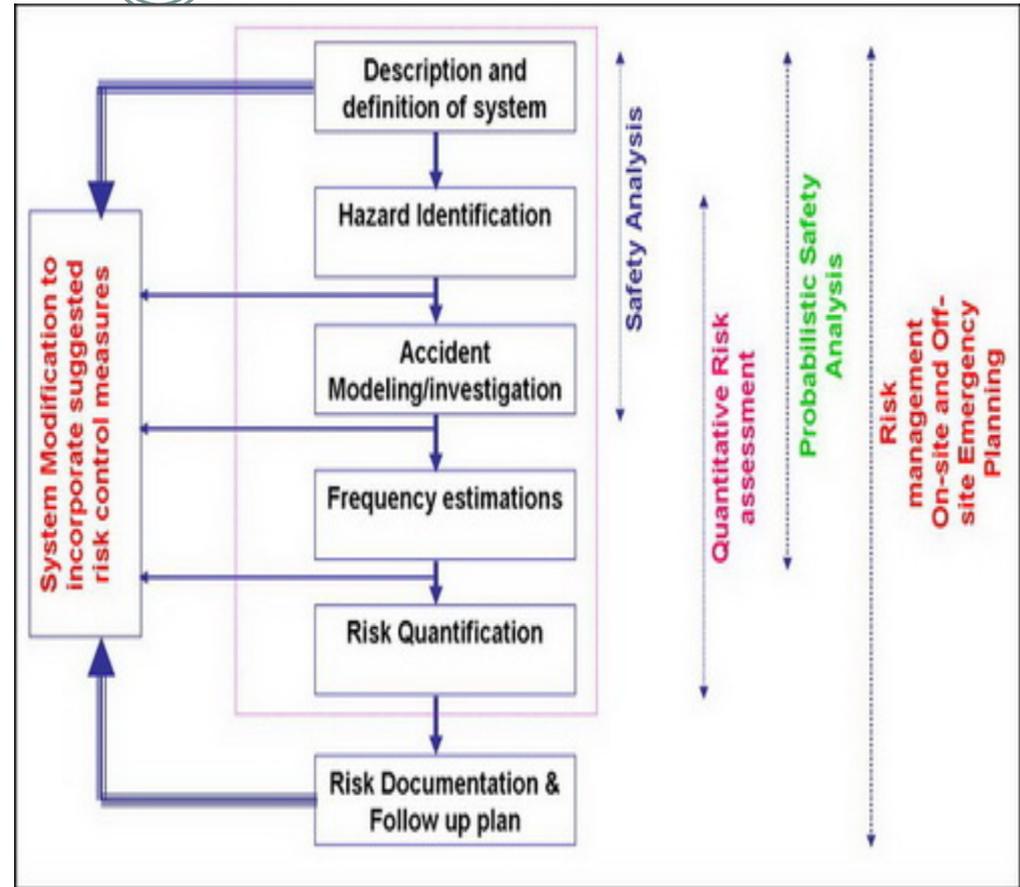


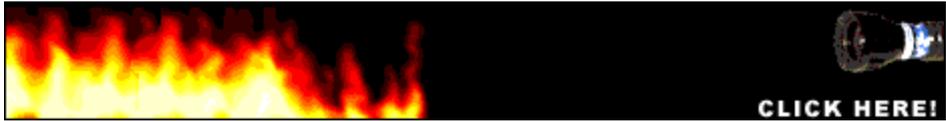
- A variety of incidents occur in process industry from minor innocuous leaks to major explosive catastrophes.
- Mother Nature also lends to such catastrophes.
- Both can have dramatic impact.
- Possess unique challenges.

Union Carbide Factory Explosion, Bhopal 1984



http://www.cameradistribuzioni.it/public/bhopal_969.jpg





Objectives



- The scope of applicable topics is broad.
- Understand the hazards presented to the First Responder at an industrial explosion.
- Examining the hazards found at rocket fuel plants.
- Unique hazards presented by fine particulate matter.
- Understanding of the nature and the mechanism of each event that can occur.
- Understand basic knowledge of positive overpressure effects which will allow an estimation of the likelihood of Primary Blast Injury.

Explosions



- Latin word *explodere*
 - to drive off the stage by clapping
- Sudden burst of energy
- Ability to generate massive over-pressurization.
- Sudden release of physically or chemically generated and stored energy.
- Shock wave/blast wave of significant magnitude, rapidly moving out from the explosion source.

Explosions



- Explosions cause more complex and multiple forms of damage than any other wounding agent.
- Potential to inflict many different types of injuries on victims.
- All blast injuries lead to multi-system injuries.
- It is even more compounding and complex when there is an explosion + an industry.

Some explosions we look forward to...



Space Shuttle Lift-Off

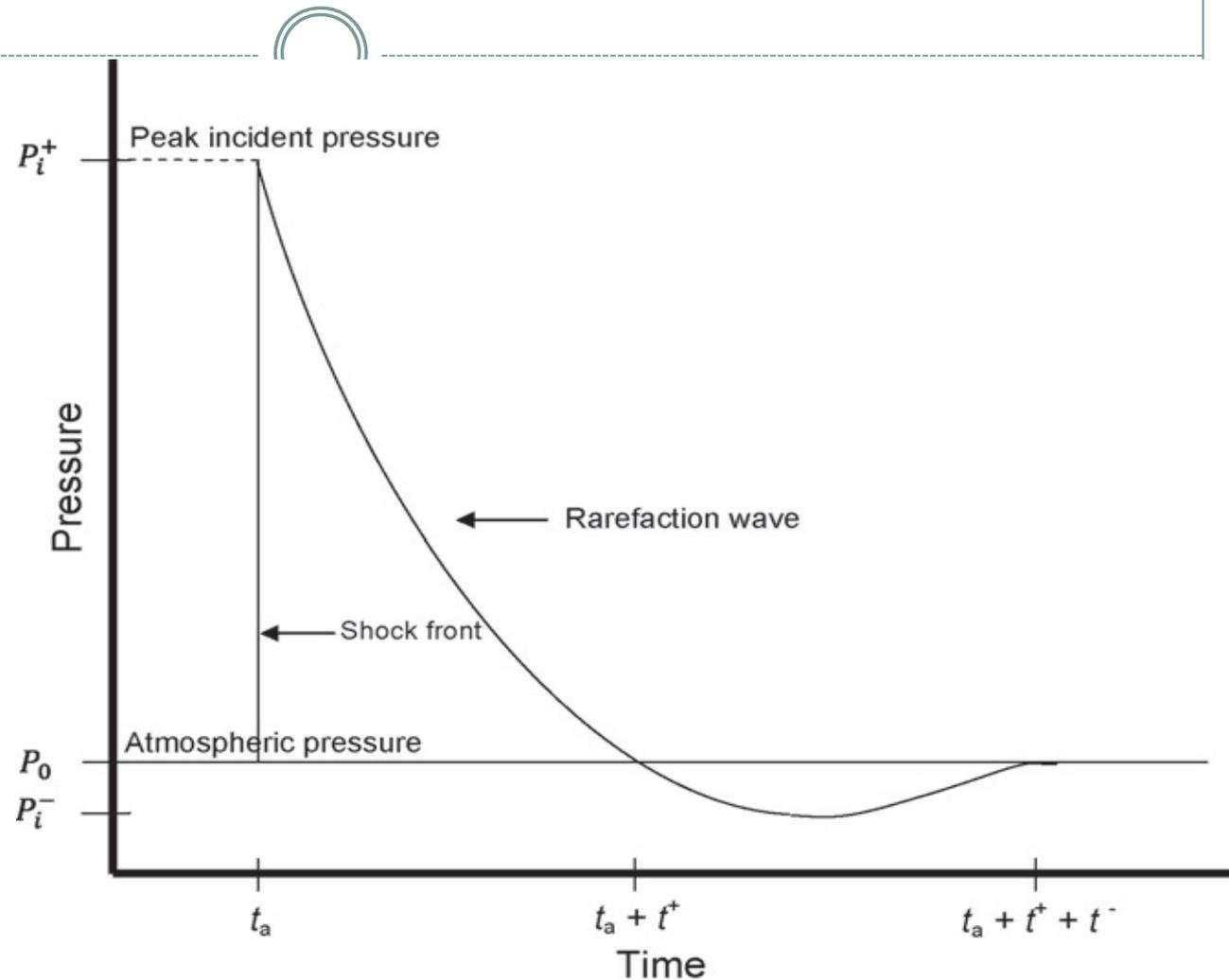
And some we don't...



**Ammonium Perchlorate Explosion and Fire,
Henderson NV, 1988, 2 killed, 372 injured**

Blast Wave

Blast wave led by a shock and followed by a rarefaction wave; t_a , t_+ and t_- represent times of peak incident pressure, positive phase duration and negative phase duration, respectively





- Hazardous materials (HazMat) are integral to industrialized societies, and in almost all instances originate at a location other than their destination.
- Approximately 94% of all individual hazmat shipments in US are transported by trucks, which also account for 63% of overall hazmat accidents



- Any human activity or act of nature can be the cause of an accident.
- Whether producing, transporting, or working on material, there are technological risks that can increase the possibility of an accidental event on a site using products or processes that are dangerous.



- Sites storing or producing explosives are a serious concern for public and occupational safety:
 - nature of the processed and stored explosive substances
 - severity of their consequences should they explode.

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- Large quantities of hypergolic fuels and oxidizers stored on site.
- Used as rocket fuel because they do not require an ignition source or oxygen to react, but react on contact with each other.
- Toxic, corrosive, and harmful if inhaled, ingested, or simply through contact.



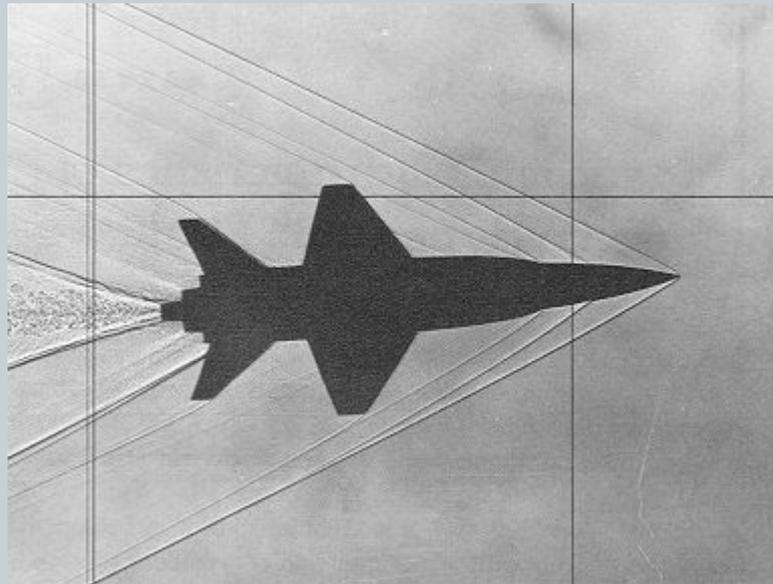
- Cryogenics (super cold fluids, below -423°F) liquid hydrogen, liquid nitrogen and liquid oxygen (LOX) and high pressure gasses at operating pressures in excess of 3,000 psi.



- Shockwave phenomena and projection of fragments that follow an explosion of explosive substances have been reported to reach radius of several kilometers from the point of the explosions.
- Shock waves possess a characteristic termed *brisance* or, shattering effect.
- Or, the speed at which an explosive reaches its maximum pressure.



- Shockwave (overpressure) is one of the main consequences in the case of an explosion.



X-15 free-flight model being fired into a wind tunnel vividly details the shock-wave patterns for airflow at Mach 3.5. NASA



**Faster than a
speeding
bullet...
or at least sound**



A plane moving faster than the speed of sound creates shock waves that form a cone around the plane.

- Blast waves are only a few millimeters thick.
- They highly pressurize and superheat molecules in the medium of the blast front to propel the wave faster than the speed of sound

The speed of sound in air is 343 m/s
(713 mph) at sea level

BLAST EFFECTS



A. BEFORE BLAST WAVE STRIKES.



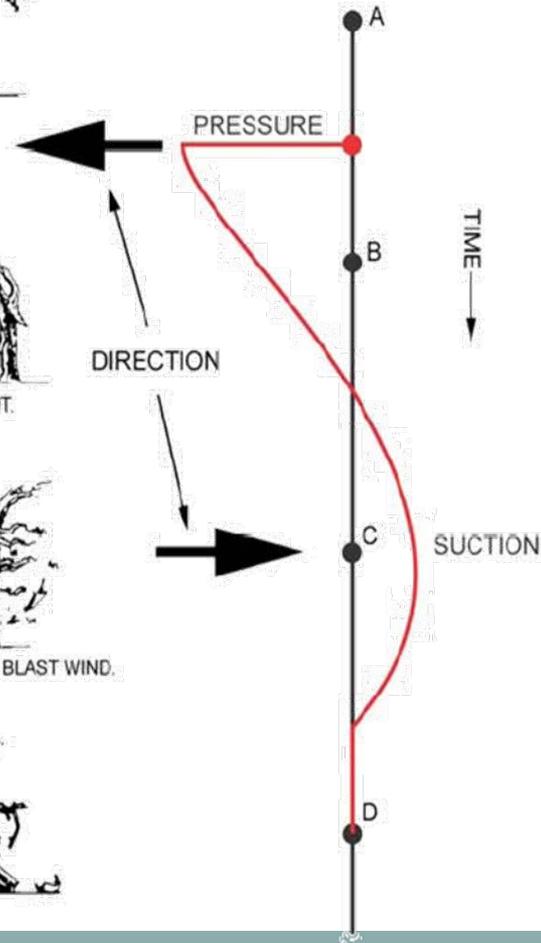
B. IMMEDIATELY AFTER PASSAGE OF THE SHOCK FRONT.



C. IN NEGATIVE OVERPRESSURE PHASE WITH REVERSED BLAST WIND.



D. AFTER BLAST WAVE SUBSIDES.

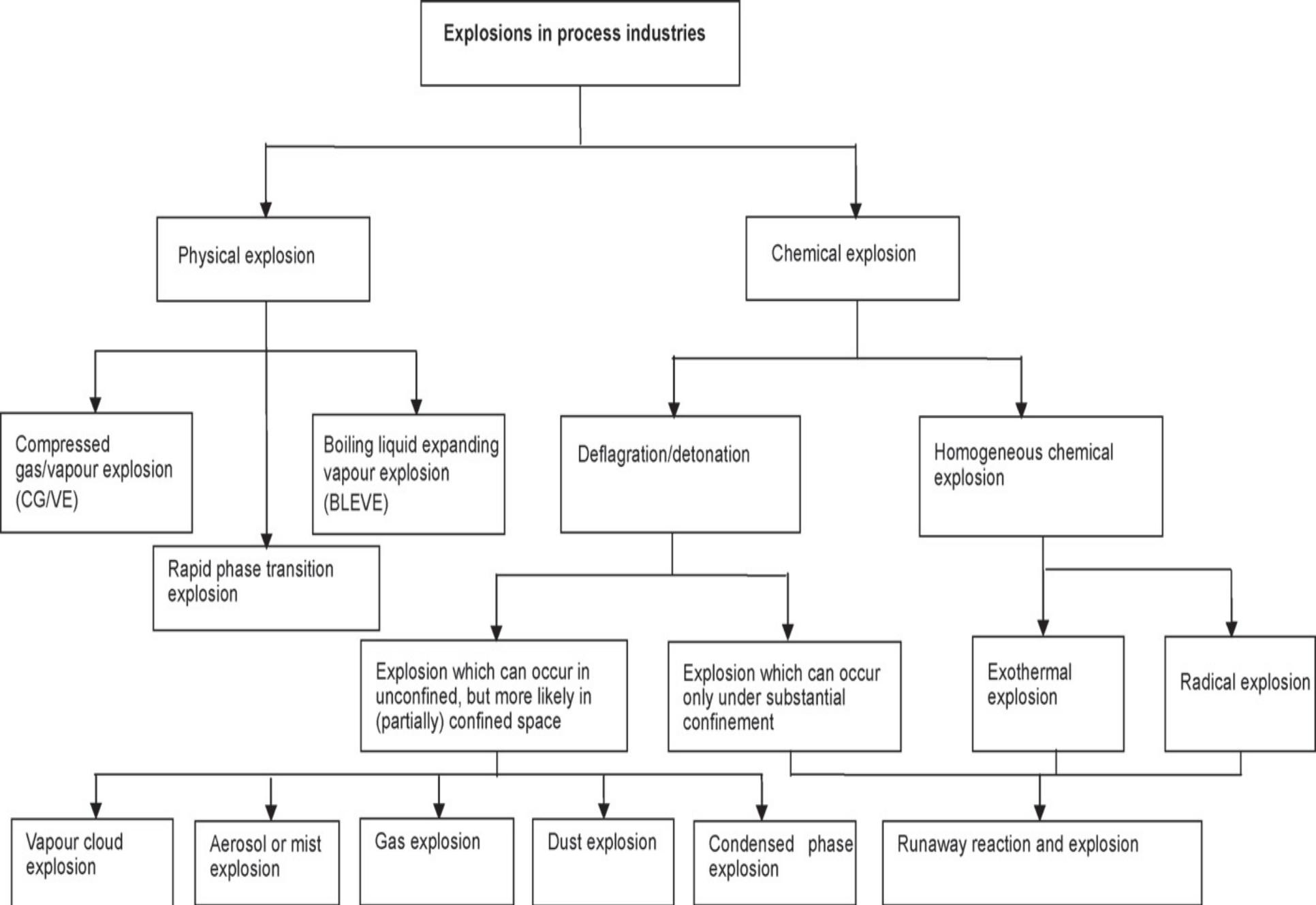


Anatomy of an Industrial Accident



- All process industry accidents fall under three broad categories:
 - Fire
 - Explosion
 - Toxic release

Explosions cause the greatest proportion of losses in chemical process industry



Carbon Nanotube Technology



- Nanotechnology has emerged at the forefront of science research and technology development.
- Carbon nanotubes (CNTs) are major building blocks of this new technology.
- They possess unique electrical, mechanical, and thermal properties, with potential wide applications in the electronics, computer, aerospace, and other industries

To consider



- **Particle characteristics:**
 - Size
 - Agglomeration
 - Morphology
 - Solubility
- **Surface chemistry**
- **Exposure/dose metrics**
 - Mass
 - Size
 - Surface area

Nanosize Particles



- Have a potentially high efficiency for deposition.
- Target both the upper and lower regions of the respiratory tract.
- Retained in the lungs for a long period of time.
- Induce more oxidative stress and cause greater inflammatory effects than their fine-sized equivalents.



- The First Responder must be aware – if not trained to respond to any such potential situation.
- Know what you are responding to
 - Personal Protective Equipment (PPE)
- **SCENE SAFETY**
 - safety and protection of first responders and medical personnel is the most important first step

Not the usual attire...



AA801

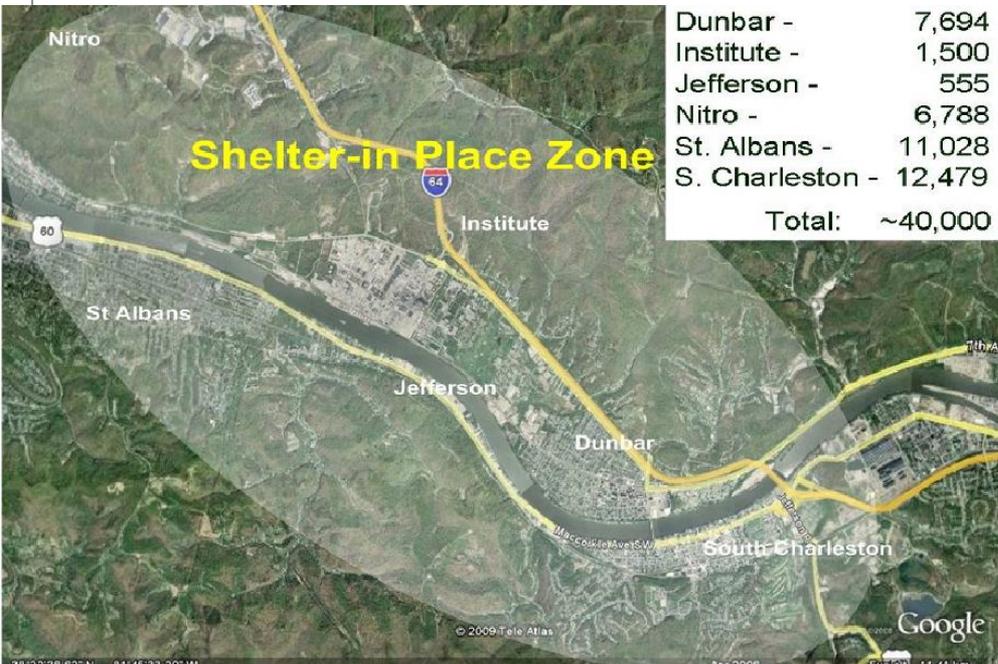


Just not that simple



- The danger of additional explosions.
- The possibility of toxic products being released with the smoke.
- The need to search for and treat victims in the immediate area and surrounding area(s).
- The need for damage assessment and emergency medical treatment in the entire area affected by the explosions.

? Believe what you are told?

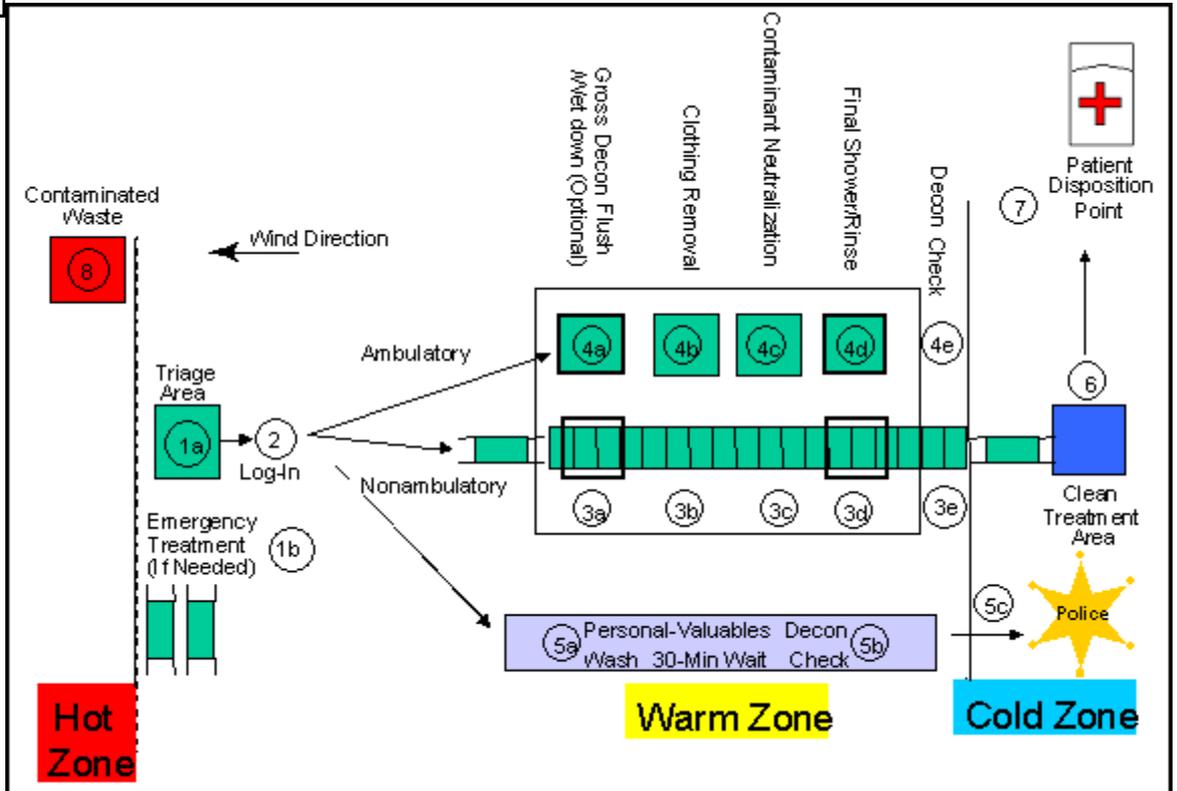
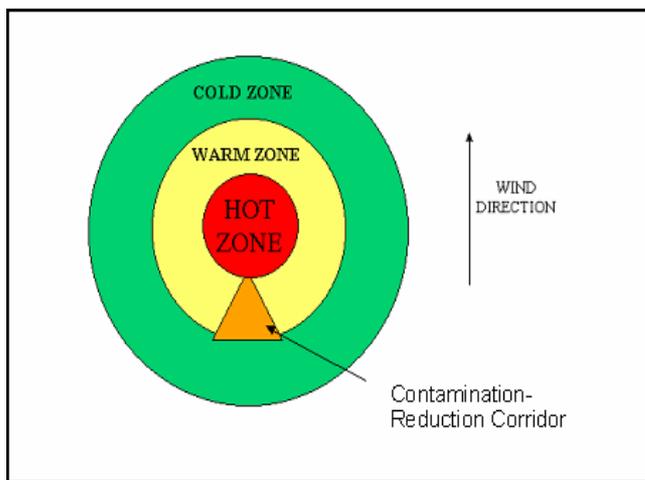


Shelter in place zone in the aftermath of the Bayer CropScience pesticide plant explosion on August 28, 2008.

When the explosion occurred at 10:35 p.m. on the night of August 28, the flammable and toxic contents of the residue treater, amounting to about 2,500 gallons, were suddenly ejected and a major fire erupted in the unit. Chemical pipes and venting systems were broken open and their contents released to the atmosphere. Projectiles were hurled in all directions... The county's 9-1-1 call center was told, fifteen minutes into the response, that no dangerous chemicals had been released. That information came from Bayer's incident commander and was relayed by the Institute volunteer fire chief, who was also a Bayer employee."

Expected EMS Response

- **Scene survey identifies HAZMAT and isolates scene**
 - **Defines a SAFE ZONE**
- **EMS activity is to prevent additional injury while HAZMAT defines control zones**
 - **Maintains a SAFE ZONE**
- **EMS Sets up EMS Branch**
 - **In a safe zone**





EMS in the HOT Zone

Get by with a little help from your friends...



- Fire Departments
- Police Departments
- Health Departments
- Hazardous Materials Response Teams
- Local Industry Response Teams
- DMAT



Ironic



First Responders



- Responder safety
- Life safety / Incident stabilization
- Property conservation



KEY



- Appropriate triaging of patients and proper insight of the injury patterns and understanding the pathophysiology of blast injuries will go long way in decreasing the morbidity and mortality in the event of blast injuries.
- Optimal triage, evacuation, and care of patients with both multiple cause of injury (thermal injuries, trauma, chemical) after a massive explosion is a challenge in many instances.

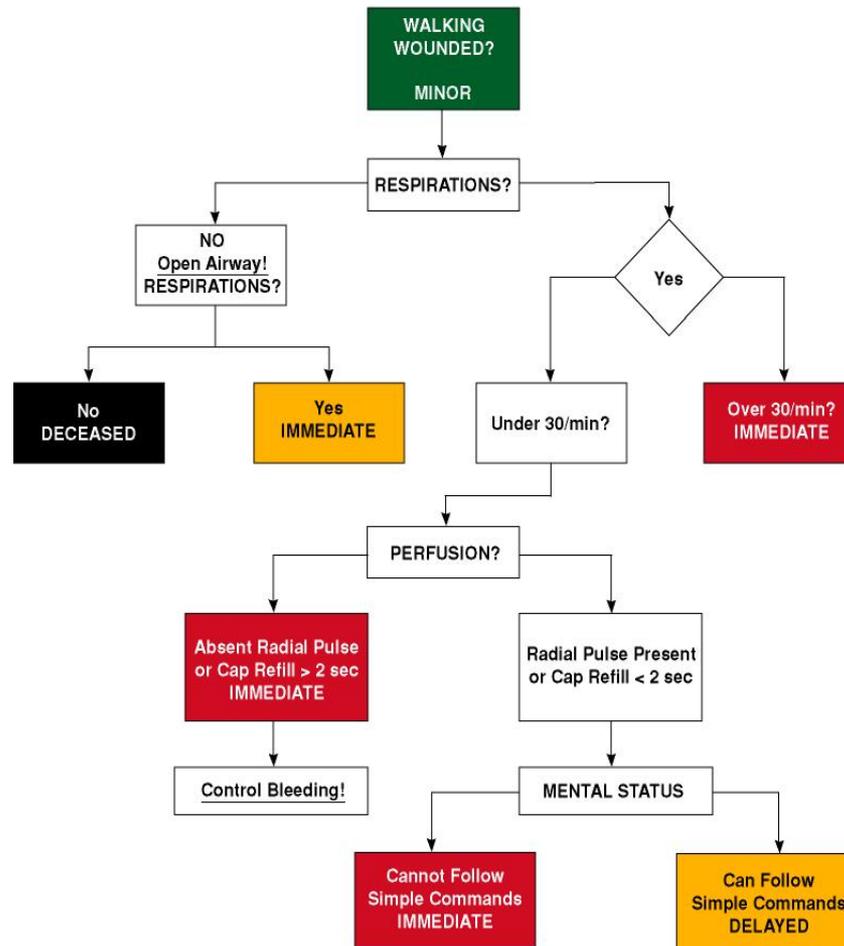
MCI TRIAGE



- To do the most good for the greatest number of victims with the given resources.
- Continuous process.
- A tough job.

Simple Triage and Rapid Transport

START TRIAGE SYSTEM



Trauma from Blast Injuries



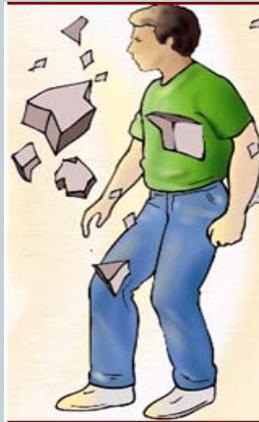
- **Primary Blast Injury (PBI)**
 - occurs as a direct effect of changes in atmospheric pressure caused by a blast wave.
 - interaction of the blast shock wave with the body





- **Secondary Blast Injuries**

- occur when objects accelerated by the energy of the explosion strike a victim, causing either blunt or penetrating ballistic trauma.





- **Tertiary Blast Injuries:**

- result from a victim's body being displaced by expanding gasses and high winds



Other Effects Include:



- Inhalations of:
 - Dust
 - Smoke
 - Carbon monoxide
 - Chemicals
- Burns from secondary fires
- Crushing injuries from structural collapses
- Impaling objects

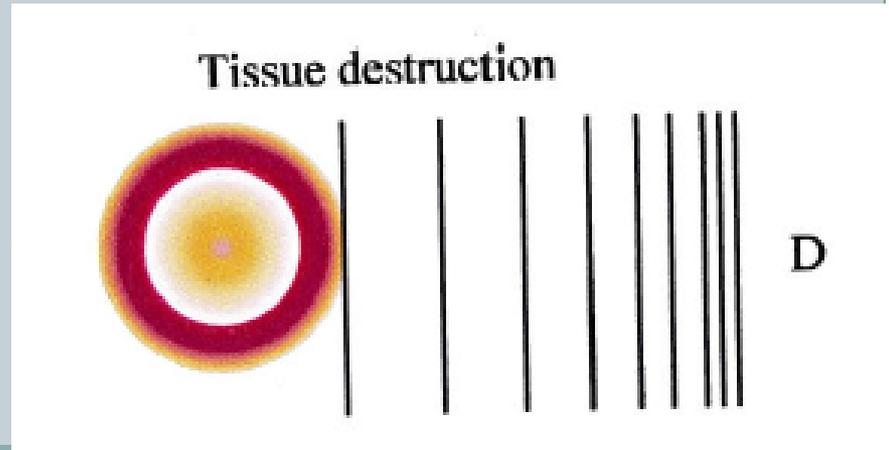
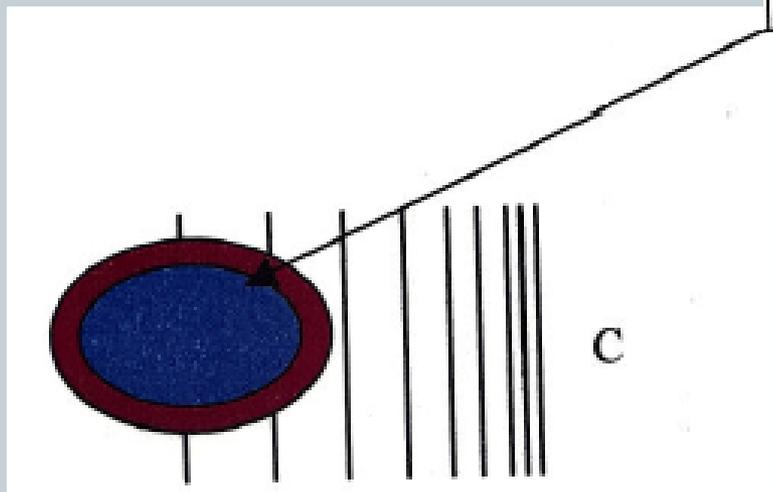
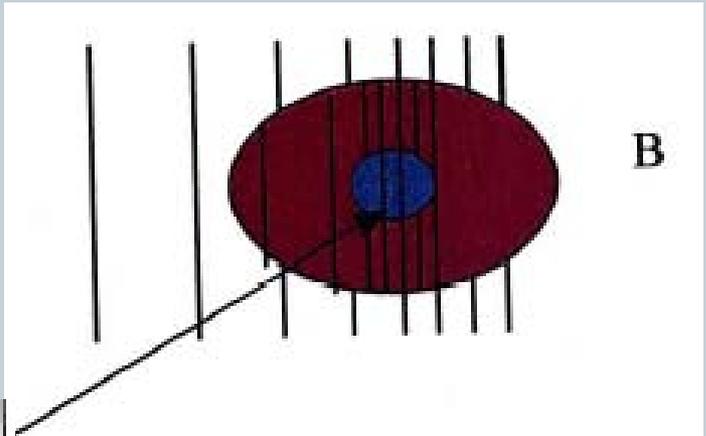
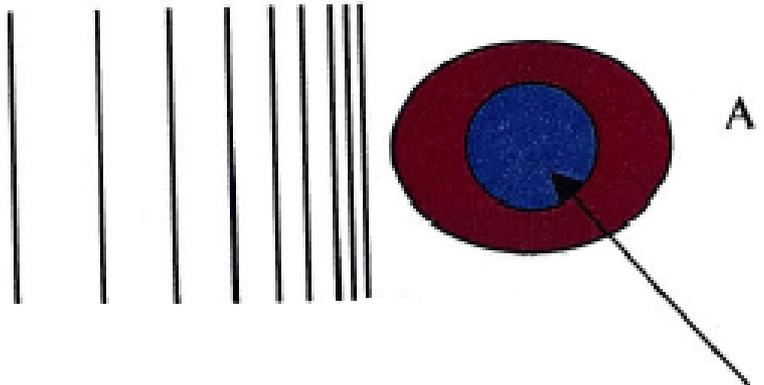
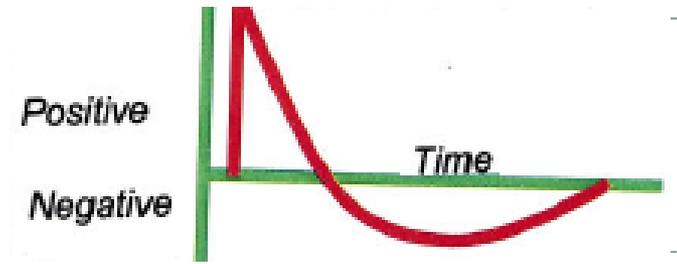
Primary Blast Injuries



- Commonly occur in gas-containing organ systems middle ear, the lungs, and the bowel, however there are many reports of other anatomical injuries.
- Depends on where the patient was located at the moment the blast/explosion occurred.

Primary Blast Injuries

Effect on Gas Containing Organs



Air spaces

Tissue destruction

Tympanic Membrane



Normal
eardrum



Ruptured
eardrum



Airway, Breathing

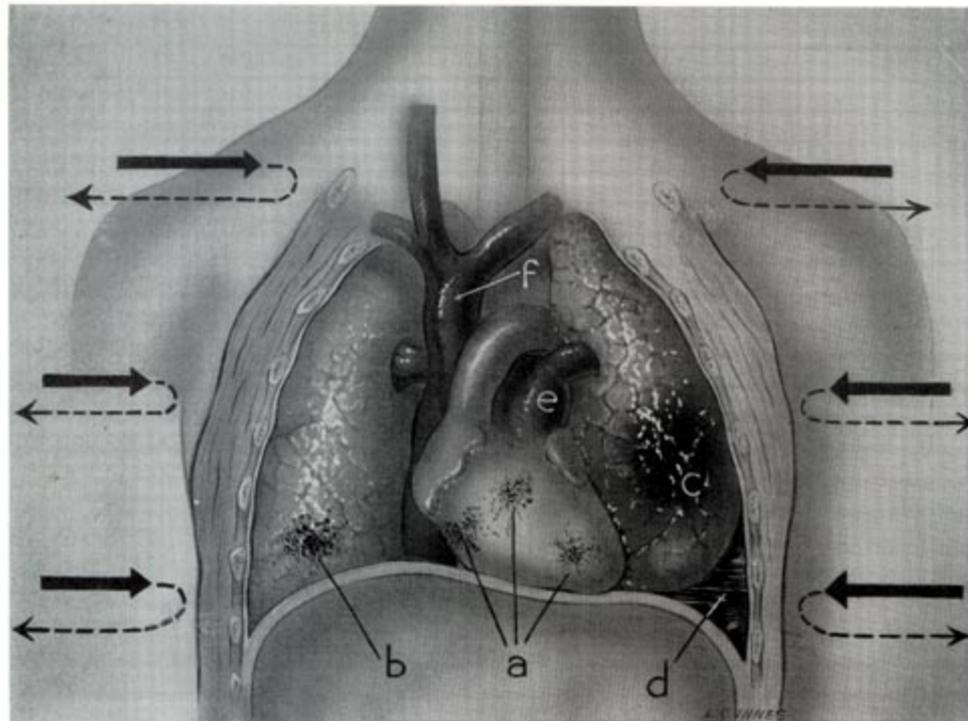


FIGURE 10.—Schematic showing of pathologic physiology of blast injury (wave of positive pressure shown by solid arrow, wave of negative pressure by dotted arrow): Petechial hemorrhage, cardiac (a), petechial hemorrhage, pulmonary (b), gross pulmonary hemorrhage (c), pleural hemorrhage (d), engorged pulmonary artery (e), and engorged vena cava (f).



- Alveolar rupture can lead to:
 - Pulmonary interstitial edema
 - Systemic Air Embolization
 - Pneumomediastinum
 - ✦ Pneumothorax
 - ✦ Subcutaneous emphysema
 - ✦ Pneumopericardium
 - ✦ Pneumoretroperitoneum
 - pneumoperitoneum

Cardiac Injuries

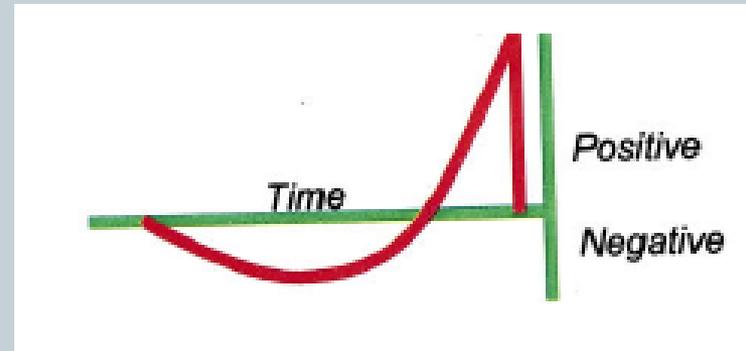
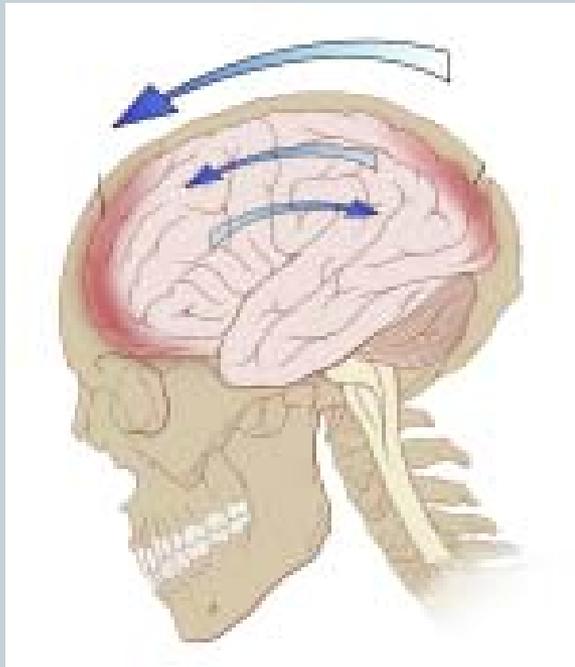


- Pericardial tamponade
- Cardiac contusion
- Dysrhythmias
- Coronary artery obstruction from air emboli

Primary Injuries – Brain Injuries



As white and gray matter do not weigh the same amount they react to force differently causing “shearing” type injuries



Brain Injuries of this nature might not display visible skin/musculoskeletal signs.

Intra-Abdominal



- **Bowel**
 - Injuries range from minor submucosal hemorrhage to full thickness disruption and perforation
 - Colon and ileocecal junction most commonly affected sites
 - Delayed perforations are common and can occur up to 14 days following initial blast as a consequence of ischemia
- **Liver**
- **Spleen**
- **High risk of developing abdominal compartment syndrome**

Secondary / Tertiary / Quaternary Injuries

Secondary Injuries

- Debris / Other Material (Screws, Nails, Glass, etc...)

Tertiary

- Victim comes in contact with a large object
- Crush syndrome

Quaternary and Quinary Injuries

- burns / asphyxiation
- radiation/chemicals
- bacteria – human remains



Above all:



- Scene Safety
- PPE
- Airway
- Breathing
- Circulation

Primum non nocere

Summary



- Knowledge of the potential mechanisms of injury early signs and symptoms natural courses of these problems associated with the understanding of the pathophysiology of the blast injury patient will greatly aid the management of blast-injured patients
- Appropriate triaging of patients will aid in decreasing the morbidity and mortality in the event of any type of blast injuries.
- Staff should be trained and exercise drills with local responders on a regular basis.

Summary



- Other than safety measures designed to prevent an explosion, the most effective preincident actions involve establishing an effective rescue and medical infrastructure.
- Preexisting and practiced plan for rapid rescue, disposition, and treatment of casualties can reduce morbidity and mortality in any situation.
- We must do what we can to protect those responding to the call.

Thank you



EXPLODE!!!