Chemical Hazards

Purpose of Lectures on Chemical Safety

- **To understand the hazardous properties of chemicals prior to their use.**
- **To transport / handle / use / manage chemicals safely.**

Outline of Lectures on Chemical Hazards

Lecture 1:

- **Definitions**
- **Accident Statistics**
- **The Accident Process**
- **Case Histories**
- **Regulatory Requirements**

Lecture 2:

- **Toxicology / Industrial Hygiene**
- **Chemical Release / Dispersion**
- **Fires / Explosions**

Definitions - 1

Safety: **Strategy of Accident Prevention**

Loss Prevention: **Prevention of accidents which result in injury to humans, damage to the environment, loss of production, damage to equipment, or loss of inventory.**

Definitions - 2

Hazard: **An inherent physical or chemical characteristic of a material, system, process or plant that has the potential for causing harm.**

Chemicals provide additional hazards due to the toxic, flammable, explosive, and reactive hazards.

Risk: **For episodic events, risk is a function of probability and consequence.**

Risk Analysis: **Quantitative estimate of risk**

Risk Assessment: **Results of risk analysis are used to make decisions.**

Statistics-1

OSHA **Occupational Safety & Health Administration**

incidence rate per 100 worker years = 200,000 h exposure

FAR **Fatal Accident Rate**

fatalities per 1000 employees and entire life = 10^8 h exposure

FR **Fatality Rate**

per person per year (exposure poorly defined)

Statistics-2

	OSHA	FAR	FR
Chemical Industry	0.49	4*	
Steel Industry	1.54	8	
Coal Mining	2.22	40	
Agriculture	4.53	10	
Staying at Home		3	
Travelling by Car		57	17×10^{-5}
Rock Climbing		4000	4×10^{-5}
20 Cigarettes / day			500×10^{-5}
Struck by Meteorite			6×10^{-11}
Struck by Lightning			1×10^{-7}
Fire			150×10^{-7}
Run over by Car			600×10^{-7}

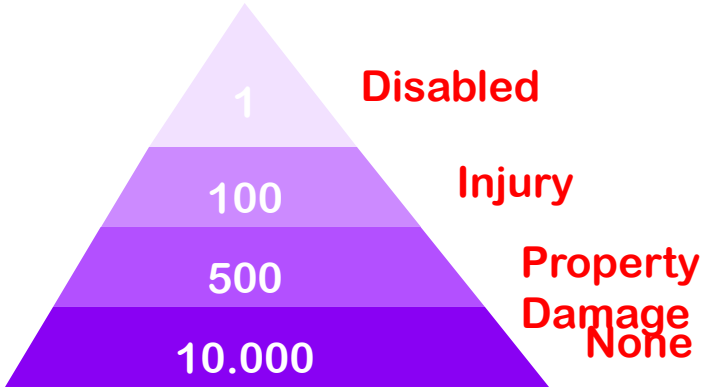
*50% by chemical exposure

Statistics-3

US Accident Fatalities:	1990	1999
Auto:	47,000	40,800
Total Industry:	6,217	6,026
Walking across street:	6,475	5,220
Bicycles:	642	
Trains:	601	
Airlines:	39	
Home:	22,500	30,800
Chemical Industry:	22	

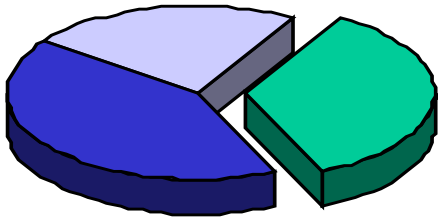
Chemical Plant Accidents

	Risk	Hazard Fatalities	Hazard Economic Loss
Fire	High	Low	Intermediate
Explosion	Intermediate	Intermediate	Hi
Toxic Release	Low	High	Low



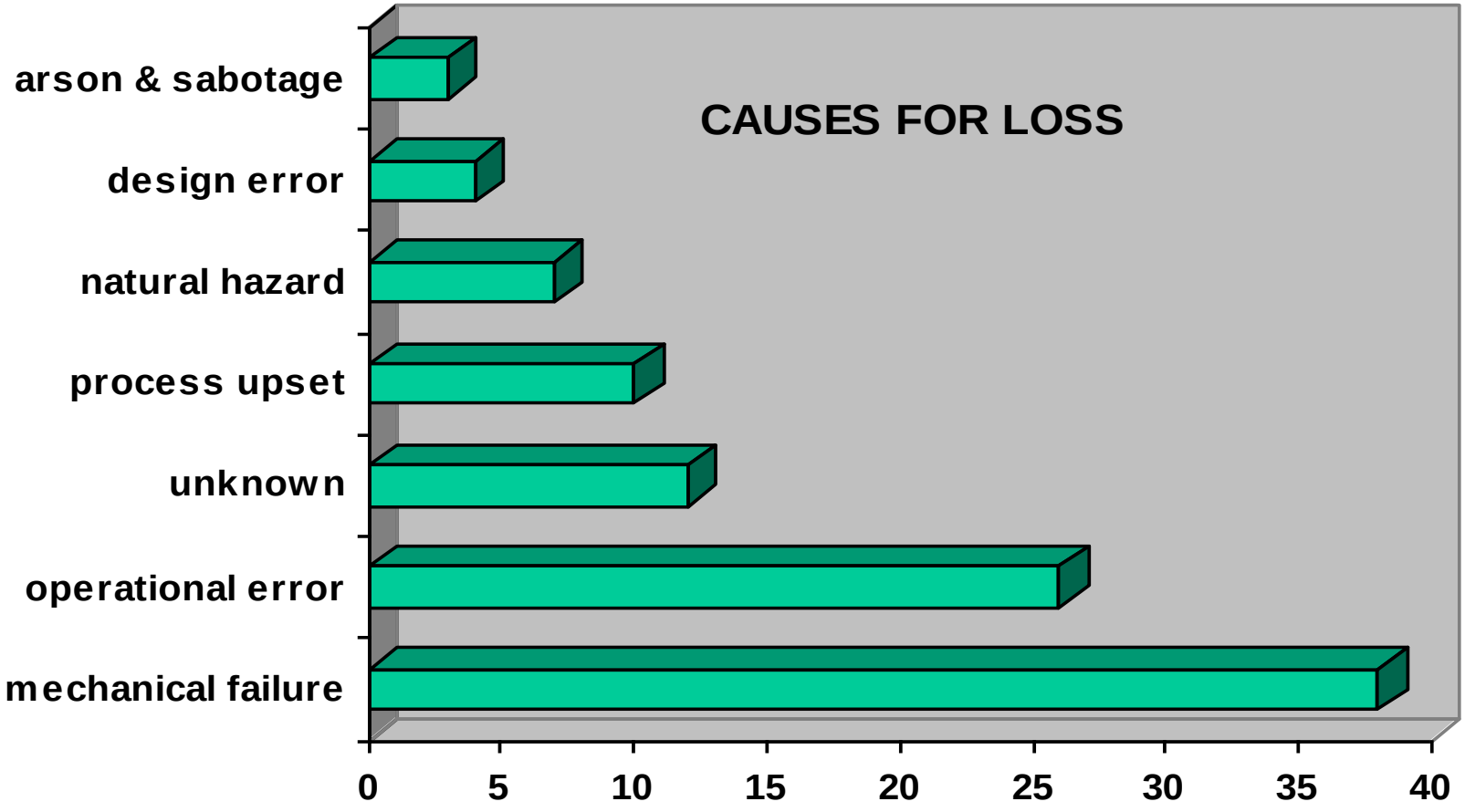
Accident Pyramid

Explosions

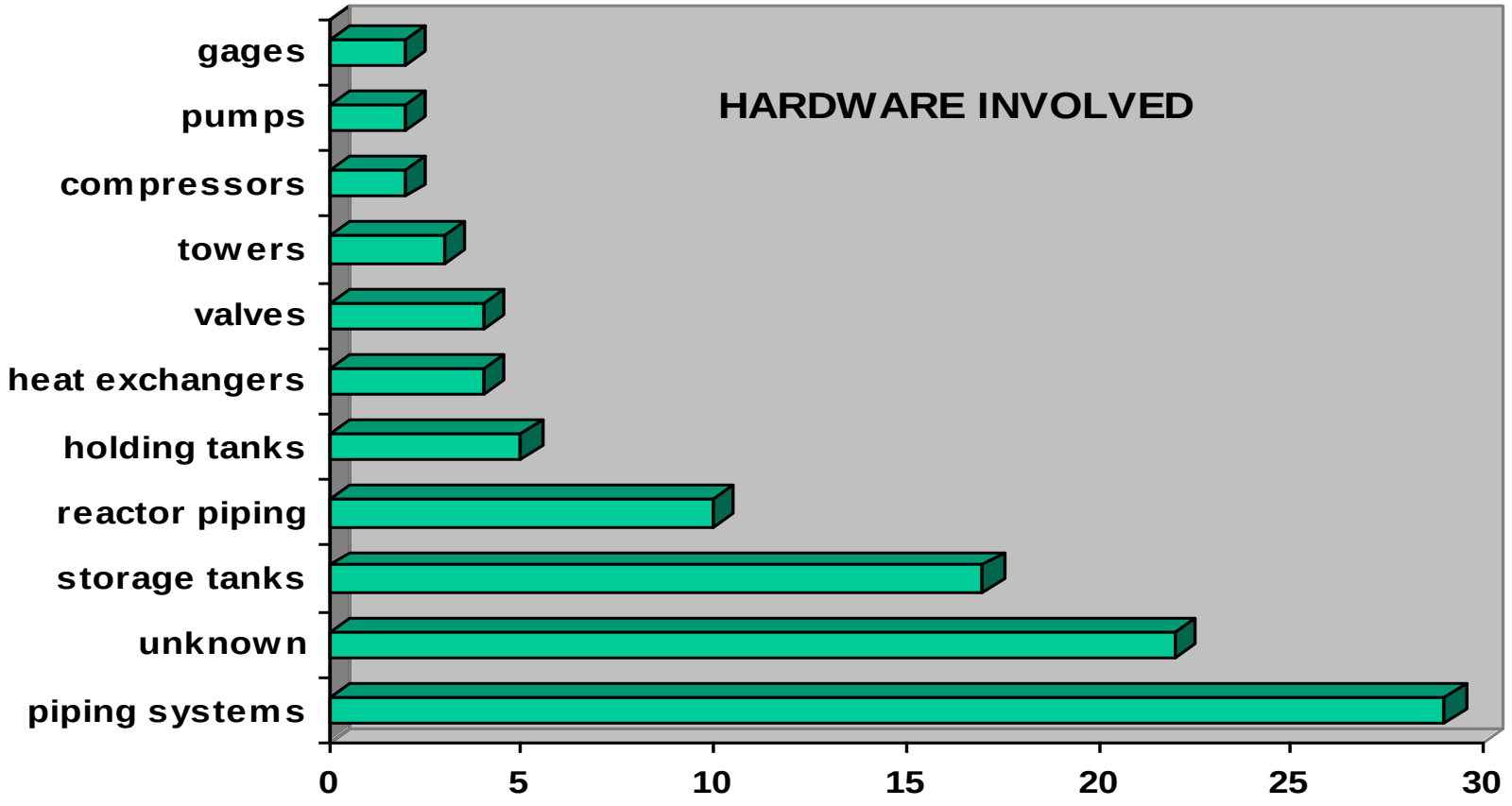


vapor cloud

Nature of Accidents - 1



Nature of Accidents - 2



Defeating Accidents

STEP	DESIRED EFFECT	PROCEDURE
Initiation	Diminish	Grounding, bonding Inerting Explosion proof electrical Guardrails and guards Maintenance procedures Hot-work permits Human factors design Process design Awareness properties chemicals
Propagation	Diminish	Emergency material transfer Reduce inventories of flammables Equipment spacing and layout Nonflammable construction materials Emergency shut-off valves
Termination	Increase	Firefighting Relief systems Sprinklers Emergency shut-off valves

Significant disasters

Flixborough, England, 1974

rupture inadequately supported bypass pipe, 155 ^{o}C, 7.9 atm

vapor cloud 30 ton cyclohexane

explosion & fire inventories (10 days)

28 killed, 36 + 53 injured, much damage

Seveso, Italy, 1976

reactor out of control (run away)

vapor cloud 2 kg dioxin

700 affected, 730 evacuated

25 ^{2} km contaminated (40 factories)

Bhopal, India, 1984

not operating scrubber & flare system

vapor cloud 25 ton toxic MIC

2000 killed, 20.000 injured, no damage

Regulatory Concerns

OSHA - Occupational Safety and Health Administration.

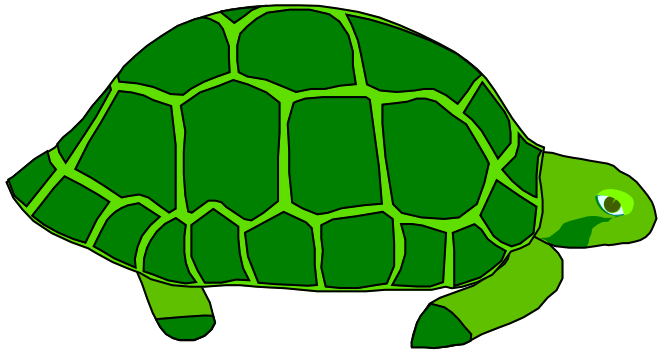
Force of law with respect to on-site workplace hazards / accidents.

OSHA 1910.119 - Process Safety Management

- Must identify hazards
- Must train and certify workers
- Safe work system
- Management of Change
- Accident investigations
- Process Info / Documentation
- Contractor safety
- Operating procedures
- Mechanical integrity
- Others

EPA - Environmental Protection Agency

Handles releases outside of plant.



EPA RMP - Risk Management Plan

- Considers offsite impacts due to fires / explosions / toxic release
- Must perform risk assessment
- Must perform consequence analysis

Implemented May, 1996.
First report due May, 1999.