



PROCESS SAFETY ENGINEERING (0905477)  
01 – DEFINITIONS AND INTRODUCTION

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The superior man, when resting in safety, does not forget that danger may come.... When all is orderly, he does not forget that disorder may come. Confucius (551 BC – 479 BC)

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## Outline

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- Something to Ponder About
- Events: Incidents , “Near Misses” and Accidents
- Safety, Hazard and Risk
- Risk and Associated Terms
- True and Perceived Risks
- Main Types of Hazards in Chemical Plants
- Incident Outcomes and Consequences
- Impact of Accidents
- Accident Causation Theory
- A Matter of Perspective and Focus?
- Ingredients of a Successful Safety Program
- Good and Outstanding Safety Programs



## Something to Ponder About

- More complex processes require more complex safety technology.
- Development and application of safety technology sets a constraint on the growth of the chemical industry.
- As chemical process technology becomes more complex, chemical/process engineers will need a more detailed and fundamental understanding of safety.

**FAWCETT, "TO KNOW IS TO SURVIVE AND TO IGNORE FUNDAMENTALS IS TO COURT DISASTER."**

H.H. Fawcett and W.S. Wood, Safety and Accident Prevention in chemical operation, New York, Wiley, 1984.



Events: Incidents , “Near Misses” and Accidents

■ **Incident:** The loss of **containment of material or energy;**

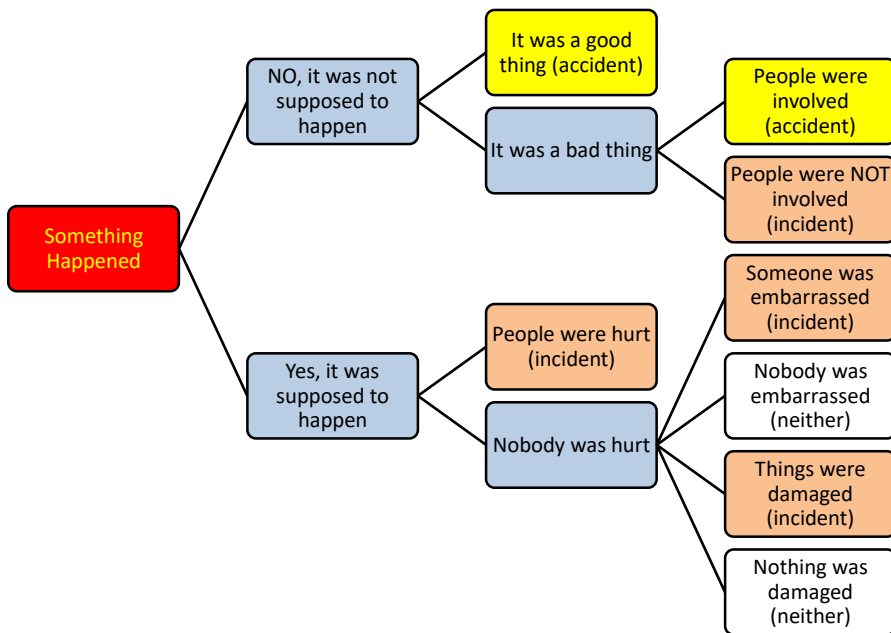
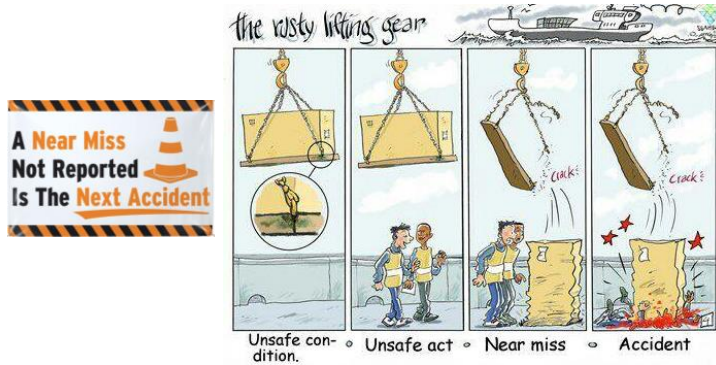
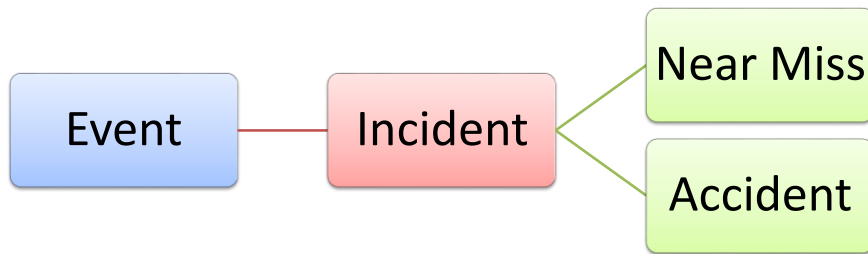
- **Near-Miss (near-hit):** Incident which by chance did not result in injury or illness (to humans) but may result in property loss/damage.
- **Accident:** The occurrence of a sequence of events that produce unintended deterioration of **health of a living organism**, value of an organization and/or quality of the environment.

- “Accident” refers to the event, not the result of the event.



**Not all events propagate into incidents;  
not all incidents propagate into accidents.**





## Scenario, Incident Outcome and Consequence

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- **Scenario:** A description of the events that result in an accident or incident. The description should contain information relevant to defining the root causes.
- **Incident outcome:** The physical manifestation of an accident.
- **Consequence:** A measure of the expected effects of the results of an incident.



## Safety, Hazard and Risk

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- **Safety or loss prevention:** the prevention of accidents through the use of appropriate technologies to identify the hazards of a chemical plant and eliminate them before an accident occurs.
  - Loss Prevention: Prevention of injury to people, damage to environment, loss of equipment, inventory or production.
  - Safety : Strategy of accident prevention.
- **Hazard:** a chemical or physical condition that has the potential to cause damage to **people, property**, or the **environment**.
- **Risk:** probability of a hazard resulting in an accident. A measure of human injury, environmental damage, or economic loss in terms of both
  - the incident likelihood (**probability**) and
  - the magnitude of the loss or injury.



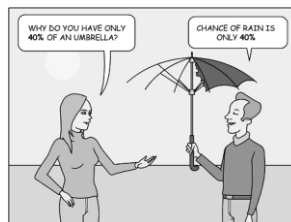
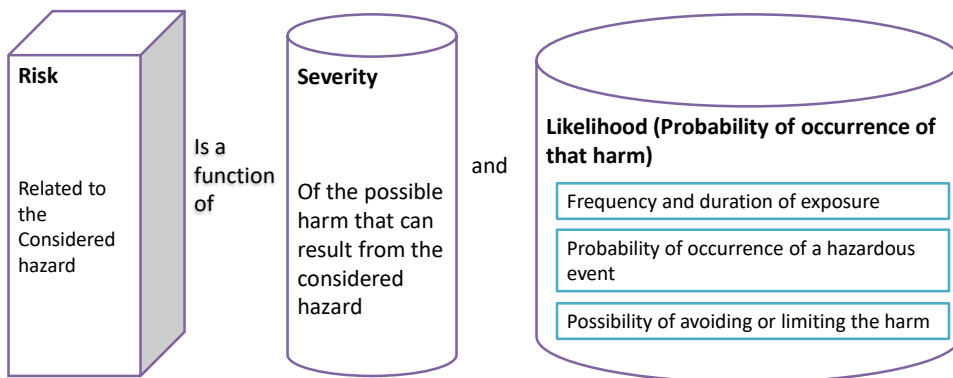
## Hazard, Risk, and Consequence



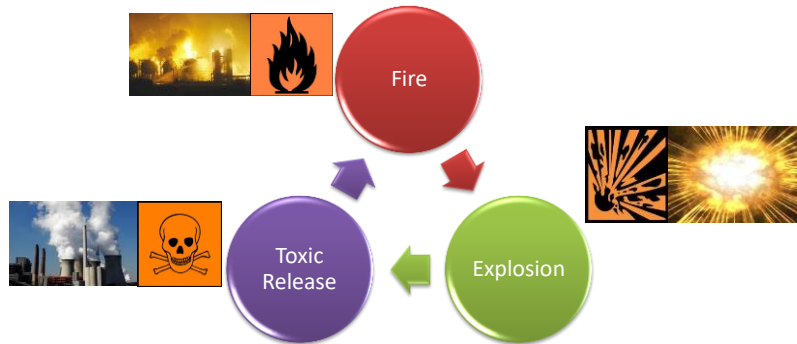
Cheetahs go into anaerobic metabolism when sprinting, in order to achieve such high speeds. They can move long distances at much lower speed. Anaerobic metabolism means **there is not enough oxygen to convert all of the glucose into carbon dioxide and water. Instead, some of the glucose is converted into lactic acid. Lactic acid is toxic, and it disables muscles.** Therefore, cheetah running at top speed will build up lactic acid, and it will not be able to keep running at that speed. Rather than building up lactic acid to the point that it will be completely disabled (and cannot run at all), it will give up. That is because being disabled on the open savanna is dangerous, since other predators, such as lions and hyenas, may move in to kill the cheetah.



## What is Risk?



## The Nature of Accident Process

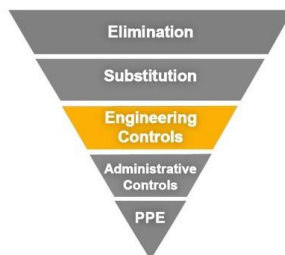


Type of accident	Probability of occurrence	Potential for fatalities	Potential for economic loss
Fire	High	Low	Intermediate
Explosion	Intermediate	Intermediate	High
Toxic release	Low	High	Low

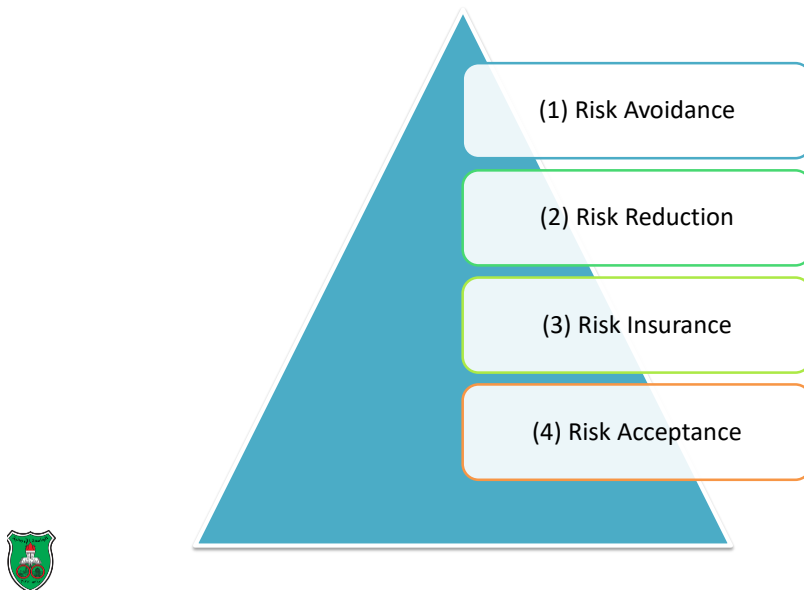


If we can't take away the hazard we shall have to:

- ☐ reduce the risk,
- ☐ reduce the frequency, and/or
- ☐ reduce the consequence.



## Elements of Risk Management



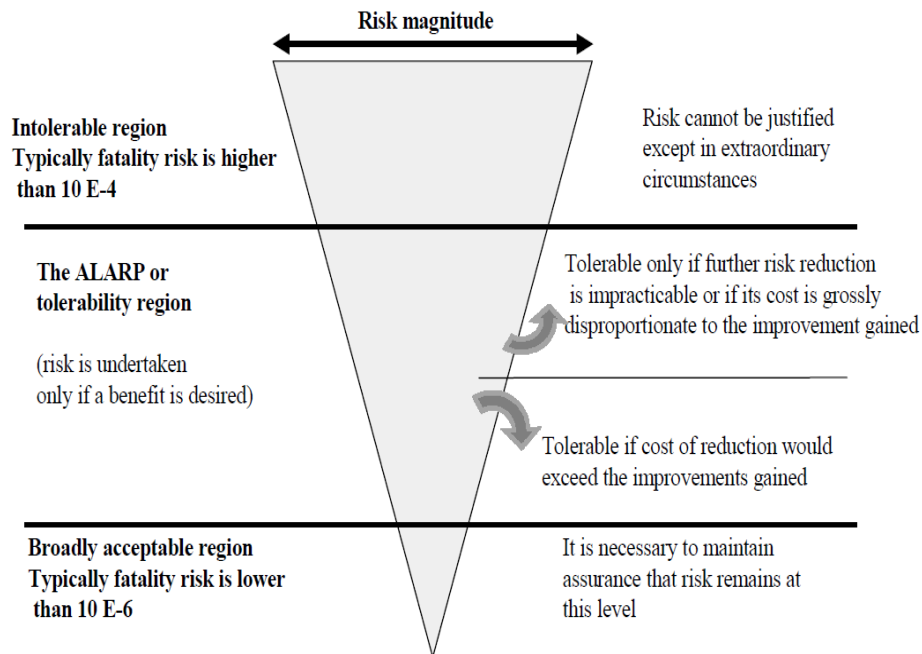
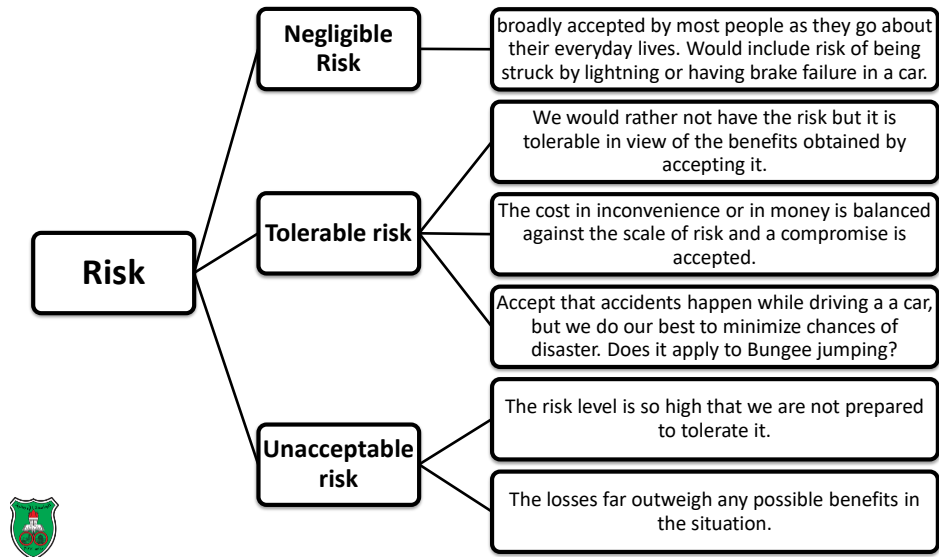
## What is an Acceptable Risk?

- We cannot eliminate risk entirely. Every chemical process has a certain amount of risk associated with it.
- At some point in the design stage someone needs to decide if the risks are “**acceptable**.” That is, are the risks greater than the normal day-to-day risks taken by individuals in their nonindustrial environment?
  - Certainly it would require a substantial effort and considerable expense to design a process with a risk comparable to being struck by lightning ( $6 \times 10^{-11}$ ).
  - Is it satisfactory to design a process with a risk comparable to the risk of sitting at home? For a single chemical process in a plant composed of several processes, this risk may be too high because the risks resulting from multiple exposures are additive.
  - Engineers must make every effort to minimize risks within the economic constraints of the process. No engineer should ever design a process that he or she knows will result in certain human loss or injury, despite any statistics.



# ALARP (As Low As Reasonably Practicable)

■ A principle that recognizes three categories of risks:





## True and Perceived Risks

- 400,000 smoking-related deaths/year.
- 40,000 deaths/year on U.S. highways.
- An airline crash with 300 deaths draws far more attention over a longer time.

- Three years old kid killed in water knee-deep by an alligator: reported nationally
  - Only 7 recorded fatalities by alligator.
- Primary hazards were minimum supervision and shallow water.
  - In 1995, 300 children under 4 years old drowned at home: reported locally.

رغم كل الجهود المبذولة، يشير العجلوني، بأسى، إلى نتائج دراسة أجريت العام 2004، لرصد ما آل إليه واقع المرض في الأردن، وثبتت ارتفاع نسبة المضامين إلى 30 في المئة، وهي نسبة تصفها بـ «المفجعة»، وعزوها إلى غياب إستراتيجية شاملة للتعامل مع المرض، والحكومات المتعاقبة كما يقول «تتعامل مع الكوارث فقط».

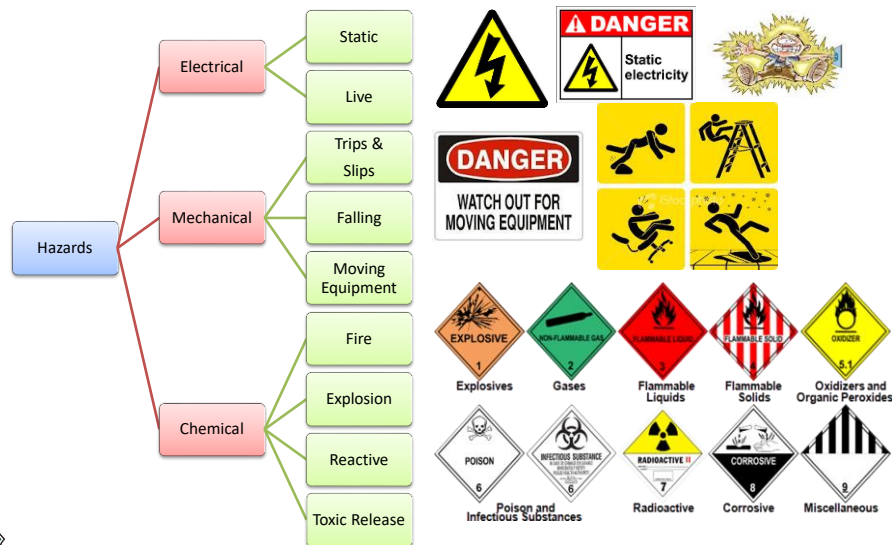
«الوضع كارثي فعلاً»، في رأيه، لأن هناك «خمسین شخصاً يموتون يومياً في الأردن بسبب السكري ومضاعفاته التي تشمل الذبحة القلبية والجلطات الدماغية والفشل الكلوي وغيرها».

الوجه الثاني للكارثة كما يقول، يكمن في أنّ الدولة تدفع سنوياً ما يقارب 1.3 بليون دينار، هي قيمة التكلفة المباشرة وغير المباشرة لعلاج مرض السكري، ويمكنها أن تخفّض الفاتورة بشكل هائل فيما لو استطاعت الالتزام بسياسة تقوم بشكل أساسي على الوقاية من المرض من خلال اتخاذ إجراءات بسيطة «مثلاً تشجيع الناس على المشي بإخلاء الأرصفة التي احتلتها الأشجار والسيارات وبسطات البائعين، ومنع المقاصف المدرسية من بيع السكاكر والمشروبات الغازية والعصائر المصنّعة للأطفال».

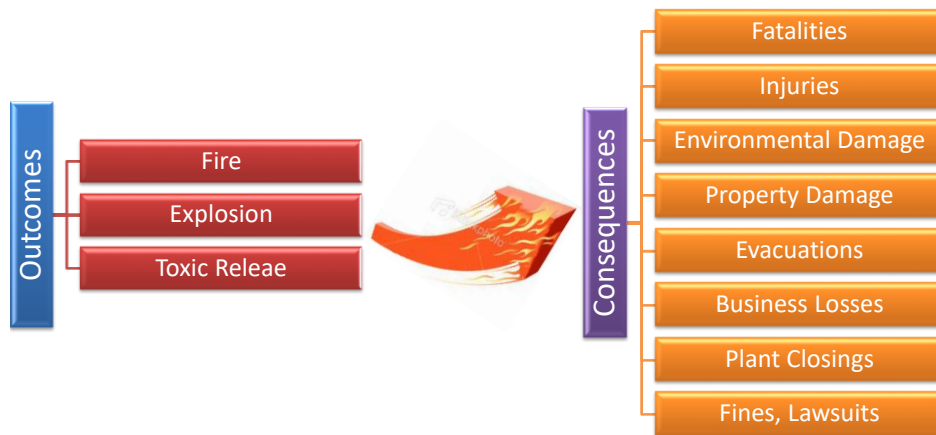
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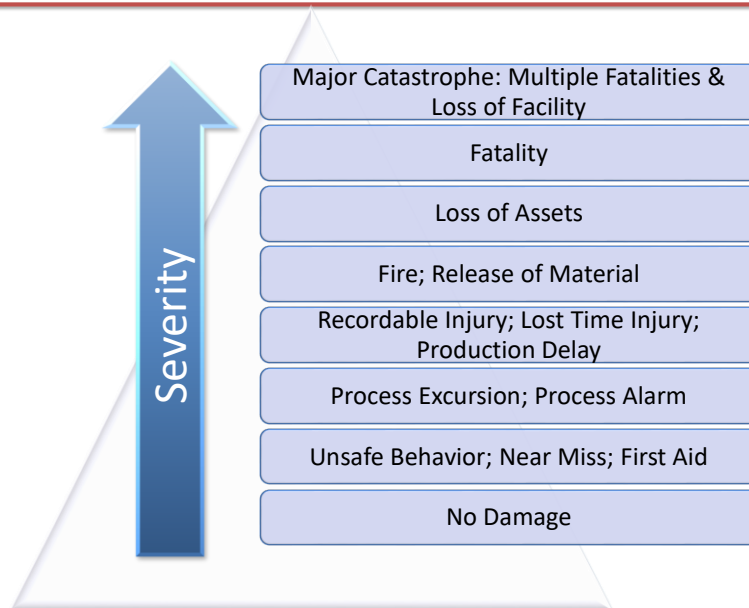
## Main Types of Hazards in Chemical Plants



## Incident Outcomes and Consequences



## Severity of Consequences



## The Accident Pyramid

- Property damage and loss of production must also be considered in loss prevention. These losses can be substantial.
- Accidents of this type are much more common than fatalities.
  - The numbers provided are only approximate. The exact numbers vary by industry, location, and time.
- “No Damage” or “**near misses**” provide a good opportunity for companies to determine that a problem exists and to correct it before a more serious accident occurs.
  - “The cause of an accident is visible the day before it occurs.”
  - Inspections, safety reviews, and careful evaluation of near misses will identify hazardous conditions that can be corrected before real accidents occur.



## Impact of Accidents

### ***All for the want of a nail.....***

*For want of a nail, the shoe was lost,  
 For want of a shoe, the horse was lost,  
 For want of a horse, the rider was lost,  
 For want of a rider, a message was lost,  
 For want of a message, the battle was lost,  
 For want of a battle, the kingdom was lost,  
 And all for the want of a nail.....*

George Herbert, in outlandish proverbs(1640)



## Accident Causation Theory

### ■ "Acts of God"

- An instance of uncontrollable natural forces in operation.

### ■ "Pilot Error" – beginning of industrial revolution

- The action or decision of the pilot that, if not caught or corrected, could contribute to the occurrence of an accident or incident, including inaction or indecision.

### ■ "Mismanagement" – current legal leanings

- The process of managing something badly or wrongly.

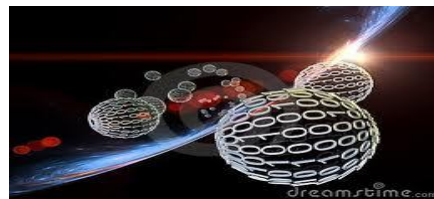


## A Matter of Perspective and Focus?

- Recent advances in chemical plant safety emphasize the use of appropriate technological tools to provide information for making safety decisions with respect to **plant design and operation.**



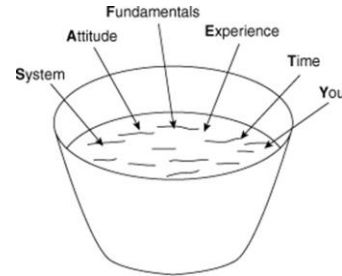
The word "safety" used to mean the older strategy of accident prevention through the use of hard hats, safety shoes, and a variety of rules and regulations. The main emphasis was on worker safety.



Recently, "safety" has been replaced by "loss prevention." This term includes: hazard identification, technical evaluation, and the design of new engineering features to prevent loss.



## Ingredients of a Successful Safety Program



**SAFETY CANNOT BE PRIORITIZED - IT IS A CONDITION OF EMPLOYMENT!**



The ingredients of a successful safety program.



**SAFETY CANNOT BE PRIORITIZED - IT IS A CONDITION OF EMPLOYMENT!**



## Good and Outstanding Safety Programs

- A **good** safety program identifies and **eliminates existing** safety hazards.
- An **outstanding** safety program has management systems that **prevent the existence** of safety hazards.
- Commonly used management systems directed toward eliminating the existence of hazards include
  - safety reviews,
  - safety audits,
  - hazard identification techniques,
  - checklists, and proper application of technical knowledge.



درهم وقاية خير من قنطار علاج



شكرا لحسن الاستماع