PROCESS SAFETY ENGINEERING (0905477)
03 – ACCIDENT AND LOSS STATISTICS

ALI KH. AL-MATAR (aalmatar@ju.edu.jo)

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)

Chemical Engineering Department, University of Jordan
Amman 11942, Jordan

Outline

- Why Accident and Loss Statistics?
- Systems of Incident Reporting
- OSHA Incident Rate
- Fatal Accident Rate (FAR)
- Fatality Rate

Why Accident and Loss Statistics?

- Accident and loss statistics are important measures of the effectiveness of safety programs.
- These statistics are valuable for determining whether a **process is safe** or whether a **safety procedure is working effectively or is improving**.

OSHA

OSHA Occupational Safety and Health Administration

- Occupational Safety and Health Administration (USA).
- Established by US Congress in 1970 in the “Occupational Safety and Health Act of 1970” OHSAct.
- OSHA has defined terms related to work related losses.

Glossary of Terms Used by OSHA and Industry to Represent Work-Related Losses (Table 1.2)

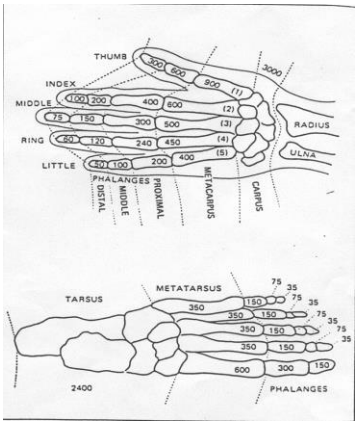
- First aid
  - Any one-time treatment and any follow-up visits for the purpose of observation of minor scratches, cuts, burns, splinters, and so forth that do not ordinarily require medical care. Such one-time treatment and follow-up visits for the purpose of observation are considered first aid even though provided by a physician or registered professional personnel.
- Incident rate
  - Number of occupational injuries and/or illnesses or lost workdays per 100 full-time (FT) employees.
- Lost workdays
  - Number of days (consecutive or not) after but not including the day of injury or illness during which the employee would have worked but could not do so, that is, during which the employee could not perform all or any part of his or her normal assignment during all or any part of the workday or shift because of the occupational injury or illness.
- Medical treatment
  - Treatment administered by a physician or by registered professional personnel under the standing orders of a physician. Medical treatment does not include first aid treatment even though provided by a physician or registered professional personnel.
- Occupational injury
  - Any injury such as a cut, sprain, or burn that results from a work accident or from a single instantaneous exposure in the work environment.
- Occupational illness
  - Any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. It includes acute and chronic illnesses or diseases that may be caused by inhalation, absorption, ingestion, or direct contact.

Glossary of Terms Used by OSHA and Industry to Represent Work-Related Losses (Table 1.2)

- Recordable cases
  - Cases involving an occupational injury or occupational illness, including deaths.
- Recordable fatality cases
  - Injuries that result in death, regardless of the time between the injury and death or the length of the illness.
- Recordable nonfatal cases without lost workdays
  - Cases of occupational injury or illness that do not involve fatalities or lost but do result in (1) transfer to another job or termination of employment or (2) medical treatment other than first aid or (3) diagnosis of occupational illness or (4) loss of consciousness or (5) restriction of work or motion.
- Recordable lost workday cases due to restricted duty
  - Injuries that result in the injured person not being able to perform their regular duties but being able to perform duties consistent with their normal work.
- Recordable cases with days away from work
  - Injuries that result in the injured person not being able to return to work on their next regular workday.
- Recordable medical cases
  - Injuries that require treatment that must be administered by a physician or under the standing orders of a physician. The injured person is able to return to work and perform his or her regular duties. Medical injuries include cuts requiring stitches, second-degree burns (burns with blisters), broken bones, injury requiring prescription medication, and injury with loss of consciousness.

Tables of “lost work days”

- Assigned to losses of various members of the body.
  - These “lost work days” are not only based on how long it will take to recover but also on the individuals diminished ability to carry out the job function
- Fatality is equivalent to 24 worker years (8760 days)



B. IMPAIRMENT OF FUNCTION

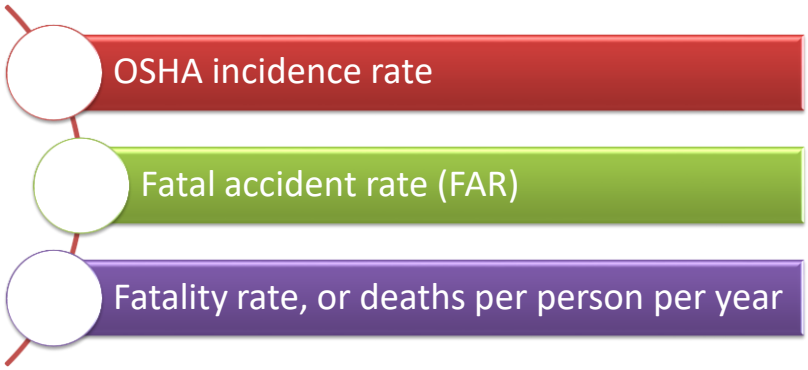
One eye (loss of sight), whether or not there is sight in the other eye	1,800
Both eyes (loss of sight), in one accident	6,000
One ear (complete industrial loss of hearing), whether or not there is hearing in the other ear	600
Both ears (complete industrial loss of hearing), in one accident	3,000
Unrepaired hernia (for repaired hernia, use actual days lost	50

C. FATAL OR PERMANENT TOTAL DISABILITY 6,000

راجع قانون الضمان الاجتماعي الأردني لعام **2014** لقائمة بالأمراض المهنية (جدول **1**) واصابات العمل (جدول **2**) .

Systems of Incident Reporting

- Many statistical methods are available to characterize accident and loss performance.
- These statistics must be used carefully. Like most statistics they are only averages and do not reflect the potential for single episodes involving substantial losses.
- Unfortunately, no single method is capable of measuring all required aspects.
- All three methods report the number of accidents and/or fatalities for a fixed number of workers during a specified period.



OSHA Incident Rate

- **Number of occupational injuries and/or illnesses or lost workdays per 100 full-time employees.**
  - Based on cases per 100 worker years. A worker year is assumed to contain 2000 hours (50 work weeks/year × 40 hours/week). Is therefore based on 200,000 hours of worker exposure to a hazard.
  - Calculated from the number of occupational injuries and illnesses and the total number of employee hours worked during the applicable period.

Based on injuries and illnesses

$$\text{OSHA icidence rate} = \frac{\text{Number of injuries and illnesses} \times 200{,}000}{\text{Total hours worked by all employees during period covered}}$$

Based on lost workdays

$$\text{OSHA icidence rate} = \frac{\text{Number of lost workdays} \times 200{,}000}{\text{Total hours worked by all employees during period covered}}$$

OSHA Incident Rate

- Provides information on all types of work-related injuries and illnesses, including fatalities.
- Provides a better representation of worker accidents than systems based on fatalities alone.
  - For instance, a plant might experience many small accidents with resulting injuries but no fatalities.
  - On the other hand, fatality data cannot be extracted from the OSHA incidence rate without additional information.

Fatal Accident Rate (FAR)

- Reports the number of fatalities based on 1000 employees working their entire lifetime.
  - The employees are assumed to work a total of 50 years. Thus the FAR is based on 10^8 working hours.
  - Used mostly by the British chemical industry.
  - Used because there are some useful and interesting FAR data available in the open literature.

$$\text{Fatal Accident Rate FAR} = \frac{\text{Number of fatalities} \times 10^8}{\text{Total hours worked by all employees during period covered}}$$

Fatality Rate (FR)

- Or deaths per person per year.
  - Independent of the number of hours actually worked and reports only the number of fatalities expected per person per year.
  - Useful for performing calculations on the general population, where the number of exposed hours is poorly defined.

$$\text{Fatality rate} = \frac{\text{Number of fatalities per year}}{\text{Total number of pople in applicable population}}$$

Both the OSHA incidence rate and FAR depend on the number of exposed hours. An employee working a ten-hour shift is at greater total risk than one working an eight-hour shift. A FAR can be converted to a fatality rate (or vice versa) if the number of exposed hours is known. The OSHA incidence rate cannot be readily converted to a FAR or fatality rate because it contains both injury and fatality information.

Example

A process has a reported a FAR of 2. If an employee works a standard 8-hr shift 300 days per year, compute the deaths per person per year.

Solution

$$\frac{\text{Deaths}}{\text{Person.year}} = \frac{8\text{hr}}{\text{day}} \times \frac{300\text{days}}{\text{year}} \times \frac{2\text{deaths}}{10^8\,\text{hr}} = 4.8 \times 10^{-5}$$

That is if this establishment has 20000 employees then it is likely that one of them would be exposed to a fatal accident in a year

The FAR for travel by car is reported as 57 while that for travel by air is 240

1) If the average speed of travel is 50 mph by car and 250 mph by air, determine the deaths per million miles travel by car or air.

2) If you are required to make a round trip from St. Louis to Los Angeles, which is the safer mode of transportation as indicated by the statistics?

1) Calculations

$$\text{Car} -> \left(\frac{57 \text{ deaths}}{10^8 \text{ hr}}\right)\left(\frac{1 \text{ hr}}{50 \text{ miles}}\right)\left(\frac{10^6}{\text{Million Miles}}\right)$$

$$= 0.0114 \ {}^{\text{deaths}}\!/_{\text{Million Miles}}$$

$$\text{Air} -> \left(\frac{240 \text{ deaths}}{10^8 \text{ hr}}\right)\left(\frac{1 \text{ hr}}{250 \text{ miles}}\right)\left(\frac{10^6}{\text{Million Miles}}\right)$$

$$= 0.0096 \ {}^{\text{deaths}}\!/_{\text{Million Miles}}$$

2) For a fixed distance, air travel is the safer mode

Example

If twice as many people used motorcycles for the same average amount of time each, what will happen to (a) the OSHA incidence rate, (b) the FAR, (c) the fatality rate, and (d) the total number of fatalities?

Solution

a) The OSHA incidence rate will remain the same. The number of injuries and deaths will double, but the total number of hours exposed will double as well.
b) The FAR will remain unchanged for the same reason as in part a.
c) The fatality rate, or deaths per person per year, will double. The fatality rate does not depend on exposed hours.
d) The total number of fatalities will double.

Example

A friend states that more rock climbers are killed traveling by automobile than are killed rock climbing. Is this statement supported by the accident statistics?

Solution

The data from the table show that traveling by car (FAR = 57) is safer than rock climbing (FAR = 4000). Rock climbing produces many more fatalities per exposed hour than traveling by car. However, the rock climbers probably spend more time traveling by car than rock climbing. As a result, the statement might be correct but more data are required.

Accident Statistics for Selected Industries

	OSHA incident rates (U.S.)				FAR (UK)	
	Recordable	Days Away from Work	Fatality			
Industrial activity	2007	2007	2000	2005	1974–78	1987–90
Agriculture	6.1	3.2	24.1	27	7.4	3.7
Chemical and allied products	3.3	1.9	2.5	2.8	2.4	1.2
Coal mining	4.7	3.2	50	26.8	14.5	7.3
Construction	5.4	2.8	10	11.1	10	5.0
Vehicle manufacturing	9.3	5.0	1.3	1.7	1.2	0.6
All manufacturing	5.6	3.0	3.3	2.4	2.3	1.2

From Chemical Process Safety: Fundamentals with Applications, Third Edition

The FAR figures show that if 1000 workers begin employment in the chemical industry, 2 of the workers will die as a result of their employment throughout all of their working lifetimes. One of these deaths will be due to direct chemical exposure. However, 20 of these same 1000 people will die as a result of nonindustrial accidents (mostly at home or on the road) and 370 will die from disease. Of those that perish from disease, 40 will die as a direct result of smoking.

Approximately half these deaths are due to ordinary industrial accidents (falling down stairs, being run over), the other half to chemical exposures

Fatality Statistics for Common Nonindustrial Activities

Activity			FAR (deaths/10^8 hours)	Fatality rate (deaths per person per year)
Voluntary activity				
	Staying at home		3	
	Traveling by			
		Car	57	17×10^{-5}
		Bicycle	96	
		Air	240	
		Motorcycle	660	
	Canoeing		1000	
	Rock climbing		4000	4×10^{-5}
	Smoking (20 cigarettes/day)			500×10^{-5}
Involuntary activity				
	Struck by meteorite			6×10^{-11}
	Struck by lightning (U.K.)			1×10^{-7}
	Fire (U.K.)			150×10^{-7}
	Run over by vehicle			600×10^{-7}

From Chemical Process Safety: Fundamentals with Applications, Third Edition

Individuals are willing to take a substantially greater risk if it is voluntary. It is also evident that many common everyday activities are substantially more dangerous than working in a chemical plant (FAR ≈ 2).

If CPI is Safe, Why Worry Then?

- Recognizing that the chemical industry is safe, why is there so much concern about chemical plant safety?
- The concern has to do with the industry's potential for many deaths, as, for example, in the Bhopal, India, tragedy.
- Accident statistics do not include information on the total number of deaths from a single incident.
  - For example, consider two separate chemical plants. Both plants have a probability of explosion and complete devastation once every 1000 years. The first plant employs a single operator. When the plant explodes, the operator is the sole fatality. The second plant employs 10 operators. When this plant explodes all 10 operators succumb.
  - In both cases the FAR and OSHA incidence rate are the same; the second accident kills more people, but there are a correspondingly larger number of exposed hours. In both cases the risk taken by an individual operator is the same.
- It is human nature to perceive the accident with the greater loss of life as the greater tragedy. The potential for large loss of life gives the perception that the chemical industry is unsafe.

Steadily Increasing Incident Cost With Time?

- Loss data published for losses after 1966 and in 10-year increments indicate that the total number of losses, the total dollar amount lost, and the average amount lost per incident have steadily increased.
- The total loss figure has doubled every 10 years despite increased efforts by the chemical process industry to improve safety.
- Why? The increases are mostly due to
  - an expansion in the number of chemical plants,
  - an increase in chemical plant size, and
  - an increase in the use of more complicated and dangerous chemicals.

The 100 Largest Losses, 1972–2001: Large Property Damage Losses in the Hydrocarbon-Chemical Industries, 20th ed., Marsh's Risk Consulting Practice, Feb. 2003

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