Health safety and Environmental Management in Petroleum and Offshore Industries

Key to Tutorials

(Please refer the key along with the tutorial questions)

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Tutorial 1

1. Accident
2. Hazard
3. B
4. Societal risk
5. Risk characterization
6. Frank & Morgan risk analysis.
7. D
8. Risk aversion
9. D
10. FN curves
11. Safety
12. .***Individual risk***: Defined as frequency at which individual may be expected to sustain a given level of harm from realization of hazard. It usually accounts only the risk of death. Expressed as risk per year

    Societal risk: Defined as relationship between the frequency and # of people suffering a given level of harm from realization of hazard. Societal risks are expressed as: FN curves, showing relationship between the cumulative frequency (F) and # of fatalities (N).
13. ***Safety or Loss prevention***: Prevention of hazard occurrence (accidents) through proper hazard identification, assessment and elimination.

    Risk: measure of magnitude of damage along with its probability of occurrence.
14. Risk assessment often relies on inadequate scientific information or lack of data. For example, any data related to repair may not be useful to assess newly designed equipment. It means that even though the data available is less, still all data related to that event cannot be considered as qualified data to do risk assessment.

15. Identifies and eliminates existing safety hazards

    Safety knowledge, Safety experience, Technical competence, Safety management support Commitment to safety

16. ***Loss***: severity of negative impact

    Acceptable risk: Level of human and/or material injury or loss from an industrial process that is considered to be tolerable by a society or authorities in view of the social, political, and economic cost-benefit analysis.

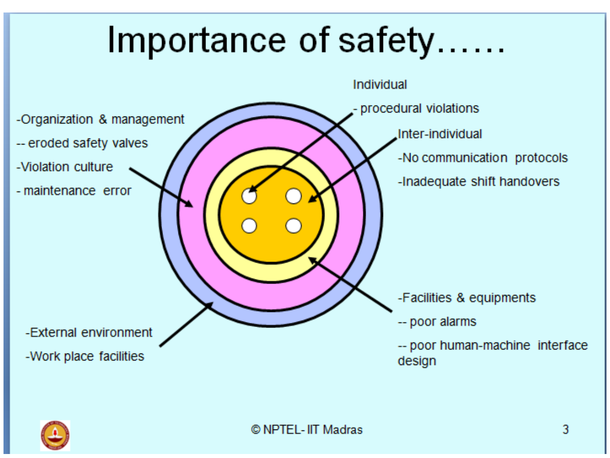
17. ***Safety assurance***: is the application of safety engineering practices, intended to minimize the risks of operational hazards. Strategies include Reactive, proactive, predictive, and iterative. Risk analysis is one of the methods.

    Safety assessment: assessed as to their potential severity of impact (generally a negative impact, such as damage or loss) and to the probability of occurrence. Methods: risk assessment, hazard identification, risk characterization etc.

18. ***Goal setting regimes:*** Duty holder assesses risk. Should demonstrate its understanding Controls cover management, technical and systems issues. Keeps pace with new knowledge. Opportunity for workforce engagement

    Rule based regimes: Legislator sets the rules. Emphasizes compliance rather than outcomes Slow to respond. Less emphasis on continuous improvement. Less work force involvement.

19.



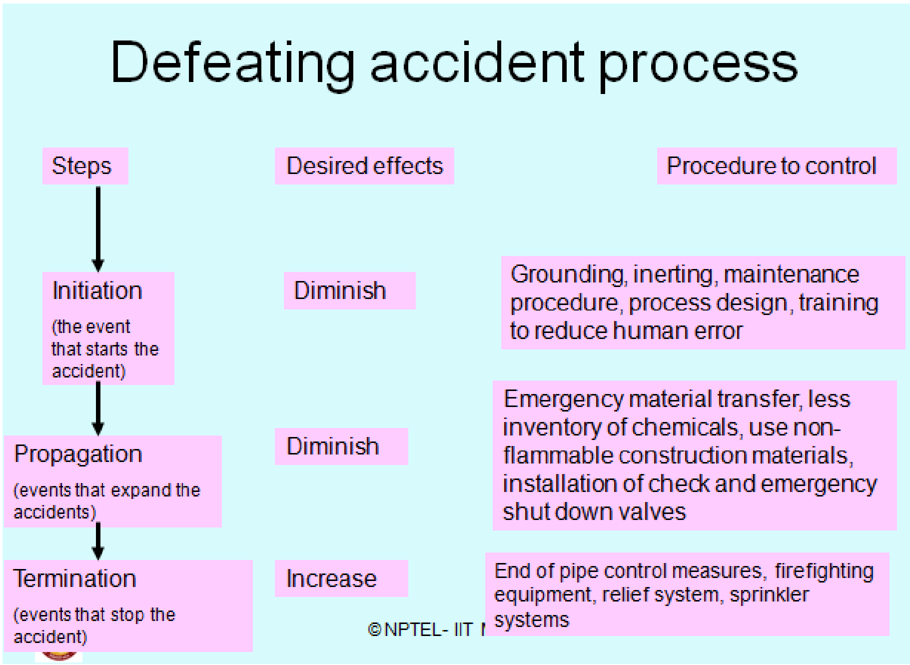
20. A-1, C-2, E-3, D-4, B-5, F-6.

Tutorial 2

1. Well kick
2. Marginal field
3. D, Complex operations, Innovative equipments, Skilled labours
4. A, Dispersion
5. BOP
6. System design is "complete integration of all parts into the whole which should be considered in the beginning itself". Consultations are required between Field development engineers, Equipment manufacturer, Service Engineer, Maintenance Engineer, Drilling company, Reservoir engineer etc
7.
   - Highly complex and technically challenging operation.
   - Uses innovative equipments and techniques.
   - Require highly special individuals to design/execute the drilling operation

8.
   - OSHA (Occupational Safety and Health Administration, US Dept of Labour)
   - Fatal Accident Rate (FAR)
   - Fatality rate or deaths per person per year
   - All three methods report # of accidents and/or fatalities for a fixed # of working hours during a specified period.

9. .



Different types of risk inlcude strategic, financial, compliance, operations.

10. Advantages

- Early production for improved cash flow
- Several wells in a leg can be completed and placed in production
- Drilling rig moves to a well cluster in another leg
- When wells in the 2nd leg are drilled and completed, they can be placed in production
- Continuous flow is maintained
- Time and money savings if two rigs are used.
- Use a normal rig for drilling and lighter rig for completion works
- While completion rig completes the work while drilling proceeds in another leg well cluster
- Elapsed time can be reduced
- Cost savings- due to reduced on-site requirement of heavier drilling rigs

Disadvantages

- Limited to size of the completion equipment used
- Major limitation
- # of wells that can be practically installed in a given leg

Tutorial 3

1. HAZID
2. Gold plated
3. Hazop
4. FTA
5. FTA
6. (C) Erode
7. (C)
8.
    - Process hazard check lists
    - Hazard surveys
    - HaZOP
    - Safety review

9.

Hazard control: Sometimes hazard can be eliminated altogether, but most often measures has to be put to manage hazard efficiently and it also helps to be systematic. This is a step by step procedure which starts from the big ones, like whether to repair or upgrade the equipment and working down until you find a practical solution.

Hazard evaluation: Hazard evaluation can be performed at any stage. If the hazard evaluation shows low probability and minimum consequence, then the system is called GOLD PLATED. Potentially unnecessary and expensive safety equipment and procedures are implemented in the system.

Hazard monitoring: Hazard controls need to be reviewed periodically to make sure they are still effective and appropriate. This can be part of your regular safety inspections. Talking with staff and the Joint Health and Safety Committee (if you have one) is an excellent way to start to get an idea about how well controls are working and what could be done even better. Some questions to consider when reviewing hazard controls are:

- Is the hazard under control?
- Have the steps taken to manage it solved the problem?
- Are the risks associated with the hazard under control too?
- Have any new hazards been created?

10.

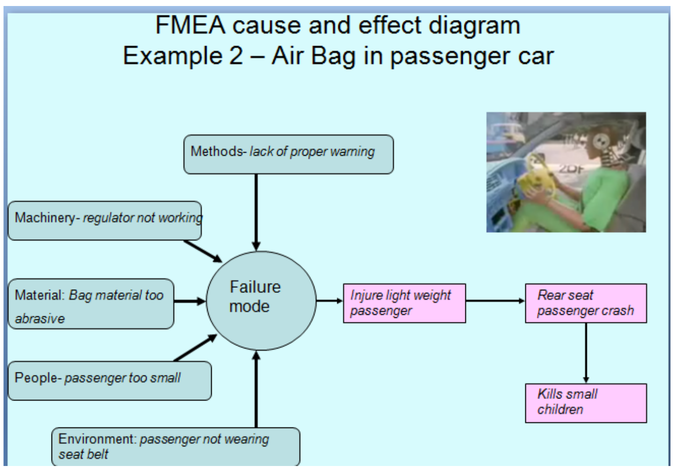
- Identification of undesired events that lead to materialization of a hazard
- Analysis of the mechanisms by which these undesired events could occur
- Estimation of the extent, magnitude and likelihood of any harmful effects

Tutorial 4

1. Severity
2. failure prevention, & detection
3.
    - Deals with engineering failure assessment
    - Evaluate the reliability of specific segments of a plant operation
    - To determine probabilistic results of failure
    - Faulty tree analysis is one such common form of engineering failure assessment
    - Limitations: It is not identified until an accident occurs
4. FMEA
5.
    - Weak link will be the one that has highest rank of failure
    - Do detailed analysis of the components present in the weak link
    - One may also do re-design to reduce the probability of failure of the components in the weak link

      This is identified while conducting FMEA
6. Design FMEA, Process FMEA
7.
    - HaZOP supplements the design ideas with imaginative anticipation of deviations.These may be due to equipment malfunction or operation error
    - In the design of new plants, designers shall oversight few issues related to safety in the beginning . HaZOP highlights these errors.

- HazOP is an opportunity to correct these errors before such changes become too expensive or impossible. HazOP methodology is widely used to aid LOSS PREVENTION
- HaZOP is a preferred tool of risk evaluation

8. 

9. **Full recording:** Later practices were to report everything. Each key word is clearly stated as applied to the system under study. Even statements like "no cause could be identified" or "no consequence arose from the cause recorded" are seen in these statements.

   Recording by exception: In earlier Hazop reports, only potential deviations with some negative consequences were recorded. Also, for handwritten records, it certainly reduces the time - both in study itself and subsequent production of hazop report. In this method, it is assumed that anything that is not included is deemed to be satisfactory

10.

FMEA- anti-skid braking system of Car

component	Failure mode	Failure effect	comment
Front wheel sensor S1, S2	No output signal	Computer will assume that one wheel as stopped. Sends a signal to open relief valve on that wheel. Results in partial loss of front wheel braking	Uneven braking on front wheels. Alarm system required to switch off computer
Front wheel valves V1, V2	Fail to open	One front wheel could lock on heavy braking	Not desired. Test facility required
	Fail to close	Partial loss of front brake	Uneven braking on front wheels. Additional stop valve required?

component	Failure mode	Failure effect	comment
Rear wheel sensor, S3	No output signal	Micro computer will have no reference speed from rear wheel. Will not attempt to close V1 or V2. Both front wheels could lock on heavy braking	Alarm system required
Micro computer	No output signals to either front wheel valves	Both front wheels could lock on heavy braking	Alarm system required
	No output signal to one front wheel valve	One front wheel could lock on heavy braking	Alarm system required
	Spurious output to both front wheel valves	Total loss of front wheel braking	Alarm system required to switch of computer
	Spurious output to one front wheel valve	Partial loss of front wheel braking	Alarm system required to switch off computer

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Tutorial 5

1. 1
2. Dermal absorption
3. CEI
4. Lethal dose curve
5. E6 (C)
6. Dermal absorption (A)
7. Toxic dose (C)
8. TLV-C (B)
9. Lethal dose, Effective dose, Toxic dose, Lethal concentration
10. TD (Toxic Dose) – if the response to the agent is toxic (it causes an undesirable response that is not lethal but is irreversible, for example, liver damage or lung damage), the response-log dose curve is called TD curve.

Tutorial 6 Answers

11. TLV
12. TLV – STEL
13. ERPG
14. Physical hazard
15. TLV-TWA, TLV –STEL, TLV-C
16. Science devoted to identification, evaluation and control of occupational conditions that cause sickness and injury.

    Identification: Determination of presence or possibility of workplace exposures

    Evaluation: Determination of magnitude of exposure

    Control: Application of appropriate technology to reduce workplace exposures to acceptable levels

17. $$TWA = \frac{410ppm \times 1.5hrs + 250ppm \times 3.5\ hrs + 75ppm \times 2\ hrs}{1.5hrs + 3.5hrs + 2hrs}$$

$$= \frac{1640ppm.hrs}{7hrs} = 234ppm$$

$$8hr - TWA = \frac{1640ppm.hrs}{8hrs} = 205ppm$$

18. PEL: 6.7ppm; TLV: 5 ppm

$$PEL = \frac{8\ hrs}{12hrs} \times 10\ ppm = 6.7ppm$$

$$TLV = \frac{8hrs}{12hrs} \times \frac{24 - 12hrs}{16hrs} \times 10 = 5ppm$$

19. $L = 9.44 \times 10^{-7} \times 50.8^2 \times 594.5 \times \sqrt{\frac{1000 \times 1050}{594.5} + 9.8 \times 4} = \mathbf{61.61 kg/s}$

$$Fv = 4.01 \times 10^{-3}\left(42 - (-33.4)\right) = 0.3$$

Since $F_v > 0.2 \rightarrow AQ = L$

$AQ = 61.61$ kg/sec

CEI

$CEI = 655.1(61.61/139)^{1/2} = 436.14$ for ERPG-2

Hazard Distances

$HD = 6551(61.9/17)^{1/2} =$ **12471.21m**

$HD = 6551(61.9/139)^{1/2} =$ **4361.4m**

$HD = 6551(61.9/696)^{1/2} =$ **1949.08m**

20.

Airborne Quantity (AQ)

$AQ = 4.751*10^{-6}\,(25)^2(889.5)(70.91/(40+273))^{1/2} =$ **1.26kg/s**

CEI

$CEI = 655.1(1.26/9.0)^{1/2} = 245.12$ for ERPG-2

Hazard Distances

$HD = 6551(1.26/3)^{1/2} =$ **4245.53m**

$HD = 6551(1.26/9)^{1/2} =$ **2451.2m**

$HD = 6551(1.26/58)^{1/2} =$ **965.56**

HSE Management in Petroleum and offshore industries

Tutorial 8

Total marks: 30

Questions 1 to 5 carry one mark each

1. BLEVE
2. Inerting & Purging
3. Stoichiometry
4. Flash point temperature
5. Run- up distance

Questions 6 to 10 carry two marks each

6. $\beta = 10 \log\left(\frac{I}{I_0}\right) = 2db$
7.

THE TNT EQUIVALENCE METHOD

From the total mass of fuel (hydrocarbon) in the release (1200 kg) determine;

TNT equivalence = energy ratio factor × efficiency factor

$= 10 \times 0.04 = 0.4$

Equivalent mass of TNT $= 1200 \times 0.4 = 480$ kg

From Figure 3.2 (see page 18) an incident peak overpressure of 0.04 bar occurs at a scaled radius of 25, hence the actual radius (r) from the explosion centre is

given by:

$$r = 25 \times (480)^{1/3} = 195.7 \text{ m}$$

8.

$$L_{FL} = \frac{100}{\frac{6}{2.1} + \frac{10}{3.0} + \frac{84}{5.0}} = 4.35\%$$

9. Relation between the quantities of substances that take part in a reaction or form a compound (typically a ratio of whole integers). It is the calculation of quantitative (measurable) relationships of the reactants and products in a balanced chemical reaction (chemicals)

$$LFL = \frac{55}{4.76m + 1.19x - 2.38y + 1}$$

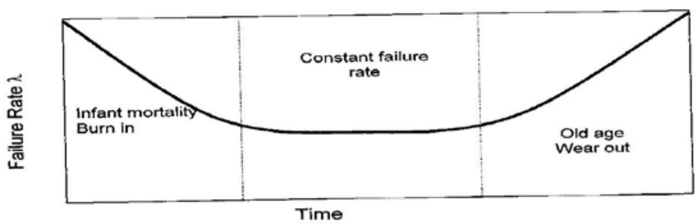
$$UFL = \frac{350}{4.76m + 1.19x - 2.38y + 1}$$

10. $$OSFC = \frac{LFL}{1 - z\left[\frac{LFL}{21}\right]} = \frac{LOC}{z\left[1 - \left[\frac{LOC}{21}\right]\right]}$$ $$ISOC = \frac{z\,x\,LFL}{1 - \left[\frac{LFL}{100}\right]} = \frac{z\,x\,LOC}{z - \left[\frac{LOC}{100}\right]}$$

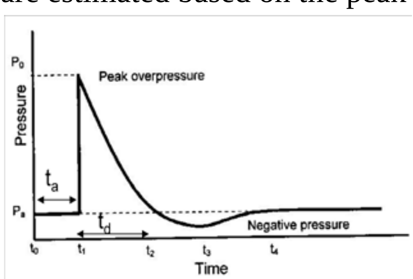
OFSC = 11.53% ISOC = 11.64%

Questions 11 to 15 carry three marks each

11. Failure rate follows a typical bath-tub curve. Highest failure rate exhibits for a component at infant mortality stage and old stage; between these two stages, failure rate is reasonably constant. On average, most components fail after certain period of time. This is called average failure rate (λ) with units faults per time. For constant failure rate (λ), is given by exponential distribution



12. Damage is function of rate of pressure increase and duration of blast wave. Blast damage are estimated based on the peak side-on overpressure.



TNT equivalence method

$$m_{TNT} = \frac{\eta\, m\, \Delta H_c}{E_{TNT}} \qquad Z_e = \frac{r}{\sqrt[3]{m_{TNT}}}$$

13. a) $E = \frac{(p-p_o)}{\gamma-1} V_o = E = \frac{(450-1)}{1.4-1} \times 10^5 \times 1 \quad = 112.25\ MJ$

Equivalent mass = $\frac{112.25\times10^3}{4520} = 24.83\ kg\ of\ TNT$

b) Percentage yield = $\frac{1.37}{24.83} \times 100 = 5.52\%$

14. **Confined vapor cloud explosion (CVCE):** An explosion in vessel or building caused due to release of high pressure or chemical energy

Vapor cloud explosion (VCE): Explosion caused by instantaneous burning of vapor cloud formed in air due to release of flammable chemical

Boiling liquid expanding vapor explosion (BLEVE): Explosion caused due to instantaneous release of large amount of vapor through narrow opening under pressurized condition

Vented explosion (VE): Explosion due to high speed venting of chemical

Dust explosion: Explosion resulted from rapid combustion of fine solid particles

15.