CH 421

Hall Ticket Number:

IV/IV B.Tech (Regular)DEGREE EXAMINATION

March, 2017 **Chemical Engineering**

Eighth Semester

Safety and Hazard Analysis
Scheme of Evaluation

Time: Three Hours **Maximum :** 60 Marks

Answer Question No.1 compulsorily. (1X12 = 12 Marks)

Answer ONE question from each unit. (4X12=48 Marks)

1 Answer all questions (1X12=12 Marks)

a) Definition of Safety
It is a positive organized activity or program based knowledge of the reaction between man and his working environment

b) Types of Hazards
Physical chemical and biological

c) Runaway Reaction
is a chemical **reaction** over which control has been lost. It continues to accelerate in **reaction** speed until it either runs out of reactants or the vessel containing it overpressures, losing containment – frequently with high risk of injury and equipment damage.

d) FTA
It is a top down, deductive failure **analysis** in which an undesired state of a system is **analyzed** using Boolean logic to combine a series of lower-level events.

e) Fail safe position
The valve's**fail position** is a **safety** precaution that protects your process in emergency situations.

f) Significance of Safety Education and Training

g) P & ID
A piping and instrumentation diagram/drawing (**P&ID**) is a detailed diagram in the process industry which shows the piping and vessels in the process flow, together with the instrumentation and control devices.

h) Fire Triangle
The **fire triangles** or combustion **triangles** are simple models for understanding the necessary ingredients for most **fires**. The **triangle** illustrates the three elements a **fire** needs to ignite: heat, fuel, and an oxidizing agent (usually oxygen)

i) Name some toxic agents in Chemical Industries
Ammonia, Chlorine, HF etc

j) Hot Work Permit System
A **permit**-to-**work system** is a formal written **system** used to control certain types of**work** that are potentially hazardous. A **permit**-to-**work** is a document which specifies the **work** to be done and the precautions to be taken. **Permits**-to-**work**form an essential part of safe **systems** of **work** for many maintenance activities.

k) SCBA
A self-contained breathing apparatus, or **SCBA**, sometimes referred to as a compressed air

breathing apparatus (CABA), or simply breathing apparatus (BA), is a device worn by rescue workers, firefighters, and others to provide breathable air in an immediately dangerous to life or health atmosphere

l) Significance of Safety Effectiveness

UNIT I

2. List out various Hazardous Commercial Chemical Operations and Reactions in Chemical Industry. Explain any five of yourchoice for each of them. 12M

Commercial chemical reactions 1M

combustion, oxidation, neutralization, electrolysis, double decomposition, calcinations, nitration, esterification ,reduction, halogination, chlorination ,bromination, hydrogenation, alkylation condensation polymerization

Any 5 of the above reactions each 1M= 5M

Commercial chemical operations 1M

Heat transfer,size reduction, mixing,material handling, mass transfersimultaneous heat and mass transfer momentum transfer

Any 5 of the above operations each 1M= 5M

(OR)

3. Explain about Fault Tree and Event Tree Analysis with examples 12M

<u>Fault Tree Analysis:</u>

Fault tree diagrams represent the logical relationship between sub-system and component failures and how they combine to cause system failures. The TOP event of a fault tree represents a system event of interest and is connected by logical gates to component failures known as basic events.

After creating the diagram, failure and repair data is assigned to the system components. The analysis is then performed, to calculate reliability and availability parameters for the system and identify critical components.

FTA analysis involves five steps:

1. Define the undesired event to study

Definition of the undesired event can be very hard to catch, although some of the events are very easy and obvious to observe. An engineer with a wide knowledge of the design of the system or a system analyst with an engineering background is the best person who can help define and number the undesired events. Undesired events are used then to make the FTA, one event for one FTA; no two events will be used to make one FTA.

1. Obtain an understanding of the system

Once the undesired event is selected, all causes with probabilities of affecting the undesired event of 0 or more are studied and analyzed. Getting exact numbers for the probabilities leading to the event is usually impossible for the reason that it may be very costly and time consuming to do so. Computer software is used to study probabilities; this may lead to less costly system analysis.

System analysts can help with understanding the overall system. System designers have full knowledge of the system and this knowledge is very important for not missing any cause affecting the undesired event. For the selected event all causes are then numbered and sequenced in the order of occurrence and then are used for the next step which is drawing or constructing the fault tree.

1. Construct the fault tree

After selecting the undesired event and having analyzed the system so that we know all the causing effects (and if possible their probabilities) we can now construct the fault tree. Fault tree is based on AND and OR gates which define the major characteristics of the fault tree.

1. Evaluate the fault tree

After the fault tree has been assembled for a specific undesired event, it is evaluated and analyzed for any possible improvement or in other words study the risk management and find ways for system improvement. This step is as an introduction for the final step which will be to control the hazards identified. In short, in this step we identify all possible hazards affecting in a direct or indirect way the system.

1. Control the hazards identified

This step is very specific and differs largely from one system to another, but the main point will always be that after identifying the hazards all possible methods are pursued to decrease the probability of occurrence.

Event Tree Analysis:

Event Tree is widely used in Chemical industries as an important **risk assessmenttechnique**. It starts with an initiating event which often corresponding to a release of hazardous material. Each event following the initiating event is conditional on the occurrence of its precursor event. The method can be used to uncover weakness in safeguard system, or to identify possible incident outcomes and their possibilities.

There are seven steps in a complete Event Tree Analysis.

1. Identify the initiating event

The initiating event is a general equipment failure or process upset. This failure event will be identified in Hazard Identification process.

2. Identify safety function/hazard promoting factor and determine outcomes

All the factors that can materially affect the outcome of the initiating event much be carefully listed. These factors including safety functions, which are device, action, or barrier that can interrupt the sequence from initiating event to a hazardous outcome, and hazard promoting factors, which may change the final outcome of the accident. However the number of the factors shall be limited to 7 or 8 for a manageable degree of complexity of the event tree.

3. Construct event tree to all important outcomes

The factors identified in step 2 are listed across the top of the sheet from left to right in chronological order of occurrence. Starting from the initiating event, the event tree is constructed from left to right. At each factors (or called node), two or more alternatives are analyzed / branches are drawn until a final outcome is obtained for each node.

4. Classify the outcomes in categories of similar consequence

The final event tree outcomes can be classified according to type of consequence model that must be employed to complete the risk assessment.

5. Estimate probability of each branch in the event tree

The branches at each node correspond to a conditional probability of some outcome if the preceding event has occurred and each is assigned a probability. The probability data may be taken from the historical data, plant and process date, chemical data, meteorological data, etc.

6. Quantify the outcomes

The frequency of each outcome can be determined by multiplying the initiating event frequency with the conditional probabilities along each path leading to that outcome. The frequencies of those outcomes with similar consequence are added together to give the frequency of that category of consequence.

7. Test the outcomes

Major error may be uncovered by comparing the calculated result with common sense and historical record.

UNIT II

4. a) What is the significance of Process Design in Chemical Industries? Explain about the components of process design 8M

Process Design

The technique for safe process design which includes the flow sheet, separation section, material handling, storage section 8M

b) List out the Various Instrumentation for Safe Operation 4M

Self acting pressure regulators,self acting temperature regulators, the potentiometer controller, the pneumatic controller, float switches, bubbler type level gages, displacer type level controller, alarm on recording controller, solenoid valves, annunciators

(OR)

5. Explain Safety Education and Training With the help of a module 12M

Safety education

Employee training procedures, on the job training, job instructor training, meetings and instruction presentations, 12M

UNIT III

6. Define Toxicity. Explain about the effect of toxic agents on Respiratory and Digestive system. 12M

Toxicity definition 2M

Effect of toxic chemicals and the skin

Effect of toxic chemicals on chemicals and eye

Effect of toxic chemicals on chemicals and respiratory tract

Effect of toxic chemicals on digestive tract

Any 4 of the above effects each 3M =12M

(OR)

7. a) What is the significance of Work Permit system? List out various work permit systems 6M

Permit to Work system is a formal safety control document designed to prevent injury to employees, contractors and third parties as well as to property, particularly when work with foreseeable high hazard content is undertaken. The Permit sets out the work to be done, precautions to be taken and the responsibilities of individuals. This guidance is intended to assist Line Managers, Head teachers, and people in charge of divisional units to ensure that a safe system of work is in place for maintenance work, small or short term projects where previously hazardous conditions have been identified. A permit to work system will be required to ensure no worker is subjected to any significant risk, and also in fulfilling legal obligations under the Health and Safety At Work Act 1974, and The Management of Health and Safety Regulations 1999.

A permit to work system forms an essential part of a safe system of work. It also forms an integral part of a risk assessment process, where specific hazards are identified, and suitable control measures are implemented prior to commencement of the work task. However, it is important to ensure that people carrying out work task where a permit to work system is required have the necessary competence to undertake the job safely.

When Are Permit to work Systems Required?

A permit to work system is required or should be considered whenever works intended to be carried out may adversely affect the safety of people, plant or the environment. Permit to work systems are not required for routine maintenance activities in a non-hazardous environment. Permit to work systems should be considered where: • Non -production work (e.g. maintenance, repairs, inspections, testing, etc); • Works where two or more individuals need to co-ordinate activities to complete the job safely; • Jobs where there is a transfer of work and responsibilities from one contractor to the other; • Non -routine operations or activities.

As a general guide a permit to work system may be required for work activities that involve: • Confined space working; • Hot works such as welding, flame cutting and grinding; • Working at height; • Certain excavation works; • Working on fragile roofs; • Maintenance work on lifts, conveyors, hoists etc; • Work on high voltage electrical equipment or other work on electrical equipment which may give rise to potential dangers; • Any activity which require additional precautions or personal protective equipment (PPE) to be in place; • Work involving the use of hazardous/dangerous substances.

b) Explain any one work permit system of your choice. 6M

HOT WORK PERMIT SYSTEM (Welding, cutting, open flame)

Fire has been the greatest universal hazard to which chemical operations are exposed. Numerous times uncontrolled welding and cutting operations have been the source of fire of all types of industrial operations. These activities can be closely controlled by an effective permit system. There are many areas where smoking, open flames and welding and cutting operations are prohibited during normal operations because of the nature of exposure or the large damage potential of the area. In these areas a permit system can provide for the controlled use of heat or open flame sources.

The approval and granting of a “hot work” permit is usually restricted to a senior supervisor of the area involved and for a limited time period. Most of these permits actually require inspection of the area and approval by the plant safety supervisor, the fire chief or their representatives and the local area supervisor.

The below table is a sample of “hot work” permit system. The issuing of the permit is usually the responsibility of area supervisor, who must inspect the area and verify that the following measures have been taken:

1. The equipment has been emptied and cleaned and all flammables, combustibles or toxic materials have been removed from the area and those items that cannot be removed have been shielded or wet down.
2. The area and equipment have been inspected by the safety or fire department personnel and adequate tests have been conducted, if necessary, to insure that there are no flammables or explosive atmospheres present.

The foreman or supervisor of the work crew inspects the area. When satisfied that the area is in proper condition and the permit has been properly completed and signed, he assigns a "fire watch" and then signs the permit and authorizes the work to be performed. Upon completion of the work, the area is inspected by the worker and the "fire watch" to insure that there are no smoldering or incipient fires started in the area. They then sign the form certifying the work has been completed safely and return it to their supervisor. He, in turn, forwards it to the are supervisor and to the plant engineers office or the safety department.
Work postponed beyond the period of permit usually requires reissue or extension of the permit after the review of the area and conditions by specified personnel. Fires, or significant changes of conditions in the area during the work, usually voids the permit and reissue is required.

UNIT IV

8. What are Personnel Protective Equipments? Explain them in detail 12M

What is PPE? PPE is equipment that will protect the user against health or safety risks at work. It can include items such as safety helmets and hard hats, gloves, eye protection, high-visibility clothing, safety footwear and safety harnesses. Hearing protection and respiratory protective equipment provided for most work situations are not covered by these Regulations because there are other more specific regulations that apply to them. However, these items need to be compatible with any other PPE provided. Cycle helmets or crash helmets worn by employees on the roads are not covered by the Regulations. Motorcycle helmets are legally required under road traffic legislation. The Employment Act 1989 gives an exemption for turban-wearing Sikhs working on construction sites from the need to wear head protection. What do the Regulations require? PPE should be used as a last resort. Wherever there are risks to health and safety that cannot be adequately controlled in other ways, the Personal Protective Equipment at Work Regulations 1992 require PPE to be supplied. The Regulations also require that PPE is: ■ properly assessed before use to make sure it is fit for purpose; ■ maintained and stored properly; ■ provided with instructions on how to use it safely; ■ used correctly by employees.

Assessing suitable PPE To make sure the right type of PPE is chosen, consider the different hazards in the workplace and identify the PPE that will provide adequate protection against them; this may be different for each job. Ask your supplier for advice on the types of PPE available and their suitability for different tasks. In some cases, you may need to get advice from specialists or from the PPE manufacturer. Another useful source of information is the British Safety Industry Federation (www. bsif.co.uk). Consider the following when assessing suitability: ■ Does the PPE protect the wearer from the risks and take account of the environmental conditions where the task is taking place? For example eye protection designed to protect against agricultural pesticides may not offer adequate protection when using an angle grinder to cut steel or stone. ■ Does using PPE increase the overall level of risk or add new risks, eg by making communication more difficult? ■ Can it be adjusted to fit the wearer correctly? ■ What are the needs of the job and the demands it places on the wearer? For example, the length of time the PPE needs to be worn, the physical effort required to do the job or the requirements for visibility and communication. ■ If someone wears more than one item of PPE, are they compatible? For example does using a respirator make it difficult to fit eye protection properly? Selection and use When selecting PPE: ■ choose good quality products which are CE marked in accordance with the Personal Protective Equipment Regulations 2002 – suppliers can advise you; ■ choose equipment that suits the wearer – consider the size, fit and weight; you may need to consider the health of the wearer, eg if equipment is very heavy, or wearers have pre-existing health issues, standard PPE may not be suitable; ■ let users help choose it, they will be more likely to use it. Using and distributing PPE to your employers: ■ instruct and train people how to use it; ■ tell them why it is needed, when to use it and what its limitations are; ■ never allow exemptions for those jobs that 'only take a few minutes'; ■ if something changes on the job, check the PPE is still appropriate – speak with your supplier, explaining the job to them; ■ if in doubt, seek further advice from a specialist adviser.

The hazards and types of PPE Eyes Hazards: Chemical or metal splash, dust, projectiles, gas and vapour, radiation. Options: Safety spectacles, goggles, face-shields, visors. Note: Make sure the eye protection has the right combination of impact/dust/ splash/molten metal eye protection for the task and fits the user properly. Head Hazards: Impact from falling or flying objects, risk of head bumping, hair entanglement. Options: A range of helmets, hard hats and bump caps. Note: Some safety helmets incorporate or can be fitted with specially-designed eye or hearing protection. Don't forget neck protection, eg scarves for use during welding. Do not use head protection if it is damaged – replace it. Breathing Hazards: Dust, vapour, gas, oxygen-deficient atmospheres. Options: Disposable filtering face-piece or respirator, half- or full-face respirators, airfed helmets, breathing apparatus. Note: The right type of respirator filter must be used as each is effective for only a limited range of substances. Where there is a shortage of oxygen or any danger of losing consciousness due to exposure to high levels of harmful fumes, only use breathing apparatus – never use a filtering cartridge. Filters only have a limited life; when replacing them or any other part, check with the manufacturer's guidance and ensure the correct replacement part is used. If you are using respiratory protective equipment, look at HSE's publication Respiratory protective equipment at work: A practical guide (see 'Further reading'). Protecting the body Hazards: Temperature extremes, adverse weather, chemical or metal splash, spray from pressure leaks or spray guns, impact or penetration, contaminated dust, excessive wear or entanglement of own clothing. Options: Conventional or disposable overalls, boiler suits, specialist protective clothing, eg chain-mail aprons, high-visibility clothing. Note: The choice of materials includes flame-retardant, anti-static, chain mail, chemically impermeable, and high-visibility. Don't forget other protection, like safety harnesses or life jackets.

Hands and arms Hazards: abrasion, temperature extremes, cuts and punctures, impact, chemicals, electric shock, skin infection, disease or contamination. Options: Gloves, gauntlets, mitts, wrist-cuffs, armlets. Note: Avoid gloves when operating machines such as bench drills where the gloves could get caught. Some materials are quickly penetrated by chemicals so be careful when you are selecting them, see HSE's skin at work website (www.hse.gov.uk/skin). Barrier creams are unreliable and are no substitute for proper PPE. Wearing gloves for long periods can make the skin hot and sweaty, leading to skin problems; using separate cotton inner gloves can help prevent this. Be aware that some people may be allergic to materials used in gloves, eg latex. Feet and legs Hazards: Wet, electrostatic build-up, slipping, cuts and punctures, falling objects, metal and chemical splash, abrasion. Options: Safety boots and shoes with protective toe caps and penetration-resistant mid-sole, gaiters, leggings, spats. Note: Footwear can have a variety of sole patterns and materials to help prevent slips in different conditions, including oil or chemical-resistant soles. It can also be anti-static, electrically conductive or thermally insulating. It is important that the appropriate footwear is selected for the risks identified. Training ■ Make sure anyone using PPE is aware of why it is needed, when to use, repair or replace it, how to report it if there is a fault and its limitations. ■ Train and instruct people how to use PPE properly and make sure they are doing this. Include managers and supervisors in the training, they may not need to use the equipment personally, but they do need to ensure their staff are using it correctly. ■ It is important that users wear PPE all the time they are exposed to the risk. Never allow exemptions for those jobs which take 'just a few minutes'. ■ Check regularly that PPE is being used and investigate incidents where it is not. Safety signs can be useful reminders to wear PPE, make sure that staff

(OR)

9. Write about a) Dry powder fire extinguishers 8M 4M

This is a powder based agent that extinguishes by separating the four parts of the fire tetrahedron. It prevents the chemical reactions involving heat, fuel, and oxygen (combustion), thus extinguishing the fire. During combustion, the fuel breaks down into free radicals, which are highly reactive fragments of molecules that react with oxygen. The substances in dry chemical extinguishers can stop this process.

- Monoammonium phosphate, also known as *tri-class*, *multipurpose*, or *ABC* dry chemical, used on class A, B, and C fires. It receives its class A rating from the agent's ability to melt and flow at 177 °C (351 °F) to smother the fire. More corrosive than other dry chemical agents. Pale yellow in color.
- Sodium bicarbonate, *regular* or *ordinary* used on class B and C fires, was the first of the dry chemical agents developed. In the heat of a fire, it releases a cloud of carbon dioxide that smothers the fire. That is, the gas drives oxygen away from the fire, thus stopping the chemical reaction. This agent is not generally effective on class A fires because the agent is expended and the cloud of gas dissipates quickly, and if the fuel is still sufficiently hot, the fire starts up again. While liquid and gas fires do not usually store much heat in their fuel source, solid fires do. Sodium bicarbonate was very common in commercial kitchens before the advent of wet chemical agents, but now is falling out of favor, as it is much less effective than wet chemical agents for class K fires, less effective than Purple-K for class B fires, and is ineffective on class A fires. White or blue in color.
- Potassium bicarbonate (principal constituent of Purple-K), used on class B and C fires. About two times as effective on class B fires as sodium bicarbonate, it is the preferred dry chemical agent of the oil and gas industry. The only dry chemical agent certified for use in ARFF by the NFPA. Colored violet to distinguish it.

- Potassium bicarbonate & Urea Complex (AKA Monnex), used on class B and C fires. More effective than all other powders due to its ability to decrepitate (where the powder breaks up into smaller particles) in the flame zone creating a larger surface area for free radical inhibition. Grey in color.
- Potassium chloride, or Super-K, dry chemical was developed in an effort to create a high efficiency, protein-foam compatible dry chemical. Developed in the 60s, prior to Purple-K, it was never as popular as other agents since, being a salt, it was quite corrosive. For B and C fires, white in color.
- Foam-compatible, which is a sodium bicarbonate (BC) based dry chemical, was developed for use with protein foams for fighting class B fires. Most dry chemicals contain metal stearates to waterproof them, but these will tend to destroy the foam blanket created by protein (animal) based foams. Foam compatible type uses silicone as a waterproofing agent, which does not harm foam. Effectiveness is identical to regular dry chemical, and it is light green in color (some ANSUL brand formulations are blue). This agent is generally no longer used since most modern dry chemicals are considered compatible with synthetic foams such as AFFF.
- MET-L-KYL / PYROKYL is a specialty variation of sodium bicarbonate for fighting pyrophoric (ignites on contact with air) liquid fires. In addition to sodium bicarbonate, it also contains silica gel particles. The sodium bicarbonate interrupts the chain reaction of the fuel and the silica soaks up any unburned fuel, preventing contact with air. It is effective on other class B fuels as well. Blue/red in color.

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b) Measuring Safety Effectiveness

The most important factor in any organization is the system of measuring its effectiveness. in the absence of a credible measure a program moves haltingly at best. Its administrator's efforts will not be recognized satisfactorily. When a measure that is not credible is tried its value in motivating performance and signaling shifts in strength diminishes rapidly. In the final analysis any system whose success depends on a current understanding of the vigor and direction of its components relies on measuring of optimizing its effectiveness and determining the degree of recognition to be accorded its contributors.

Criteria for effective Measures

The principal requirements for an acceptable measure are that it be reliable and valid.

Reliability requires that the value reported by the measure will be reproducible by any qualified investigator with much same accuracy with in reasonable limits.

validity means that the measure truly appraises what it purports to measure.

STADARD MEASURES

In the United States, the standard means for appraising safety progress is the American standard method of recoding and measuring work injury experience, Z 16.1, R.1959, published by the American standard association. This has been the accepted approach since 1937 for computing and measuring work injury experience. It reflects the opinions and practical experience of those interested in or affected by the application of the measure. Each interested group (such as employers, employees, governments, insurance companies, the national safety council, the American society of safety engineers and so on) named a representative and alternate to a committee, which was balance with respect to opposite and allied interests, according to the procedures of American standard association. This working group, representing a cross section of those interested in the standard, is known as a sectional committee. From time to time the standard is reviewed by the committee and it is either reaffirmed or revised as necessary, according to the experience of the users.

The accepted standard measures of work injury experience or frequency and severity. The first term refers to the frequency of occurrence of disabling injuries as defined by the American standard. The second term refers to the total days lost plus time charges for deaths and permanent disabilities resulting from the disabling injuries