International Diploma in Safety Engineering (IDSE)
Qualifi Endorsed Qualification

UNIT 2: Principles and Applications of Science and Technology in Safety

Total Time: 24 Hours (+2 hours for submission) Total Marks: 150
Total Questions: 13 Passing Marks: 75

Exam Instructions

- This is an Open Book Non-invigilated exam. Total Marks are 150 and maximum marks for the questions are given against each.
- Do not add any picture or sketch from the internet as part of your answer. You can however draw a linear sketch as part of your answer.
- Support your answers with **logical arguments** and **examples** relevant to the given scenario. Generic and Bookish answers will not be accepted by the examiners.
- All Questions are compulsory and must be answered to gain maximum marks
- **Do not directly copy/paste from any source. Write all answers in your own words.**
- Do not take help from any individual/ organization in any manner, to complete your answers.
- Do not help other learner/s to complete their answers, in any manner
- Your answers will be compared with other learners' work and any collusion found in terms of similar ideas, similar responses will form the basis for malpractice investigation and the results will be withheld.
- **You must only type your answer in the given answer sheet. Hand written responses will not be accepted.**

Note: This is a sample exam only for reference. Actual exam Questions may vary but total exam score will be 150 marks

Section A

Carefully analyze the following scenario and answer to the 5 questions in context with given scenario only. Any generic or irrelevant response will not be accepted by the examiner

Workplace Situation/ Scenario

"Silk Aviation Suppliers Pvt. limited Company" is a reliable supplier for aviation components, hardwares and chemicals to a number of airlines in the region. The company employs 3000 workforce including supervisors, managers and directors. Their business strategy is to be amongst top 10 suppliers (in terms of business revenue) in the region within next 5 years. They maintain huge inventory of aviation parts and deliver those parts to their customers using 3rd party courier service. The courier company staff is often required to pick some heavy products directly from the warehouses using their own manpower and necessary equipment. The company has 10 huge warehouses which are used to store various inventory items based on their sizes, chemical properties, fragility etc. The retrieval of the items from the warehouses require the manual as well as mechanical operations which are often done simultaneously creating various safety hazards for the workers. There are certain health hazards as well while working in the chemical warehouse or pulling/pushing the inventory on manual carts. The pushing of carts to or from the warehouse becomes very tedious as ramps are used to approach the warehouses. Latest regulatory limit for pushing force for the cart has been set to 50 Lbs. however, it has been observed that workers are required to use force beyond the legal limit when they push the cart on a ramp.

The company has previously trialed a semi-automated storage and retrieval system without the need for workers to physically store or retrieve the loads but it caused delays in delivery. The company has now planning to redesign the ramps so lesser pushing force is required for storage/retrieval manually through the carts in order to be regulatory compliant.

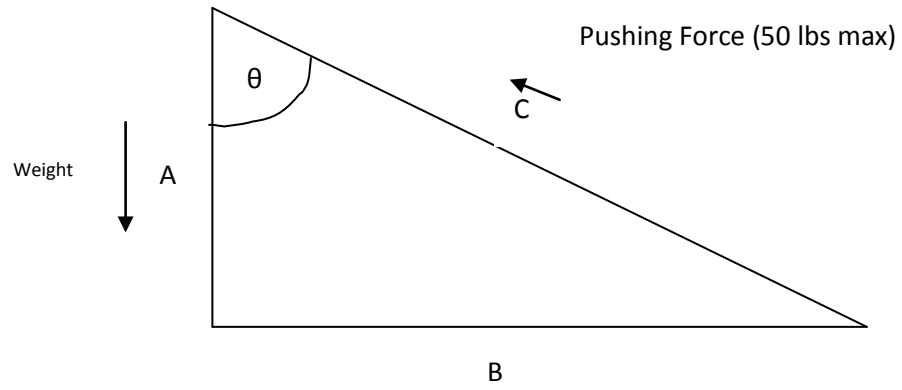
Another problem with the chemical warehouse is that it is used to store a number of chemicals under the same roof. Although the company ensures that short term and long term exposure limits (STEL and LTEL) for various hazardous airborne chemicals should be complied yet there have been instances when workers had health issues due to the exposure with airborne chemicals. The company has put a time bar on every worker (Reduced from 8 hours to 6 hours) beyond which the workers cannot be in the chemical warehouse but again this practice has caused delays in the deliveries. Moreover, the production managers found it very difficult to ascertain the exact time for which the workers remain present inside the warehouse as it requires frequent movements between the warehouse and the packing/delivery point by each worker which cannot be documented in real time.

All 5 questions carry 10 marks each (Total 50 Marks)

Keeping in view the above mentioned scenario, please answer to the following questions;

Question 1- Calculate the suitable ramp angle for a maximum of 100 lbs. load on the cart so the required pushing force remain under 50 lbs.? **10 Marks**

Reference: Unit 2; page 61



We know the formula for components of a Force, as follows:

Cos θ = 50/100 = 0.5

$\theta = 60^0$

Reference

Unit 2; Page 62

Question 2- Why do you think there have been ill health issues at the chemical warehouse if the STEL and LTEL limits are being complied? What additional measures will you take to eliminate/mitigate the risk of ill-health in the given scenario.

10 Marks

The possible issues, why there were ill health cases despite the STEL and LTEL in place include

- The environment conditions at the workplace like, temperature, humidity, etc... All these should be considered since it can affect the integrity of the equipment. For example some detection devises don't give accurate results in low oxygen area.
- how many airborne chemical agents are present? So monitoring equipment must be provided to identify the presence and the concentrations of all hazardous chemicals, bearing in mind that detectors most of the time are designed to detect one kind of chemicals.
- Detection range requirement not met e.g. 0-50 PPM
- Resolution not as required e.g. 10.0, 10.00 or 10.000 etc.
- The competence of the people who are supposed to use, operate and maintain and any specific training requirement not met
- Calibration frequency and other pertinent requirements not met
- The reliability & repeatability of the equipment (quality of monitoring/ measurement)
- Requirement of being tamper- proof & ruggedness, not met, especially when they're less educated
- The types of monitors e.g. fixed or portable. For example, for operators working in oil plant; it's important to give the H_2S portable devise since H_2S may release accidentally anywhere in the plant
- Other factors which may somehow invalidate the legal limits are age, fatigue, alcoholism, gender and environmental conditions like extreme temperatures, humidity, pressure, mixed chemicals as there are no limits set for such a situation etc.

The additional measures include

- review selection of equipment to make sure they are fit for purpose in the given situation
- review as to which type is required, whether portable or fixed or both e.g. the one which can give TWA will be preferable
- review the performance specifications including accuracy, reliability etc.
- review the existing control measures e.g. ventilations, awareness , supervision, PPE
- more frequent health surveillance checks etc.

Question 3- What control measures you may wish to take (without any financial implications) in the prevailing circumstances in order to increase the OHS performance.

10 Marks

Among various admistrative controls, these may include

- more focus on in-house trainings in regards to operation, use and maintenance
- maintenance strictly in line with the manufacture' recommendation
- more frequent calibrations
- more awareness to workers in regards to the consequences, if tampered or not used properly
- more competent supervision to make sure they wear PPEs properly and don't stay more than 6 hours
- taking into consideration 1) age, 2)alcoholism history, 3) gender and other such things

Question 4 - What technological solution you may advise to the management in order to ensure that eachworker does not remain inside the chemical warehouse beyond 6 hours during their 8 hours shift and additional 4 hours over-time duration? You must explain the technical details along with the cost implications of the proposed solution.

- RFID combined with Facial recognition (most preferred) **10 Marks**
- A tamper proof measuring and monitoring equipment/system that can accurately & reliably measure and give TWA
- biometric system combined with competent supervision?

Question 5 - What technological options will you suggest for fully automated storage and retrieval system? You must explain the technical details of the proposed solution in terms of the process flow including the use of Information technology tools where applicable.

AS/AR system (browse in Google & YouTube) **10 Marks**

Section B

Carefully analyze the following scenarios and answer to the question/s in context with given scenariosonly. Any generic or irrelevant response will not be accepted by the examiner.

Workplace Situation/Scenario

A large textile company "Star Textiles" has its own weaving, dying, stitching and packaging units employs 6500 workforce at different administrative and functional levels. The company operates in 3 shifts on weekdays and 2 shifts on weekends. There are 6 separate buildings as follows;

1- Admin block (4 storey building) with the capacity of 150 people on each floor.
2- Weaving and stitching unit (2 storey building) with capacity of 500-600 workers on each floor3- Dying Unit (single storey) with capacity of 300 workers in each shift
4- Packaging unit (Single storey) with capacity of 350 workers in each shift
5- Raw materials warehouse (2 storey) with capacity to accommodate 50 workers in each shift
6- Maintenance unit (single storey) with capacity to accommodate 60 workers in each shift

Each building/ storey has an entrance and a separate exit doors (each 10 foot wide).

The company believes in "Equal Opportunity" and therefore 50% of the manpower is female. There are 10 workers who have hearing impairment while 7 workers have mobility issues. The administrative building is a 4 storey building where lifts are used however, 10 feet wide stairs have been made available as well.

Question 6 - Write down a comprehensive "Fire Evacuation Plan" as per the given scenario requirements.

20 Marks

Reference

Page 123, Heading 5.7, Unit 2

Fire Evacuation Plan (Frame Work)

The context

Few people can think clearly and logically in a crisis, so it is important to do so in advance, when you have time to be thorough. The best way is to prepare to respond to an emergency before it happens.

The approach

Brainstorm the worst-case scenarios. Ask yourself what you would do if the worst happened. What if a fire broke out due to short circuiting?
Once you have identified potential emergencies, consider how they would affect you and your workers and how you would respond.

Consultation

An emergency action plan covers designated actions employers and employees must take to ensure employee safety from emergencies.
include your management and employees in the process.
Explain your goal of protecting lives and property in the event of an emergency, and ask for their help in establishing and implementing your emergency action plan.
Their commitment and support are critical to the plan's success.

The plan

This shall include the following, at a minimum:

- If you have more than one worksite, each site should have an emergency action plan.
- A preferred method for reporting emergency;
- An evacuation policy and procedure;
- Emergency escape procedures and route assignments, such as floor plans, workplace maps, and safe or refuge areas;
- Names, titles, departments, and telephone numbers of individuals both within and outside your company to contact for
- Additional information or explanation of duties and responsibilities under the emergency plan;
- Procedures for employees who remain to perform or shut down critical plant operations, operate fire extinguishers, or perform other essential services that cannot be shut down for every emergency alarm before evacuating; and
- Rescue and medical duties for any workers designated to perform them.
- You also may want to consider designating an assembly location and procedures to account for all employees after an evacuation.

In addition, you may find it helpful to include in your plan the following:

- The site of an alternative communications center to be used in the event of a fire or explosion; and
- A secure on- or offsite location to store originals or duplicate copies of accounting records, legal documents, your employees' emergency contact lists, and other essential records.

How do you alert employees to an emergency?

Your plan must include a way to alert employees, including disabled workers, to evacuate or take other action, and how to report emergencies, as required.
Among the steps you must take are the following:

- Make sure alarms are distinctive and recognized by all employees as a signal to evacuate the work area or perform
- actions identified in your plan;
- Make available an emergency communications system such as a public address system, portable radio unit, or other means to notify employees of the emergency and to contact local law enforcement, the fire department, and others.
- Stipulate that alarms must be able to be heard, seen, or otherwise perceived by everyone in the workplace. You might want to consider providing an auxiliary power supply in the event that electricity is shut off.
- You also may want to consider the following:
    - Using tactile devices to alert employees who would not otherwise be able to recognize an audible or visual alarm; and
    - Providing an updated list of key personnel such as the plant manager or physician, in order of priority, to notify in the event of an emergency during off-duty hours.

Evacuation policy and procedures?

A disorganized evacuation can result in confusion, injury, and property damage. That is why when developing your emergency action plan, it is important to determine the following:

- Conditions under which an evacuation would be necessary;
- A clear chain of command and designation of the person in your business authorized to order an evacuation or shutdown. You may want to designate an "evacuation warden(s)" to assist others in an evacuation and to account for personnel;
- Specific evacuation procedures, including routes and exits. Post these procedures where they are easily accessible to all employees;
- Procedures for assisting people with disabilities or who do not speak English or;
- Designation of what, if any, employees will continue or shut down critical operations during an evacuation. These people must be capable of recognizing when to abandon the operation and evacuate themselves; and
- A system for accounting for personnel following an evacuation. Consider employees' transportation needs for community-wide evacuations.

Underwhat conditions should you call for an evacuation?

A designated person within your business should be responsible for making the decision to evacuate or shut down operations. Protecting the health and safety of everyone in the facility should be the first priority. In the event of a fire subsequent to a short circuit, an immediate evacuation to a predetermined area away from the facility is the best way to protect employees.

What role should employees play in your emergency action plan?

- The best emergency action plans include employees in the planning process, specify what employees should do during an emergency, and ensure that employees receive proper training for emergencies.
- When you include your employees in your planning, encourage them to offer suggestions about potential hazards, worst-case scenarios, and proper emergency responses.
- After you develop the plan, review it with your employees to make sure everyone knows what to do before, during and after an emergency.
- Keep a copy of your emergency action plan in a convenient location where employees can get to it, or provide all employees a copy. If you have 10 or fewer employees, you may communicate your plan orally.

What employee information should your plan include?

In the event of an emergency, it could be important to have ready access to important personal information about your employees. This includes their home telephone numbers, the names and telephone numbers of their next of kin, and medical information.

The procedure must be rehearsed at suitable intervals and corrective actions should be taken to continually improve the procedure.

What type of training do your employees need?

Educate your employees about the types of emergencies that may occur and train them in the proper course of action.

The size of your workplace and workforce, processes used, materials handled, and the availability of onsite or outside resources will determine your training requirements.

Be sure all your employees understand the function and elements of your emergency action plan, including types of potential emergencies, reporting procedures, alarm systems, evacuation plans, and shutdown procedures.

Discuss any special hazards you may have onsite such as flammable materials, toxic chemicals, radioactive sources, or water-reactive substances.

Clearly communicate to your employees who will be in charge during an emergency to minimize

confusion.
General training for your employees should address the following:

- Individual roles and responsibilities;
- Threats, hazards, and protective actions;
- Notification, warning, and communications procedures;
- Means for locating family members in an emergency;
- Emergency response procedures;
- Evacuation, shelter, and accountability procedures;
- Location and use of common emergency equipment; and
- Emergency shutdown procedures.
- You also may wish to train your employees in first-aid procedures e.g. Respiratory protection, including use of an escape only respirator; and methods for preventing unauthorized access to the site.
- Once you have reviewed your emergency action plan with your employees and everyone has had the proper training, it is a good idea to hold practice drills as often as necessary to keep employees prepared. Include outside resources such as fire and police departments when possible. After each drill, gather management and employees to evaluate the effectiveness of the drill. Identify the strengths and weaknesses of your plan and work to improve it.

How often do you need to train your employees?

Review your plan with all your employees and consider requiring annual training in the plan. Also offer training when you do the following:

- Develop your initial plan;
- Hire new employees;
- Introduce new equipment, materials, or processes into the workplace that affect evacuation routes;
- Change the layout or design of the facility; and
- Revise or update your emergency procedures.

Workplace Situation/Scenario

A large construction company utilizes various lifting equipment for the transportation of men and materials on large storey under construction buildings. Lately there have been an accident when a material lifting equipment failed resulting free fall of the lifting platform and collapse of the whole assembly. Fortunately there have been no injuries but the incident alarmed the regulatory body as well as the management who are concerned with the safety of people. You are working as safety manager in the construction company head office and has been assigned to carry out a technical investigation.

Question 7 - Establish the scope of the investigation for the perusal of Safety Director and the management? **10 Marks**

As an investigation office, I'd like to interact and have an access to the following personnel, agencies, equipment, documentation as follows:

- Designer and manufacture of the equipment and pertinent documentation e.g. Manuals
- Calibration and maintenance personnel and pertinent records
- Purchase personnel and associated records of purchase
- Operators of the equipment for interviewing and review of pertinent records
- inspection and review of related records of other similar equipment in the company, as needed
- Third party inspection provider; their inspector(s) and related inspection and other records e.g. accreditation certificate, scope, etc.
- internal inspection records and the personnel
- regulatory body

Question 8 - Based on the scope of the investigation, establish a checklist as per the following format;

10 Marks

Sr#	**Potential Cause of the Accident**	**Evidences you wish to collect to "Establish"or "Rule Out" the potential cause**
	Manufacturer documents. Installation Date.	To check the equipment was being used beyond its serviceable life period as recommended by the designer and/or manufacturer
	Maintenance log.	Was maintenance carried out as recommended and required
	Spare purchase and consumption records	To ascertain the quality
	Interview with the operators to check the level of control they had and any complaints regarding operations	Tampering with safety devices by the Operators for any reason including False Alarm etc
	The market repute and accident history of the manufacturer' products. The certifications of manufacturer and the manufacturing and testing standards.	Design Failure
	▪ Modification records	▪ Unauthorized modification carried

	▪ Maintenance Log book ▪ Inspection of debris collected from accident site	out on the equipment which weakened its structure ▪ Were there any signs of physical abuse with the equipment?
	Interview with the operators about the usual process	▪ Were they following instructions or not? ▪ Were there any excessive loading? ▪ Was it a sudden failure or certain early waning defects appeared and or reported by anyone?
	Inspection and testing of the equipment (external)	Accreditation status, scope, competency of the inspector etc.
	Inspection records (routine)	Were the routine inspections carried out as per manufacturer/ designer recommendations?
	Was there any weather or other environmental factors which expedited the material failure	Inspection of debris

Scenario

The recent Corona Virus Pandemic has affected the whole world. It caused business and life disruptions all over the world. There were various administrative measures taken by each and every country to curtail the spread of the virus but the efforts were mostly not very effective as to-date, there are thousands of people being affected daily. The situation alarmed the scientists, politicians as well as the citizens who urged the need for more scientific development in the field of public health. The Health and Safety Officer have also been observing the impacts of Pandemic and the way it is being managed. They have also been discussing the limitations of prevailing technological options which could not effectively work to reduce the spread of Corona Virus.

Question 9 - Which technological invention you wish to have in near future which may curtail the spread of virus or increase the effectiveness of existing control measures? Propose a single specific product/service (Except the vaccine) and explain in detail how it will be used in order to control the spread of similar or more deadly viruses in future. **20 Marks**

Workplace Situation/Scenario

An oil refinery company "Silverline Oil Refinery" had deployed various engineering controls for its process safety to eliminate the risk of explosion. There have been lately an occurrence when a "Pressure Release Valve" could not maintain the required pressure flow resulting huge pressure build-up within the system. The abnormal situation was observed by the vigilant staff of main control room who brought the pressure "under control" by shutting down the process (administrative Controls) which resulted in heavy financial losses to the refinery. The refinery has carried out a technical investigation and the cause of the failure was identified as "Equipment Failure" i.e. the subject valve failed to perform its intended function although it was calibrated and tested only a week ago.

Question 10 - Why Engineering controls cannot be 100% reliable and which factors influence their performance? **10 Marks**

Reference:

Page 183, Heading 9.2

It is not imperative that all engineering controls will be effective. The effectiveness of engineering controls relies on a number of factors which have been outlined as follows:-

- The selection of engineering control options for a specific hazard is very important factor for the effectiveness of engineering controls in occupational safety and health. Consider a workplace with significant chemical agents present but a local exhaust ventilation (LEV) system has been purchased which has very low capacity. The required suction rate should have been 100 m^3/min but the selected LEV has the capacity of only 25 m^3/min. So the capacity of engineering controls is an important factor in their effectiveness. In simple words, engineering controls should be suitable and sufficient for specific hazards.
- The second aspect in selection of engineering controls is their use in a specific work environment. For example, a proximity sensor may have limitations due to the type of environment. A sensor may not work well in a chemical or corrosive environment so engineering controls should be selected for correct rating so that they may be used with effective output in a specific type of environment.
- Engineering equipments installed and commissioned as engineering controls against certain hazards will require maintenance after a certain period of time. Engineering controls may not serve their intended function if not maintained as per the manufacturer recommendations and/or requirements as per the workplace environment. The engineering controls will remain effective only if they are properly maintained. Certain monitoring and detection sensors and equipment as part of engineering control may also require calibration after specific period. If the calibration is not carried out, the results from sensors or other such equipments will be dubious and engineering control effectiveness will be compromised.
- Another factor in engineering control is their fool proofing or tamper proofing. The employees have tendency to bypass engineering controls to expedite the productions. They may alter the engineering controls if the provision may allow. The effectiveness of engineering controls will thus be compromised if the workers can alter or change the way the engineering controls have been installed. A simple example is a fixed guard installed on the machine. The worker may prefer to uninstall the guard to avoid wastage of time in frequent installations due to requirements of

maintenance in a machine.

- Engineering controls should be robust for the type of environment in which they are being used and the competency and risk perception of the people who will be beneficiary of the engineering controls. An unintentional change in the engineering control by the worker of accidental damage to the engineering controls can compromise the effectiveness of the engineering controls. For example, a damaged fixed guard may collide with moving parts of the machinery and create more hazards for the workers etc.
- Engineering controls may fail due to the failure of some part or equipment i.e. material failure. We have discussed in preceding elements about the material failure reasons. If any such failure occurs, the engineering controls will not work for the intended function.
- Any modifications and alterations in the engineering controls without suitable authorizations and testing may also lead to ineffectiveness of engineering controls. Some engineering controls have provisions for expansions while others do not. It should be ensured that the modification or alteration in engineering control should only be carried out by competent professionals and the authorization should be taken from the designers.

Question 11 - The management has decided to deploy redundant engineering control for the subject process. An additional "Pressure Release Valve" will be installed in parallel so if one fails, the other will take over. If the reliability of existing valve is 93% and for additional valve, its 97% then what will be the combined availability of the system during next one year? **10 Marks**

Reference
Page: 187, Unit 2

The combined availability in a parallel system will be
Availability= 1-(1- Availability of component A)^2

Component	Availability	Downtime/Year
A (existing)	93 %	25.55 Days per year
2 Components operating in parallel	=1-(1-0.93)^2 = 0.9951 = 99.51 %	= (99.51/100)*365 = 363.21 (availability) = 365 - 363.21 = 1.8 Days ~ 2 days during next year

Workplace Situation/Scenario

A local theme park "Joy City" has installed a range of joy rides including a roller coaster. The company carries out frequent inspections (mostly visual inspections) using its own staff to ascertain the integrity of the structures and its components. The company also has a 3rd party annual inspection contract with a renowned inspection body who certifies them against the given criteria. During a routine daily pre-use inspection, one of the workers accidently found 2 large bolts supposedly disengaged from the roller coaster and reported to you (safety manager). The matter was discussed with the management who were alarmedto foresee the potential impact on public safety and the business, had it not been timely reported.

Question 12 - What do you think are the issues with the existing inspection scope, method or criteria?

10 Marks

Reference:

Unit 2; Page 81; 2.5 Mechanical structures and their Inspection and evaluation

From an HSE practitioner' perspective, there are certain things to be ensured to maintain the integrity of the mechanical structure for its implications on occupational safety and health which may be compromised if not complied with.

It takes years of experience to visually inspect a structure and reach to a conclusion that the structure is safe for operation; so, 100% guaranty cannot be given because the visual inspection too has certain limitations.

The visual inspection is used to identify:

- Any obvious deflection of change in structure position etc.
- Any missing components of the structure
- Any loose components of the structures
- Erosion and corrosion in the structure parts and components
- Any cracks initiation

The designers mostly include a checklist for visual inspection and provide criteria for acceptance and rejection. For example, in certain mechanical structures, a dent or crack of 5mm may be allowed at some part but in the same structure within any other part, a dent or crack of 2 mm may not be allowed and require the maintenance staff to carry out the maintenance job as per the design requirements.

The designs of mechanical structure make use of safety factor. For example, a structure is required to withstand a load of 3 ton; the designer keeps a safety margin of 2 or more i.e. the design will be made to withstand a load of 6 ton (safety factor 2) or 9 ton (Safety factor 3) to incorporate any environmental or other adverse conditions. However, the maximum load limit will still be 3 ton even if the safety factor is 3.

For safety critical structures e.g. a roller coaster and industrial cranes etc. only visual inspection is not sufficient. The parts of such structures undergo various non destructive testing (NDT) methods to ensure that there are no internal cracks with the parts of the structures which may lead to deformation or collapse of structure.

The NDT method, frequency of inspection and criteria for inspection is provided by the designers.

Question 13 - Which different inspection methods can be used to ascertain the structures integrity without dismantling them? **10 Marks**

Reference

Unit 2; page 90; Non-destructive test methods

End of Question Paper