SECTION 2

HEALTH AND SAFETY

ENGINEERING PRACTICE

Health and Safety in Engineering Practice

Introduction

Engineering accidents, also known as industrial accidents or technological accidents, are incidents that occur due to failures or errors in the design, operation, maintenance, or management of engineering systems and processes. Accidents in engineering practice can have far-reaching consequences, ranging from devastating injuries and loss of life, to significant financial and reputational damages. The causes of these accidents often involve a combination of human, organisational, and technical factors. Safety is everyone's responsibility. Whether you are a hobbyist or a professional, it is crucial to prioritise safety in any workshop setting to prevent accidents, injuries, and potential hazards. In this section, you will learn about the importance of workshop safety, the potential hazards associated with tools and machinery, and the responsibility of individuals to prioritise their safety and the safety of others in the workshop environment. The lessons in this section will equip you to demonstrate general competence in the *use of both hand* and *power tools* while following proper health and safety protocols. As a learner, always remember that safety is paramount when using tools. Ensure you follow the specific guidelines and instructions provided by the tool manufacturer, along with adhering to local safety regulations.

At the end of this section, you should be able to:

- List accidents that occur in engineering practice.
- Identify the causes of accidents in engineering practice and explain their effects.
- Explain the health and safety protocols associated with basic workshop tools and machinery.
- Demonstrate the use of both hand and power tools according to proper health and safety protocols.

Key Ideas

- Every engineering practice is governed by procedures and protocols that are crucial to preventing accidents. Failure to observe or follow such procedures or protocols may lead to engineering accidents.
- Different engineering accidents may be due to different causes or failures and may have different consequences.
- **Health** is a complex aspect of well-being that encompasses physical, mental, emotional, and social dimensions. In engineering, considerations for health often revolve around ensuring the safety and well-being of individuals, communities, and the environment.
- **Safety** is paramount in any engineering endeavour, encompassing the protection of human life, property, and the environment.
- Both power and hand tools should be handled with the utmost care, and proper techniques must be ensured to maintain control and stability.

ACCIDENTS THAT OCCUR IN ENGINEERING PRACTICE

Engineering accidents, as already stated in the introduction, is also known as industrial accidents or technological accidents, are incidents that occur due to failures or errors in the design, operation, maintenance, or management of engineering systems and processes.

The following are some examples of accidents that can happen in engineering practice

1. **Structural Failures:** Structural failures occur when a component, system, or entire structure does not perform as intended and collapses or becomes compromised. These failures can have severe consequences, including loss of life, property damage, and disruption of services. Collapse of buildings, bridges, dams, or other structures can be due to design flaws, inadequate construction, or unforeseen loads.

Fig. 2.1: A picture of a structural failure

2. **Electrical Accidents:** Electrical accidents can result in serious injuries, fatalities, and property damage. They occur due to several factors, including electrical faults, improper installation, equipment malfunctions, and human error. Electrical accidents may be electrical fires, electrocutions, or equipment malfunctions resulting from faulty wiring, inadequate grounding, or human error.

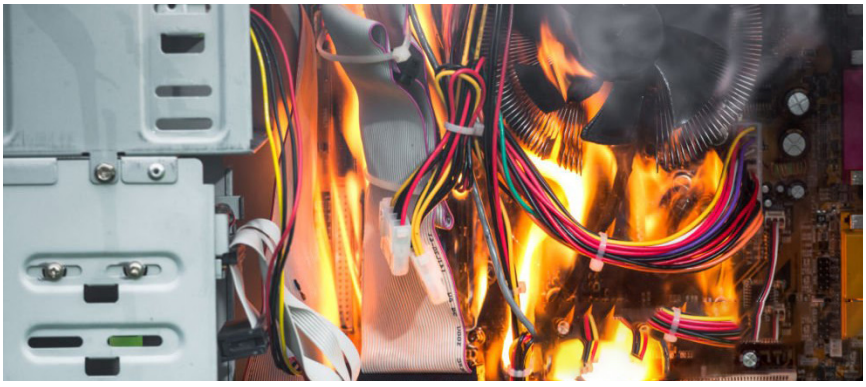


Fig. 2.3: A picture of an electrical accident

3. **Industrial Accidents:** Industrial accidents refer to incidents that occur within industrial settings such as factories, manufacturing plants, construction sites, or other industrial facilities. These accidents can result in injuries, fatalities, property damage, environmental pollution, and disruptions to operations. Accidents in manufacturing plants, chemical plants, refineries, or factories can lead to fire outbreaks, explosions, or toxic releases.

Fig. 2.2: A picture of an industrial accident

4. **Mechanical Failures:** Mechanical failures occur when components, systems, or machinery do not perform as intended, leading to malfunctions, breakdowns, or catastrophic events. These failures can result from several factors, including design flaws, material defects, manufacturing errors, inadequate maintenance, and unexpected operating conditions. Mechanical failures may be malfunctioning machinery or equipment that leads to injuries, such as in factories, construction sites, or transportation vehicles.

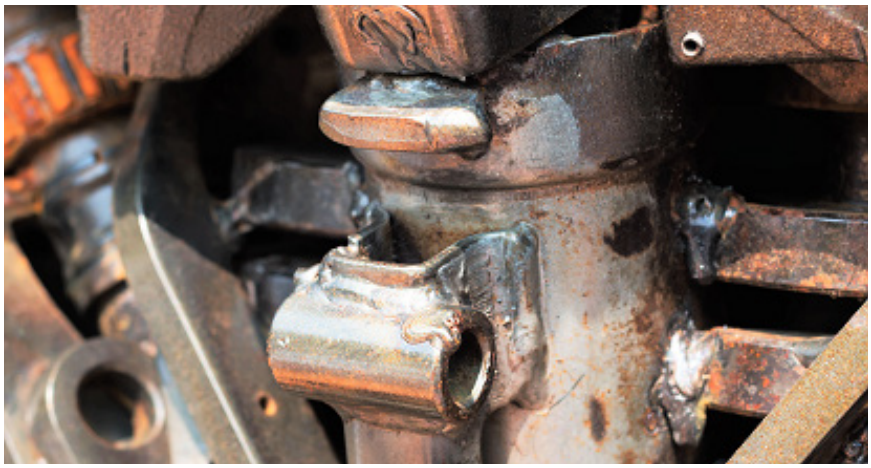


Fig. 2.4: A picture of a mechanical failure of a machine

5. **Pipeline explosions:** Pipeline explosions are catastrophic events that can result in significant loss of life, property damage, environmental pollution, and economic disruption. These incidents occur when there is a sudden release of flammable or combustible substances from a pipeline, leading to ignition and explosion. These accidents involve gas or oil pipelines due to corrosion, inadequate maintenance, or external factors like digging.

Fig. 2.5: A picture of a pipeline explosion

6. **Aviation Accidents:** Aviation accidents refer to incidents involving aircraft that result in damage, injury, or loss of life. These accidents can occur during various phases of flight, including take-off, cruise, and landing, and may involve commercial airlines, general aviation aircraft, helicopters, or military aircraft. They may be plane crashes or incidents involving aircraft due to mechanical failure, pilot error, or adverse weather conditions.

Fig. 2.6: A picture of an aircraft involved in an accident

7. **Maritime Accidents:** Maritime accidents encompass incidents that occur in or on bodies of water, including oceans, seas, rivers, and lakes, involving vessels such as ships, boats, ferries, and offshore platforms. These accidents can result in various consequences, including vessel damage, environmental pollution, injury, loss of life, and economic impact. They may be shipwrecks, collisions, or capsizing of vessels due to navigation errors, equipment failures, or storms.

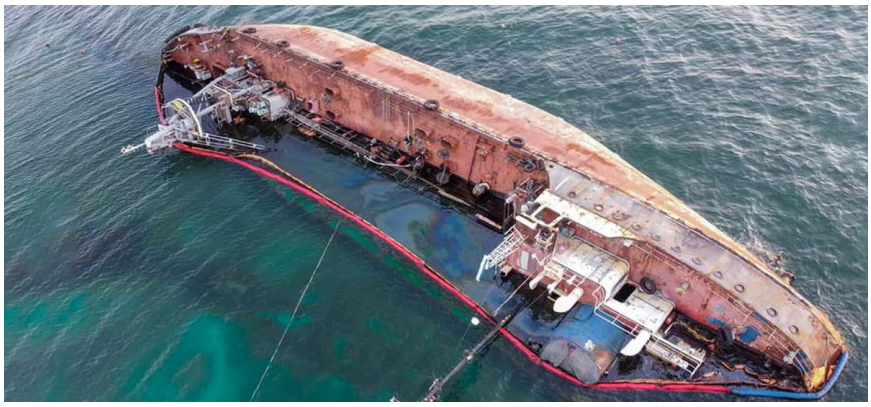


Fig. 2.7: A picture of a capsizing vessel

8. **Train Derailments:** Train derailments refer to incidents in which one or more rail vehicles leave the tracks, resulting in disruptions to railway operations, property damage, injuries, and sometimes fatalities. Derailments can occur for several reasons, including track defects, equipment failures, human error, adverse weather conditions, or external factors. These accidents involve trains derailing due to track defects, signal failures, or human mistakes.

Fig. 2.8: A picture of a train derailing

9. **Mining Accidents:** Mining accidents refer to incidents that occur in the mining industry, involving workers, equipment, infrastructure, or the environment. These accidents can result in injuries, fatalities, property damage, and environmental harm. Mining operations are inherently hazardous due to the nature of the work, the use of heavy machinery, confined spaces, and exposure to geological and environmental risks. These incidents in mines related to cave-ins, explosions, or gas leaks are often caused by safety violations or inadequate procedures.

Fig. 2.9: A picture of a mining accident

10. **Construction Site Accidents:** Construction site accidents refer to incidents that occur during the construction, renovation, or demolition of buildings, structures, roads, or infrastructure projects. These accidents can result in injuries, fatalities, property damage, and project delays. Construction sites are inherently hazardous environments due to the presence of heavy machinery, equipment, elevated work areas, and various construction materials. They may be falls, collapses, or equipment-related incidents at construction sites due to poor safety practices or negligence.

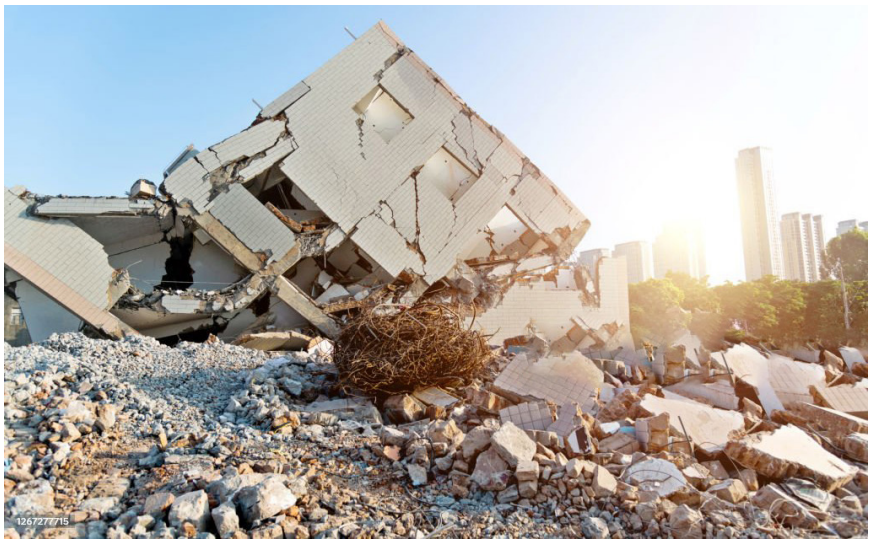


Fig. 2.10: A picture of a collapsed building

11. **Nuclear Accidents:** Nuclear accidents involve incidents that occur at nuclear power plants, research reactors, nuclear fuel processing facilities, or during the transportation of radioactive materials. These accidents can result in radioactive releases, equipment failures, radiation exposure, environmental contamination, and public health risks. These disasters at nuclear power plants result from reactor failures, coolant leaks, or natural disasters.

Fig. 2.11: A picture of a nuclear accident

12. **Oil Rig Accidents:** Oil rig accidents, also known as offshore accidents, refer to incidents that occur on offshore drilling platforms or rigs used for oil and gas exploration and production. These accidents can result in injuries, fatalities, environmental damage, equipment failure, and disruptions to oil and gas operations. They may be explosions, fires, or oil spills on offshore drilling platforms due to equipment failures or human errors.

Fig. 2.12: A picture of an oil rig accident

13. **Chemical Accidents:** Chemical accidents refer to incidents involving the release, spill, leak, or mishandling of hazardous chemicals or substances, leading to adverse effects on human health, the environment, property, or infrastructure. These accidents can occur in various settings, including industrial facilities, storage tanks, transportation networks, laboratories, and manufacturing processes. These accidental releases or leaks of hazardous chemicals in laboratories, plants, or storage facilities.

Fig. 2.13: A picture of a chemical accident

14. **Transportation Accidents:** Transportation accidents encompass incidents involving various modes of transportation, including road vehicles, railways, aviation, maritime vessels, and public transit systems. These accidents can result in injuries, fatalities, property damage, and disruptions to transportation networks. These accidents involve automobiles, buses, or trains due to mechanical failures, human error, or adverse weather conditions.

Fig. 2.14: A picture of automobiles involved in an accident

15. **Environmental Accidents:** Environmental accidents refer to incidents that result in harm to the environment, including pollution of air, water, soil, or ecosystems. These accidents can occur in various industries and activities, such as industrial operations, transportation, agriculture, and energy production, and can have significant ecological, social, and economic impacts. These accidents result in environmental damage, such as oil spills, toxic waste releases, or chemical contamination.

Fig. 2.15: A picture of an environmental accident

Application of Engineering Knowledge in the Aftermath of Engineering Accidents

1. **Root Cause Analysis:** Root Cause Analysis (RCA) is a systematic process used to identify the underlying causes or factors contributing to an incident, problem, or undesirable outcome. It aims to determine the fundamental reasons why an event occurred rather than just addressing its symptoms. It involves digging deeper beyond the immediate causes to uncover the root or systemic factors that contributed to the occurrence. Root Cause Analysis is important because it helps organisations understand why incidents happen and how they can be prevented in the future. By addressing root causes, organisations can implement more effective corrective and preventive measures to improve safety, quality, and performance. Engineers are skilled at conducting root cause analysis, which involves examining all the contributing factors that led to the accident.

2. **Risk Assessment:** Risk assessment is a systematic process used to identify, evaluate, and prioritise potential risks or hazards associated with activities, processes, products, or projects. It involves assessing both the probability of occurrence and the severity of consequences associated with specific risks. Engineers are also skilled at conducting risk assessments, in which they determine the source of risk, their probability of occurrence, their severity levels, etc., and use such information to prioritise addressing the risks based on the likelihood, impact, and urgency.

3. **Failure Analysis:** Failure analysis is the process of investigating and identifying the root cause or causes of a failure or malfunction. It involves examining the physical, chemical, mechanical, or environmental factors that contributed to the failure to determine why it occurred. Failure analysis is important because it helps organisations understand why failures occur and how they can be prevented in the future. By identifying the root causes of failures, organisations can implement corrective actions and preventive measures to improve product quality, reliability, and safety. Engineers use their knowledge of materials, structural integrity, and

system behaviour to analyse the failed components or systems involved in the accident.

4. **Computer Simulations and Modelling:** Engineers use computer simulations and modelling tools to recreate the accident scenario virtually. By inputting the known parameters and variables, they can test different scenarios and assess the possible outcomes.
5. **Lessons Learnt and Best Practices:** Engineers contribute to compiling a report detailing the findings of the accident investigation. They identify the lessons learnt and suggest best practices to avoid similar accidents in the future.
6. **Safety and Risk Assessments:** Safety and risk assessments are crucial processes used in various fields to identify potential hazards, evaluate associated risks, and implement measures to mitigate or eliminate those risks. Engineers play a critical role in performing safety and risk assessments for existing and modern designs.
7. **Design Improvements:** Based on the findings of the accident investigation, engineers work on redesigning components, systems, or processes to eliminate the identified weaknesses.
8. **Regulatory Compliance:** Regulatory compliance refers to the process of ensuring that an organisation adheres to the laws, regulations, guidelines, and standards relevant to its industry and operations. Engineers work closely with regulatory bodies to ensure that their designs and solutions comply with safety standards and regulations.
9. **Training and Education:** Training typically focuses on acquiring specific engineering skills or competencies related to a particular job or task, while education encompasses a broader range of learning experiences aimed at developing critical thinking, problem-solving abilities, and conceptual understanding in each engineering area. Training and education are important because they enable individuals to acquire the knowledge, skills, and competencies needed to perform effectively in their roles, pursue career advancement opportunities, adapt to changing job requirements, and contribute to organisational success. Engineers play a vital role in educating and training other engineers, technicians, and personnel involved in the industry.

Causes of Accidents in Engineering Practice and Their Effects

Accidents in engineering practice can have far-reaching consequences, ranging from devastating injuries and loss of life to significant financial and reputational damages. The causes of these accidents often involve a combination of human, organisational, and technical factors.

Common causes of accidents in engineering practice and their effects.

1. Human Error

Human error is one of the leading causes of accidents in engineering. It can result from fatigue, lack of attention, poor training, or even intentional violations of safety protocols. The effects of human error can vary widely, from minor mistakes that cause inconvenience or minor injuries to major incidents that lead to severe damage, injuries, or loss of life.

2. Equipment Malfunction or Failure

Defects, malfunctions, or failures in engineering equipment can lead to accidents. Whether it is a structural failure, electrical malfunction, or mechanical breakdown, the effects can be severe, causing injuries, property damage, and operational disruptions.

3. Inadequate Maintenance

Failure to properly maintain engineering equipment and infrastructure can lead to accidents over time. Regular maintenance is crucial to ensure that systems function as intended and that potential issues are identified and addressed before they escalate into accidents. The effect of inadequate maintenance can result in unexpected failures, safety hazards, and costly repairs.

4. Poor Design

Engineering projects with flawed designs can lead to accidents. These flaws may not be apparent during initial testing or implementation, but they can surface later during operation, causing accidents. Poor design can compromise the safety and efficiency of structures, systems, or processes, leading to potential disasters.

5. Environmental Factors

Environmental factors refer to elements of the natural world that can have an impact on individuals, organisations, communities, and ecosystems. External factors, such as severe weather conditions (e.g., hurricanes, earthquakes, floods) or geological instability, can lead to accidents in engineering projects. These natural events can cause damage to structures, disrupt operations, and put people at risk.

6. Inadequate Risk Assessment

Insufficient or improper risk assessment before starting an engineering project can lead to unforeseen hazards. Engineers must identify and evaluate potential risks to develop appropriate safety measures. Failure to do so can result in accidents that might have been preventable.

7. Lack of safety procedures

If safety protocols in engineering are not enforced properly or are too relaxed, the risk of accidents increases significantly. It's crucial to follow strict safety procedures and guidelines to protect workers, equipment, and the environment from harm.

8. Communication Breakdown

Miscommunication or poor communication between different stakeholders involved in an engineering project can lead to misunderstandings, errors, or overlooked safety concerns. Effective communication is crucial for ensuring that everyone is aware of potential risks and safety measures.

9. External Interference

Accidents can also occur due to interference from external factors, such as third-party activities, accidents in neighbouring areas, or security breaches. These can disrupt operations, damage equipment, and compromise safety measures.

Engineers use their knowledge and skills to carefully investigate accidents, suggest design improvements, assess risks, ensure compliance with regulations, implement maintenance and inspection protocols, utilise simulation and modelling tools, promote ongoing improvement, provide training, and collaborate with various experts. All these efforts help prevent engineering accidents and improve safety in their projects and industries.

How engineers identify the causes of accidents in engineering practice:

1. Structural Failure: A Bridge Collapse

Engineers will conduct a thorough inspection of the collapsed bridge and collect data on the materials used, construction methods, and maintenance history. They may use non-destructive testing techniques like ultrasonic testing or X-rays to evaluate the integrity of critical components. Finite element analysis and computer simulations might be used to understand how external factors such as weather conditions and traffic loads contributed to the failure.

2. Chemical Plant Accidents: A Chemical Release or Explosion

An engineer will analyse the process data leading up to the accident and review the design specifications, operating procedures, and safety systems of the plant. They might recreate the accident scenario using computer simulations or scale models to understand the sequence of events. Detailed chemical analysis can help identify the presence of hazardous substances and their reaction pathways during the accident.

3. Aviation Accidents: An Aeroplane Crash

A team of aerospace engineers will examine the wreckage, flight data recorders (black boxes), and maintenance records of the aircraft. They will recreate the flight path and conditions during the accident using flight simulators and conduct computational fluid dynamics (CFD) analyses to understand the aerodynamic behaviour. Human factors experts will also be involved to investigate potential pilot error or cockpit design issues.

Activity 2.1

1. Select an engineering firm within your community and arrange a visit. During your visit, research at least one accident that has occurred at the firm. Identify the causes of this accident and explore the steps engineers have taken to prevent a similar incident from happening again.

Objectives:

a. Understand how real-world engineering firms handle accidents.
b. Learn about the importance of implementing effective safety protocols.
c. Gain insight into how engineering practices evolve to enhance safety.

Instructions:

a. Choose an engineering firm and contact them to schedule a visit.
b. During your visit, ask about any past accidents and their causes.
c. Investigate the safety measures or changes that have been implemented since the accident.
d. Prepare a report detailing your findings, including the accident's causes and the preventive measures now in place.

2. Observe your school environment for potential engineering-related hazards, such as faulty electrical wiring, uneven structural elements, or equipment malfunctions. After identifying these hazards, create a checklist of safety procedures that could prevent the accidents from happening.

Instructions:

a. Walk around your school premises and observe places where accidents could happen, such as in classrooms, laboratories, etc.
b. Identify at least ten (10) possible types of accidents that could occur (e.g., electrical hazards, equipment failure, among others).
c. For each identified hazard, write down a short description explaining how the accident could happen.
d. Next, for each accident, list at least three (3) safety precautions or procedures that could be taken to prevent the accident (e.g., proper signage, correct use of equipment, etc.).
e. Combine your findings into a checklist that includes the types of accidents, their causes, and the safety measures that can prevent them. Use the table below to guide you to develop the checklist.

Type of Accident	Cause of Accident	Safety Precaution

Activity 2.2

In 2021, a mining tunnel at a large hardrock mining site collapsed, causing the deaths of several workers and significant financial losses. The collapse was traced back to negligence in maintaining the tunnel's structural integrity. Reports revealed that the engineering team and project managers had been aware of the deteriorating condition of the tunnel supports but had failed to take corrective action. Budget constraints and project deadlines were cited as reasons for not addressing the safety issues adequately.

Questions:

1. What specific actions or inactions by the engineering team and project managers contributed to the tunnel collapse?
2. How did the decision-making processes and prioritisation of budget and deadlines over safety contribute to the accident?
3. What are the ethical responsibilities of engineers and project managers when it comes to ensuring safety and addressing known risks in their projects?
4. How should engineers and project managers balance cost and time constraints with the imperative to maintain safety standards?
5. What are the potential legal and ethical consequences for the engineers and project managers involved in this case?
6. What measures should be put in place to ensure accountability and prevent similar incidents in the future?
7. What strategies could have been employed to prevent the negligence that led to the tunnel collapse?
8. How can engineering firms improve their safety protocols and decision-making processes to ensure that safety is not compromised for financial or time-related reasons?
9. Reflect on the impact of ethical considerations on engineering practice. How can engineers ensure they maintain high ethical standards in their work to safeguard public safety and uphold professional integrity?

Activity 2.3

1. Write a short essay on how an organisation's culture can prevent accidents in engineering. Give examples of companies that have strong safety cultures and explain the benefits.

Instructions:

a. Research or reflect on how organisations implement safety practices.
b. Write an essay (200–300 words) on how organisational culture affects accident prevention, including real-life examples.

2. Complete the following tasks to complete this activity

Instructions:

a. Design a poster that highlights key safety measures and risk mitigation strategies relevant to engineering or general safety.

b. Clearly outline why these safety measures are crucial and how they can help prevent accidents. Make sure your poster explains the importance of each measure and its impact on reducing risks.

c. Put your poster in a prominent area of the classroom or school where it is easily visible to your friends and classmates.

d. Invite your friends and classmates to view your poster and provide their feedback. Engage in a discussion about the effectiveness and clarity of the information presented.

e. Examine the posters created by your friends and classmates. Participate in further discussions to share insights and learn from each other's work.

Activity 2.4

In groups of five, read the case study below and answer the questions that follow.

Case Study

Strong Pillar Engineering, a leading construction company, is known for its strict adherence to safety protocols and a strong organisational culture focused on accident prevention. They have completed several large-scale projects with an outstanding safety record. However, during the construction of a new school building, an accident occurred due to a scaffolding collapse. Investigations revealed that one of the site managers had overlooked some minor safety checks in the rush to meet project deadlines.

The accident injured three workers, with one sustaining serious injuries. It was later revealed that the company had not conducted a thorough risk assessment before the work began, and there were gaps in the communication of safety procedures to new workers. Strong Pillar has since reviewed its safety protocols and conducted an extensive retraining programme for its staff. Despite this, the accident raised questions about the role of organisational culture, the ethical responsibilities of engineers and managers, and the importance of regular risk assessments.

Questions:

1. **Organisational Culture and Accident Prevention**

a. Based on the case of Strong Pillar Engineering, explain how the company's strong safety culture may have helped prevent accidents in the past. What role does organisational culture play in maintaining safety standards in engineering?

b. Research and give examples of companies known for their strong safety cultures and explain how this has benefited them.

2. **Risk Assessment and Accident Prevention**

   a. Discuss how conducting a thorough risk assessment before the project began could have prevented the scaffolding collapse. What specific hazards might have been identified, and what mitigation strategies could have been implemented?

   b. Write a short report on how risk assessments can reduce potential hazards and improve safety in engineering projects.

3. **Ethical Implications of Accidents Due to Negligence**

   a. Reflect on the ethical responsibilities of the site manager who failed to complete the safety checks. How does negligence in engineering affect not only the workers but also the company's reputation and the community?

   b. Suggest three (3) measures that Strong Pillar Engineering could implement to avoid such incidents in the future, focusing on negligence prevention and ethical practices.

4. **Essay Task**

   Write an essay (300–400 words) discussing how the accident at Strong Pillar Engineering reflects the interconnectedness of organisational culture, risk assessment, and ethical responsibility in accident prevention. Include suggestions on how engineers and project managers can maintain high safety standards to avoid negligence and prevent future accidents.

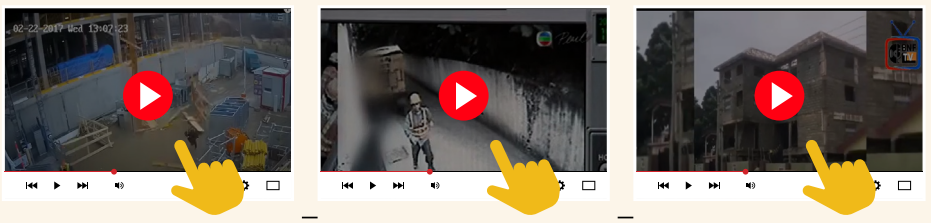
   NB: Submit the essay to your class teacher.

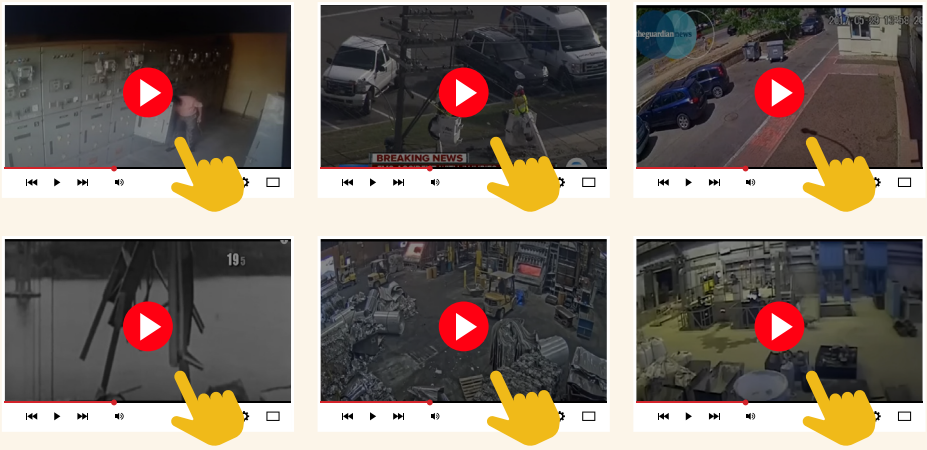
5. **Presentation**

   Summarise the essay and responses into key points for a brief digital or manual presentation to share with the class for review.

Activity 2.5

Watch the following videos of major engineering accidents around the world.





After watching, write a summary report of three (3) accidents, the causes, the safety measures that were lacking, and what has been done to prevent similar accidents in the future.

Present your report to your classmates and teacher for review.

THE HEALTH AND SAFETY PROTOCOLS ASSOCIATED WITH BASIC WORKSHOP TOOLS AND MACHINERY

Safety is everyone's responsibility. Whether you are a hobbyist or a professional, it is crucial to prioritise safety in any workshop setting to prevent accidents, injuries, and potential hazards. This learning indicator emphasises the importance of workshop safety, the potential hazards associated with tools and machinery, and the responsibility of individuals to prioritise their safety and the safety of others in the workshop environment.

Below are some essential health and safety protocols associated with basic workshop tools and machinery:

1. **Personal Protective Equipment (PPE)**: Personal Protective Equipment refers to any equipment or clothing worn in the workshop to reduce exposure to hazards that may cause injury or illness. Engineers use diverse PPEs in industries to protect them from physical, chemical, biological, and other occupational hazards. The commonly used PPEs include safety goggles, ear protection, gloves, and closed-toe shoes. Depending on the task, additional equipment such as a dust mask or a face shield may be necessary. PPEs for a protective barrier between the body of the engineer and the potential hazards in the environment.

Fig. 2.16: A picture of a man wearing PPE

2. **Proper Training and Familiarisation:** Proper training and familiarisation must precede the use of all workshop tools or machines. Good practices require that all users have received proper training on the safe operation of each tool and piece of machinery to ensure workplace safety. One should never operate a tool or machine without the requisite training and familiarisation. Some basic training necessary includes safety protocols, emergency preparedness, and procedures.
3. **Work Area Safety:** Work area safety comprises the range of measures and practices necessary to ensure a safe and healthy working environment for employees. For instance, the workshop must be kept clean and organised to minimise hazards and prevent tripping or slipping accidents. Ensure adequate lighting to see the work area and the tool controls.
4. **Machine Inspection and Maintenance:** Machine inspection and maintenance are critical processes for ensuring the safe and efficient operation of machinery, equipment, and industrial systems. Regular inspections and maintenance activities help identify potential issues, prevent breakdowns, and extend the lifespan of machinery. Regularly inspect tools and machinery for any damage or malfunction before use. Follow the manufacturer's maintenance schedule and guidelines to ensure proper functioning.
5. **Safe Handling and Operation:** Read and follow the instruction manuals and safety guidelines provided by the manufacturer for each tool. Always use the appropriate tool for the task at hand. Do not use a tool or machine for a purpose it is not intended for.

6. **Electrical Safety:** Electrical safety refers to the practices, protocols, and measures implemented to prevent electrical hazards and minimise the risk of electric shock, fires, and other accidents associated with the use of electricity. Keep cords and cables away from sharp edges or moving parts to prevent damage. Check cords for wear and tear, and never use damaged cords.
7. **Guarding and Safety Features:** Guarding and safety features are essential components of machinery and equipment designed to protect workers from hazards, prevent accidents, and ensure a safe working environment. These features encompass various physical barriers, devices, and systems that mitigate risks associated with moving parts, electrical hazards, and other potential dangers. Ensure all safety guards and features on the machinery are in place and functional. Do not bypass or disable safety mechanisms.
8. **Tool Maintenance and Sharpness:** Tool maintenance and sharpness are crucial for ensuring the effectiveness, safety, and longevity of hand tools, power tools, and cutting implements. Proper maintenance practices help keep tools in optimal condition, reducing the risk of accidents, improving performance, and prolonging their lifespan. Keep cutting tools sharp and well-maintained to prevent accidents caused by using dull tools.
9. **Handling Materials Safely:** Handling materials safely is essential to prevent accidents, injuries, and damage in various settings, including workplaces, construction sites, warehouses, and manufacturing facilities. Use clamps or other appropriate methods to secure the workpiece during cutting or shaping operations. Avoid hand-feeding materials into moving machinery.
10. **Fire safety** encompasses measures and protocols designed to prevent fires, minimise the risk of fire-related hazards, and protect lives and property in the event of a fire. Keep a fire extinguisher and a first aid kit readily available in the workshop. Know the location of emergency shut-off switches for machinery. Install smoke detectors, heat detectors, and fire alarm systems in the workshop to detect signs of fire and alert occupants promptly.
11. **Proper body positioning:** Proper body positioning is essential for maintaining comfort, safety, and efficiency during various activities, including work tasks, sports, and everyday movements. Stand and position yourself correctly to maintain balance and stability while using tools and machinery.
12. **No Horseplay:** Horseplay refers to rough, boisterous, or playful behaviour often exhibited by individuals engaging in various activities. While horseplay can be seen as harmless fun, it can sometimes lead to accidents, injuries, or property damage if not properly supervised or controlled. Strictly enforce a no-horseplay policy in the workshop to prevent distractions and potential accidents.

Fig. 2.17: No Horseplay Signs

13. **Emergency Procedures**: Emergency procedures are predefined plans and protocols designed to guide individuals and organisations in responding to several types of emergencies effectively and safely. These procedures outline steps to follow in different emergency scenarios to minimise harm, protect lives and property, and facilitate a coordinated response. Know the workshop's emergency procedures, including how to shut off power and what to do in case of an accident or injury.
14. **Chemical Safety:** Chemical safety encompasses practices and protocols designed to prevent harm from exposure to hazardous chemicals in various settings, including workplaces, laboratories, and homes. Store and handle hazardous chemicals properly in designated areas, following safety data sheets and guidelines.
15. **Supervision:** Supervision involves overseeing, guiding, and supporting individuals to help them perform tasks effectively, adhere to rules and regulations, and achieve desired outcomes. Ensure that novice or inexperienced individuals are supervised when using workshop tools and machinery.

By strictly adhering to these health and safety protocols, the risk of accidents and injuries in a workshop setting can be significantly reduced, creating a safer working environment for all.

Some Machines Have Safety Protocols

1. **Machine Guarding:** Machine guarding refers to measures put in place to protect workers from hazards posed by machinery and equipment in the workplace. These guards are physical barriers or devices designed to prevent contact with moving parts, flying debris, electrical hazards, and other dangerous elements of machinery. Engineers design and implement machine guarding systems to prevent operators from coming into direct contact with hazardous moving parts of machinery.
2. **Safety Interlocks:** Safety interlocks are devices or mechanisms used to ensure the safe operation of machinery and equipment by preventing or interrupting hazardous conditions. These interlocks are designed to automatically stop or prevent machine operation when specific conditions are not met, or a hazard is detected. Engineers often incorporate safety interlock systems into workshop tools and machinery. These systems ensure that certain safety conditions are met before the machine can operate.

3. **Emergency Stop Systems:** Emergency stop (E-stop) systems are safety mechanisms designed to halt machinery or equipment operations quickly and effectively in emergencies to prevent accidents, injuries, or damage. These systems provide a rapid means of shutting down machinery in case of unforeseen hazards or emergencies. Engineers equip workshop machinery with emergency stop systems to immediately halt operations in the case of an emergency.
4. **Lockout-tagout:** Lockout-tagout (LOTO) is a safety procedure to ensure that machinery and equipment are properly shut off and cannot be started until maintenance or servicing work is completed. Engineers equip workshop machinery with Lockout-tagout.

Some Common Hazards Associated with Tools and Machinery

Tools and machinery are essential in various industries and everyday tasks, but they come with inherent risks. Understanding these common hazards is crucial for ensuring safety and preventing accidents. By recognising potential dangers and implementing appropriate safety measures, we can minimise risks and maintain a safe working environment.

1. **Mechanical Hazards**
    - **Moving Parts:** Rotating, reciprocating, or otherwise moving parts of machinery can cause entanglement, crushing, or shearing injuries if individuals encounter them.
    - **Pinch Points:** Machinery with parts that come together or move in proximity can pinch or trap body parts, causing injuries.
    - **Cutting, shearing, or sharpening:** Cutting tools, blades, or saws can cause lacerations, amputations, or other severe injuries if mishandled or operated without proper guards.
2. **Electrical Hazards**
    - **Electrical Shock:** Contact with live electrical components, faulty wiring, or damaged cords can result in electric shock, burns, or electrocution.
    - **Arc Flash:** Short circuits or electrical faults can generate intense heat and light, causing arc flashes that can result in severe burns or eye injuries.
3. **Chemical Hazards**
    - **Exposure to Hazardous Substances:** Chemicals, solvents, lubricants, or cleaning agents used in machinery maintenance or operations can pose risks of skin irritation, burns, respiratory issues, or long-term health effects if improperly handled.
    - **Chemical reactions:** Mixing incompatible chemicals or using incorrect cleaning agents can lead to chemical reactions, spills, or releases that may cause fires, explosions, or toxic exposures.

4. **Noise and Vibration Hazards**
    - **High Noise Levels:** Operation of machinery or power tools can generate excessive noise levels, leading to hearing loss or impairment if individuals are not adequately protected with hearing protection.
    - **Whole-Body Vibration:** Prolonged exposure to machinery vibrations, such as those from heavy equipment or power tools, can cause musculoskeletal disorders, circulation problems, or other health issues.
5. **Fall Hazards**
    - **Working at Heights:** Using ladders, scaffolds, or elevated platforms to access machinery or perform tasks can pose risks of falls, resulting in injuries or fatalities if proper fall protection measures are not in place.
    - **Slips, Trips, and Falls:** Wet or slippery surfaces, cluttered work areas, or uneven flooring near machinery can increase the risk of slips, trips, and falls, leading to injuries.
6. **Fire and Explosion Hazards**
    - **Ignition Sources:** Machinery or tools that generate heat, sparks, or friction can serve as ignition sources in the presence of flammable materials or combustible atmospheres, leading to fires or explosions.
    - **Combustible Dust:** Operations involving cutting, grinding, or processing of materials can produce combustible dust that, when dispersed in the air, can ignite and explode if exposed to ignition sources.
7. **Crushing and Striking Hazards**
    - **Falling Objects:** Tools, equipment, or materials stored at heights can fall and strike individuals below, causing head injuries, fractures, or fatalities.
    - **Equipment Overturns or Collapses:** Heavy machinery or equipment tipping over or collapsing can crush or strike nearby workers, resulting in severe injuries or fatalities.

The Use of Both Hand and Power Tools According to Proper Health and Safety Protocols

Under this topic, we will explore the use of both hand and power tools while adhering to proper health and safety protocols. Remember, safety is paramount when working with tools, so always refer to the specific guidelines and instructions provided by the tool manufacturer and your local safety regulations.

Power tools are electric or pneumatic devices used to perform various tasks in construction, woodworking, metalworking, and other industries. These tools are powered by electricity, batteries, or compressed air, and they offer efficiency, precision, and versatility in completing tasks that would otherwise be time-consuming or difficult to accomplish manually. They include power saws, drills, grinders, and more.

Hand tools are manual devices powered by human effort, used for various tasks in construction, woodworking, automotive repair, maintenance, repairs, and do-it-yourself (DIY) projects. These tools are versatile, portable, and typically do not require electricity. They include screwdrivers, spanners, hammers, wrenches, pliers, chisels, and more.

Fig. 2.18: Power tools

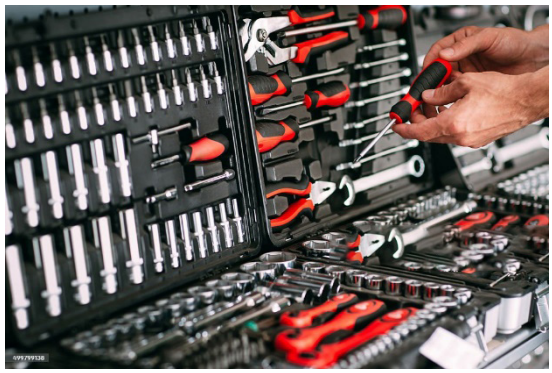


Fig. 2.19: Hand tools

Scenario: Using a hand drill and a power saw

1. Hand Drill:

Step 1: Safety gear and workspace setup

- Put on appropriate personal protective equipment (PPE) such as safety glasses, hearing protection, a safety boot, overalls, and gloves.
- Choose a well-ventilated and well-lit workspace.

Step 2: Secure the Workpiece

- Clamp the workpiece securely to a stable surface, such as a working table, to prevent movement while drilling.

Step 3: Inspect the Hand Drill

- Ensure the drill is in good condition, with no frayed cords or damaged parts.
- Check that the chuck is securely holding the drill bit.

Step 4: Drill Bit Selection

- Choose the appropriate drill bit size for the task.
- Insert the drill bit into the drill and secure it properly.

Step 5: Drilling

- Hold the drill with a firm grip, keeping your hands away from the rotating parts.
- Align the drill bit with the desired hole location.
- Apply gentle pressure and start the drill at a low speed.
- Gradually increase the speed while maintaining control.

Fig. 2.20: A picture of a hand drill

2. Power Saw (Circular Saw)

Step 1: Safety gear and workspace setup

- Wear safety glasses, hearing protection, gloves, a safety boot, overalls, and a dust mask.
- Set up your workspace with adequate lighting and ventilation.

Step 2: Secure the Workpiece

- Place the workpiece on a stable surface, such as a working table, and secure it with clamps if needed.

Step 3: Inspect the Circular Saw

- Ensure the saw's blade is in good condition and properly tightened.
- Check that the safety guard moves smoothly.

Step 4: Saw Blade Selection

- Choose a blade appropriate for the material you are cutting.
- Insert the blade into the saw and secure it properly.

Step 5: Cutting

- Hold the saw with both hands, one on the handle and one on the auxiliary handle.
- Start the saw away from the workpiece, then gently bring it into contact with the material.
- Allow the blade to reach full speed before cutting.
- Maintain a steady pace and avoid forcing the saw.

Fig. 2.21: A picture of an engineer using a power saw

General Safety Tips

When working with tools and machinery, adhering to general safety tips is essential to prevent accidents and ensure a safe working environment. These guidelines cover fundamental practices and precautions that help minimise risks and protect both yourself and those around you. Thus, the general safety tips are:

1. Always read the user manual for each tool before use.
2. Always wear your personal protective equipment (PPE) before using any tool.
3. Keep your workspace clean and organised to prevent tripping hazards.
4. Ensure the workpiece is securely clamped or stabilised before operating the tool to prevent the workpiece from moving unexpectedly during use.
5. Disconnect power tools when changing accessories or adjusting.
6. Keep bystanders away from your work area.
7. Never wear loose clothing or jewellery that might get caught in the tools.
8. If you are working for an extended period, take regular breaks to prevent fatigue and maintain focus.
9. After use, store the tools properly in a dry, secure location, away from unauthorised users.

Note: If you are unsure how to use a tool safely, seek guidance from a knowledgeable person or take a training course.

Activity 2.6

1. In groups of five, read, analyse every aspect of the case study below and answer the questions that follow. Note that the questions fall under the following subheadings identification of factors, root-cause analysis, preventive measures, and long-term strategies.

Case Study

Background

John, a 35-year-old construction worker, was using an electric circular saw to cut wooden planks on a construction site. During the operation, the saw suddenly kicked back, causing severe lacerations to John's hand. The injury required immediate medical attention and led to John being unable to work for several weeks.

Incident Details

- **Date and Time**: The accident occurred on a sunny afternoon.
- **Work Environment**: The construction site was busy, with multiple activities happening simultaneously.
- **Tool Involved**: An electric circular saw, which had recently been used by several workers without reported issues.
- **Worker's Condition**: John had been working for six hours with a short break and was visibly tired.
- **Safety Measures**: The site had safety protocols in place, including personal protective equipment (PPE) requirements and tool safety checks. However, the enforcement and adherence to these protocols were inconsistent.
- **Training**: John had undergone basic training for using power tools but had not received recent refresher training.

Contributing Factors

- **Tool Condition**: The saw was inspected after the accident and found to have a dull blade, increasing the likelihood of kickbacks.
- **Work Environment**: The site was cluttered, and there was limited space for safe operation of the saw.
- **Worker Fatigue**: John was fatigued from extended work hours without adequate breaks.
- **Safety Protocol Adherence**: Although safety protocols existed, they were not strictly enforced, and workers often neglected PPE.
- **Training and supervision**: Lack of recent training and insufficient supervision on the use of power tools.

Questions for Analysis

a. Identification of factors

i. What immediate factors contributed to the accident?
ii. How did the condition of the tool influence the incident?
iii. What role did the work environment play in the accident?
iv. How did worker fatigue contribute to the accident?
v. How might inconsistent enforcement of safety protocols have influenced the incident?

b. Root Cause Analysis

i. What underlying issues can be identified from this accident (e.g., tool maintenance, training, supervision)?
ii. How does the culture of safety at the construction site impact worker behaviour and accident rates?
iii. Were there any warning signs that were ignored or missed prior to the accident?

c. Preventive Measures

i. What measures could have been taken to ensure the circular saw was in proper working condition?
ii. How can the work environment be modified to enhance safety when using power tools?
iii. What steps should be taken to address worker fatigue and ensure adequate rest breaks?
iv. How can adherence to safety protocols be improved among workers?
v. What additional training or refresher courses should be implemented for workers using power tools?

d. Long-term Strategies

i. How can the organisation foster a culture of safety and accountability?
ii. What regular maintenance and inspection procedures should be implemented for power tools?
iii. How can communication about safety concerns and incidents be improved on-site?
iv. What role should supervisors play in ensuring tool safety and worker compliance with protocols?

e. Compile all your answers or responses into a digital or manual presentation and present them to your class for constructive feedback.

Activity 2.7

1. Write a short report on the importance of maintaining tools in good working condition. Include examples of maintenance tasks that should be performed regularly on both hand and power tools, such as cleaning, oiling, and inspecting for damage.

Instructions:

a. Research the types of maintenance tasks needed for hand and power tools.

b. Write a report (150–200 words) explaining why keeping tools well-maintained is crucial for safety and efficiency.

c. Include specific examples of tasks such as sharpening blades, tightening screws, and cleaning tool surfaces.

4. Perform the following tasks to complete this activity.

NB: Answer the questions that follow in your notebooks. Submit your proposal to your class teacher.

Tasks:

a. Look at a sample safety design for a workspace, such as a workshop or factory. Review how the design incorporates safety measures.

b. Assess the effectiveness of the safety features included in the design, such as tool guards, emergency stops, and clear safety signage.

c. Write a proposal: Based on your evaluation, propose improvements or additions to the safety design to enhance worker safety.

Questions:

a. What are the key safety features included in the sample design?

b. How effective are these features in preventing accidents and ensuring safety?

c. What additional safety measures would you recommend?

Activity 2.8

Investigate personal protective equipment (PPE), analyse a workplace safety design, and draft a section of a safety manual for your school workshop. Focus on how PPE and safety design work together to prevent accidents and ensure a safe working environment.

Instructions:

a. **Personal Protective Equipment (PPE):**

   i. Research different types of PPE (e.g., safety goggles, gloves, ear protection) and explain how each piece protects the user.

   ii. Create a poster illustrating the various types of PPE, with brief explanations of why each is necessary.

b. **Workplace Safety Design:**

   i. Examine the layout of a workshop or workspace, identifying safety features such as clear walkways, proper ventilation, and safety barriers.

   ii. Write a short description (100–150 words) explaining how these safety features prevent accidents and ensure an organised, hazard-free environment.—

c. **Safety Manual Preparation:**

   i. Using the knowledge gained from the PPE research and safety design analysis, draft a section of a safety manual for your school workshop.

   ii. Focus on guidelines for tool maintenance, PPE usage, and safe workspace layout. Ensure the manual includes clear instructions (200–250 words) that can be easily followed by all users of the workshop.

Activity 2.9

1. Create a poster listing different types of PPE needed when using hand and power tools. Explain why each piece of PPE is necessary and how it protects the user.

Instructions:

a. Research various types of PPE (e.g., safety goggles, gloves, ear protection).

b. Design a poster with images and descriptions of each type of PPE.

c. Display the poster on your classroom wall for the class to review.

d. Write a brief explanation (50–100 words) for why each item is important for safety.

2. Perform the following tasks to complete the activity and answer the questions in your jotters or notebooks.

Tasks

a. Prepare a draft safety manual for a workshop or engineering workspace. Include sections on tool use, PPE, emergency procedures, and maintenance protocols.
b. Include Safety Protocols: Ensure that your manual outlines clear safety protocols and guidelines to follow when using tools and machinery.
c. Review and Revise: Have your draft reviewed by peers or instructors. Make any necessary revisions based on feedback.

Questions:

a. What essential information should be included in a safety manual?
b. How can a well-prepared safety manual contribute to accident prevention?

Review Questions

1. How do you understand an engineering accident?
2. Explain any four engineering accidents.
3. Environmental accidents have become a major issue in Ghana and require immediate action. What are some examples of these environmental accidents?
4. How does human error contribute to accidents?
5. How can risk assessment help prevent accidents?
6. After an accident occurs, how do engineers apply their knowledge to assess the aftermath and prevent similar incidents in the future?
7. A student enters the workshop and notices a petrol spill on the floor. What safety procedures should the student follow to ensure the spill is cleaned up without causing harm to themselves or others in the workshop?
8. You are given a piece of wood to cut in two. Which tool would you use and why: a power saw or a hand drill?

Extended Reading

- Kemper, J. D., and Sanders, B.R. (2001), "*Engineers and Their Profession,"* Oxford University Press.
- Spellman, F. R. (2018), Safety Engineering: Principles and Practices. United States: Bernan Press.

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Acknowledgements

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