This document outlines key aspects of health, safety, and environment management across several chapters, focusing on process equipment operations, emergency response, human factors in safety, accident investigation, and environmental protection. **CHAPTER 5: START-UP AND SHUTDOWN OF PROCESS EQUIPMENT** This chapter focuses on the safe start-up and shutdown of process equipment, which is designed for specific, single purposes such as storage, reactions, flow control, steam production, and heat exchange, commonly found in refineries, chemical plants, and heavy industries. While most safety concerns are addressed during the design phase and through various equipment mountings, and issues like toxicity, reactivity, corrosion, hazmat threats, fire, and explosions were covered previously, this chapter specifically addresses operational safety during start-up and shutdown. A pre-startup safety review is crucial for new or modified equipment. **5.2 START-UP OPERATIONS OF PROCESS EQUIPMENT** General start-up procedures for equipment like boilers, pressure vessels, storage tanks, and heat exchangers include: * Powering on components such as burners, pilots, preheaters, compressors, and cooling towers, as applicable. * Verifying all valves (flow, pressure, direction control) are properly seated. * Checking the functionality of safety mountings. * Slowly charging the system to reach rated operating parameters (e.g., pressure, temperature). * Ensuring smooth operation of all automatic controls. For boilers specifically, start-up involves: * Powering the burner, proving pilot and main flames. * Confirming the boiler vent and drain between main stop valve(s) and non-return valve are open. * Opening the equalizing valve around main steam-stop valves, if installed. * Opening the main steam-stop valve. **5.3 SHUT-DOWN OPERATIONS OF PROCESS EQUIPMENT** Proper shutdown is vital to prevent damage and breakdowns. Abrupt closures or drainage of equipment operating at elevated temperatures and pressures can cause distortion, affect dimensional stability, and lead to crack formations due to residual heat. This is particularly true for fractional distillation columns, boilers, furnaces, and heat exchangers. A safe shutdown process is crucial for equipment durability and preventing future failures, though there isn't a singular universal method as it varies by function and design. General sequential shutdown operations include: * Gradually reducing temperature to ambient conditions. * Closing the fuel supply after operating parameters are lowered. * Shutting down accessories that enhance process efficiencies first. * Shutting down feed systems. * Avoiding hot drainage, as it can cause warpage, distortions, and leaks in internal parts like tubes and shells. For boilers, shutdown involves: * Shutting off fuel to the burner. * Opening the superheater outlet drain valve, if equipped. * Closing the main steam stop valve(s) and opening all drains. * Shutting down the boiler feed system. **SUMMARY (Chapter 5)** Ultimately, start-up and shutdown processes must follow manufacturer guidelines and prevailing standards to ensure safe, reliable, and efficient operation, maintenance, and repairs. Developing checklists for these operations is recommended. **PRACTICAL ACTIVITIES AND TASKS FOR STUDENTS (Chapter 5)** Students are asked to research and present information on process equipment start-up and shutdown. **ASSESSMENTS (Chapter 5)** Quizzes, short tests, and reports on topics like start-up/shutdown operations and OSHA standards. Exercises include multiple-choice questions on process equipment examples, pre-startup reviews, and theoretical questions on pre-startup safety reviews and boiler start-up operations. --- **CHAPTER 6: FIRST AID AND HANDLING EMERGENCIES** This chapter

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emphasizes the importance of correct actions during industrial emergencies for safety, particularly in hazardous industries like petroleum, chemical, and manufacturing. It covers emergency procedures, first aid, and laboratory/workshop safety. **6.2 EMERGENCY PREPAREDNESS AND RESPONSE** Emergencies pose various hazards. Employers and contractors must understand appropriate responses to ensure safety. Preparedness and response strategies depend on the type of emergency. **6.3 WORKPLACE EMERGENCY** A workplace emergency is an unforeseen situation threatening workers, employees, contractors, the public, and other stakeholders, stemming from controllable or uncontrollable causes such as accidents, fire, toxic gas leaks, chemical spills, explosions, radiological incidents, floods, hurricanes, or earthquakes. Preparedness and response actions include: * Training for worst-case scenarios. * Developing an emergency action plan. * Alerting employees about emergencies. * Creating an evacuation plan and routes. * Defining roles for safety wardens and coordinators. A detailed emergency action plan should specify: * Methods for reporting fires or accidents. * Emergency escape routes and procedures, including floor plans and refuge areas. * Names and contact details of coordinators, wardens, and emergency contacts. * Assignment of special duties for shutdown, emergency response, and fire extinguisher operation. * Medical duties and designated rescue workers. * Types of alternative communications. * Assembly points and public announcement systems. Thorough, continuous training is essential for effective emergency preparedness and response. **6.4 FIRST AID** Health and safety managers typically oversee first aid processes and plant nurses. A well-trained, qualified, and experienced first aid person must always be available. First aid is immediate assistance given to an injured or ill person before specialized medical care, aiming to prevent worsening conditions, preserve life, and promote recovery. Different first aid procedures for various situations: **6.4.1 UNCONSCIOUS/UNRESPONSIVE** The ABC principle is adopted: * **Airway:** Clear the person's airway (e.g., vomit, fluid) while in the recovery position. * **Breathing:** If no response after clearing the airway, provide rescue breathing. * **Circulation:** If not breathing, perform chest compressions to aid circulation. **CARDIAC ARREST** Perform Cardiopulmonary Resuscitation (CPR) or use an Automated External Defibrillator (AED), which can be operated by untrained individuals. **BURNS** First aid varies by burn type: * **First-Degree Burn:** Minor, affecting outer skin (epidermis), causing redness and swelling. * **Second-Degree Burn:** Major, causing redness, swelling, and blistering; more painful and severe if large or on critical areas; affects the dermis. * **Third-Degree Burn:** Severe, life-threatening, affecting deeper skin layers (hypodermis), appearing blackened or white with numbness. Initial action for any burn is to stop the burning process (e.g., clean chemical burns, cut off electricity for electrical burns). For first- and second-degree burns: * Cool the area with running water for an extended period. * Apply ointment for minor burns. * Apply a light gauze bandage. * Do not break blisters. For major burns, seek emergency medical attention. Ibuprofen or acetaminophen can be used for pain relief as advised by a plant nurse. For third-degree burns: * Do not apply ointment. * Do not soak with water. * Do not remove burned clothing stuck to the area. **BROKEN BONES OR FRACTURE** All hand and foot injuries are treated as fractures until X-ray confirmation. Medical assistance is needed, but not always an emergency rush. First aid: * Use a splint to immobilize the part. * Do not attempt to straighten the bone. * Apply a cold pack. * Do not move the person if a spinal injury is suspected. * Transport to a hospital.

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NOSE BLEEDS Caused by factors like nose picking, dry air, forceful nose blowing, high blood pressure, chemical fumes, or high altitudes. First aid: * Lean forward. * Pinch the nose just below the bridge; repeat if bleeding doesn't stop. * Apply a cold pack to the bridge of the nostrils. * Seek medical assistance if bleeding persists. **BLEEDING** Bleeding can occur from capillaries (trickling, stops quickly), veins (dark red, consistent flow), or arteries (bright red, sprouts, significant blood loss). All types of bleeding can be stopped. First aid: * Wash hands and wear gloves to prevent contagious disease transmission. * Rinse the wound with water. * Cover the area with gauze or clean cloth. * Apply direct pressure for profuse bleeding. * Elevate the bleeding part above heart level. * If the cloth is soaked, place another cloth over it; do not remove the original. * Apply a bandage if bleeding stops; otherwise, seek medical assistance. **SPRAIN** Symptoms are similar to a fracture until X-ray confirmed; involves ligament injury (e.g., ankles, wrists). Causes severe pain with movement and inability to bear weight. Not a serious injury; apply cold packs and seek medical assistance. **WASP/BEE STINGS** Painful and potentially dangerous for those allergic to venom. First aid: * Quickly remove the stinger. * Wash the area with soap, water, and disinfectants. * Apply ice or a cold pack. * Plant nurse should administer medication for allergic individuals. **CHOKING** Throat blockage by food or particles can lead to unconsciousness or death. Perform the Heimlich maneuver: * Stand behind the person, make them lean forward. * Wrap arms around their waist. * Clench one fist between the rib cage and navel (for right-handed persons). * Grab the clenched fist with the other hand. * Push the clenched fist backward and upward under the rib cage in five quick thrusts, repeating until the object is expelled, before medical assistance arrives. **6.4.2 SAFETY IN LABORATORIES AND WORKSHOPS** Safety is ensured by following instructions from teachers, supervisors, and technicians. Students must prioritize safety and maintain high discipline, obeying rules even unsupervised. * Observe signals and visual instructions on campus, including parking areas. * Wear mandated PPE (e.g., safety shoes, lab coat, coveralls, gloves, aprons) in labs and workshops. * Never operate untrained machinery. * In chemistry labs, observe labels and Material Safety Data Sheets (MSDS). * In electrical workshops, follow electrical safety instructions. * Wash hands thoroughly after work, before contact with others, and before eating. * Be aware that grease containing lead is carcinogenic. * Maintain correct posture in computer labs. * Drink plenty of water during outdoor tasks in summer to prevent sunstroke. * Participate seriously in mock safety drills to understand evacuation processes. **SUMMARY (Chapter 6)** Providing immediate first aid is critical for injured persons before advanced medical care. First aid equipment must be well-maintained, and a responsible first aid person must always be available, ensuring coverage during their absence. OSHA standard 29 CFR 1910.151(b) governs general industry first aid methods. **PRACTICAL ACTIVITIES AND TASKS FOR STUDENTS (Chapter 6)** Students should receive practical first aid training, write reports on emergency situations, benefit from professionals from industries/hospitals, and gather information on local industry emergency response and first aid. **ASSESSMENTS (Chapter 6)** Quizzes, short tests, and reports on emergency preparedness, first aid, and OSHA standards. --- **CHAPTER 7: HUMAN ERROR AND BEHAVIOURAL SAFETY** This chapter explores how human factors influence health and safety excellence, emphasizing the need for continuous improvement and avoiding complacency. Human factors significantly impact industrial

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performance and the social characteristics of work groups. **7.2 HUMAN ERROR AND BEHAVIOURAL SAFETY** As per H.W. Heinrich's Domino theory, 88% of workplace accidents result from unsafe acts, which stem from human error and behavior. **7.2.1 UNDERSTANDING HUMAN FAILURE** Human failure is categorized into two main types: 1. **Violations:** Deliberate wrong actions. 2. **Human Error:** Unintended actions or decisions, not deliberate violations. Human errors are further classified: * **Skill-based errors:** Occur even with trained, experienced workers. * **Slips:** Not performing an intended action correctly (e.g., omitting steps, working too fast/slow, incorrect task direction, PPE omission, noting wrong dial value). They occur with familiar tasks due to thoughtlessness, completion fatigue, or interruptions. Prevention methods include checklists, sequential layouts, phone bans, and engineering controls like barcode readers. * **Lapses:** Forgetting to perform an action (e.g., forgetting to wear a mask after talking, switching off equipment, turning off a stove). * **Mistakes:** Failures in decision-making, where incorrect actions are taken based on a belief that they are right. These can be: * **Rule-based mistakes:** Applying the wrong rule or misinterpreting a rule (e.g., wrong overtaking, entering a road on the wrong side). Often happen under time pressure or while multi-tasking, influenced by environmental, social, or individual stress, and equipment problems. Prevented by situational awareness (e.g., rumble strips). * **Knowledge-based mistakes:** Errors arising from insufficient knowledge or understanding. Prevented by effective supervision and instructions. **Violations** are deliberate wrong actions (e.g., not wearing seat belts/harnesses, allowing untrained drivers, working without goggles, succumbing to peer pressure, ignoring perceived "strict" rules). They cause many accidents and can be controlled through routine monitoring, supervision, convincing workers of rule importance, creating conducive environments, continuous training, and encouraging problem reporting. **7.3 BEHAVIOURAL SAFETY** Behavioral safety aims to prevent unconscious unsafe behaviors developed through habit. Inappropriate behavior contributes significantly to accidents, influenced by attitudes and observations. Safety managers must define safe/unsafe behavior and provide feedback. Managers and peers play a vital role in reinforcing safe behavior. Behavioral safety training can employ various approaches: * Systematic and continuous improvement. * Observations and data collection. * Worker participation. * Focus on specific unsafe behaviors. * Feedback focused on performance. * Involvement of data-driven decision making. Key considerations for behavioral safety include: * Acting only when truly necessary. * Developing support networks. * Taking ownership of the work system. * Listening to employers and peers. * Piloting processes and only rolling out fully secure and confident systems. * Not underestimating safety instructions and plans. * Performing tasks correctly to develop good habits. **SUMMARY (Chapter 7)** A positive safety culture is built on healthy communication, strong senior management commitment, high training standards, good working conditions, and a stress-free environment. Behavioral safety offers advantages like reduced accidents, enhanced quality, faster task completion, improved efficiency, better employer-employee relations, stronger teamwork, increased employee engagement, and commitment. However, it requires significant time, additional resources, and dedicated effort and commitment from senior management. **PRACTICAL ACTIVITIES AND TASKS FOR STUDENTS (Chapter 7)** Students analyze behavioral safety case studies and develop improvement plans based on learned concepts. **7.4 ASSESSMENTS (Chapter 7)** Quizzes, short

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tests, and reports on case studies and behavioral safety approaches. Exercises include multiple-choice questions on challenges in health and safety, examples of rule-based mistakes and violations, and theoretical questions on behavioral safety training approaches and descriptions of slips and lapses. --- **CHAPTER 8: ACCIDENT INVESTIGATIONS, REPORTING AND RISK ASSESSMENT** This chapter covers the essential processes of reporting, tracking, and investigating accidents and incidents to prevent future occurrences. Accident reports are valuable input for ongoing safety training. Risk assessment is introduced as a method for identifying potential hazards and analyzing their consequences, with the risk assessment observation sheet being an effective management tool. **8.2 ACCIDENT/INCIDENT REPORTING** An **accident** is an unintentional event leading to damage, injury, fatality, or a combination. An **incident** is an unintentional event that *may not* result in damage, injury, or fatality. Reporting and recording work-related accidents causing death, serious injuries, industrial diseases, and dangerous occurrences is compulsory. Legally, any accident causing a worker to be absent from work for at least three days must be reported. OSHA standards 1960.29 and 1904.39 cover reporting, while 1960.70 and 1904.7 cover record keeping. Main aspects for reporting include: * Identifiable work-related accidents causing injury. * The injury type falling into a reportable category. * Type of death, if involved. * Type of injury sustained. * Injuries to non-workers. * Reportable occupational hazards. * How work was organized. * Who supervised the work. * Machinery or equipment used. * Condition of the accident site. * Other relevant findings. The "5W&H" rule (What, Why, When, How, Where, and Who) provides an easy reporting guideline. A sample reporting and investigation form is typically included in an appendix. **8.3 RISK ASSESSMENT** Understanding risk assessment requires defining: * **Hazard:** An act, source, or situation potentially leading to injury, ill health, death, property damage, or a combination (e.g., heavy noise in spinning mills). * **Risk:** The combination of an event's probability and the severity of its harmful consequences. Quantified as probability multiplied by severity. * **Chance:** A measure of the likelihood of an accident. * **Severity:** A measure of the seriousness of injury from an accident. * **Control Measures:** Steps taken to eliminate or reduce hazards and risks. Risk assessment follows three main steps: 1. **Identify hazards:** Categorize as physical, chemical, health, or human factors. * Example: Heavy noise in spinning mills. 2. **Assess risks:** Classify risks (low, medium, high) based on likelihood, seriousness, and worker exposure frequency. * Example: High health risk for an operator, medium risk for a manager. 3. **Apply control measures:** * Aim to eliminate the hazard. If not possible, explore alternate methods or apply precautions to reduce risk effects. * Example: Provide earmuffs for the worker and earplugs for the manager entering the area. **8.4 RISK ASSESSMENT MATRIX** A risk assessment matrix, or risk matrix, evaluates the probability and severity of an expected action. It's a valuable tool for prioritizing actions and attention levels within an industry. A sample matrix typically visualizes these relationships. **8.5 RISK ASSESSMENT OBSERVATION SHEET** This sheet is used to assess and measure risk based on its impact, probability, and severity. A sample sheet is usually provided in an appendix. **8.6 ACCIDENT, FREQUENCY AND SEVERITY RATE** These rates are calculated as follows: * **Accident Rate = (Total numbers of lost time injury / Average number of employees) x 1000** * **Frequency Rate = (Total numbers of lost time injury / Man-hours worked) x 1,000,000** * **Severity Rate = (Total man-

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days lost / Man-hours worked) x 1,000,000** * **Incident Rate = (Total man-days lost / Number of incidents reported)** Examples illustrate these calculations: * Example 1: For 200 employees, 8 hours/day, 26 days/month, 2 LTI: Total man-hours = 41600. Accident Rate = 10 per thousand. Frequency Rate = 48 per million. * Example 2: 75 man-days lost over a year, 15 reported incidents: Incident Rate = 5 (meaning 5 man-days lost per reported incident). * Example 3: 50 man-days lost, 500,000 man-hours worked: Severity Rate = 100 (meaning 100 man-days lost per 1,000,000 man-hours worked). **8.6 OTHER RISK ANALYSIS TECHNIQUES** Quantitative risk assessment techniques for familiarity include: * **HAZOP Analysis (Hazard and Operability Analysis):** Assesses equipment hazards and vulnerabilities. * **Job Hazard Analysis (JHA):** Identifies hazards in specific jobs or tasks by studying the task, worker, tools, and environment to eliminate threats. * **Event Tree Analysis (ETA):** Analyzes processes and events leading to likely accidents. * **Fault Tree Analysis (FTA):** A systematic tool for examining and finding hazardous areas for mitigation and prevention. **SUMMARY (Chapter 8)** Safety risk assessment is a methodical procedure for identifying, assessing, and preventing hazards through control measures. It involves a detailed examination of processes, equipment, and the work environment to support safety management. **PRACTICAL ACTIVITIES AND TASKS FOR STUDENTS (Chapter 8)** Students are asked to create accident reports using a provided appendix as a reference. **ASSESSMENTS (Chapter 8)** Quizzes, short tests, reports on risk assessment, and calculations of accident rate, frequency, and severity. Exercises include multiple-choice questions on hazard, chance, types of analysis, and theoretical questions explaining risk assessment steps and differentiating JHA and FTA. --- **CHAPTER 9: ENVIRONMENTAL SAFETY AND INDUSTRIAL EFFLUENTS** This chapter focuses on environmental safety as a comprehensive policy ensuring an environment free from hazards, thereby promoting the well-being of employees, the public, and flora and fauna, by preventing harmful releases. HSE managers are responsible not only for employee safety but also for compliance with environmental regulations and standards. **9.7 RESPONSIBILITIES OF HSE MANAGER** The HSE manager's key environmental safety responsibilities include: * Assessing operational risks. * Conducting job hazard analysis. * Investigating incidents. * Ensuring industrial hygiene. * Ensuring environmental safety compliance. * Conducting safety observations via worksite walkthroughs. * Controlling hazardous materials (Hazmat). * Appointing safety committees. * Providing HSE training. * Collecting data on leading and lagging indicators. * Guiding the industry toward environmental safety qualifications like ISO 14000. **9.8 OMANI STANDARDS FOR ENVIRONMENTAL PROTECTION** Oman has various laws and Sultani decrees governing environmental safety: * Omani law on conservation of the environment and prevention of pollution (MD 5/86). * Omani law on protection of potable water sources from pollution. * Sultani decree 114/01 on habitat protection through an environmental permit system, requiring MOECA certification for construction. * Regulations for solid waste management (MD 17/93) and hazardous waste (MD 18/93). * MD 15/2021 regarding specific waste exports. * MD 23/2020 banning single-use plastic bags. * MD 34/1974 controlling marine pollution. **9.9 INDUSTRIAL EFFLUENT TREATMENT** Rapid industrial growth leads to significant waste generation, harming air quality (gases, smoke particulates), and causing soil, aqua, and marine pollution from solid wastes and mixed pollutants. **Effluent Treatment

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Plant (ETP)** Environmental rules mandate ETPs for industries to prevent pollutant discharge into water bodies. ETPs are compulsory for sectors like food processing, dairy, textile, paper, and pharmaceuticals. Gas flaring in petroleum, petrochemical, and refinery industries is a major environmental pollutant. ETPs typically comprise storage, equalization, neutralization tanks, primary clarifiers, anaerobic reactors, aeration tanks, final clarifiers, sludge pumps, and sludge drying pumps. The basic ETP processes are depicted in a flow chart. **Table 9.1 Level of effluent Treatment** Different ETP levels and their processes: * **Pretreatment or Preliminary Treatment:** A physical process removing large solids (rags, grit, grease) using screens and grit chambers. * **Primary Treatment:** A physical and chemical process removing settleable, floating, and suspended solids, achieving up to 70% suspended solids removal and 30% Biological Oxygen Demand (BOD) reduction. Sludge from the primary clarifier is pumped out for processing. * **Secondary Treatment:** A biological and chemical process removing biodegradable organic matter (85% removed) through aerobic processes. * **Tertiary Treatment or Advanced Treatment:** Physical, chemical, and biological processes removing residual suspended and dissolved solids, improving water quality through methods like chlorine, ozone, or UV light to remove microorganisms. **Working of Effluent Treatment Plant** 1. **Wastewater Influent & Preliminary Treatment:** Raw wastewater enters, undergoes screening and grit removal to eliminate large solids. 2. **Primary Clarifier (Primary Treatment):** Heavier suspended solids settle as "primary sludge," and lighter materials like oil/grease are skimmed off. Partially clarified water moves to the next stage. 3. **Aeration Tank (Secondary Treatment – Activated Sludge Process):** Air is injected to promote "activated sludge" (microorganisms) growth, which consumes organic matter, biologically cleaning the water. 4. **Secondary Clarifier (Secondary Treatment):** The mixture from the aeration tank separates; activated sludge settles, leaving clearer treated water. * **Recycle Activated Sludge:** Part of the settled sludge is returned to the aeration tank to maintain microbial population. * **Waste Activated Sludge:** Excess sludge is removed for further treatment and disposal. 5. **Disinfection (Tertiary Treatment):** Treated water is disinfected (e.g., chlorine, UV light) to kill remaining microorganisms before discharge or reuse. 6. **Final Effluent:** Disinfected water is released into the environment or reused (e.g., irrigation). 7. **Sludge Treatment and Disposal:** Primary and waste activated sludge are processed (thickening, digestion, dewatering) to reduce volume and stabilize for safe disposal or beneficial reuse (e.g., fertilizer, biogas). A flow chart illustrates the entire process. **9.10 ISO 14000** ISO 14000 is a quality standard that guides industries in reducing their adverse environmental effects. It provides a framework for improving operations and environmental consciousness within quality management systems. **9.11 SUMMARY (Chapter 9)** ETPs purify wastewater for reuse and prevent environmental harm by removing contaminants like oil, grease, toxic materials, and pollutants, ensuring safe discharge. ETP design and construction depend on effluent quality, wastewater quantity, land availability, and local regulations. HSE managers are responsible for industrial safety, accident prevention, and environmental safety, all crucial for sustainable development. **9.12 PRACTICAL ACTIVITIES AND TASKS FOR STUDENTS (Chapter 9)** Students may visit industrial sites to observe safety and ETPs firsthand and write reports. **9.13 ASSESSMENTS (Chapter 9)** Quizzes, short tests, .and reports based on industrial visits

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