

# **Advanced Troubleshooting Guide**

## **Health Safety Environment**



**DEMHA CONSULTANTS**

*The Professional Engineers*



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**Why a guide dedicated to HSE?**

Leading Indicators help identify areas of potential risk, allowing organizations to take proactive measures to prevent incidents from occurring, while lagging indicators provide a retrospective view of safety performance, allowing organizations to identify areas where they need to focus their efforts to improve. Leading indicators include; Safety Training Completion Rates, Safety Audit Compliance Rates. Lagging indicators include; Total Recordable Incident Rate (TRIR), Lost Time Injury Frequency Rate (LTIFR), or Injury Severity Rate.

**How do ISO standards mitigate risks?**

Risk management is the cornerstone of effective compliance. This turns management into a proactive approach and should help to reduce surprises in the business. Thus, it drives sustainability, improvement, profitability, and better stakeholder engagement.

**What's the note taken?**

By tracking both types of KPIs, companies can develop a more effective safety management program and achieve better safety outcomes.

**Case study:** Industries, Commercial and Residential Buildings, Dryports, Warehouses, Petrol stations and yards.

**HSE** needs to be an integrated player in all departments, all employees should understand their own responsibility to safety. This guide will help understand necessary tools and training to develop a pro-active attitude towards HSE and Quality management and later continue to build an HSE culture so that it becomes a second nature to all levels.

**Editor:** Ahmed H. H. Mansoor – Founder, DEMHA Group

## 1.0 Introduction

The HSE Policy aims to ensure alignment to the mission and values, where ‘Dedication to Safety’ means ensuring that harm is not inflicted upon its employees, contractors, service providers, or the environment, assets, as well as members of the public affected by its operations, infrastructure and all operational activities within the scope of heavy lifting, special transport, assembly, disassembly and maintenance in industry and infrastructure.

The management and all employees are committed to well-being and protection of human life, environmental duty of care, protection of assets and customer satisfaction by applying our Plan-Do-Check-Act (PDCA) cycle and our Code of Conduct in all activities. DEMHA has integrated health, safety and environment requirements into all activities; more specifically in the DEMHA Project Management Procedure (DPM) and care for preventive maintenance so that decisions made ensure the consideration of economic development, environmental quality and social equity to continually improve performance and achieve stakeholder requirements.

DEMHA commitment to Health, Safety and Environment management is achieved through:

1. Implementation of an integrated management system in accordance with ISO9001:2015, ISO14001:2015, OHSAS18001:2007 (in transition into ISO 45001:2018) and SCC*P 2017/6.0 (Benelux).
2. Achieving compliance with applicable legislation and other requirements to which DEMHA subscribes and in the absence of these, setting internal standards to meet the intent of this policy.
3. Addressing the needs and expectations of customers and stakeholders.
4. Setting HSE objectives goals and measuring our performance (KPI’s) against these with the objective of continual improvement.
5. Periodical risk-based medical surveillance for all DEMHA employees, to monitor and manage occupational health risks inherently present in the nature of our business.
6. HSE training and safety based behaviour training for all employees.
7. Ensuring that our suppliers and service suppliers meet and adhere to DEMHA HSE requirements.
8. Promoting open communication with all stakeholders and sharing of our HSE knowledge.
9. Real accountability for all our managers and employees in performing and tracking our HSE goals and targets.
10. Design, construction and operation of our services in a safe, secure, efficient and environmentally responsible manner.

In order to put this policy into practice and avoid incidents and accidents, the DEMHA 10 Life Saving Rules (LSR) are developed and implemented. All employees are expected to perform their job in accordance with this company philosophy and follow all applicable procedures and instructions including the Stop & Consult Procedure as a final Last-Minute Risk Assessment (LMRA) before commencement of work. Where necessary, the management will take measures by using our Consequence Management Procedure.

In addition to first using collective protection equipment, all employees have appropriate work wear and Personal Protection Equipment that meets the highest standards in accordance with local legislation. The Management team shows clear responsibility and commitment to verify the effectiveness of our integrated HSE Management system by completing workplace inspections on a regular basis.

## 2.0. Process Safety

### 2.1. Process Safety Management

Process Safety Management, or PSM, is a systematic approach to proactively managing risks associated with hazardous processes. It doesn't rely on reacting to incidents, but instead implements measures like hazard identification, control procedures, training, and incident investigation to prevent them entirely.

It reduces accident risks through proactive hazard identification and controls, safeguarding lives and preventing costly disruptions. Adhering to regulations avoids fines and protects your business, while optimised processes and minimised downtime from incidents boost productivity and profitability. More than that, a strong safety culture built on communication fosters trust and engagement, leading to a happier, more productive workforce.

#### Applications of Process Safety Management

1. Chemical and petrochemical facilities: Managing risks associated with flammable, toxic, or reactive chemicals.
2. Oil and gas refineries and pipelines: Ensuring safe handling and transportation of hydrocarbons.
3. Pharmaceutical and food processing plants: Maintaining hygiene and product safety in complex manufacturing environments.
4. Explosives and fireworks manufacturing: Controlling risks associated with hazardous materials.
5. Any industry involving hazardous materials or processes: Implementing PSM creates a safer, more sustainable future for all.

#### Process Safety Management Standard Code Reference

1. Occupational Safety and Health Administration (OSHA) Process Safety Management Standard (29 CFR 1910.119): Establishes core PSM requirements for hazardous chemical processes in the United States.
2. American Institute of Chemical Engineers (AIChE) Center for Chemical Process Safety (CCPS) Guidelines: Provide best practices for implementing effective PSM programs.
3. International Organisation for Standardisation (ISO) 45001:2018 Occupational Health and Safety Management Systems: Establishes a framework for managing occupational health and safety risks, often integrated with PSM programs.
4. Industry-specific regulations and guidelines: Ensure compliance with additional standards relevant to your specific sector and processes.

#### PSM Involves Different Aspects of Business Operations Including:

1. Designing and building facilities safely.
2. Training employees on safety procedures and equipment maintenance.
3. Identifying hazards in the workplace, such as fire and gases, and developing plans for how to prevent them from happening.
4. Developing emergency response plans for when an accident does occur.

#### Methodology for PSM Services

1. Needs assessment and gap analysis: Analysis of existing safety practices and identify areas for improvement.

2. Development of a customised PSM program: Recreate a program that aligns with specific risks, industry standards, and organisational goals.
3. Implementation and training: A guide through the implementation process, providing comprehensive training for your personnel.
4. Ongoing support and audits: Conduct regular audits to ensure the effectiveness of the PSM program.

PSM Services Deliverables

1. Process safety management audits.
2. Process safety training development and delivery.
3. Process safety management systems design, implementation and maintenance.

**2.2. HAZOP Study**

HAZOP Study (Hazard and Operability Study) is a systematic, collaborative examination of a process system, like a chemical plant or refinery. It uses “guidewords” to imagine deviations from normal operation, then analyzes potential hazards and operability problems arising from these deviations. This proactive approach identifies hidden risks before they become accidents, improving safety, efficiency, and regulatory compliance across diverse industries.

HAZOP Study Focuses on:

1. Identify hazards and opportunities
2. Prioritize hazards for further investigation
3. Determine the severity of each hazard
4. Determine the probability of each hazard occurring
5. Identify measures to reduce or eliminate each hazard

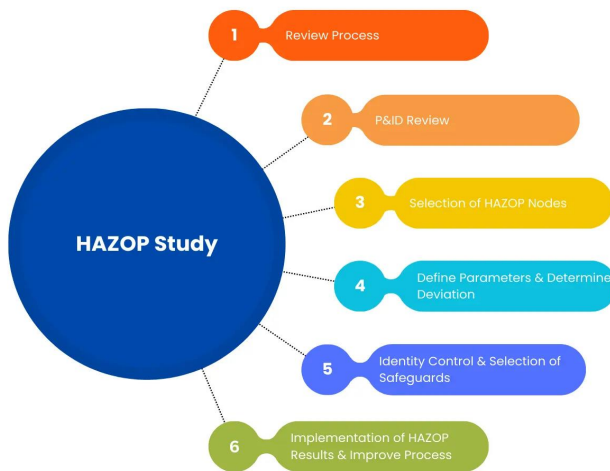


Fig. 2.2. HAZOP Study

Benefits of HAZOP Study

The benefits of HAZOP Study is that the resulting knowledge, obtained by identifying potential hazards and operability problems in a structured and systematic manner, which is of great assistance in determining appropriate remedial measures. While a HAZOP is not appropriate in all circumstances, one of the major benefits that can be used to help justify the cost and time investment is that it also helps to avoid operating problems and can thus provide a clear return on the investment beyond the reduction in hazards.

1. The team approach to a HAZOP makes it a multidisciplinary study.
2. The process covers safety as well as operational aspects.
3. HAZOP Study consider operational procedures.
4. HAZOP Study cover human errors and record results.
5. As a systematic process it provides rigor for focusing on system elements and hazards.

#### Importance of HAZOP Study Across Industries

Across the industrial landscape, chemical, pharmaceutical, oil and gas, nuclear, and mining industries, HAZOP Study stand as the gold standard for proactive risk assessment. This highly structured method meticulously dissects any potential deviation in complex processes, safeguarding not just people, but productivity and profitability. Its relevance and influence span diverse industries, offering a critical lifeline in three key ways:

1. **Early Hazard Detection:** By systematically analyzing deviations, they illuminate hidden threats like equipment malfunctions or process inconsistencies, allowing for early implementation of risk mitigation strategies. This proactive approach translates to fewer accidents, lower costs, and a safer, more secure work environment.
2. **Adapting to Change:** Industrial processes are not static entities. Modifications and upgrades are essential for progress. However, these changes can introduce unforeseen risks. HAZOP studies provide a vital safety net during process modifications, to identify how deviations from the original design intent might pose new threats. This ensures that adaptations are made safely and efficiently.
3. **Aligning Operations with Goals:** HAZOP studies act as a compass, guiding you towards optimized performance. By analyzing how process deviations impact business goals, they reveal inefficiencies and hidden risks that hinder productivity. This insights-driven approach empowers you to make informed decisions, fine-tune your processes, and ensure smooth, profitable operations.
4. **Compliance Assurance:** HAZOP studies offer a helping hand, ensuring your process adheres to relevant safety standards and guidelines. By systematically identifying and addressing potential hazards, you minimize the risk of non-compliance, avoiding costly fines and legal repercussions.

#### Various Types of HAZOP Study Include:

1. HAZOP Study for new processes or modifications to existing processes
2. Incident investigations and root cause analysis
3. Risk assessments for new equipment designs and new technologies

#### HAZOP Study Methodology

1. **Preparation:** Thoroughly review process documentation, P&IDs, and relevant safety regulations to establish a comprehensive understanding of your system.
2. **Node Identification:** Break down your process into key “nodes” where critical events can occur, ensuring no potential hazard slips through the cracks.
3. **Guideword Application:** Using a structured set of “guidewords,” Systematically explore potential deviations from normal operation for each node and analyzing risks.
4. **Consequence Assessment:** Evaluate the severity and likelihood of identified hazards, prioritizing them for appropriate mitigation strategies.
5. **Recommendations and Actions:** Provide clear and actionable recommendations for addressing identified risks, including procedural changes, equipment modifications.
6. **Report and Documentation:** A comprehensive report is prepared, detailing the HAZOP findings, recommendations, and action plan, ensuring transparency and traceability.

### 2.3. Safety Integrity Level

The Safety Integrity Level (SIL) is a quantitative measure of the risk reduction required for a safety instrumented function (SIF) within a hazardous process. It essentially acts as a grading system for safety systems, ranging from SIL 1 (lowest risk reduction) to SIL 4 (highest). By assigning the appropriate SIL level to each SIF based on the potential severity and likelihood of a hazard, we can ensure that the safety systems have the right level of reliability and robustness to effectively prevent or mitigate dangerous situations, promoting a safer operational environment.

#### Importance of Safety Integrity Level (SIL)

For industries like chemical, oil & gas, nuclear, and pharmaceuticals, Safety Integrity Level (SIL) becomes the cornerstone of responsible operational excellence. It's not just a technical requirement, but a proactive approach to:

1. **Safeguard lives and the environment:** By meticulously assessing risks and implementing robust mitigation strategies through appropriate SIL levels, you significantly reduce the likelihood of catastrophic incidents, protecting both personnel and the surrounding communities.
2. **Optimize operational efficiency and resource allocation:** Avoiding accidents minimizes costly downtime, repair expenses, and potential legal consequences, allowing your organization to channel resources towards productivity and growth.
3. **Foster a culture of safety and trust:** A demonstrably safe work environment inspires employee confidence and empowers them to perform at their best, boosting overall productivity and morale.
4. **Demonstrate a commitment to responsible governance:** Adherence to established safety regulations and rigorous SIL assessments showcases your organization's dedication to ethical and accountable operations, attracting investors and strengthening public trust.

#### Key Safety Integrity Level (SIL) Study Standards

1. **IEC 61508:** This international behemoth provides the fundamental framework for achieving functional safety across industries. It outlines principles, requirements, and guidelines for design, implementation, and assessment of safety instrumented systems. It is the blueprint for the entire SIL study symphony.
2. **IEC 61511:** This industry-specific standard focuses on the process sector, including chemical, petrochemical, and other industrial processes. It offers detailed guidance on implementing SILs in these fields, covering hazard assessment, design, operation, maintenance, and testing.
3. **ISA-84 / ANSI/ISA 84.00.01:** Developed by the International Society of Automation, this standard aligns with IEC 61511 but adds a process industry lens. It provides practical guidelines for identifying, designing, implementing, and operating SIS in this sector.
4. **EN 61508-6:** This standard offers specific guidance on applying IEC 61508-2 and IEC 61508-3, focusing on the application of requirements for safety instrumented functions.
5. **ISO/TR 12489:** This technical report acts as a bridge between the world of IEC 61508 and IEC 61511 and the practicalities of industrial process measurement, control, and automation.

#### Integrity Level Methodology

Safety Integrity Level (SIL) studies are fundamental components of risk management for complex industrial systems. These systematic analyses play a vital role in mitigating threats and ensuring operational safety.



1. **Hazard and Risk Assessment:** The cornerstone of any SIL study is a comprehensive hazard and risk assessment. This deep dive identifies potential dangers, analyzes their likelihood and severity, and quantifies the related risks. This forms the solid foundation upon which subsequent steps are built.
2. **Safety Instrumented Function (SIF) Definition:** Based on the risk assessment, specific safety instrumented functions (SIFs) are defined. These critical actions, implemented by safety instrumented systems (SIS), serve as the first line of defense against identified hazards.
3. **SIL Determination:** With a clear understanding of hazards and SIFs, the next crucial step is assigning appropriate SIL levels to each SIF. SIL levels, ranging from 1 to 4, represent the required level of risk reduction for each function. This determination ensures robust mitigation strategies are tailored to the severity of each risk.
4. **Verification and Validation:** Following SIF definition and SIL assignment, a rigorous verification and validation process takes place. This involves systematically evaluating the design, performance, and reliability of the proposed SIFs against the assigned SIL levels. This step guarantees that the planned SIFs can effectively manage their designated risks.
5. **SIS Design and Implementation:** With verified and validated SIFs in place, the design and implementation of the SIS itself commence. This stage involves selecting appropriate sensors, logic solvers, final elements, and redundancy configurations to ensure a failsafe system that meets the required SIL levels.
6. **Verification and Validation (Again!):** Before deployment, a final layer of verification and validation is applied to the entire SIS. This comprehensive testing and analysis ensures the system performs as intended and meets all safety requirements under real-world operational conditions.
7. **Documentation and Reporting:** Every aspect of the SIL study, from initial hazard identification to final system validation, is meticulously documented and reported. This serves as a crucial reference point for ongoing maintenance, future modifications, and regulatory compliance.
8. **Operation and Maintenance:** Ensuring the ongoing effectiveness of the SIS is paramount. Regular monitoring, testing, and maintenance remain integral throughout the system's lifespan. This vigilance guarantees the SIS continues to fulfill its role as a reliable guardian against potential hazards.

#### Key Methods for Assigning Safety Integrity Levels

In Safety Integrity Level (SIL) studies, assigning the appropriate SIL to each safety function is important. This decision dictates the level of risk reduction required, ensuring robust safeguards for your operations. To navigate this process effectively, a toolkit of specialized methods is employed:

1. **Risk Matrices:** These visual tools map the likelihood and severity of potential hazards, providing a clear foundation for SIL assignment.
2. **Risk Graphs:** These graphical representations offer a more nuanced approach, factoring in additional variables like exposure time and probability of failure on demand. They provide a more detailed roadmap for SIL determination, ensuring a comprehensive risk assessment.
3. **Layers of Protection Analysis (LOPA):** This method delves into the effectiveness of existing safety layers, identifying potential gaps and quantifying the required risk reduction. It's like a security audit for your safety systems, revealing areas that need reinforcement.

## 2.4. Quantitative Risk Assessment

Quantitative Risk Assessment (QRA) is a systematic and data-driven approach to measuring the likelihood and consequences of potential hazards. It utilizes scientific and engineering principles to analyze and quantify risks associated with complex systems, processes, or activities. Essentially, it helps in answering the question: How likely is a hazardous event to occur and how bad would it be if it did?

Quantitative Risk Assessment (QRA) is used to demonstrate the risk caused by the activity and to provide the competent authorities with relevant information to enable decisions on the acceptability of risk related to developments on site, or around the establishment.

It aims to reduce the likelihood of negative outcomes by taking into account the probability of adverse events occurring, their severity if they occur, and their potential impact if they do occur. QRA uses probabilistic models to analyze potential threats and vulnerabilities.

Applications of Quantitative Risk Assessment (QRA):

1. Chemical, oil, and gas industries:  
Assessing risks associated with pipelines, refineries, and hazardous materials handling.
2. Nuclear power plants: Evaluating accident scenarios and mitigating safety risks.
3. Infrastructure and transportation: Analyzing risks associated with bridges, tunnels, and transportation systems.
4. Project management: Assessing risks associated with large-scale projects and infrastructure developments.

The process of Quantitative Risk Assessment (QRA) involves three main stages:

Quantitative risk assessment process determines the probability and severity of an event based on historical data, rather than relying on intuition or other subjective factors. It is often used by insurance companies and government agencies to help them determine how likely it is that the insurance policy will pay out in claims.

1. Identifying a action that could potentially lead to an adverse outcome and determining how likely it is that this outcome will occur based on the current state of knowledge about the system or situation.
2. Calculating the probability that this outcome will occur based on available data about past events, ongoing processes, and other factors (e.g., regulatory requirements).
3. Determining which actions need to be taken in order to reduce or eliminate these risks

Quantitative Risk Assessment (QRA) can be broken down into three steps:

1. Determine your exposure to risk
2. Calculate your loss expectancy (LE) and Determine your LE/Exposure Ratio

Requirements of Quantitative Risk Assessment (QRA):

1. To quantify the risks associated with a facility (e.g. Risk Contours, Individual Risk Per Annum (IRPA), Potential Loss of Life (PLL) and F-N Plots)
2. Regulatory Compliance.
3. To have better understanding of the hazards and the measures needed to control them.
4. Analysis of very rare but potentially catastrophic events.
5. Considers thousands of scenarios that involve multiple failures, thus providing an in-depth understanding of system failure modes.
6. Determining the potential frequencies and consequences of the identified hazards.

Quantitative Risk Assessment (QRA) deliverables are:

QRA is a powerful tool for understanding and managing risks in various industries and activities. By providing a quantified picture of potential hazards and their consequences, QRA helps organizations make informed decisions to enhance safety, optimize resources, and improve overall performance.

1. 2D/3D Fire/ Modelling
2. Modelling Vapour Cloud Dispersion
3. Effects of Ignition of Vapour Cloud
4. Toxic Exposure Dispersion
5. Individual Risk Calculation
6. Societal Risk Calculation
7. Preparation of Emergency Response and Disaster Management Plan

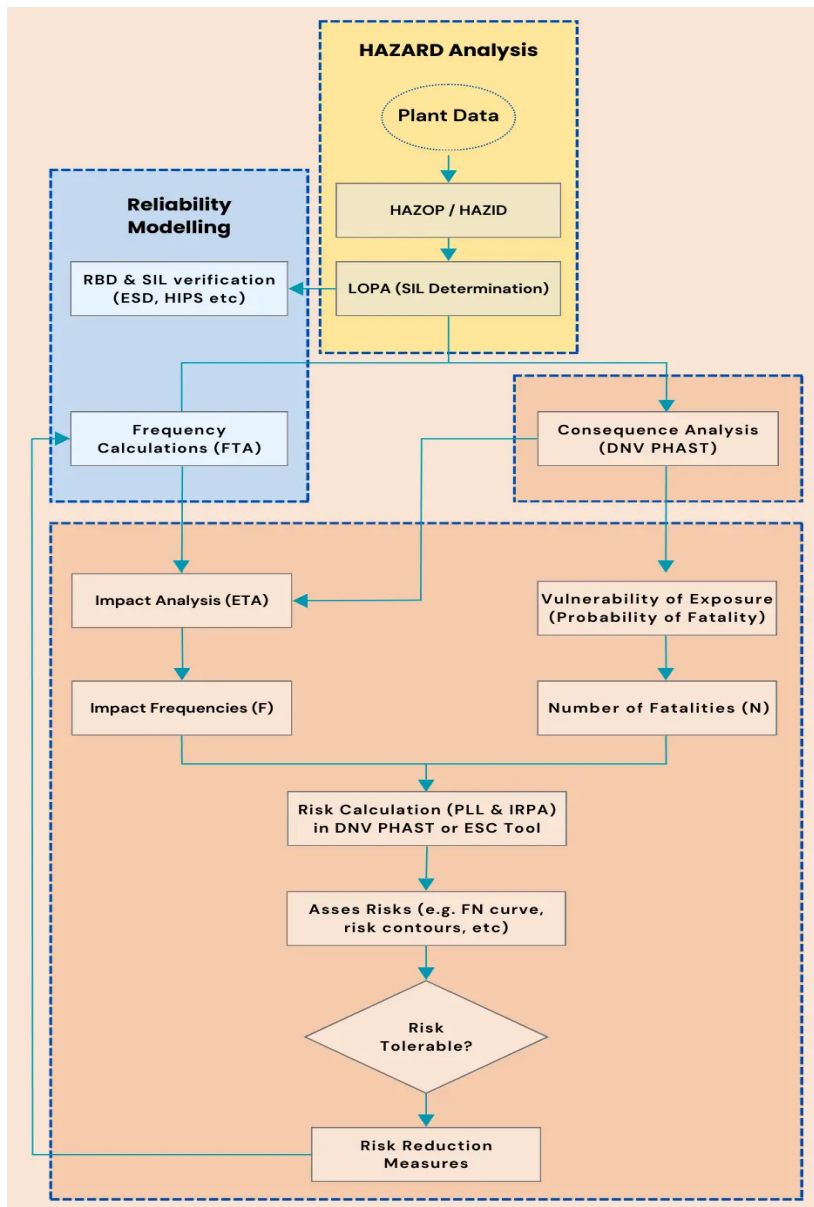


Fig. 2.4.1. HAZARD Analysis

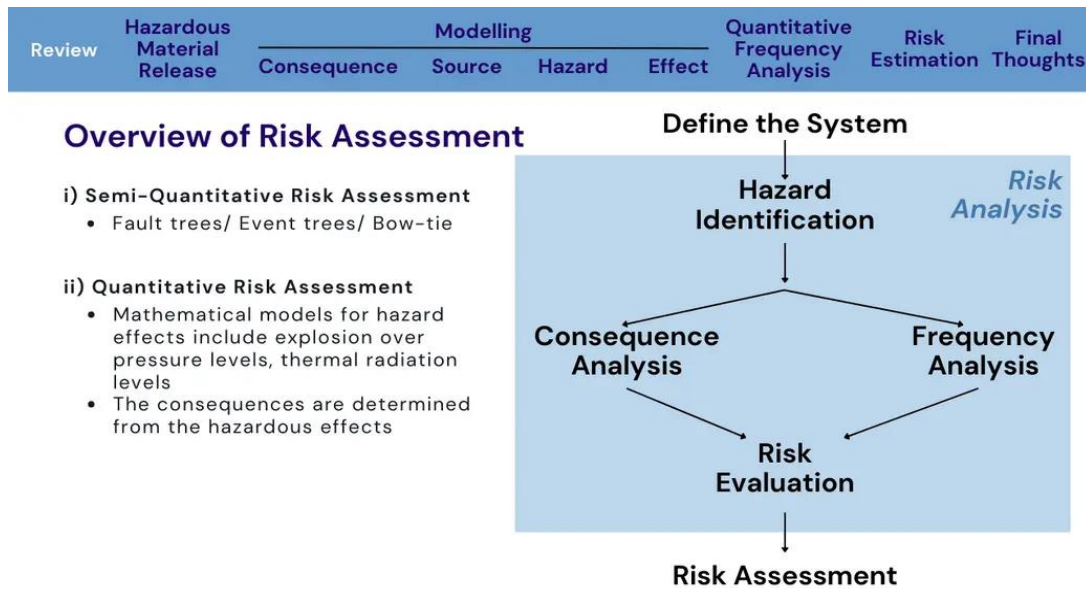


Fig. 2.4.2. Overview of Risk Assessment

**2.5. Hazardous Area Classification**

Hazardous Area Classification (HAC) is a systematic safety protocol that identifies and classifies areas within industrial facilities where potentially explosive atmospheres composed of flammable gases, vapors, or combustible dusts could lurk.

It’s essentially a detailed roadmap for preventing fires and explosions, prioritizing safety by meticulously analyzing risk, classifying zones based on threat levels, and selecting appropriate equipment to mitigate any dangers. HAC safeguards your people, operations, and future, building a foundation of proactive risk management for a safer and more sustainable industrial landscape.

**Importance of Hazardous Area Classification**

Hazardous Area Classification (HAC) transcends routine compliance to become a cornerstone of operational excellence in high-consequence industries. It isn’t merely a checkbox exercise; it’s a proactive investment in protecting your people, assets, and reputation. Here’s why HAC is indispensable:

1. **Safeguarding Lives:** By identifying and mitigating hazardous zones, you effectively remove the threat of explosions and fires, protecting your most valuable assets: your employees. HAC stands as your frontline defense, preventing such tragedies and fostering a culture of safety.
2. **Optimizing Operational Efficiency:** HAC acts as a proactive risk management tool, minimizing the likelihood of such disruptions. By identifying and addressing potential hazards, you ensure smooth operations, optimize efficiency, and protect your financial health.
3. **Building Trust and Brand Reputation:** Implementing a robust HAC program showcases your commitment to ethical and sustainable operations. This enhances stakeholder trust and strengthens your brand reputation, attracting investors, securing partnerships, and solidifying your position as a leader in your industry.
4. **Optimizing Insurance Costs:** HAC, by proactively minimizing risks, makes your operations a safer bet for insurers. This can lead to significant cost reductions on insurance premiums, freeing up resources for investing in growth and innovation.

5. **Fostering a Culture of Safety:** HAC lays the foundation for a culture of safety, and proactive in identifying and reporting potential hazards. where everyone feels empowered to contribute to a safer workplace, resulting in a more collaborative and productive team.

### Classification of Hazardous Zones

These hazardous zones are categorized based on the likelihood and extent of the presence of such materials. The purpose of hazardous zone classification is to ensure that appropriate measures are taken to prevent and mitigate the risks associated with potential ignition sources in these areas.

1. **Zones 0 & 1:** These areas harbor constant or frequent threats, demanding the highest level of vigilance and specialized equipment. Imagine a firefighter charging into a raging inferno – that’s the level of caution required.
2. **Zone 2:** This zone harbors a lesser, but still present, risk. Think of it as a smoldering ember – vigilance is key, but the immediate danger is lower.
3. **Dusts:** Explosions aren’t just about gases! Fine dusts can also pose a significant threat, and HAC accounts for these unseen dangers as well.

### Hazardous Area Classification Standards

Hazardous Area Classification (HAC) is guided by various international standards and guidelines that provide methodologies, criteria, and best practices for classifying and managing areas where potentially explosive atmospheres may occur. These standards ensure a consistent and systematic approach to minimizing the risks associated with hazardous environments. Here are some key hazardous area classification standards:

1. IEC 60079-10-1: Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres
2. IEC 60079-10-2: Explosive Atmospheres – Part 10-2: Classification of Areas – Combustible Dust Atmospheres
3. NFPA 70: National Electrical Code (NEC)
4. NFPA 499: Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
5. API RP 500: Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 & Division 2
6. EN 60079-10-1: Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres
7. EN 60079-10-2: Explosive Atmospheres – Part 10-2: Classification of Areas – Combustible Dust Atmospheres

HAC Methodology includes:

1. **Risk Assessment:** Experts conduct a thorough evaluation of your facility, identifying potential sources of flammable materials, analyzing ventilation and process conditions, and assessing factors like leakage potential and ignition sources.
2. **Zone Classification:** Based on the risk assessment, areas are classified into zones corresponding to the likelihood and duration of presence of an explosive atmosphere. Zone 0 represents areas with continuous or frequent threats, while Zone 2 signifies areas where risk is less likely but still present.
3. **Dust Hazard Analysis:** This additional step, crucial for industries handling combustible dusts, involves identifying the type and explosiveness of dusts present, their ignition sensitivity, and minimum ignitable concentration.
4. **Equipment Selection:** Explosion-proof equipment becomes your frontline defense. Experts carefully select equipment and installations like electrical motors, lighting

fixtures, and control systems specifically designed to withstand the hazards present in each classified zone.

5. Documentation and Signage: The HAC findings are meticulously documented and communicated through detailed reports, clear signage, and labeling, ensuring personnel and contractors are always aware of the potential hazards and safety precautions.

## **2.6. Process Safety Gap Assessment**

Process Safety Gap Assessment is a meticulous examination of your industrial processes, uncovering potential weaknesses in your approach to safety. Imagine running a safety microscope over your operations, identifying any gaps between current practices and recognized best practices or regulatory requirements. Through in-depth analyses of your equipment, procedures, and emergency response plans, this assessment exposes vulnerabilities that could lead to accidents, fires, or explosions. It's your opportunity to proactively plug these gaps before they become devastating breaches, safeguarding your people, assets, and reputation.

### Common Types of Gaps during Process Safety Gap Assessment

Process Safety Gap Analysis isn't mere compliance; it's a proactive voyage into your operational depths, exposing vulnerabilities before they become breaches. This meticulous dissection reveals three core fault lines in your safety framework:

1. Hazard Identification Gaps: This gap exposes the need for continuous hazard identification programs and enhanced employee training, ensuring everyone can recognize and respond to even unseen dangers.
2. Controls Gaps: This gap arises when safeguards are either absent or insufficient to effectively contain potential accidents. Identifying these control gaps empowers you to implement robust safety measures, from engineering controls to foolproof procedures, turning potential disasters into controlled situations.
3. Responsibility Gap: This gap emerges when accountability for managing specific risks remains unassigned or diffused. Addressing this gap involves establishing clear chains of command, ensuring everyone knows their role in the safety symphony, and empowering them to take ownership of risk mitigation.

### Benefits of Process Safety Gap Assessment Includes:

1. Improving the ability to detect problems with processes
2. Reducing the cost of maintaining safe operations by preventing major problems before they happen
3. Increasing worker productivity by reducing equipment downtime due to maintenance issues or repairs

### Process Safety Gap Assessment Can Be Classified Into Three Types:

1. Those associated with the environment
2. Those associated with equipment
3. Those associated with humans

## **2.7. Functional Safety**

Functional Safety in the Process Industry is a systematic approach to ensuring the safe operation of process plants by minimizing the risk of unintended process events that could harm people, the environment, or property. It focuses on the correct functioning of safety-related systems and equipment to prevent incidents such as explosions, fires, toxic releases, and equipment failures.

Here are the key aspects of Functional Safety in the Process Industry:

1. Risk Assessment: Identifying hazards and assessing their potential consequences and likelihood of occurrence. This helps prioritize risks and determine necessary safety measures.
2. Safety Integrity Level (SIL): Assigning a SIL to each safety function based on the severity and probability of the associated hazard. The SIL determines the required level of reliability and performance for the safety function.
3. Safety Instrumented Systems (SIS): Designing and implementing systems that are independent of the process control system and solely dedicated to safety functions. These systems typically comprise sensors, logic solvers, and final elements (actuators) that take corrective action in case of deviations from safe operating conditions.
4. Lifecycle Management: Applying a comprehensive approach throughout the entire lifecycle of the process plant, from concept design and construction to operation, maintenance, and decommissioning. This ensures that safety considerations are integrated into all phases of the process.

Benefits of Functional Safety in the Process Industry:

1. Reduces the risk of accidents and incidents
2. Protects people, the environment, and property
3. Improves operational efficiency and reliability
4. Reduces potential financial losses
5. Ensures compliance with safety regulations

Standards and Guidelines for Functional Safety in the Process Industry:

The process industry adheres to various international and national standards and guidelines for implementing Functional Safety, such as IEC 61508, IEC 61511, ISA S84.01, and ANSI/ISA-12.01. These standards define requirements for risk assessment, SIL determination, SIS design, and other aspects of Functional Safety.

1. IEC 61508: This is the fundamental international standard for Functional Safety. It provides a generic framework for managing the risk of electrical / electronic / programmable electronic safety-related systems (E/E/PES) in all industries, including the process industry.
2. IEC 61511: This is a sector-specific standard built upon IEC 61508 and tailored for the process industry. It provides additional guidance on applying Functional Safety principles to safety-instrumented functions (SIFs) used in process plants.
3. Additional Guidelines: While IEC 61508 and IEC 61511 are the primary standards, several other guidelines complement their implementation.

### **2.8. Hazard Identification and Risk Assessment**

Hazard Identification and Risk Assessment (HIRA) is a systematic process used to identify potential hazards, assess their likelihood and consequences, and implement measures to manage or mitigate the associated risks like flammable materials or faulty equipment. This process is a fundamental component of various safety management systems, including Process Safety Management (PSM), and is applied across industries to prevent hazards and threats.

Benefits of Hazard Identification and Risk Assessment

1. Identifying potential hazards before they occur.
2. Reducing workers' compensation claims related to work injuries due to negligence on behalf of management.
3. Ensuring compliance with safety regulations set forth by OSHA (Occupational Safety & Health Administration).

### Process of Hazard Identification and Risk Assessment

1. **Hazard Identification:** This step involves systematically identifying all possible hazards that could arise within a process, system, or facility. Hazards can include potential sources of danger, such as chemicals, equipment, operations, and external factors. Various techniques are used for hazard identification, such as brainstorming, checklists, process flow diagrams, and more advanced methods like Hazard and Operability Studies (HAZOP) and Failure Modes and Effects Analysis (FMEA).
2. **Risk Assessment:** Once hazards are identified, the next step is to assess the risks associated with each hazard. Risk assessment involves evaluating the likelihood of a hazard occurring and the potential consequences if it does. This often involves assigning numerical values to likelihood and consequence levels, leading to a risk matrix or risk score. Risks are typically categorized as low, medium, or high based on their scores.
3. **Risk Evaluation:** In this step, the assessed risks are evaluated to determine which ones require further action. Risks are usually prioritized based on their severity and likelihood. High-risk hazards that could lead to catastrophic consequences or have a high likelihood of occurrence are given the highest priority for mitigation.
4. **Risk Control and Mitigation:** For high-risk hazards, appropriate control measures are identified and implemented to reduce the risk to an acceptable level. This might involve modifying processes, adding safety features, implementing safeguards, changing procedures, or providing training to personnel. The goal is to reduce the likelihood of the hazard occurring and/or minimize the potential consequences if it does.
5. **Monitoring and Review:** Once risk control measures are in place, ongoing monitoring and periodic reviews are crucial to ensure that the risks remain adequately controlled. As processes, equipment, and conditions change over time, the effectiveness of the control measures should be assessed and adjustments made as necessary.

### Hazard Identification and Risk Assessment Standards

The following standards provide methodologies, principles, and guidance for conducting hazard identification and risk assessment across different industries and contexts.

1. **ISO 31000:** This international standard outlines universally applicable principles for managing risks, including HIRA. It serves as a foundational framework for organizations across diverse sectors.
2. **ISO 12100:** Specifically focused on machinery safety, this standard provides detailed procedures for risk assessment during machinery design and construction.
3. **API RP 750:** Renowned in the oil and gas industry, this recommended practice offers comprehensive guidelines for conducting process hazard analyses, a critical component of HIRA in these sectors.
4. **IEC 61508:** This international standard addresses functional safety for electrical / electronic / programmable electronic safety-related systems, including risk assessment methodologies within this context.
5. **NIST SP 800-30:** Dedicated to information technology systems, this guide from the National Institute of Standards and Technology (NIST) in the US provides valuable insights into risk assessment methodologies applicable to these systems.

## **2.9. Gas Dispersion Modelling**

Gas Dispersion Modelling utilizes advanced software and scientific principles to simulate the release, transport, and diffusion of gases in the atmosphere. By accounting for real-world factors like weather conditions, terrain variations, and gas properties, it predicts the



concentration of gas at different locations and times after a release. This information is invaluable for assessing potential risks, ensuring regulatory compliance, and guiding decisions related to safety, facility design, and emergency planning.

The model is used to assess whether pollutants released into the atmosphere will pose a threat to human health and safety, as well as how far they will spread. The model can also be used to determine if a pollutant is likely to reach ground level in its current form, or if it needs to be treated before it does so. Gas dispersion modelling can also help predict where chemicals will travel through the air, which can help emergency responders know where to focus their efforts.

#### Applications of Gas Dispersion Modelling

1. Chemical and petrochemical facilities: Assess risks associated with accidental releases of toxic or flammable gases.
2. Oil and gas pipelines and storage facilities: Evaluate potential consequences of pipeline leaks or storage tank failures.
3. Emergency planning and response: Develop effective response plans for accidental releases, minimizing risk to personnel and communities.
4. Environmental impact assessments: Analyze the potential impact of proposed projects on air quality and public health.
5. Landfill and waste management facilities: Predict and manage odor dispersion from landfills and waste treatment plants.

#### Gas Dispersion Modelling Standard Code Reference

1. American Society of Mechanical Engineers (ASME) Standard GD-6-07: Guidelines for Gas Dispersion Modeling: Provides best practices for conducting gas dispersion modelling studies.
2. Environmental Protection Agency (EPA) Guidelines on Air Quality Models: Outlines regulatory requirements and acceptable modelling practices.
3. European Union (EU) Directive 2001/42/EC on the Assessment of the Effects of Certain Plans and Programmes on the Environment (SEA Directive): Requires consideration of air quality impacts in environmental assessments.
4. Industry-specific regulations and guidelines: Ensure compliance with additional standards relevant to your specific sector and activities.

#### Gas Dispersion Modelling Methodology

1. Project scoping and data gathering: Analyze your facility layout, gas properties, and relevant environmental data.
2. Selection of appropriate modelling software: Choose the tool that best fits your specific needs and regulatory requirements.
3. Development of a customized modelling scenario: Incorporate relevant environmental conditions, release characteristics, and receptor locations.
4. Model execution and analysis: Run the simulations and interpret the results, identify potential risks and areas of concern.
5. Report generation and recommendations: Deliver a comprehensive report with clear conclusions, risk mitigation strategies, and recommendations for further action.

### **2.10. Dust Hazard Analysis**

Dust Hazard Analysis (DHA) is a systematic process used to identify, evaluate, and mitigate the risks associated with combustible dust in industrial facilities. Combustible dust refers to fine particles that can ignite and cause explosions or fires when dispersed in the air under

certain conditions. Dust Hazard Analysis are particularly important in industries such as food processing, woodworking, chemical manufacturing, and mining, where the presence of combustible dust can pose significant safety hazards.

The majority of powders that are used in the processing industries are combustible (also referred to as flammable, explosible). An explosion will occur if the concentration of the combustible dust that is suspended in air is sufficient to propagate flame when ignited by a sufficiently energetic ignition source. A systematic approach to identifying dust cloud explosion safety against their consequences generally involves

A systematic approach to identifying dust cloud explosion safety against their consequences generally involves:

1. Identification of locations where combustible dust cloud atmospheres could be present
2. Understanding of the explosion characteristics of the dust(s)
3. Identification of potential ignition sources that could be present under normal and abnormal conditions
4. Proper process and facility design to eliminate and/or minimize the occurrence of dust explosions and protect people and facilities against their consequences
5. Adequate maintenance of facilities to prevent ignition sources and minimize dust release

Key steps in conducting a Dust Hazard Analysis (DHA) includes:

1. Dust Identification and Assessment: Identify the types of combustible dust present in the facility. Different types of dust have varying levels of combustibility. Assess the characteristics of the dust, such as particle size, concentration, and ignition properties.
2. Dust Generation and Dispersion: Evaluate the processes and operations that generate and disperse dust within the facility.
3. Area Classification: Classify the areas where combustible dust is present based on its likelihood and extent.
4. Ignition Sources Identification: Identify potential sources of ignition that could trigger dust explosions.
5. Risk Assessment: Assess the risks associated with dust explosions or fires. Consider factors such as the concentration of dust, potential ignition sources, ventilation conditions, and possible consequences.
6. Mitigation Measures: Develop and implement measures to mitigate the identified risks.
7. Documentation and Communication: Document the findings of the Dust Hazard Analysis, including the identified hazards, risk assessment results, and mitigation measures. Communicate the findings to relevant personnel, contractors, and authorities.
8. Review and Update: Periodically review and update the Dust Hazard Analysis as processes, equipment, or conditions change.

Here are some key standards related to dust hazard analysis:

Dust Hazard Analysis (DHA) standards provide guidelines, methodologies, and best practices for conducting assessments of combustible dust hazards in industrial facilities. These standards help organizations identify, evaluate, and mitigate the risks associated with dust explosions.

1. NFPA 652: Standard on Fundamentals of Combustible Dust
2. NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
3. NFPA 61: Standard for the Prevention of Dust Explosions in Agricultural facilities.

4. EN 15089: Explosive Atmospheres – Explosion Prevention and Protection – Determination of Minimum Ignition Energy of Dust/Air Mixtures
5. ASTM E2931: Standard Practice for Limiting Water-Induced Damage to Buildings
6. OSHA General Duty Clause and Industry-Specific Standards

These standards offer valuable guidance for identifying and mitigating combustible dust hazards through Dust Hazard Analysis. Organizations should select the appropriate standard based on their industry, specific processes, and geographical location to ensure compliance with regulations and the adoption of best practices for managing dust-related risks.

### **2.11. Bow Tie Analysis**

Bow-Tie Analysis is a graphical tool for comprehensive risk management. It visually depicts potential accidents or events like a bow-tie: the top representing the undesired outcome, the left side identifying contributing causes, and the right detailing potential consequences. The crucial knot at the center focuses on control measures implemented to prevent the event and mitigate its impact.

This visually-driven approach offers several advantages:

1. Proactive risk identification: It goes beyond immediate causes and underlying factors.
2. Prioritization: High-impact risks demanding immediate attention are easily identified.
3. Control measure optimization: It ensures controls address all potential pathways.
4. Effective communication: Complex information is readily understandable for everyone

Bow-tie diagram is used to organize the results of this analysis, with one side representing probability & the other side representing consequence. It is a tool that allows companies to identify the most important factors in their risk assessments. It helps them to focus on the areas that have the greatest impact on the safety of their employees & facilities, & allows them to prioritize those areas for improvement.

Uses of Bow-Tie Analysis

1. Identify the different hazards present in a process, such as explosions, or toxic releases.
2. Determine what might trigger those hazards and what could happen if triggered.
3. Assess how likely each hazard is to occur or be triggered, based on its severity.
4. Determine which controls are currently in place to prevent or mitigate these hazards.
5. Determine which additional controls should be added to address any gaps identified.

Bow-Tie Analysis Deliverables

1. Bow-Tie Terms of Reference (ToR)
2. Bow-Tie Worksheets
3. Bow-Tie Analysis Report

## **3.0. Structural Safety**

### **3.1. Structural Audit**

A structural audit of buildings is a correct diagnosis establishing the cause, nature, and extent of damage, and the weakness or deterioration caused in the structure where the report gives a detailed description of the condition of a structure, the scale of deterioration, and effectiveness of a repair or retrofitting.

The aforementioned data is presented to the client as a part of a structural audit report where due consideration is given to make reports purposeful and easy to understand. Once the report is presented to the client, a structural audit of the structure is considered complete. To pursue & implement the recommendations of the report is at the client's discretion.

Structural audit is a process that assesses the condition of a facility's facilities, systems, and operations, including their physical structure and the way they operate. The structural audit includes an assessment of the condition of the building's foundation, structural members, interior spaces, and utilities, as well as its mechanical and electrical systems.

Structural Audit is performed for many reasons including

1. To ensure that buildings meet regulations set by government agencies or insurers
2. To identify potential hazards to life safety (e.g., unsafe building conditions)
3. To determine if there are any issues with the building's structural stability

#### Visual Inspection

Visual inspection for surface damages, cracks, flaking, coloration, local weaknesses, etc., and their damage classification. Simple tools and instruments like a camera with flashlight, magnifying glass, binoculars, and gauge for crack width measurement, chisel, hammer, etc. shall be used for measuring the distresses. The visual inspection shall largely cover areas of high distress, cracks and their location, moisture, leakage, abnormal variations in structure, algae and fungus growth, efflorescence, etc. Visual inspection would be documented in the form of worksheets, photographic records, distress over drawings, etc.

#### NDT Testing

1. Rebound hammer
2. Ultrasonic Pulse Velocity Test
3. Covermeter scanning
4. Core cutting
5. Dye penetration inspection
6. Ultrasonic thickness measurement
7. pH Value & Carbonation of concrete (Partially destructive)
8. Chloride content test
9. Sulphate content test
10. Cement content

The design will be analyzed for loading at structural members. Dead loads such as self-load of structure & machines, live loads such as human loading, and impact of machines, shall be analyzed for different load combinations and include the governing environment forces. These structural members are verified for the mentioned parameters as per Indian Standard 567:2000, IS 800, IS 1983:2000, etc.

### **3.2. Structural Retrofitting**

Structural retrofitting is a way to strengthen the structure of buildings, whether they are residential or commercial. The goal is to reduce the risk of collapse in case of an earthquake or other natural disaster. Structural retrofitting can also be used to make a building more comfortable for its occupants. Structural retrofitting can be done on any type of building, including residential, commercial, and industrial buildings.

If a structural audit report contains non-compliances or structural distresses which are meant to be addressed then rehabilitation & retrofitting of the structure is supposed to be carried out to address these issues. Structural rehabilitation stands for repairs to be carried out at building areas damaged during service life, whereas structural retrofitting is a complete re-strengthening exercise where necessary changes are made to the old design to serve the intended purpose of the structure. For example – grouting of plaster, concreting repairs by uniting spray & epoxy, welding of steel sections/ reinforcements, and painting are rehabilitation methods. While column jacketing, the addition of reinforcement on the beam on old structural members constitutes part of retrofitting.

Rehabilitation is a methodology-based approach where the effectiveness of a solution is dependent on application whereas retrofitting is a design + methodology-based approach. Retrofitting is commonly employed to increase the seismic resistance and addition of stories in a structure. Success both depends on the sound diagnosis, proper selection of materials, and repair techniques. These services receive relatively less attention in comparison to conventional methods of demolition of old and construction of new.

### **3.3. Structural NDT Testing**

Structural NDT Testing is a critical aspect of assessing the health and strength of structures without causing any damage. In the context of RCC and Steel Structures, Structural NDT Testing plays a pivotal role in identifying potential issues such as cracks, corrosion, and material defects, allowing for timely and proactive maintenance.

Benefits Structural NDT Testing are:

1. Early Detection of Potential Structural Issues
2. Compliance With Regulatory Requirements
3. Increased Safety and Longevity of Structures
4. Cost-Effective Compared to Traditional Destructive Testing
5. Optimized Maintenance Strategies
6. Improved Structural Performance
7. Minimizes Downtime and Disruptions to Operations
8. Environmental Sustainability

Types of Structural NDT Testing for RCC and Steel Structures are:

1. Visual Testing (VT): Direct visual inspection to identify surface imperfections like cracks, surface corrosion, deflection, loosening, spalling & more.
2. Drone Survey: Aerial inspection using drones to capture high-resolution videos, providing a bird's-eye view for a comprehensive assessment of structures and facilities.
3. Thermography: Infrared imaging technology reveals temperature variations to detect hidden issues like insulation gaps, delamination and water leaks in structures.
4. Rebar Locator: Utilising magnetic waves to locate and assess reinforcement bars in concrete, ensuring structural integrity by checking the concrete cover and diameter of bars.
5. Ultrasonic Pulse Velocity Testing (UPV): Evaluates the integrity of concrete structures by measuring the speed of pulses, providing insights into material homogeneity and potential defects.
6. Schmidt Hammer (Rebound Hammer): Assessing concrete strength instantly by measuring the rebound of a spring-loaded hammer.
7. Half-Cell potential: Evaluating the corrosion potential of reinforcing steel in concrete to identify areas prone to corrosion and guide preventive measures.

- 8. Carbonation (Concrete Alkalinity): Measuring the alkalinity levels within concrete to assess the risk of carbonation and potential corrosion of embedded steel.
- 9. Magnetic Particle Testing (MPT): Detecting surface and near-surface flaws in ferrous materials by applying magnetic fields and observing particle accumulations at defect locations.
- 10. Dye Penetration Testing (DPT): Identifying surface-breaking defects in materials by applying a coloured dye, enhancing visibility of flaws for precise detection.
- 11. Eddy Current Testing: Detecting surface and near-surface defects in conductive materials, offering a non-invasive and efficient method for quality assessments in various industries using electromagnetic fields.
- 12. Phased Array Ultrasonic Testing (PAUT): Employing advanced ultrasonic techniques with multiple transducer elements for detailed imaging and flaw characterization in various materials.
- 13. Short Range Ultrasonics (SRUT): Provides detailed assessments of material thickness, corrosion, and other defects in a non-contact manner, ensuring precise structural evaluation using ultrasonic waves.

**Structural NDT Testing Standards Adopted:**

The guidelines from organizations such as ASTM, ASNT, and ISO, guarantee that your structures meet or exceed industry requirements.

1. BRITISH STANDARD (BS) 3923 Part 1
2. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) C597
3. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) C805
4. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) C 876 – 91
5. AMERICAN CONCRETE INSTITUTE (ACI) 201.1R-08
6. BRITISH STANDARD (BS) 6072:1981
7. BRITISH STANDARD (BS) 3889 (part 2A)
8. INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO) 3452
9. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) E2700-09

**Methodology of Structural NDT Testing:**

**Construction**

**Quality Assurance:** In the construction industry, Structural NDT testing ensures the quality and integrity of newly erected buildings and infrastructure. By identifying any hidden defects or structural issues early on, builders can rectify problems before they become major concerns.

**Oil and Gas**

**Pipeline Integrity:** Structural NDT testing plays a critical role in ensuring the integrity of pipelines used in the oil and gas sector. By detecting corrosion, cracks, or other potential issues, our testing services help prevent leaks and enhance the overall safety of the pipeline network.

**Storage Tanks:** Regular inspections using Structural NDT methods are vital for assessing the condition of storage tanks. This ensures that these structures can safely contain hazardous materials without risk of leaks or structural failure.

**Infrastructure**

**Bridges and Viaducts:** Structural NDT testing is essential for assessing the structural health of bridges and viaducts. By identifying any deterioration, corrosion, or fatigue in the materials, our testing services contribute to the maintenance and longevity of these critical transportation structures.

**Dams and Tunnels:** Structural NDT testing is employed to evaluate the integrity of dams and tunnels. Identifying potential issues such as cracks or voids helps prevent catastrophic failures, safeguarding both infrastructure and surrounding communities.

## Manufacturing

**Fabricated Steel Components:** Industries involved in manufacturing steel components, such as beams, columns, and other structural elements, benefit from Structural NDT testing to ensure the quality and reliability of the fabricated materials. This is crucial for maintaining the structural integrity of the final products.

**Weld Inspections:** Structural NDT testing is commonly used for inspecting welds in manufacturing processes. This helps detect any welding defects or discontinuities that could compromise the strength and durability of welded joints.



Fig.3.3. Personnel – NDT WBS

### 3.4. Structural Stability Certificate

A structural stability certificate is a compulsory document required in municipalities' bylaws of many states issued by a structural engineer after a thorough assessment of the structure and its components. The authority of the issuer & validity of structural stability certificate varies from region to region however few things remain common throughout the industry.

The certificate is based on the design criteria for the particular type of structure being evaluated. It will describe how much force the structure can take before it breaks or collapses due to being over-stressed. This is done by comparing how much force was applied during its construction with how much force it can withstand as it ages.

#### Project methodology

1. Site physical inspection
2. Nondestructive testing
3. Staad Analysis

Structural stability certificates are a vital part of building safety. They help ensure that buildings meet the requirements set by the government, and they can be used to identify problems that could lead to accidents. These certificates are also used to monitor the condition of a building's structure over time and make sure it is safe to occupy.

## 4.0. Electrical Safety

### 4.1. Arc Flash Risk Assessment

ARC Flash Risk Assessment is a detailed evaluation of the potential danger posed by arc flashes in specific electrical equipment and systems.

ARC Flash Risk Assessment goes beyond simply identifying potential arc flash hazards. It involves in-depth analysis, risk quantification, and practical recommendations to effectively minimize the risk of arc flash incidents and protect workers from potential electrical injuries.

What is ARC Flash Risk Assessment?

ARC Flash Risk Assessment is a detailed evaluation of the potential danger posed by arc flashes in specific electrical equipment and systems.

ARC Flash Risk Assessment goes beyond simply identifying potential arc flash hazards. It involves in-depth analysis, risk quantification, and practical recommendations to effectively minimize the risk of arc flash incidents and protect workers from potential electrical injuries.



Fig. 4.1.1. Arc Flash Risk Assessment

ARC Flash Risk Assessment Involves:

1. Identifying hazards: Your electrical system is dissected, revealing potential flash points like energized conductors, open fuses, and faulty connections.
2. Estimating the risk: The intensity of potential arc flashes is calculated, considering factors like voltage, current, and arc gap. This determines the severity of potential injuries.
3. Protective measures: Based on the calculated risk, the assessment recommends appropriate personal protective equipment (PPE) and safe work practices to minimize the chance and impact of an arc flash.

The primary purpose of ARC Flash Risk Assessment is to systematically identify, evaluate, and mitigate potential dangers associated with electrical arc flashes. This process ensures the safety of personnel, protects equipment, and safeguards the surrounding environment.

### Causes of ARC Flash

ARC flash events result from low-impedance connections through the air to the ground or another voltage phase. These events are characterized by electrical explosions, with temperatures exceeding 35,000 °F (19,400 °C), posing significant risks of explosions, equipment damage, fires, and injuries.





Fig. 4.1.2. Factors leading to Arc Flash

#### ARC Flash Risk Assessment for Prevention of ARC Flash Incidents

To prevent ARC flash incidents, the following strategies can be employed:

1. De-energize electrical equipment
2. Wear suitable Personal Protective Equipment (PPE)
3. Keep a safe distance
4. Reduce energy output from an incident
5. Carry out comprehensive ARC Flash Risk Assessment

ARC Flash Risk Assessment encompasses:

1. Load Flow Analysis
  - Voltage profile analysis for normal & contingency conditions
  - Observations on power flow patterns
  - Adequacy check for equipment ratings
  - System losses determination
2. Short Circuit Analysis
  - Phase current, voltage & phase angle for various faults
  - Verification of switchgear rupture capacity
  - Effects of fault current on system components
  - Assessment of short circuits on system voltage profile
  - Protective relay settings determination
3. PPE Recommendations
  - Recommendations for PPE based on arc flash hazard calculations
  - Guidance on PPE types and levels for specific work locations and tasks
4. ARC Flash Hazard Calculations
  - Results for arcing fault magnitude, clearing time, arc duration
  - Arc flash boundary and working distance calculations
  - Recommendations for equipment or system changes
5. Labeling Electrical Equipment
  - Generation of warning labels for each analyzed work location
  - Labels key details: Header & sub-header, Nominal voltage, Arc flash boundary, Incident energy, Working distance, Approach boundaries, and Report details.
6. Protection Coordination Analysis
  - Summary of: Fault current calculations, Listing peak, Breaking currents.
  - Recommendations for replacement or retrofit of over-burdened devices.
7. Strategies to Mitigate ARC Flash
  - Strategies to mitigate incident energy levels.
  - Recommendations for reducing arc flash energy levels below 40 cal/cm<sup>2</sup>.

Software & Tools for ARC Flash Risk Assessment

We at 4A Energy, use the tested and proven software to model & simulate electrical systems, perform short circuit studies, and arc flash risk assessments. These tools enhance accuracy and provide valuable insights into potential risks.

1. ETAP
2. SKM Power Tool
3. DIGSILENT

#### Reference Standards to Perform ARC Flash Risk Assessment:

1. National Fire Protection Association (NFPA): NFPA 70E - Standard for Electrical Safety in the Workplace (Article 130.5)
2. Institute of Electrical and Electronics Engineers (IEEE) 1584-2018: IEEE Guide for Performing Arc-Flash Hazard Calculations.
3. National Electric Code (NEC) 110.6 (Label requirement)
4. Occupational Safety and Health Administration (OSHA) Standards.
5. OSHA 29 CFR 1910.269- to protect workers from flames and electrical arcs.
6. OSHA 29 CFR 1910.333- importance of workplace habits to protect against electrical hazards.
7. IEC 60909-0:2016 - Short-circuit currents in three-phase A.C. systems - Part 0: Calculation of currents.
8. IEC 61439 series - Low-voltage switchgear and control gear assemblies.
9. Occupational Health and Safety Assessment (OHSA) guidelines.

## 4.2. Electrical Safety Audit

Electrical Safety Audit is a systematic and independent examination of a building's electrical installations and practices to identify potential hazards and ensure compliance with safety regulations. It's like a thorough checkup for your electrical system, uncovering hidden risks before they evolve into accidents and injuries.

### Electrical Safety Audit Categories

Electrical Safety Audit (ESA) can be broadly classified and grouped into three categories:

1. Human Safety Audit – Electrical safety related to humans.
2. Equipment Safety Audit – Electrical safety related to equipment.
3. Statutory Audit – Statutory requirements.

### Why Electrical Safety Audit is Crucial

The major hazards of working with the electrical system of any facility are electrical shock and burns, body injury, and body part damage, and it can be even catastrophic as electrocution death, or explosion.

Electricity is an essential component for any building or organization. So, this can be risks and hazards can be managed effectively. Studies report that 45% to 60% of facility fire accidents result from short circuits or electrical issues. This percentage is even higher for the industries handling flammable chemicals.

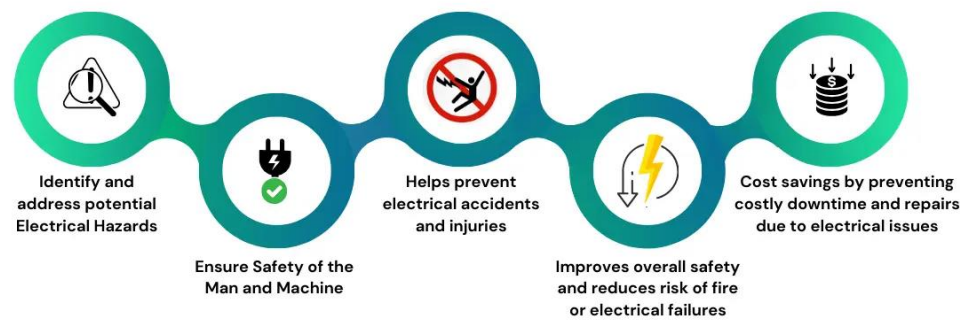
The Major Hazards & Risks Working with the Electrical System of any Facility are:

1. Hazard: Electrical Shock and Burns! Body Injury & Body part Damage, Electrocution Death and Explosion
2. Risk: Loss of human life, Loss of property! Loss of data, Legal implications! Equipment damage and Disruption in business continuity

These hazards and risks can be effectively managed by strengthening the work procedures and practices, maintenance programs, safety training, electrical system design & adherence to policies.

#### Benefits of Electrical Safety Audit

The main objective of the Electrical Safety Audit is to identify potential electrical hazards; flaws in the design system, maintenance system, etc. top reverent minimize loss of life and property.



#### Electrical Safety System Management

1. Review of Electrical Protection System.
2. Review of Connected Load, Sanctioned Load/Contract Demand.
3. Review of the Complete Electrical Distribution System.
4. Review of Quality of Electrical Safety and Protective Systems: RCCBs, Main switch, MCCBs, MCBs, ELCBs/RCBs, Isolators, UPS, Battery and Server Room, Lightning Arrestor, Cable routes, Deteriorated insulation, Unused openings in live panels, Loose terminations due to improper supports, crimping, Earthing defects, etc.
5. Review of Static Electricity Hazards in the Electrical System/Installation Operations (as per IS 7689).
6. Review of Electrical System/Installation Lightning Protection System (need, adequacy, installation, and maintenance) as per IS 62305.
7. Evaluate the potential electrical fire hazards.

#### Preventive Maintenance

1. Review of Electrical Accidents and Near-Misses to Identify Root Causes.
2. Review of Electrical Systems & Procedures. (Work permits, interlocks & lockout tags)
3. Evaluate providing Limits of Hazardous Area Zoning for Chemical Storage.
4. Review of the importance given to electrical safety in the company safety policy, safety committee, continuous electrical risk identification, etc.
5. Review of rubber mats being used.
6. Checking of earth continuity.
7. Review of test records, evaluating test results: Transformer oil test, Insulation Resistance Tests, Earth Resistance tests, Relay Test Records.

#### Emergency Preparedness

1. Evaluate if existing control measures reduce risk to a tolerable level.
2. Review the organization's emergency response plan for electrical incidents.
3. Evaluate communication protocols and evacuation procedures.
4. Assess the frequency and effectiveness of emergency response drills

#### Emergency Lighting System

1. Review the operational status of emergency lighting systems.
2. Evaluate the visibility and condition of exit signs.

Complain with Statutory Requirement

1. NFPA 70E Validation
2. Code of Practices such as NEC 2023, NBC 2016 and various relevant IS Standards
3. IS 732 – Code of Practice of Electrical Wiring Installations
4. IS 3043:2018 – Code of Practice for Earthing
5. IS 5216 – Guide for Safety Procedures and Practices in Electrical Work
6. IS 10118 – Code of Practice for the installation, and maintenance of switchgear
7. IEEE: 519 & IEEE: 1159: Reference standards for Power quality and harmonics
8. NBC 2016: National Building Code 2016
9. IS 7689: Code of Practice against Static Charges
10. IS 1646: Code of practice for fire safety of buildings (general): Electrical Installations

Methodology for Electrical Safety Audit:



Fig. 4.2. Electrical Safety Methodology

**4.3. Lightning Protection Risk Assessment**

Lightning Protection Risk Assessment is a comprehensive study that evaluates the vulnerability of a structure and its surroundings to lightning strikes, and determines the necessity and type of lightning protection system required to mitigate those risks. It’s essentially a proactive approach to ensuring the safety of people, property, and critical infrastructure from the potentially devastating effects of lightning.

Lightning flashes can cause significant structural damage to a building, including damage to machinery and equipment inside and outside the building, and may harm the occupants. The damages and failures may also extend to the structure’s surroundings and involve the local environment. The scale of this extension depends on the structure’s characteristics and the lightning flash’s characteristics.

Lightning Protection Risk Assessment Will Look at Factors Such as:

1. Height and shape of the structure
2. Nearby trees or other tall objects
3. Location on or near water
4. Building material

Lightning Protection Risk Assessment is used to identify areas that are especially likely to be struck by lightning. These areas are called “Lightning Protection Zones” or LPZs.

Lightning Protection Risk Assessment is also useful for discovering whether or not your organization needs additional insurance coverage. Because lightning can cause such extensive damage, it may be necessary for you to purchase additional protection against this risk so that you don’t have to pay out-of-pocket when something goes wrong.

Benefits of Lightning Protection Risk Assessment includes:

1. Identifying areas of your business that are at risk for lightning strikes
2. Identifying areas where lightning may have already struck
3. Determining whether or not there are any existing building codes or laws regarding lightning protection
4. Providing recommendations on how to prevent future damage from occurring

Lightning Protection Risk Assessment Services, include:

1. Lightning Strike Analysis Services
2. Lightning Protection Systems Installation Services
3. Lightning Protection Systems Maintenance Services

Deliverables of the Lightning Protection Risk Assessment Report are:

1. Calculation and Summary sheet of the Building Risk Assessment.
2. Review of the existing lightning protection measures.
3. Identification of LPL (Lightning Protection Level) required for the structure.
4. Layout with marking of zones of protected areas.
5. Review & suggestions on the requirement of Internal Protection System.
6. Implementation plan and estimate of material/quantities.
7. Testing report of existing lightning protection.

Lightning & Surge Protection is Based on the Following Standards:

1. IEC 62305 – 1: Protection against lightning - Part 1: General Principles
2. IEC 62305 – 2: Protection against lightning - Part 2: Risk Management
3. IEC 62305 – 3: Protection against lightning - Part 3: Physical damage to structures
4. IEC 62305 – 4: Protection against lightning - Part 4: Surge Protection of equipment
5. IS 2309 - 2005: Protection of Buildings and Allied Structures Against Lightning
6. OISD GDN 180: Oil Industry Safety Directorate - Lightning Protection guidelines
7. IS 3043 – 2006: Code of Practice for Earthing (First Revision)
8. IS 7689: Code of Practice against Static Charges
9. IEEE 80- Guide for Safety in AC Substation Grounding
10. IEEE 998 – Guide for Direct Lightning Stroke Shielding of Substations
11. NFPA 780 – 2008: Standard for the installation of Lightning Protection Systems

### Thermography

Infrared thermography is equipment or method, which detects infrared energy emitted from object, converts it to temperature, and displays image of temperature distribution. To be accurate, the equipment and the method should be called differently, the equipment to be called as infrared thermograph and the method to be called as infrared thermography.

### Advantage of Thermography

1. It is non-contact – uses remote sensing
2. It keeps user out of danger while scanning live electrical components
3. Targets at very high position can also be detected
4. Does not affect the target
5. No SHUT DOWN is required

### Power Quality Test

To achieve the objective of this study, the power quality shall be assessed based on following parameters:

1. Harmonics – sinusoidal voltages or currents having frequencies that are integer multiples of the frequency at which the supply system is designed to operate
2. Phase-phase/Neutral RMS voltage variations

3. Frequency variations
4. Ground – Neutral RMS voltage variations
5. Load RMS current variations
6. Power Factor – Improvement in power factor

### Earthing System Test

In electricity supply systems, an earthing system or grounding system is circuitry which connects parts of the electric circuit with the ground, thus defining the electric potential of the conductors relative to the Earth's conductive surface. The choice of earthing system can affect the safety and electromagnetic compatibility of the power supply. In particular, it affects the magnitude and distribution of short circuit currents through the system, and the effects it creates on equipment and people in the proximity of the circuit.

If a fault within an electrical device connects a live supply conductor to an exposed conductive surface, anyone touching it while electrically connected to the earth will complete a circuit back to the earthed supply conductor and receive an electric shock.

1. Physical walkthrough to check earth-pit and connection condition
2. Earth pit resistance measurement and comparison with the Indian standards
3. Earth resistance of all electrical and electronic equipment
4. Insulation resistance test

An insulation resistance (IR) test measures the total resistance between any two points separated by electrical insulation. The test, therefore, determines how effective the dielectric (insulation) is in resisting the flow of electrical current. Such tests are useful for checking the quality of insulation, not only when a product is first manufactured but also over time as the product is used.

### Earth Loop Impedance test

An earth loop impedance test is conducted to make sure that, if a fault occurs in an electrical circuit, the fault current will strong be enough to set off the circuit protection. If a fault current is left undetected, circuits can overheat and catch on fire.

Electricity takes the path of least resistance to the ground. Electrical wiring systems in buildings are often connected to the ground. This is referred to as an earth return circuit. The grounding wire is there for electrical current to pass through when a short circuit happens.

## **4.4. Power System Audit**

Power System Audit is a systematic process of evaluating the condition of an electrical distribution system and its components, designed to identify potential issues and optimize its performance. Power system audits are conducted to ensure that a business is operating in the safest and most efficient manner possible. They can be used to help reduce energy consumption, detect potentially hazardous conditions, and improve the reliability of a facility's supply.

### Benefits of Power System Audit

1. Identify problems and potential issues with your power system, so that you can take preventative measures to avoid future issues.
2. Make informed decisions about what to do if an issue arises, such as whether to spend money on repairs or replacement parts.
3. Document your findings for future reference.

Three Main Categories of Components That Are Inspected During Power System Audit:

1. Power transformers (also known as "power boxes" or "busbars"), which convert electricity from high voltage to low voltage
2. Transformers, which convert electricity from one voltage level to another
3. Switches and circuit breakers are used to control the flow of electricity in a circuit.

Any organization using a complex electrical system can benefit from a power system audit

1. Commercial buildings: Offices, hospitals, schools, and other facilities with significant electrical demands.
2. Industrial facilities: Factories, manufacturing plants, and other large energy consumers.
3. Data centers: Critical infrastructure relying on uninterrupted power supply.
4. Renewable energy installations: Solar farms, wind farms, and other renewable energy.

Power System Audit Includes:

1. Examine all drawings and documentation
2. Complete site survey.
3. Analysis of the system in terms of load flow, volt drops, breaker and cable ratings.
4. Checking the condition of switchgear, cabling, bus bars, transformers, and others.
5. Protection System Audit.
6. Preparation of full report, a controlled document.

#### **4.5. E HAZOP**

This is a brainstorming approach conducted by a multidisciplinary team. The approach simulates the creativity of the team members to generate new ideas. As a result of this study, numerous, qualitative recommendations have been made for the electrical design of the safety and operability problems out of the major power system upgrade. Among the recommendations are suggestions on protection and control strategy, materials of construction, process material releases, alternative design options, and maintenance of this power system upgrade.

E-HAZOP is a technique used to identify design flaws in a project right from the Feed stage. It is also known as the SAFOP (Safety and Operability) Study.

1. Assess, eliminate/ or minimise the potential hazards presented to personnel in the vicinity of Electrical Installations.
2. Provide a critical review of both the Electrical System Design and the Plant to be installed. Assess any limitations and their effects on both Operability and security of the overall system (SYSOP)
3. Analyse tasks set for Operators, assess the information, facilities, and instructions provided to undertake these tasks, and recommend measures to avoid Operator error(OPTAN)

#### **4.6. Thermography Testing**

Thermography testing or infrared thermography (IRT) for electrical systems, is a specialized application of thermography focused on inspecting electrical equipment for abnormalities based on temperature variations. It's essentially using a thermal camera to see "heat signatures" of electrical components, potentially revealing hidden problems before they lead to failures or even fires.

Applications of Thermography Testing are:

1. Identifying potential problems with electrical systems
2. Identifying areas of poor insulation on electrical components that may lead to overheating or fire

3. Assessing the condition of insulation on cables and wires that may have been damaged by heat stress
4. Identifying areas of poor bonding between wires and terminals which can lead to shorts or open circuits in electrical equipment

#### Benefits of Thermography Testing:

Thermography testing is a valuable tool for maintaining the health and safety of electrical systems. By proactively identifying potential problems through heat signatures, it helps prevent costly breakdowns, improve safety, and optimize system performance.

1. Preventative maintenance: Early detection of problems allows for corrective action before expensive failures and downtime.
2. Safety improvement: Identifies potential fire hazards due to electrical issues, minimizing safety risks.
3. Reduced costs: Proactive maintenance saves money compared to reactive repairs and potential damage from major failures.
4. Non-destructive and safe: No disruption to operations or risk of damage to equipment during testing.
5. Fast and efficient: Covers large areas quickly and provides immediate visual results.

#### Thermography Testing can Verify Followings:

1. Power distribution panels and switchgear
2. Motors and generators
3. Transformers and cables
4. Circuit breakers and fuses
5. Lighting systems
6. Control panels and electronics

Thermography Risk Categorisation shall be based on the following Standards: -

1. NFPA 70B (National Fire Protection Association)
2. NETA (International Electrical Testing Association)

#### Electrical Thermography Risk Levels

##### Alarming Level:

1. Delta temperature (differential temperature between the maximum & minimum / temperature near the object) more than 16 degree centigrade.
2. Failure could result in major fire / explosion / over-pressure situation /major abnormality.
3. Any of the hazardous situations mentioned in Note 1.

##### Caution:

1. Delta temperature (differential temperature between the maximum & minimum temperature) between 4 to 15 degree centigrade.
2. Impact may be confined to the equipment.
3. Failure may not have a large impact on safety / environment / production but repair cost may not be insignificant.

##### Check & Monitor:

1. Delta temperature (differential temperature between the maximum & minimum temperature) between 1 and 3 degree centigrade.
2. Mostly of a minor / regular disruption that will not affect safety / production / environment.

Normal Level: Normal temperatures



### Electrical Thermography Testing Methodology – Data Collection from Client Site

1. Site Visit
2. Report Preparation and submission of Draft report
3. Draft report review by Client
4. Final Report Submission (after incorporating client points If any)
5. Thermography After rectification (Optional)

#### **4.7. LOTO Audit**

Lockout Tagout (LOTO) Audit is a critical review of an organization's safety protocols for controlling hazardous energy sources during equipment maintenance. It meticulously examines procedures, equipment, and worker training to ensure locks, tags, and safety practices effectively isolate energy, preventing accidental energization and safeguarding workers from harm. This rigorous assessment identifies gaps, bolsters compliance, and ultimately unlocks a safer, more efficient work environment.

#### What Does LOTO Audit Entail?

1. Procedure Scrutiny: The audit dissects the organization's established LOTO procedures, verifying their compliance with safety regulations and their suitability for specific equipment and tasks.
2. Equipment Inspection: Every lock, tag, and energy-isolating device undergoes a close inspection, ensuring it's functional, appropriately labeled, and readily available.
3. Training Assessment: Worker knowledge and adherence to LOTO practices are evaluated through observations, interviews, and even hands-on simulations.
4. Gap Identification: The audit pinpoints any inconsistencies, deficiencies, or potential loopholes within the program, paving the way for targeted improvements.

#### Benefits of LOTO Audit

1. Enhanced Safety: By identifying and addressing vulnerabilities, the audit minimizes the risk of accidents and protects lives.
2. Reduced Downtime: Streamlined, effective LOTO procedures shorten maintenance times, keeping operations running smoothly.
3. Compliance Assurance: The audit guarantees adherence to safety regulations, avoiding potential legal repercussions.
4. Cost Savings: Preventing accidents translates to lower insurance premiums and reduced medical expenses.

#### Who Needs a LOTO Audit?

1. Manufacturing facilities: Where production lines hum with potential dangers.
2. Construction sites: Where temporary installations and diverse equip pose varied risks.
3. Chemical plants: Where volatile materials demand extra vigilance.
4. Maintenance and repair companies: Who constantly interact with diverse energy sources.

#### Lockout Tagout (LOTO) Onsite Training:

The Lockout Tagout (LOTO) safety course from Safety First Training is an OSHA-based program that teaches proper lockout/tagout equipment procedures, required lockout tagout devices, hazardous energy sources, injury prevention, and legislative requirements.

1. Introduction, Safety Video! Review OSHA Regulations / Bill C45
2. Main causes of Lockout Tagout injuries! Hazardous energy sources! Types of devices
3. Safety procedures / logs! Safe removal of Lockout
4. Temporarily re-activating equipment procedures
5. Maintenance of the Lockout Tagout, Personal protective equipment

## 5.0. Fire Safety

### 5.1. Fire Safety Audit

The fire safety audit is the process of evaluating a building’s fire safety practices and procedures. It helps to identify potential hazards, evaluate existing safety measures, and recommend improvements.

Fire Safety Audit is important to businesses as it helps ensure that the safety of employees and any visitors is not compromised. It also ensures that there is no damage done to the property of the company or any loss of valuable assets.



Fig. 5.1.1. Fire Safety Audit

#### Benefits of Fire Safety Audit

1. Protect Life and Property
2. Improves Employee Morale and Safety
3. Increases Productivity
4. Enhances Profitability and Reduces Losses
5. Reduction of Insurance Premium
6. Enhance Reputation and Trust
7. Compliance with Regulations

#### Fire Safety Audit Standards

1. National Building Code:2016
2. IS 1644 - Code of practice for Fire Safety of buildings: Exit Requirements and Personnel hazard.
3. IS 2190 -Selection, installation and maintenance of first-aid fire extinguishers, code of practice
4. IS 2189- Selection, Installation and maintenance of Automatic Fire Detection and alarm system, Code of Practice (Third Revision)
5. IS 15683: Portable fire extinguishers
6. IS 1646-Code of practice for Fire Safety of buildings: Electrical Installations
7. IS 12459 – Code of practice for fire safety in Cable runs
8. IS 1648: Code of practice for fire safety of buildings (general) : Firefighting Equipment
9. State Building Codes

Approach and Methodology for Fire Safety Audit



Fig. 5.1.2. Methodology for Fire Safety Audit

Fire Safety Audit Service Covers:

1. Comprehensive Fire risk assessment
2. Customized audit plans based on facility type
3. Walkthrough of all floors or areas within the building (any storage facilities nearby)
4. Review of fire protection systems (sprinkler, hydrant systems, and extinguishers, etc.)
5. Evaluation of fire detection, alarm systems (smoke and heat detectors, manual points)
6. Assessment of emergency evacuation procedures
7. Assessment of any hazardous materials stored on site
8. Assess Fire safety signages and passive fire protection systems
9. Evaluate Control measures and emergency response plan
10. Assess Communication protocols and evacuation procedures
11. Evaluate the frequency and effectiveness of emergency response drills
12. Compliance check with fire safety regulations
13. Detailed reports and recommendations for robust fire safety solutions

**5.2. Fire and Gas Mapping Study (3D)**

Fire and gas mapping is a study that helps determine the location of fire and gas hazards. The study determines where the potential for fire or gas hazards is, and then it uses this information to create a plan for improving safety.

Fire and gas mapping study is a process of installing sensors in buildings to measure the amount of heat, smoke, and fire conditions that occur within their premises. This information is used by fire safety professionals to determine what precautions are necessary to ensure safety and reduce damage. The purpose of this study is to examine how the effectiveness of measures taken by building owners can be improved.

It should be noted that the results obtained from a fire or gas mapping study should not be considered definitive until after thorough testing has been conducted by an independent party.

STANDARDS	TITLE
DEP 32.30.20.11	Fire, Gas, and Smoke Detection Systems
NFPA 72	National Fire Alarm Signalling Code
NFPA 12	Standard on Carbon dioxide extinguishing systems
NFPA 2001	Standard on clean agent fire extinguishing systems
IEC 61508	Functional Safety of electrical/ electronic/ programmable electronic safety-related systems
IEC 61511	Functional safety – Instrumented systems for the process industry sector
ASME B 31.8	Gas Transmission and Distribution Piping Systems
UK HSE	Land Use Planning Guidelines

### 5.3. Fire Load Calculation

Fire Load Calculation is the process of measuring the total amount of combustible material present in a specific space or building.

This involves:

1. Identifying combustible materials: Wood, plastics, textiles, and even certain liquids fall under this category.
2. Quantifying their weight: Every kilogram of these materials translates to potential fuel for a fire.
3. Applying calorific values: Each material has a specific “heat release” value, indicating how much heat it generates when burned.
4. Calculating fire load: Multiplying weight by calorific value for each material and adding them together gives you the fire load in kilojoules per square meter (kJ/m<sup>2</sup>).

Fire load Calculation is instrumental for a multitude of reasons such as when evaluating active and passive protection systems required in a building, conducting fire scene investigations, modeling the movement of fire, smoke, and gases in buildings, and assessing insurance premiums. They are also useful in establishing building risk profiles when preparing fire safety risk assessments.

Classifications of Fire Load Calculation

#### 1. High Hazard

These occupancies hold the highest potential for rapid and intense fires due to the presence of large quantities of highly flammable materials. Think factories storing plastics, chemical plants, or warehouses brimming with textiles. Here, fire load typically exceeds 550,000 kcal/m<sup>2</sup> (220,000 Btu/ft<sup>2</sup>), necessitating robust fire protection measures like sprinkler systems, fire walls, and specialized ventilation systems.

#### 2. Moderate Hazard

Occupancies in this category fall between the extremes, housing a moderate amount of combustible materials. Examples include retail stores with stocked shelves, offices with furniture and equipment, or multi-story car parks. Their fire load ranges from 275,000 kcal/m<sup>2</sup> (110,000 Btu/ft<sup>2</sup>) to 550,000 kcal/m<sup>2</sup>, requiring a balanced approach to fire safety. Automatic sprinklers are often mandatory, along with adequate separation between compartments and clear evacuation routes.

#### 3. Low Hazard

These occupancies pose the least fire risk due to limited combustible materials. Think residential buildings, libraries with mostly non-flammable materials, or churches with primarily stone and concrete structures. Their fire load sits below 275,000 kcal/m<sup>2</sup> (110,000 Btu/ft<sup>2</sup>), allowing for simpler fire safety measures like smoke detectors, portable extinguishers, and clear escape routes.

Fire load directly impacts the intensity and spread of a potential fire. Knowing the fuel available helps us design effective fire protection measures like:

1. Sprinkler systems: The intensity of a fire determines the required water flow for effective suppression.
2. Fire walls: These barriers limit the spread of fire by compartmentalizing spaces based on fire load.
3. Building materials: Fire-resistant materials can slow down or even prevent the spread of fire.
4. Evacuation planning: Knowing the potential fire growth rate helps design safe exit routes.

### Benefits of Fire Load Calculation

1. Fire Load Calculation plays an important role in determining the basis for the assessment and mitigation of fire risks for any industry. This indicates how much heat is released per unit area for a site when its contents and the area are completely burned.
2. In engineering theory and by compliance, all fire systems of infrastructure should be designed based on total fire load. This fire load is calculated for all flammable substances present and their calorific values.
3. There are several methods for Load Calculation and can be utilized on a case-to-case base such as Weight Inventory or a combination of both. There are other several associated exercises that help in the better design of a fire system such as the categorization of fire load in various categories, allocation of fire fighting equipment and resources based on respective loads of areas, etc.

### Fire Load Calculation Standards

1. NFPA 557 Standard for Determination of Fire Loads for Use in Structural Fire Protection Design
2. IS 1646 Indian Standard Code of Practice for Fire Safety of Buildings (General): Electrical Installations (Second Revision)
3. BS EN 1991-1-2:2002 Actions on structures exposed to fire
4. NBC 2016 National Building Codes 2016

### **5.4. Emergency Response and Disaster Management Plan**

Emergency Response and Disaster Management Plan (ERDMP) is a comprehensive roadmap for how organizations will respond to and manage various emergency situations and potential disasters.

It's essentially a blueprint for action, aiming to:

1. **Minimize harm and damage:** The primary goal of an ERDMP is to protect human life and property in the event of an emergency. This involves anticipating potential threats, outlining clear response procedures, and ensuring resources are readily available.
2. **Maintain continuity of operations:** Emergencies can disrupt business operations, but a well-prepared ERDMP helps minimize downtime and ensure critical functions continue. This includes establishing alternative communication channels, assigning backup personnel, and outlining recovery procedures.
3. **Enhance preparedness and response:** Having a documented plan improves organizational preparedness by raising awareness, assigning roles and responsibilities, and facilitating training and drills. This proactive approach leads to faster and more effective responses when actual emergencies occur.

Key Elements of an ERDMP Typically Include: Risk assessment, Response protocols, Command structure, Resource allocation, Training and drills, Review and update

ERDMP Includes:

1. A description of what constitutes an emergency or disaster
2. A list of the types of emergencies that you might encounter
3. An outline of your organisation's response to each type of emergency
4. Procedures for notifying employees, customers, and others about emergencies
5. Procedures for reporting injuries or illnesses

## 6.0. Other Safety

### 6.1. Road Safety

Road Safety Audit is a process that identifies areas of risk on a roadway, including hazards, and assesses the effectiveness of current procedures for mitigating those risks. The road safety audit analyses the causes behind these accidents and makes recommendations for improvement to increase road safety and reduce the likelihood of accidents.

The goal of a Road Safety Audit is to reduce the number of road accidents and injuries that occur on any given roadway. The audit process includes identifying areas where drivers can be distracted or distracted by other drivers, as well as areas where pedestrians are at risk. It also takes into account whether there are enough lighting fixtures installed near street corners or intersections.

#### Benefits of Road Safety Audit

1. **Accident Prevention at its Core:** Road Safety Audit proactively scrutinize roads, unearthing potential hazards like blind corners, confusing signage, or inadequate lighting. By addressing these flaws before they claim victims, Road Safety Audit significantly reduce accident rates and severity.
2. **Comprehensive and Rigorous:** This detailed process takes a deep dive into traffic patterns, accident data, and infrastructure design. From pedestrian crossings to construction zones, no stone is left unturned in the quest for improved safety.
3. **Tailored for All Users:** Road Safety Audit goes beyond drivers, embracing the needs of every road user. Cyclists, pedestrians, and even vulnerable groups like children and the elderly are factored in, ensuring an inclusive approach to safety.
4. **Beyond Compliance, Building Resilience:** Road Safety Audit is also about building roads that adapt to future challenges. Be it unpredictable weather events, such as a landslide or a flood, or evolving traffic patterns, RSAs recommend measures to enhance long-term resilience.

The auditing process is designed to help you find ways to improve road safety performance and reduce the number of accidents on your premises. It can also help identify possible hazards that could cause injury or death to people working on-site or using your facilities.

Audit can be carried out in three phases

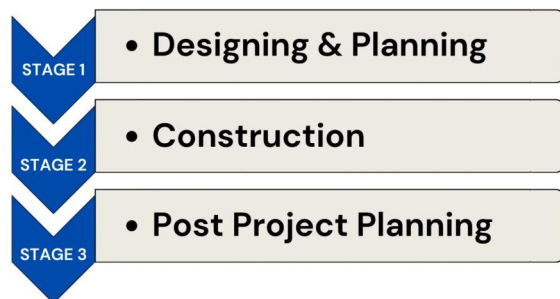


Fig. 6.1. Road Safety Audit Phases

Accident-related data, document assessment, site inspections, etc. are carried out throughout the auditing to identify accident black spots, obtain traffic volume count, and site construction practices, etc. where safety audit reports are proposed for safety recommendations.

The sole objective of the process is to minimize future road accident occurrence and severity once the scheme has been built and the road comes into use.

Advantages of Road Safety Audits include:

1. Minimize the risk & severity of accidents on the roads.
2. Optimize the road as per the needs & perceptions of all types of road users.
3. Ensure construction workers' health & safety.
4. Ensure environmental safety of work zones
5. To minimize the risk of accidents on the road.
6. Ensuring the safety of vulnerable users like cyclists & pedestrians.

Road Safety Standards:

1. Safety Manual NHAI
2. IRC: SP:88-2010 "Manual on Road Safety Audit"
3. IRC:SP:84-2009 "Manual of Specifications & Standards for four landing"
4. IRC: SP:55 "Guidelines on Safety in Road construction zones"
5. IRC:35 "Code of Practice for Road Markings"
6. IS-4756 "Safety Code for tunneling works"
7. BS-6164 "Code of Practice for Health and Safety in tunneling in the construction industries"

## 6.2. Construction Safety

Construction Safety Audit is a systematic, independent examination of a construction site's safety practices and procedures. It audits every aspect of safety, uncovering potential hazards before they evolve into accidents and injuries. A construction safety audit can help make sure that the site is being managed properly.

Guiding Principles & Construction Safety Audit

Construction safety audits adhere to internationally recognized standards like ISO 45001: Occupational Health and Safety Management Systems and OSHA (Occupational Safety and Health Administration) guidelines. These standards provide a robust framework for evaluating various aspects of site safety, ensuring a comprehensive and consistent approach.

The construction safety audit entails a multi-pronged approach:

1. Site Inspection
2. Hazard Assessment
3. Actionable Recommendations
4. Continuous Improvement

The Most important areas, during the audit at the construction site are as follows:

1. Scaffolding
2. Fall protection (scope, application, definitions)
3. Excavations (general requirements)
4. Ladders
5. Head protection
6. Excavations (requirements for protective systems)
7. Hazard communication
8. Fall protection (training requirements)
9. Construction (general safety and health provisions)
10. Electrical (wiring methods, design and protection)

### 6.3. Safety Audit

The audit is carried out as per IS 14489: 1998 on “Code of Practice on Occupational Safety & Health Audit” to check the compliance with the Factories Act, 1948 and Rules for respective states, The Environmental Protection Act & Rules and the Explosives Act.

Elements of IS-14489 Safety Audit:

1. Occupational Health & Safety Policy
  - OS&H Organizational setup
  - Education & Training
  - Employees participation in OS&H Management
  - Motivational & promotional measures for OS&H
  - Safety Manuals and Rules
  - Compliance with Statutory requirements
  - New Equipment review and Inspection
  - Accident reporting analysis, investigation and recommendations
  - Risk Assessment including Hazard Identification
  - Safety Inspections
  - Health and safety improvement plan/targets
  - First aid facilities- Occupational health center
  - Personal Protective Equipment
  - Housekeeping
2. Electrical & Personal Safeguarding
  - Material Handling Equipment
  - Ventilation, Illumination, and noise
  - Prevention of occupational diseases including periodic medical examination
  - Safe Operating Procedures and Work Permit Systems
  - Fire Prevention, Protection & Fighting Systems
  - Emergency Preparedness Plans (Onsite/Offsite)
  - Process Plant modification procedure
  - Transportation of Hazardous substances
  - Hazardous waste treatment & disposal
  - Safety in storage and warehousing
  - Contractor safety systems
  - Safety for Customers (including MSDS)
  - Machine and general area guarding
3. Safety Management System
  - Safety & Health Policy
  - Hazard identification, risk assessment, and determining controls
  - Accident Reporting & Investigation
  - Occupational Health Monitoring
  - Statutory Compliance and Review of Legal Register
  - Employee Safety Training
  - First-Aid Centre
  - Safety Communication / Motivation and review of SOPs
4. Safety in Operations & Maintenance
  - Review of critical SOP
  - Change Control Procedures
  - Work Permit System
  - Review of maintenance practices of Critical Equipment
  - Work injury prevention – Manual and mechanical Material Handling



5. Electrical Safety
  - Identification of electrical hazards (shock, fire, overloading)
  - Sample review of Hazardous Area Classification
  - Sample review of earthing and bonding practices; static electricity
  - Review of electrical maintenance systems and practices; LOTO
  - Review of Lightning protection system
6. Safety in Operations & Maintenance
  - Review of critical SOP
  - Change Control Procedures
  - Work Permit System
  - Review of maintenance practices of Critical Equipment
  - Work injury prevention – Manual & Mechanical Material Handling / Guarding
7. Fire Prevention & Protection
  - Identification of fire hazards
  - Review of fire prevention practices and review of SOPs
  - Review of Fire Protection System – Active & Passive Systems
  - Adequacy of Fire Protection System – Design and Performance Review against Standards
8. Hazardous Materials / Chemicals
  - Study of loading, unloading, and handling operations of hazardous materials and chemicals in the plant, including storage and processing areas
  - Review of safety features
9. Emergency Management Review
  - Review of the emergency management plan
  - Effectiveness of existing infrastructure to handle emergencies
  - Mock drills
  - Mutual Aid

#### **6.4. Behaviour Based Safety**

Behavior Based Safety (BBS) is a proactive approach to workplace safety that transcends traditional hazard control measures. It delves into the psychological and social factors influencing worker behavior, aiming to understand and shape choices that prioritize safety. By observing daily tasks, analyzing motivations, and providing positive reinforcement.

Behavior Based Safety (BBS) operates and focuses on a scientific foundation, adhering to recognized standards like BS OHSAS 18001:2007 and ANSI/ASSE Z10. These standards provide a framework for understanding human behavior within safety systems, allowing for targeted interventions that address the root causes of unsafe practices.

Implementing BBS Empowers Organizations to Achieve:

1. **Reduced Accident Rates:** Studies show BBS can cut incident rates by 50% or more, saving lives and reducing financial burdens from injuries and lost productivity.
2. **Enhanced Workforce Engagement:** BBS fosters a sense of ownership and responsibility for safety amongst employees, leading to a more engaged and motivated workforce.
3. **Improved Productivity and Performance:** Safe workplaces translate to fewer disruptions and a focus on efficient performance, boosting overall productivity and profitability.
4. **Stronger Company Culture:** BBS builds trust by encouraging open communication about safety concerns, creating a more positive and supportive work environment.

## 6.5. Safety Training

Safety training refers to structured learning programs designed to equip employees with precautionary processes and procedures. It empowers them to mitigate risk, prevent injuries, and ultimately safeguard themselves and their colleagues. This vital form of compliance training goes beyond mere legal requirements, protecting not just your organization from liability, but also fostering a culture of safety that permeates every aspect of your workplace.

### Benefits of Safety Training

Benefits of safety training extend far beyond mere compliance. It's an investment in your most valuable asset – your people – and delivers a cascade of positive impacts. It prioritizes the well-being of your employees, strengthens your company culture, and delivers tangible positive outcomes for both individuals and your organization.

#### For Employees:

1. **Safeguard their well-being:** Equipping employees with the knowledge and skills to navigate their work environment safely minimizes the risk of injuries, illnesses, and fatalities. This not only protects their physical health but also fosters a sense of security and well-being, leading to improved morale and job satisfaction.
2. **Empowerment and Confidence:** Effective safety training empowers employees to become active participants in creating a safer workplace. They learn to identify hazards, report issues proactively, and implement safe work practices, boosting their confidence and sense of ownership.
3. **Enhanced Skills and Productivity:** Safety training often overlaps with essential job skills, like safe equipment operation, proper lifting techniques, and emergency response procedures. This not only reduces errors and accidents but also increases efficiency and productivity.

#### For Organization:

1. **Reduced Costs and Liabilities:** Accidents and injuries not only cause human suffering but also incur significant financial costs through medical bills, lost productivity, and potential lawsuits. Proactive safety training significantly reduces these expenses and safeguarding your business against legal liabilities.
2. **Improved Safety Culture:** A comprehensive training program fosters a culture of safety from the ground up. Employees become more mindful of safety measures, leading to a ripple effect of increased awareness, responsible behavior, and overall risk reduction.
3. **Boosted Employee Retention and Recruitment:** A safe and healthy work environment attracts and retains top talent. Demonstrating a commitment to employee safety through active training programs reinforces your employer brand and positions you as a responsible and caring organization.
4. **Increased Operational Efficiency:** When accidents and injuries are minimized, downtime and disruptions are reduced. This leads to smoother operations, improved workflow, and ultimately, enhanced overall efficiency.

#### Safety Training include:

1. **Workplace Safety:** Manual Handling, Electrical Safety, Material Handling, Road Safety Training, Construction Safety Training, Emergency Response Training.
2. **Fire and Emergency:** Fire Extinguisher Training, First Aid Courses, Emergency Response Training and Mock Drills.

3. Process Safety: Process Safety Management, Hazardous Area Classification, Dust Explosions Safety, HAZOP Leadership & Management, Safety Integrity Level (SIL), Electrostatic Hazards, Layers of Protection Analysis (LOPA).
4. Management and Culture: Safety Management Systems, HSE Training, Safety Behaviour and Culture, Standard Operating Procedures & LOTO Training.
5. Compliance and Accreditation: Energy Management, ISO 5001.

### **6.6. Risk Inspection Survey**

A risk inspection or assessment survey is not an audit. A risk assessment is a method used to identify weaknesses that might prevent a business unit from achieving its goals and objectives. Part of the process is to identify the activities of the business unit and determine what could prevent the area from achieving its goals or mission.

Risk inspection surveys are used by businesses across industries to minimise their exposure to liability, as well as to improve efficiency, productivity, and quality. The process of conducting a risk inspection survey involves identifying potential hazards in your workplace and implementing preventative measures before anyone gets hurt.

Objectives of risk inspection survey:

1. To identify weak areas within a business unit.
2. To direct resources effectively. Too many people or too much time may be spent on processes that do not need attention while 'riskier' processes are lacking in attention.
3. To communicate risks – an end product that will visually show you and upper management where the problems are.

Risk Inspection Covers: Fire Risk, Electrical Risk, Process Risk, Statutory compliance, Machine Handling, Vehicle movement, Hazardous and Non-hazardous material Storage, Maintenance Practices, Material handling

### **6.7. Loss Assessment**

Loss assessment is the process of determining how much money a business has lost as a result of a natural disaster, such as a flood, fire, or accident. This process can be complicated and difficult, but it is an important part of the insurance claims process.

Inspection & Loss Assessment survey carried out by Wire Consultancy on account of the following types of claims, Marine Cargo, Engineering, Fire and Manufacturing facilities

Loss assessments are often part of an insurance claim, and they should be undertaken by professionals who have experience with this type of work. Loss assessments help insurers determine what kind of assistance they must provide to their policyholders after a disaster strikes.

The Loss Assessment Process includes:

1. An initial consultation to determine whether we are a good fit for your needs
2. A thorough review of your policy documents, including declarations page and riders
3. An examination of any relevant correspondence between yourself and the insurer
4. An examination of any relevant correspondence between yourself and the insurance company's adjuster or appraiser
5. A review of all of the physical damage reports, photographs, estimates, and others.

## 7.0. Environmental Studies

### 7.1. Environmental Impact Assessment Study

Environmental Impact Assessment (EIA) is the process by which the anticipated effects on the environment of a proposed development or project are measured. If the likely effects are unacceptable, design measures or other relevant mitigation measures can be taken to reduce or avoid those effects. The objective of Environmental Assessment is to identify and minimize potential adverse environmental impacts from plans and projects during the planning process.

Scope of Environmental Impact Assessment (EIA)

1. Screening of the projects
2. Scoping to identify which potential impacts are relevant to assess (based on legislative requirements, international conventions, expert knowledge, and public involvement), to identify alternative solutions that avoid, mitigate, or compensate for adverse impacts on biodiversity (including the option of not proceeding with the development, finding alternative designs or sites which avoid the impacts, incorporating safeguards in the design of the project, or providing compensation for adverse impacts), and finally to derive terms of reference for the impact assessment;
3. Assessment and evaluation of impacts and development of alternatives, to predict and identify the likely environmental impacts of a proposed project or development, including the detailed elaboration of alternatives;
4. Reporting the Environmental Impact Statement (EIS) or EIA report, including an environmental management plan (EMP), and a non-technical summary for the general audience.
5. Review of the Environmental Impact Statement (EIS).
6. Monitoring, compliance, enforcement, and environmental auditing. Monitor whether the predicted impacts and proposed mitigation measures occur as defined in the EMP. Verify the compliance of the proponent with the EMP, to ensure that unpredicted impacts or failed mitigation measures are identified and addressed in a timely fashion.

### 7.2. Waste Management Study

A waste management study is a comprehensive analysis of an organization's waste generation and disposal practices. The purpose of a waste management study is to assess an organization's current waste management study practices and identify opportunities for improvement, including reducing waste generation, increasing recycling and reuse, and improving waste disposal practices.

A waste management study is a systematic examination of an organization's waste generation and disposal practices with the aim of reducing waste and improving sustainability. It assesses the types and amounts of waste generated, and current waste management methods, and identifies opportunities for waste reduction, reuse, and recycling. The study results are used to develop a waste management study plan that outlines actions for waste reduction and improved waste management practices, with a focus on improving the organization's sustainability and reducing its environmental impact.

The goal of a waste management study is to promote waste minimization and encourage the implementation of environmentally sound waste management study practices. Waste management study results can help organizations reduce their environmental impact, minimize waste disposal costs, and improve their sustainability practices.

Waste management study, all those activities and actions required to manage waste from its inception to its final disposal. This includes amongst other things, collection, transport, treatment, and disposal of waste together with monitoring and regulation. It also encompasses the legal and regulatory framework that relates to waste management study encompassing guidance on recycling etc.

There are three types of waste management study: Source Reduction, Recycling and Disposal. Waste management study examines how we deal with these materials today and how we could improve upon those methods in order to reduce their impact on our environment—and thus improve the overall quality of life for everyone who lives here.

Waste management study focuses on how we can manage our waste in an efficient way and reduce the amount of pollution caused by it. This includes looking at ways to reduce our consumption of resources such as water and electricity and finding ways to reuse items instead of throwing them away.

Waste management studies are also important because they allow us to have a better understanding of how we can manage our waste properly and efficiently. Waste management study can help us know what kind of wastes should be recycled or reused so that they do not harm our environment.

The audit's objectives will largely determine the waste types and physical locations to be audited. Some examples of audit objectives could be:

1. To determine composition and quantities of waste being generated
2. To review of current practices, including recycling and disposal methods
3. An assessment of the current space used for storage, collection, transportation and disposal of all types of waste (including hazardous)
4. To measure effectiveness of existing waste management systems
5. To identify opportunities for improving waste management systems and strategies
6. To collect data for measuring the effectiveness of waste minimisation strategies.

### **7.3. Environmental Regulatory Compliance Assistance**

Environmental regulatory compliance is the process of ensuring that a company's operations are in accordance with applicable environmental laws and regulations.

Environmental regulatory compliance assistance is an essential element of any business's business operations, whether it is for compliance with government regulations, corporate policies, or internal guidelines.

Environmental Regulatory Compliance Assistance can be provided by a team of professionals who can provide cost-effective solutions for companies that are not familiar with their legal obligations. The team will work with you to map out the processes involved in meeting your obligations and take steps to ensure compliance.

Rapid development, expansion of plants, and scaling of production are often done at the cost of environmental degradation which causes problems that have local, regional & sometimes national significance. To address this problem governments across the planet have identified trouble sources and enacted some regulations.

Some of national laws for prevention & control of Urban & industrial pollution is as:

1. Water (Prevention and Control of Pollution) Act 1974
2. Air (Prevention and Control of Pollution) Act 1981
3. Environment (Protection) Act of 1986 (EPA)

#### **7.4. Green Energy**

A Green Energy Audit is a systematic analysis of an organization's energy use and energy-related emissions with the goal of reducing energy consumption, reducing carbon emissions, and improving energy efficiency. The purpose of a Green Energy Audit is to identify areas where energy use can be reduced and to recommend strategies for energy conservation, energy efficiency improvements, and the adoption of renewable energy technologies.

The results of a Green Energy Audit can help organizations reduce their energy consumption, lower their energy costs, and reduce their carbon footprint, ultimately contributing to a more sustainable and environmentally friendly energy system.

The Green Energy Audit is a systematic identification, quantification, recording, reporting, and analysis of components of environmental diversity. The 'Green Energy Audit' aims to analyze environmental practices within and outside the college campus, which will have an impact on the eco-friendly ambiance. It was initiated with the motive of inspecting the work conducted within the organizations whose exercises can cause risk to the health of inhabitants and the environment.

The Green Energy Audit process generally includes:

1. A review of policies, procedures, and practices related to sustainable development
2. An assessment of the actual performance of the company against these policies, procedures, and practices
3. Identification of areas for improvement
4. Recommendations for improvements that will help the company meet its goals more efficiently and effectively

The results of this Green Energy Audit are then used by management to create an action plan for improving energy efficiency. This plan will include new policies for reducing consumption and waste, along with suggestions for improving internal systems like ventilation or lighting fixtures so that they may use less power overall.

Green Energy audits are important for a variety of reasons. First, they help organizations gain insight into their own sustainability practices and set goals for improvement in the future. Second, they provide an opportunity for employees to participate in the process, which helps increase engagement and improve morale.

It helps them identify any gaps between what they're doing and what the standards require, so they can address those gaps with new policies and procedures that will improve their overall performance.

The main objectives of carrying out the Green Energy Audit are:

1. To ensure that the natural resources are utilized properly as per the national policy of environment.
2. To secure the environment and cut down the threats posed to human health by analyzing the pattern and extent of resource use of the campus.
3. To establish baseline data to assess future sustainability by avoiding the interruptions in environments that are more difficult to handle and their corrections requiring high cost.
4. To bring out a status report on environmental compliance.

5. To understand the awareness of employees and learners towards environmental conservation.
6. To recognize the initiative taken by the organization towards environmental conservation.
7. To understand and recognize the effects of an organization on the environment and vice versa.
8. To study waste minimization and safe disposal of waste particularly hazardous wastes.
9. Initiatives for water and energy conservation.

**Audit Coverage:**

1. Water Management
2. Energy Management
3. Green Campus
4. Waste Management
5. Carbon Footprint

### **7.5. Environmental Audit Services**

An Environmental Audit is a periodic review of the environment for an organization. It is used to evaluate the effectiveness of an organization's environmental management system, including its policies and procedures, in achieving its goals.

Environmental Audit Services is a process of reviewing and evaluating the environmental performance of an organization. It involves identifying, quantifying, and evaluating the impacts of an organization's activities on the environment and developing methods to reduce these impacts.

A typical Environmental Audit Services includes four phases:

1. Initial assessment (or scoping) phase
2. Data collection phase
3. Analysis and interpretation phase
4. Reporting phase

An environmental audit is a systematic examination of the environmental aspects of a place or organization. Environmental audits are used to assess the current state of an environment, identify problems and risks, and recommend solutions.

Environmental audits look at all aspects of your business' operations—from manufacturing processes to waste disposal—and determine whether they are in compliance with federal, state, and local regulations. They also identify areas where you can reduce your impact on the environment by reducing waste or using less energy-intensive products.

There are many reasons why companies may choose to engage in Environmental Audit Services including:

1. To assess compliance with environmental legislation such as ISO 14001:2004 or EMAS (Eco-Management and Audit Scheme)
2. To identify opportunities for improvement in relation to waste management, energy consumption etc. - for example by identifying ways in which existing processes could be improved by implementing new technology/processes or by changing practices;
3. To identify non-conformances with environmental legislation such as HSE regulations.

## 8.0. Occupational Health Studies

### 8.1. Industrial Hygiene

Industrial Hygiene Audit is the process of evaluating the effectiveness of the safety and health program in a company or an organization. This can be done by evaluating the physical environment, operational procedures, and employee practices. The audit focuses on all aspects of an organization's operations, including workplace hazards, equipment maintenance and repair, employee training programs, and emergency response plans.

The purpose of an industrial hygiene audit is to identify potential hazards at work sites and determine whether current practices are adequate to protect employees against those hazards. These audits are often performed by external consultants who specialize in this area. The consultant will visit your facility and take samples of air quality and other environmental factors such as noise levels or chemical exposure levels.

They will also observe how employees perform their jobs so they can determine if there are any areas in which they might need improvement. For example, if your employees are using dangerous chemicals without proper protection then you may need better safety equipment or training on how to use such chemicals safely (or even discontinue using them altogether).

Thus, Industrial Hygiene Audit follows the same model of safety i.e., identifies the risk in advance, quantifies, and controls. The industrial Hygiene regulations are mainly driven by OSHA (US) and OHSAS (BS). The audits and studies carried out in the field are led by certified industrial Hygienists certified by a reputable board of Industrial Hygiene such as the American Board.

The main objective of an industrial hygiene audit is to ensure that companies have adequate safeguards in place to protect workers from hazards related to their work environment. It also ensures compliance with local laws regarding occupational health and safety regulations. The information gathered during an industrial hygiene audit will help management make informed decisions about how best to protect their workforce and overall safety record.

1. Qualitative Exposure Assessment (Risk assessment) from air and water (include testing of air and water from MOEF approved lab)
2. Quantitative Exposure Assessment (Exposure monitoring) for Toxicants (like Lead) exposure in employees
3. Area heat stress / personal heat strain monitoring
4. Hygiene Survey and Risk Assessment

Industrial Hygiene scope includes:

1. Industrial Hygiene Audit
2. Quantitative Exposure Assessment
3. Qualitative Exposure Assessment (Risk Assessment)
4. Personal Heat Stress Monitoring
5. Development of Industrial Hygiene Policies
6. Occupational Health Monitoring
7. Occupational Exposure Limit
8. Ventilation Measurement
9. LUX Level Measurement
10. VOC Measurements



## 8.2.Ergonomics Study

Ergonomics study is a scientific discipline that focuses on the design of work environments and tasks to optimize human performance, comfort, and safety. Ergonomics study involves the application of knowledge about human anatomy, physiology, and psychology to the design of work environments, workstations, equipment, and tools to minimize physical strain, injury, and fatigue.

Benefits of Ergonomics Studies:

1. **Reduced Workplace Injuries:** Minimize musculoskeletal disorders (MSDs) and other work-related injuries, lowering healthcare costs, insurance premiums, and employee downtime.
2. **Enhanced Productivity and Efficiency:** Optimized workflows, improved posture, and reduced fatigue lead to increased output and quality.
3. **Improved Employee Wellbeing and Morale:** Happier, healthier employees are more engaged, motivated, and loyal to your company.
4. **Attract and Retain Top Talent:** Showcase your commitment to employee well-being and safety, becoming an employer of choice.

Purpose of Ergonomics Study

The purpose of an ergonomics study is to identify and eliminate or reduce physical strain, injury, and fatigue that can arise from performing work tasks. This is achieved by analyzing the physical demands of specific tasks, the design of workstations, and the use of tools and equipment, and making recommendations to improve the ergonomics of the work environment. The results of an ergonomics study can help organizations improve worker comfort, reduce the risk of injury, increase productivity, and enhance the overall safety of the work environment.

Scope of Ergonomics Study

Let's dissect the scope of Ergonomics Study:

### 1. Workstation Design

Ergonomics ensures it's not just aesthetically pleasing, but also functionally conducive to productivity and well-being. This involves:

- **Layout Optimization:** Arranging equipment and furniture to minimize reaching, awkward postures, and unnecessary movement.
- **Height Adjustment:** Ensuring desks, chairs, and monitors are positioned at optimal levels for individual comfort and posture.
- **Lighting Control:** Balancing natural and artificial light to prevent glare.
- **Temperature and Ventilation:** Maintaining a comfortable temperature and proper air circulation to avoid fatigue and discomfort.

### 2. Tool Selection and Application

The right tools are essential for any job, but ergonomics takes it a step further by ensuring tools are not just functional but fit the user. This means:

- **Sizing Considerations:** Selecting tools with handles and grips adapted to different hand sizes and grip strengths.
- **Weight Management:** Opting for lightweight tools or providing assistive devices to minimize muscle strain.
- **Design Optimization:** Choosing tools with features that reduce awkward postures and repetitive motions.
- **Training and Education:** Instructing employees on proper tool use techniques to prevent misuse and potential injuries.

### 3. Hazard and Risk Control

Workplaces can harbor hidden dangers, but ergonomics acts as a shield. It employs various methods to identify and mitigate potential hazards and risks:

- **Task Analysis:** Examining work tasks to identify repetitive motions, forceful exertions & awkward postures that could lead to musculoskeletal disorders.
- **Risk Assessment:** Evaluating equipment, tools, and environmental factors to pinpoint potential hazards like slips, trips, and falls.
- **Engineering Controls:** Implementing modifications to workstations, tools, and processes to eliminate or minimize identified hazards.
- **Administrative Controls:** Enforcing work practices and procedures that reduce exposure to risks, such as rotating tasks and scheduling proper breaks.

### 4. Evaluation

Ergonomics is not a one-time fix. It's a continuous process that requires evaluation and refinement. This includes:

- **Monitoring Employee Health:** Tracking MSD rates, absenteeism, and employee feedback to assess the effectiveness of implemented ergonomic interventions.
- **Data Analysis:** Using data collected through various methods to identify areas for further improvement and tailor interventions to specific needs.
- **Regular Reviews:** Conducting periodic workplace assessments to adapt to changes in tasks, equipment, or personnel.

By embracing the comprehensive scope of ergonomics study, businesses can build safer, healthier, and more productive work environments. It's an investment in their employees' well-being and a surefire way to unlock the full potential of their workforce. Remember, a happy and healthy employee is a thriving employee!

The range of Ergonomics Study:

1. **Human Factors Analysis:** Deep dive into the human-environment interaction to identify risk factors and opportunities for improvement.
2. **Ergonomic Design:** Design workstations, tools, and processes that are safe, comfortable, and maximise efficiency.
3. **Ergonomic Evaluation:** Assess existing workplaces and identify areas for ergonomic intervention.

Ergonomics study techniques include:

1. Evaluate the activities using selective methodology /tools like: Rapid Upper Limb Assessment – RULA
2. Characterisation / establishment of potential hazard area
3. Rapid Entire Body Assessment – REBA and Data interpretation
4. SNOOK Table
5. Hand Arm Vibration (HAV)
6. NIOSH Methods: like NIOSH Lifting index (Single/Multitask)
7. MSD & Ergo Hazard identification

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# Photo Credit 1: WIP<sup>1</sup> Sites – Poster

## KEY MESSAGE POSTER

### WORKING AT HEIGHT

A Key Message Poster on working at height and the key controls to follow to avoid the risks.



DEMHA TECHNOLOGY INSTITUTE  
*Invest in the Future*

### WORKING AT HEIGHT:

When working at height, outside of collective fall protection, always protect yourself against a fall.

### THE RISKS

Falling from height.

Falling objects.

### KEY CONTROLS:

<p>Be trained and authorised before working at height.</p>	<p>Inspect fall protection equipment.</p>	<p>Only use equipment tagged 'safe for use'.</p>	<p>Barricade the area below and attach tools to wrist lanyards.</p>
<p>Maintain 3 points of contact while using ladders.</p>	<p>Always tie off.</p>	<p>Have a rescue plan.</p>	<p>Wear the correct PPE.</p>

<sup>1</sup> WIP – Work in Progress

**Photo Credit 2: Integrating Workplace Safety and Wellness**



**End Note**