Global EHS - Design Performance Standard

CONTROL INFORMATION

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Contents

Tables

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1 Purpose

The purpose of this standard is to establish minimum EHS design criteria for new constructions at Micron facilities worldwide. This document presents EHS design requirements and considerations related to CSA and MEP design, and Room Readiness. Additional EHS design requirements may be called out in Facilities System Standards as well as National Codes and Standards. Therefore, it is necessary for the project design team to comply to the requirements outlined in this document as part of the Facilities Global System Standards and not as a stand-alone document.

2 Scope

Items	Details
Site(s) Impacted	All Micron sites worldwide
Target Audience	Global and Site EHS, Global and Site PSM, Global Facilities Construction & Engineering Team, Site Construction and Tool Install Teams, Equipment Procurement Team, Site IE Planning Teams Equipment
Applicability	This Standard is applicable for any greenfield construction, or any new addition and alteration to an existing facility under Micron's control This Standard is not applicable to workplaces located in buildings not managed directly by Micron

3 Roles and Responsibilities

Roles	Responsibilities
Engineering Manager	• Responsible for engineering integrity and functions • Allocate design work to appropriately qualified and experienced personnel • Organize workshops to engage appropriately qualified and experienced personnel • Ensure the requirements of the Engineering System are implemented • Implement this standard to deliver the required safety outcomes by incorporating Safety in Design within the design process
Design Manager	• Responsible for design functions • Allocate design work responsibilities • Ensure the requirements of the Engineering System are implemented
Construction Manager	• Ensure construction work is planned and managed in a way that prevents or minimizes negative safety outcomes for all persons undertaking the construction work and persons at or near the workplace during the construction work. • Consultation with the designer • Ensure that a Facility Siting Analysis, addressing all credible hazards to all occupied facilities, is performed and that all necessary actions are carried out
Design Coordinators	• Responsible for coordinating design implementation • Allocate work to the design team • Ensure the requirements of the Engineering System are implemented
Designer	• A qualified person responsible to prepare design • Demonstrate that they have identified and managed the risks in their design process

Roles	Responsibilities
	• Communicate to their Service Line Leader Best-Known Methods, Lessons Learned, Safety in Design tools, safety outcomes and relevant standards for integration into the Safety in Design data base
Project-specific change review board	• A panel consisting of Designer, Project Manager, Representatives from Global Facilities, Global Construction and Global EHS responsible to review and approve deviations from this design standard.
Site Leadership, Site EHS, or designee	• Supervision and enforcement of Micron EHS Policies and Standards for Contractor at site level. • Ensure that designers are appropriately briefed on Micron global and site EHS requirements before commencing design works. • Ensure compliance to Micron global EHS Standards, site EHS requirements and local applicable Governmental Regulations.
Global EHS	• Develop, communicate, review, and update the standard regularly. • Enforce the requirements outlined in this standard. • Audit the compliance to the standard through regular audit and site reviews.
Procurement	• Include Global EHS Standards into Procurement supplier onboarding process. • Inform designers of changes and updates to Global EHS - Design Performance Standard.

4 Terms and Definitions

Terms	Definitions
AEC	**Architecture, Engineering & Construction**
ALARP	**As Low As Reasonably Practicable** Refers to reducing the residual risk within practicable limits of construction, operation, and cost. In order for a risk to be considered ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained.
ANSI	**American National Standards Institute**
CFR	**Code of Federal Regulations**
CHAIR	**Construction Hazard Assessment Implication Review** Hazard assessment tool Published by Work cover NSW, Australia. CHAIR-1 Study: Conceptual Design Review, CHAIR-2 Study: Detailed Design Construction or Demolition Review, and CHAIR-3 Study: Detailed Design Maintenance & Repair Review
CHAZOP	**Controls Hazards & Operability Analysis** Structured hazard identification tool for instrument, control, and computer systems.
CSA	**Civil/Structural/Architectural**
CUB	**Central Utilities Building**
DMP	**Design Management Plan** Document describing “how” the design work will be carried out.
DVB	**Distribution Valve Box**

Terms	Definitions
EIA	**Environmental Impact Assessment** Regulatory requirement for projects with the potential to cause environmental, social, or economic impacts.
EPA	**Environmental Protection Agency** The Environmental Protection Agency is an agency of the United States federal government whose mission is to protect human and environmental health.
FFL	**Finished Floor Level** Finished floor level (FFL) refers to the uppermost surface of a floor once construction has been completed but before any finishes have been applied. So, in concrete construction it may be the uppermost surface of a screeded finish.
FMEA	**Failure Mode and Effect Analysis** Reliability analysis intended to identify potential failures of components that have significant consequences upon the system performance.
FMECA	**Failure Mode, Effect and Criticality Analysis** Means to identify and understand the importance of a component failure upon the system in order to recognize the level of additional controls that are required.
FMS	**Facilities Management System**
GATE REVIEWS	A formal review conducted at prescribed points in the project's life cycle. The purpose is to determine whether a project/phase has approval to proceed (“Go”), will be terminated (“No Go”), or will be asked to complete specified actions before the gate decision can be made.
HAZAN	**Hazard Analysis** Structured process which forms part of the HAZID study to identify risks in the design and record the actions to address the issues. Includes risk analysis to identify priorities and acceptability of the risk.
HAZID	**Hazard Identification Study** Structured process to identify risks in the design and record the actions to address the issues. May exclude risk analysis (HAZAN) where a simple record of risks and actions needs to be recorded and tracked.
HAZOP	**Hazard & Operability Study** A structured risk assessment designed to identify potential deviations from the design intent through the use of guidewords. HAZOP is applied to process and material flows.
HPD	**Hazard Prevention by Design** Safety by Design Process where engineering methodologies are used in a structure manner to identify potential hazards and to eliminate them by appropriate design.
HPM	**Hazardous Production Material** Any gas, liquid or solid that has the potential to be hazardous or impact a person’s health and safety. A chemical or specialty gas that is used in processing wafers that has a degree-of-hazard rating in health, flammability or reactivity of Class 3 or 4 as ranked by the Uniform Fire Code (UFC)

Terms	Definitions
IBC	**International Building Code** The International Building Code establishes minimum requirements for building systems using prescriptive and performance-related provisions. It is founded on broad based principles that make possible the use of new materials and new building designs.
IFC	**International Fire Code** The International Fire Code contains minimum requirements to safeguard life and property from fires and explosion hazards.
LSS	**Life Safety System** Any interior building element designed to protect and evacuate the building population in emergencies, including fires and earthquakes, and less critical events, such as power failures.
MEP	**Mechanical/Electrical/Plumbing** Refers to the systems that exist in a construction site that must have technically competent design and installation if the building is to be safe and function correctly.
NEC	**National Electrical Code** NFPA 70, National Electrical Code (NEC) is the benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards.
NFPA	**National Fire Protection Association** The National Fire Protection Association (NFPA) is an international nonprofit organization devoted to eliminating death, injury, property, and economic loss due to fire, electrical and related hazards. Leading information and knowledge resource on fire, electrical and related hazards.
NIOSH	**National Institute for Occupational Safety and Health** The National Institute for Occupational Safety and Health is the United States federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness.
ODA	**Oxygen Dissociation Assay** Spectrophotometric based screening platform for hemoglobin-O2 affinity modifiers.
OSHA	**Occupational Safety and Health Administration** The Occupational Safety and Health Administration (OSHA) is a large regulatory agency under the United States Department of Labor that is charged to assure safe and healthy working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.
POC	**Point of Connection** The physical location where the equipment connects to the facilities electrical source.
PPE	**Personal Protective Equipment** Any of a series of specialized devices, clothing or equipment's worn by employees for protection against hazards. PPE includes anything from gloves to full-body suits with self-contained breathing apparatus.
SA	**Siting Analysis** A mandatory analysis for occupied facilities to ensure that occupied facilities are properly located and that personnel inside the building are at no more risk than necessary.

Terms	Definitions
SDS	**Safety Data Sheet** Document that describes hazard information for a specific material especially chemicals. More commonly referred to as MSDS (Material Safety Data Sheet).
SRL	**Self-Retracting Lifeline** A self-retracting lifeline is a type of lanyard that allows a user to move around freely within an area. The lanyard rolls out and retracts based on the user's movement. The retracting function ensures the lifeline is always kept taut.
TLV	**Threshold Limit Value** Refers to airborne concentrations of substances and represents conditions under which it is believed that nearly all workers may be exposed to day-after-day for a working lifetime without adverse effects. Established by the American Conference of Governmental Industrial Hygienists (ACGIH).
UPS	**Uninterrupted Power Supply** An uninterruptible power supply or uninterruptible power source (UPS) is an electrical apparatus that provides emergency power to a load when the input power source or mains power fails.
UPW	**Ultra-Pure Water** Water that has been purified to high levels of specification.
UV	**Ultraviolet** Ultraviolet" means "beyond violet" (from Latin ultra, "beyond"), violet being the color of the highest frequencies of visible light. Ultraviolet has a higher frequency (thus a shorter wavelength) than violet light.
VOC	**Volatile Organic Compound** An air pollutant regulated in the U.S. by the EPA. Per the EPA, VOC's are compounds that break down in the atmosphere in the presence of sunlight to form ground-level ozone. Some organic (containing carbon) compounds like acetone that are volatile (usually defined as having a boiling point lower than 250C) do not form ozone and so are technically not "VOCs" according to the EPA.

5 References

Internal References	Link
Global EHS - Confined Space Program Standard	2W4373RQWREN-1568922467-146
Global EHS - Construction Performance Standard	2W4373RQWREN-1568922467-118
Global EHS - Control of Hazardous Energy (CoHE) Standard	2W4373RQWREN-1568922467-29
Global EHS - Distracted Walking and Stairwell Safety Standard	2W4373RQWREN-1568922467-26
Global EHS - EHS Risk Assessment Standard	Q6ACPCUHTZ6P-1302918059-213
Global EHS - Electrical Safety Standard	2W4373RQWREN-1568922467-388
Global EHS - Excavation Standard	2W4373RQWREN-1568922467-695
Global EHS - Lifting and Rigging Standard	2W4373RQWREN-1568922467-82
Global EHS - Incident Reporting and Investigation Standard	2W4373RQWREN-1568922467-279

Internal References	Link
Global EHS - Standard for Storing Flammables and Combustibles	2W4373RQWREN-1568922467-25
Global EHS - Toxic Gas Monitoring and Double Containment Standard	2W4373RQWREN-1568922467-11
Global EHS - Work At Heights Standard	2W4373RQWREN-1568922467-48
Global Facilities - Design & Construction Standard - Site Establishment	A3YRXSD74VDV-57553043-410
Facilities Global System Standards	Link
Construction Plant, Machinery and Tools Safety Requirements	TEDSZF665RUJ-644690799-163
Micron Construction Safety Guidebook	TEDSZF665RUJ-644690799-168
Micron's Product Content Specification	ZN5YQVW54AFP-201381568-8232

External References	Link
Please refer to specific sections	Nil

6 Standard

The effective implementation of Safety in Design (SID) involves the continuous project risks review from the tender through the design, construction, commissioning, and, into the operation and maintenance phase. It is a staged review of risks with a continual risks elimination or reduction strategy leading to a register of residual risks.

Implementation of SID is integrated with design development as part of the Model Design Review and monitored via design review process where issues are discussed and captured during the Design Review meetings. The entire process is managed with the use of Project Risks and Engineering Issues Registers.

6.1 Global & Regulatory

The design of a new facility or an addition and alteration to an existing facility shall be consistent with:

- Local legal environment, health, and safety regulations (including environmental permits, utility agreements and any other ordinances applicable to specific projects),
- International building, fire, and equipment safety standards,
- Industry best-known methods, and
- This standard

It is not the intent of this Standard to supersede the international as well as national codes and regulations. The design team shall bring to Micron's attention any areas where Micron requirements conflict with international or national requirements for review and resolution. Any deviations from this design standard must be reviewed and approved by a project-specific change review board.

Safety in Design work carried out on the project shall comply with the appropriate local Acts and Regulations, relevant National Standards, recognized International Standards, and specified Micron requirements. Review of these standards forms part of the Safety in Design process. They are not listed in this document.

Irrespective of regulatory requirements, this Safety in Design standard is the minimum Micron requirement for projects.

6.2 Safe Design Principles

During the planning, design, construction, and operations phase of any project, safeguarding the property from potential risks is critical to the project's success.

Incorporating safe design principles from the initial phases of the project guarantees the best possible outcomes (safety measures, processes, and materials) from the beginning.

The Principles of Safe Design requires those involved in the planning, design, construction, and operations phase of the project to consider the following six essential principles:

6.2.1 Collaboration

Developers, architects to trades contractors, everyone involved in the project must ensure the project meets all safety standards. In addition to the architects and engineers who create the design, any decision-makers who influence the final outcome (including project managers, EHS professionals, and more) has a responsibility to ensure project safety. A collaborative approach amongst stakeholders makes for a

smoother, and more fail-safe process. Measures to incorporate safe design principles during the early phases of the project include:

- Conducting workshops with clients and project managers during the conceptual design stage to ensure potential issues are identified early,
- Involving specialists such as engineers or building service designers during the initial risk assessment process, particularly for unusually complex designs,
- Documenting any issues identified during the research, consultation, and user input phases to inform subsequent risk assessment, and
- Incorporating Best Known Methods and Lessons Learnt.

6.2.2 Lifecycle Assessment

Safe design applies to every phase of the building lifecycle, from the initial conception through to a building's maintenance, development, and demolition. Project Managers, both from the developers as well as the as the contractors shall not neglect the post occupancy phase of the building even amidst the tight deadlines for the project. Measures to incorporate during the construction phase of the project include:

- Preparing a safe workplan, work method statement and an on-site emergency plan factoring in environmental and spatial conditions,
- Project site-specific EHS training and inductions,
- Providing the right PPE for all workers,
- Conducting regular EHS audits during construction,
- Maximizing the use of components with off-site or on the ground prefabrication to prevent high-risk/critical risk incidents,
- Scheduling the construction of permanent stairways at the beginning of construction to minimize the hazards of temporary stairs and scaffolding.

Once the construction has concluded, the project team must ensure the site is safe for public use. This is to be achieved through:

- Research and designing for the likely workflows of the building's intended function, including site-specific hazards,
- Use of slip-resistant materials, tread and nosing on floor surfaces to ensure pedestrian safety, while still conforming to aesthetics requirements,
- Separating vehicles and pedestrians in the design of any traffic areas, and designing for forward-only vehicle movements,
- Incorporating space and floor loadings with capacity for any heavy machinery/tools/equipment that may be used in the building.

The design shall also take safe maintenance and alteration into consideration:

- Ensure building safety assessments are performed regularly to remain compliant with changing regulations over time,
- Design safe access and ample space so that maintenance can be performed safely, ideally at ground level, interstitials, above ceiling space and sub-fabs,
- Reduce the need for cleaning and maintenance by avoiding dirt traps through features such as entry mats and frames.

6.2.3 Systematic Risk Management

The project team is required to identify and control potential hazards arising throughout all the project phases. Adopting a risk-based approach early on in the design process, will enable the project team to identify hazards and mitigate it well in advance, lessening the potential costs and time delays of surprises, accidents or mishaps during construction.

A risk-based approach requires the project team to:

- Collate and review a list of potential risks based on past projects at the project outset,
- Identify causes, triggers, and responses for each risk,
- Use the Construction Hazard Assessment Implication Review (CHAIR) tool to carry out collaborative risk management with key stakeholders throughout the project,
- Utilize the hierarchy of control-based approach to risk assessment so that the hazards that can't be eliminated are dealt with appropriately wherever possible,
- Consider measures to mitigate possible emergency or natural disaster occurring through factors such as egress and siting,
- Develop stringent control systems to address deviations from intended workplan,
- Ensure the project site effectively implement the risk and workplan.
- Develop Asset Integrity Management (AIM) - Life Cycle Activities (please refer to Appendix 9)

6.2.4 Design Competence

Knowledge and capability in ensuring safe design is extremely important. Those involved in or influencing the project design shall have a comprehensive and up-to-date understanding of the vast array of relevant codes of practice and legislation, both national and international, state planning principles, regulations, ministerial specifications, local environmental plans and more. Where necessary the project team shall seek expert advice to address any knowledge gaps and ensure compliance.

6.2.5 Effective Communication

The project team is to ensure that safety standards are adhered to even after the building construction is complete. There needs to be an effective flow of information between all the stakeholders involved in the process. Rigorous documentation and open communication shall be established to ensure accurate information is shared with the stakeholders.

6.2.6 Building a Safety in Design Culture

Another crucial safe design principle is to prioritize long-term objectives of safety and wellbeing rather than the minimal short-term payoff of cutting corners on subpar products. A Safety in Design culture shall be created and supported via planning, consultation, training, auditing, studies and/or project focus groups, corporate specialists, and a community of practice.

Cost-cutting measures can backfire, with tragic consequences in the form of illness, accidents, structural failure, legal action, use of non-conforming products and even death.

The project team shall, where possible, use premium quality building supplies with a long lifespan to eliminate safety risks in the project and ensure legal compliance. The project team shall utilize independently fire-tested materials that meets rigorous fire safety standards. Independent safety testing for luminance contrast and slip resistance shall be considered. In such cases, the project shall obtain proper accreditations to ensure product's claims are trustworthy.

6.3 Safe Design Methodology

6.3.1 Collaboration

The people who make decisions affecting the design of a facility, equipment or process are to be trained in Safety in Design methodology, hazard identification and risk assessment. The method is based on the Take 5 hazard identification process, the HAZID procedure, and more.

6.3.1.1 'Take 5'

Applying Take 5 on a task or design process is a simple form of hazard identification and risk assessment where the individual or small work group has the opportunity to review the design in relation to the required safety outcomes for the proposed design.

The Take 5 process places responsibility on the individual to make the decision to proceed or not based on the process outcomes. If more than one design solution exists, the Take 5 process should be used for each design separately.

6.3.1.1.1. Take 5 Process

The Take 5 process is completed as follows by the individual or workgroup:

- Person or workgroup confirms their understanding of the scope of their work and intent of the design,
- They check if a Design Criteria for the design exists,
- They review any existing hazard report for the design,
- If there is no hazard report or clear risk analysis for the design, they will complete the Take 5 risk analysis by reviewing the design and its implementation process in five stages:
  - Think through the design task and the requirements it must satisfy,
  - Spot the hazards,
  - Assess the options and risks,
  - Make the changes required to eliminate the hazard or to minimize the risk, and
  - This is followed by the question: Can I complete the design to a level where it can be built and operated with minimal residual risk?

If the answer to the question is No, the designers or design team should liaise with their design manager or discipline lead for direction.

6.3.1.1.2. Completing a Take 5 Assessment

The Take 5 form is to be used to document the findings. The forms may be completed electronically (or handwritten and scanned) and saved in the project file. The methodology for the assessment is as follows

- Detail the task on the top of the form and date it. Think through the design task. Questions to be answered includes:
  - What is the required functionality?
  - How will it be constructed, commissioned, and used?
  - Can we use standard designs?
  - Can we move labor off site?
  - Do we have the correct or sufficient information to proceed with the design?
- Spot the hazard; visualize or review the initial design in terms of workplace needs, environment and anything else relevant to the product and identify any potential hazards. Detail all hazards and control methods to be applied on the form. Check standard prompt lists of typical hazards for construction,

operations and for each relevant discipline. Refer to Appendix 3 and 4. This is an interim risk assessment. It does not replace the design risk management process.

- Assess the residual risks (consequence and likelihood) by use of the risk matrix. If the risk analysis is rated as Low or Moderate, you are allowed to complete the design task. If the risk analysis is rated as High or Very High, you must discuss the design with the project Lead Discipline Engineers who in turn may refer the matter to the Project Manager.
- Make the changes to remove or isolate hazards, prevent people from contacting hazards and to put safety controls in place. Record the changes required on the form. Ensure the design team are aware that changes are being made to the design.
- Complete the design: Continue with the task but continually monitor the development of the design for new hazards and if the situation changes, stop and re-assess the controls.
- Sign off the form to verify that the actions required have been closed out and have this verified and signed on the form.

The Take 5 form shall be readily available (in paper or electronic format) for reference purposes and to show other designers or supervisory personnel or reviewers who have an interest in the task.

6.3.1.2 HAZID

Except for relatively small projects, a HAZID workshop hosted by the appointed project architect shall take place in addition to the 'Take 5' process. This is to ensure that personnel from outside the design team, with backgrounds as the owner, operator, maintainer, and constructor, can provide input to the process of hazard identification in the design. The identified hazards must be managed throughout the design process. The preference is for identified hazards to be designed out. Where this is not possible, the hierarchy of controls is used to select control measures to minimize the risk to ALARP and residual risk reported.

The mechanism for managing HAZID actions shall be the Safety in Design Risk Register. The risk register should be arranged to show the direct link between the hazard and control measure to aid in the interpretation by the design team and ensure correct implementation of the control measure into the design. The risk register should also show the residual risk of all hazards identified to assist in passing on this critical safety information to the owner and plant operators.

The Safety in Design Risk Register uses the HAZID worksheet as a basis and can be developed further during the project engineering design by adding recommendations from other reviews and studies such as the Fire Safety Study, Environment Protection Study, Lessons Learnt and P&ID Design Reviews. It then can act as verification that all the control measures, both existing and recommended have been incorporated into the final design.

6.3.1.3 Observations

During the design process, stakeholders shall be encouraged to carry out design observations on work in progress done by others and to communicate suggestions and recommendations back to the individual. The observation should be structured as follows:

- Review the design or work in progress,
- Discuss with the designer / engineer any potential design issues,
- Establish potential consequences, and
- Agree on outcome and discuss corrective actions with discipline lead as appropriate.

6.3.2 Lifecycle Assessment

Safety in Design applies to every stage in the lifecycle of the asset from conception to disposal. It involves eliminating hazards, preventing, or minimizing risks as early as possible in the design process. The engineers and designers need to understand the procurement, construction, operation, maintenance, and disposal requirements for the asset before starting the design. Adequate information shall be gathered and included with the design file.

6.3.3 Systematic Risk Management

Risks are inherent to any activity and cannot always be eliminated. The risk process is therefore based on contemporary risk management involving the systematic identification of hazardous events, their associated causes and control measures to define the extent and likelihood of the potential loss, and hence risk. The risks can then be prioritized and assigned actions or treatments appropriate to the level of risk. These treatments are to be used to reduce the risks. The guiding principle is that the project shall be able to demonstrate that risks have been reduced to an acceptable level (ALARP). The following concepts are central to this philosophy:

- The selection of applicable techniques for risk assessment should agree with the project's context and ensure the proper risk identification, assessment, and control,
- Applying the correct risk assessment techniques to the scope of work early and at major milestones to improve the outcomes and provide for a sustainable risk managed outcome,
- Involve a range of stakeholders (e.g.: construction, operations, maintenance) in risk workshops that affect their work and the results of their work,
- The systematic identification of risk includes the assessment of the associated causes and the potential impacts. This is used to define the level of risk and to prioritize and assign the appropriate control actions,
- Risks are reduced and controlled in an effective manner through the proactive integration of risk management thinking through prompt identification, reduction, and control of risks,
- Each treatment action must be allocated to the most appropriate responsible person for its execution and implementation. There shall be only one name allocated to each action,
- Monitoring risks throughout the project and update the risk mitigation strategies and risk register accordingly,
- Actively accepting risks where required due to their nature and treatment options, and
- Transferring the residual risks at completion of the scope of work for on-going treatment and review.

The objective of Micron's Safety in Design risk management during the delivery of projects is the identification, assessment and elimination or mitigation of design related safety risks for construction, commissioning, plant operation and disposal, and the transfer of this knowledge to downstream designers, builders and operators of the facility. This is to be achieved by the various Safety in Design activities, Design Reviews and Risk Assessments applied throughout the project stages, and their associated deliverables.

Safety in Design Risk Assessments and Design Reviews verify that EHS issues have been adequately addressed during design. Examples of Micron's specific Safety in Design hazard identification and risk assessments include: Hazard Identification (HAZID) and resulting Safety in Design Risk Register, Hazard and Operability Studies (HAZOP), Safety Integrity Level (SIL) Studies, 3D Model Design Reviews, Constructability Reviews etc. and their action closeouts. Please refer to Appendix 2 for Risk Assessment Tools.

- ISO/TR 31004:2013, Risk management — Guidance for the implementation of ISO 31000
- ANSI/NFPA 551-2022, Guide for the Evaluation of Fire Risk Assessments

6.3.4 Design Competence

The discipline head for each discipline determines the design competencies required for various aspects of design pertinent to their respective discipline. Competencies are made up of:

- Qualifications or units of competence recognized by national or international qualification framework. These include qualifications issued by schools, colleges, universities, and other registered training organizations,
- Knowledge and skills, and
- Experience.

Competency requirements for various types and aspects of design shall be setup for each discipline and be available in a manual or a competency matrix. Please refer to Appendix 7.

6.3.5 Ergonomic

Safe design also incorporates ergonomic principles. Ergonomics is a scientific, user centered discipline which plays a major role in design, but it is also a philosophy and way of thinking. An ergonomic approach ensures that the design process considers a wide range of human factors, abilities and limitations affecting end users. Ergonomics considers the physical and psychological characteristics of people, as well as their needs in doing their tasks – how they see, hear, understand, make decisions, and act. User Safety, efficiency, productivity, and comfort are indicators of how effective the design is in fulfilling its purpose.

When analyzing the needs for a designed product or space, an ergonomic approach shall address five main elements:

- The user – their characteristics, including the physical, psychological, and behavioral capacities, skills, knowledge, and abilities.
- Project and task characteristics – what the users are required to do or does. This includes task demands, capacity to make decisions, work organization and time requirements.
- The work environment – the work area and space, lighting, noise, and thermal comfort.
- Equipment design and the interface with the user – including the 'hardware' needed to perform the work and including electronic and mobile equipment, protective clothing, furniture, and tools.
- Work organization – including the patterns of work, fluctuations in workload, timing of work and the need to communicate and interact with others, as well as broader industry or economic influences.

Safe design will largely focus on the 'hardware' of the design, but the effectiveness of safe design will be optimized by addressing 'hardware' within the broader system of work as defined above.

6.3.6 Fire Safety

A Fire Safety Study shall be carried out to demonstrate that all potential fire and explosion events associated with the facilities have been identified and preventative measures addressed for each scenario. It shall address thermal radiation, explosion overpressure and flammable gas dispersion distances from typical releases. The study shall examine the soundness of the facilities' layout with respect to fire and explosion events. It also identifies the necessary passive controls (containment, fire proofing, separation distance etc.), and active fire protection controls (fire water, foam systems, etc.) required to adequately protect the facilities and personnel from the potential fire and explosion scenarios it identifies. It determines the fire detection, alert, and response requirements, and examines the consequences of

potential fire scenarios to determine the firewater and foam requirements, deluge spray, fire monitor and fire hydrant locations, and fire protection design requirements. The overall objective is to ensure safety for on and off-site personnel, and to protect equipment and the environment.

6.3.7 Misconception Management

Designs can fail to meet their Safety goals due to the design being influenced by the misconceptions of the designers. These include making subconscious assumptions, working from a base of wrong beliefs or by not considering certain scenarios.

Appendix 3 contains a list of designer's potential misconceptions. This tool shall be used in the design process when carrying out observations and hazard identifications and in the formal review workshops and focus groups. It provides the user with a series of prompts to guide the review process

6.3.8 Information Transfer

Effective communication and documentation of Safety in Design risk controls and standards shall be set up and maintained between all team members and between projects and to downstream designers, constructors, and owners. This is to be done by incorporating Safety in Design risk controls and standards into project design management and execution plans, design criteria, safety study reports, risk registers, and lessons learnt.

6.3.9 Best Known Method and Lesson Learnt

Best Known Methods and Lessons Learnt must be captured and communicated to all stakeholders for actions and integration in future works. The designer shall (where possible) review the Best-Known Method and Lessons Learnt database before starting the design to familiarize themselves with any relevant Safety in Design information, applicable standards and details relevant to the design being developed.

The engineer and designer shall communicate any new Safety in Design outcomes and relevant standards, Best Known Methods, and Lessons Learnt to their Leader for integration into the corporate data base. The Project / Engineering Manager shall inform downstream designers, constructors and owners of the Safety in Design risk controls and residual risk in the finished design.

6.3.10 Incident & Audit CAPA

Incident and audit corrective and preventive action focuses on the systematic investigation of root causes of unexpected incidences to prevent their recurrence (corrective action) or to prevent their occurrence (preventive action). Therefore, where applicable, the outcome or lessons learnt from the incidences shall be captured and communicated to all stakeholders for consideration and inclusion into existing or future works.

6.4 Safe Design Risk Management

During design the relevant risks shall be revisited at several stages:

- At the design plan stage to ensure all foreseeable risks have been included,
- At the concept review (10%) stage a HAZOP shall be conducted to ensure the proposed design has not introduced any new risks particularly in the operability and construction areas. This review should be

a plant wide operation review. The construction methods for the more significant, larger pieces of the plant should be reviewed at this stage through CHAIR-1 review.

- At the material procurement stage (30 - 60%) stage to ensure the plant items can be safely operated, maintained, set to work, and shut down. At this point, a CHAIR-2 review for detailed construction hazards shall be performed. In addition, CHAZOP shall be performed as the control system concepts is expected to be completed at this stage.
- As the detailed design approaches conclusion (90%), a final review shall take place to update the project risks register. This will ensure risks that have eliminated are removed from the risks register and those that have been reduced are appropriately tagged. At this point of time the register shall only reflect residual risks and those that the constructor and the operator need to manage.

    - ISO 10252:2020, Bases for design of structures - Accidental actions

6.4.1 Project Risks Register

The Project Risks Register shall be a live document. It shall be updated on a continuous basis. When the tender commences, the project risks register shall contain foreseeable risks for design, construction, operation, and maintenance phase added. Before the tender document is complete, the project risk register shall outline all known risks, proposed risks mitigation methods and associated cost.

The register shall be handed over to the project team when the project commences.

6.4.2 Engineering Issues Register

The Engineering Issues Register, a live document, shall outline issues relevant to the design development of the plant.

When the design commences, the Engineering Issues Register shall be populated with the design issues as they arise. Each issue shall be adequately described, assigned actions and responsible person. As the agreed solutions progress, the register is updated with comments and useful notes. It shall be populated and updated on a regular basis to capture the decision and resolution process relevant to the design development.

At the end of the engineering phase, the remaining unresolved issues in the register shall be handed over the downstream stakeholders e.g. construction, commissioning, operations teams for resolution.

6.5 Safe Design Planning and Governance

At the start of a study or project a Safety in Design Management Plan must be developed and implemented. The Safety in Design Management Plan shall identify the activities necessary to establish and maintain design safety, including Microns', and regulatory design safety requirements. A Safety in Design Action Plan shall be produced and used to guide the development and management of Safety in Design and provide input into the Safety in Design Management Plan. All project participants are to be made aware of the Safety in Design aspects of the Safety in Design Management Plan.

The governance practices of Safety in Design on a project include: Safety in Design Management Plan; Safety in Design Representative; Safety in Design Program, Safety Moments in Project Meetings and Toolbox Talks; Safety in Design leading KPIs; Safety in Design Audits and; and closeout reporting.

6.5.1 Design Representative

At the kick-off of the study or project, the Project / Engineering Manager shall nominate a Safety in Design Representative. The Project Safety in Design Representative is a nominated engineer on the project to act as a liaison between the design team, the EHS Manager, Engineering Manager, and other stakeholders.

The role of the representative is to support the Project / Engineering Manager in his safety responsibilities and to maintain a link between the Project and management. The mandate of this representative will be to support the Project / Engineering Manager by reviewing this procedure and to ensure adequate implementation through plans, training, and audits.

6.5.2 Program

Design workflow and the engineering schedule must integrate Safety in Design concepts, related design tools and appropriate control points. The design program shall integrate the Safety in Design process. Please refer to Appendix 6.

Safety in Design is not a standalone process or a single milestone to complete. It is an on-going activity incorporated into the elements of the design process across all disciplines.

6.5.3 Design Review and Project Meetings

A competent facilitator and knowledgeable participants shall be selected to take part to ensure the review meetings are meaningful. Without the right expertise the full extent of the risks cannot be determined. A Design Safety Review checklist shall be used to facilitate and guide review meetings so that the approach is methodical and thorough.

EHS shall be made a specific agenda item in all project meetings, including the Toolbox. Topics such as Safe Design Principles; Inherent Safety; Risk Controls, Best Known Methods, Lessons Learnt, etc., shall be discussed.

6.5.4 Key Performance Indicators

Key performance indicators (KPI) shall be identified, communicated, monitored, and reported during a project. It shall be used to assess safety in design performance. Examples of Safety in Design KPIs include:

Leading KPI	Measurement	Monitoring Mechanism	Target
Involvement in Safety in Design related reviews e.g., HAZID/layout/HAZOP/ Constructability, etc.	Attendance	Attendance Register	Key operations, health and safety, maintenance, engineering, and project management personnel attendance - 100 % attendance.
Review Actions	On-time review actions closeout.	Register maintained with regular reviews	100% of actions closed out by due dates
Project Meetings	Safety in Design topics incorporation	Meeting minutes	Agenda item in at least 1 project meeting in a month

6.5.5 Audits and Reviews

Discipline technical and Safety in Design audits (including Safety considerations) shall be carried out by Micron's respective discipline Engineers or their delegate, during the engineering phase of projects in accordance with the Project Audit Schedule.

6.5.6 Facility Siting Analysis

A Siting Analysis (FSA) shall be performed for all Micron controlled occupied facilities. The proposed locations of all Micron occupied facilities shall be carefully evaluated by a subject matter expert to ensure that the safety hazards are identified, the risk of harm to personnel is assessed, and the appropriate actions are taken to mitigate the risk to an acceptable level. The FSA serves primarily as a screening tool to identify hazards, assess risk to buildings and personnel, guide the location of occupied facilities, and to develop criteria for building design. One of the primary goals of the FSA is to ensure that occupied facilities are properly located and that personnel inside a building are at no more risk than necessary. Prior to mobilization and assignment of Micron's or Contractors' personnel to either permanent or temporary site facilities, the Siting Analysis shall be validated at site.

The Construction/Project Manager is responsible for ensuring that an FSA, addressing all credible hazards to occupied facilities, is performed and that all necessary actions to mitigate the risk to an acceptable level are implemented prior to taking occupancy of those facilities.

The site EHS Manager is responsible for supporting the siting of Micron and contractors' occupied facilities by providing or identifying Subject Matter Experts to perform the FSA and validation of the SA at site prior to mobilization (may include a site visit).

Please refer to Appendix 5.

6.5.7 Close Out

6.5.7.1 Deliverable Review

A safety review shall be conducted at the end of the design phase of a project to ensure the integrity of the design by confirming that the current design, including changes and additions, has undergone the relevant Design Hazard Reviews (e.g. HAZID, HAZOP, etc.) and that action items and recommendations produced from safety reviews including Take 5 reviews have been satisfactorily addressed and implemented into the design. All discipline lead engineers, and project engineers are responsible for the closeout of actions from Design Hazard Reviews.

6.5.7.2 Review Report

As part of the design closeout process, a report listing remnant risks, existing at the end of the design process, must be prepared and handed to Micron for use in the construction, operation and maintenance of the asset which was the subject of the design. The report would normally include a commentary on inherent design assumptions relevant to the construction, operation, maintenance, disassembly, and demolition of the asset. This report can form part of the study or project design phase closeout report.

6.6 Human Factors

Human factors are elements that enhance or improve human performance in the workplace. It is concerned with understanding interactions between people and other elements of complex systems. Human factors apply scientific knowledge and principles as well as lessons learned from previous incidents

and operational experience to optimize human wellbeing, overall system performance and reliability. The discipline contributes to the design and evaluation of organizations, tasks, jobs and equipment, environments, products, and systems. It focuses on the inherent characteristics, needs, abilities and limitations of people and the development of sustainable and safe working cultures.

Therefore, the designers shall undertake human factors engineering assessment to ensure that the building is designed in a way that optimizes the human contribution to production and minimizes potential for design-induced risks to health, personal or process safety or environmental performance.

Impairment	Enhancement
Physical	Dedicated parking slot complete with shelter and access
	Ramp to facilitate drop-off and pick-up
	Automated door or remotely controlled access/egress
	Wheelchair friendly access throughout the plant including security check points, pantry, cafeteria, toilet
	Height adjustable workstation
	Control panel within lifts to be lowered and made accessible
	Food displayed on bain-marie to be made visible
	Adequate seating space in the cafeteria
	Panic button at toilets and emergency hold points

- SEMI S8 - Safety Guideline for Ergonomics Engineering of Semiconductor Manufacturing Equipment
- ANSI/ASSE A10.38-2013, Basic Elements of an Employer's Program to Provide a Safe and Healthful Work Environment
- ISO 26800:2011, Ergonomics — General approach, principles, and concepts
- ISO 6385:2016, Ergonomics principles in the design of work systems
- ISO 10075-2:1996, Ergonomic principles related to mental workload — Part 2: Design principles
- ISO 11428:1996, Ergonomics — Visual danger signals — General requirements, design, and testing
- ISO 11429:1996, Ergonomics — System of auditory and visual danger and information signals
- ISO 24502:2010, Ergonomics — Accessible design — Specification of age-related luminance contrast for colored light
- ISO 11428:1996, Ergonomics — Visual danger signals — General requirements, design and testing
- ISO 24509:2019, Ergonomics — Accessible design — A method for estimating minimum legible font size for people at any age
- ISO 7731:2003, Ergonomics — Danger signals for public and work areas — Auditory danger signals
- ISO 19029:2016, Accessible design — Auditory guiding signals in public facilities
- ISO 28803:2012, Ergonomics of the physical environment — Application of International Standards to people with special requirements
- ISO 8201:2017, Alarm systems — Audible emergency evacuation signal — Requirements
- ISO/DIS 23617, Ageing societies — Guidelines for an age-inclusive workforce
- ISO 11064-5: Ergonomic design of control centres — Part 3: Control room layout
- ISO 11064-5: Ergonomic design of control centres — Part 4: Layout and dimensions of workstations
- ISO 11064-5:2008, Ergonomic design of control centres — Part 5: Displays and controls

- ISO 16817:2017, Building environment design — Indoor environment — Design process for the visual environment

6.6.1 Access & Egress

Safe access to and egress from the site shall be planned at the design stage. The designer shall be aware of, and assess the risks from, the following principal hazards:

- Falls from height caused by inadequate or unsafe access to places of work or unsafe working platforms.
- Contact with moving vehicles caused by non-separation of people and vehicles.
- Struck by moving plant or machinery, inadequate visibility, height, clearance, width for moving and maneuvering plant and machinery.
- Struck by falling objects, lifting, lowering, slewing, slinging of loads in confined space.
- Hazards of working in confined spaces caused by poor access.

Designers shall refer to ANSI/ASSE A1264.1-2017, Safety Requirements for Workplace Walking/Working Surfaces & Their Access; Workplace Floor, Wall & Roof Openings; Stairs & Guardrails Systems when designing access.

- ISO 14122-2:2016, Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways
- ISO/DIS 9241-20, Ergonomics of human-system interaction — Part 20: An ergonomic approach to accessibility within the ISO 9241 series

6.6.2 Lighting

Designers shall refer to ANSI/IES RP-7-17 Recommended Practice for Lighting Industrial Facilities when deciding on lighting intensity for a given workspace taking into consideration the needs of the task being performed. As a quick reference, the designers can refer to the table below:

#	Area of Operation	Recommended Illumination	
		(fc = lm/ft^2)	(Lux)
1	Accessways, exits, gangways, stairs	10	107.6
2	General landside areas – corridors, exits, stairs, walkways	20	215.3
3	Work areas in any vessel or platform	20	215.3
4	Landside tunnels, shafts, vaults, pumping, confined areas	20	215.3
5	Landside work areas – machine, carpenter shops, outdoor	20	215.3
6	Landside work areas – electrical equipment, tool rooms	20	215.3
7	Changing rooms, showers, break areas	20	215.3
8	Task specific – surface preparation and coating application	50	538.2
9	Task specific - Inspection	200	2152.8
10	First aid stations, infirmaries, and offices	50	538.2
11	Roads leading to dock areas or where there is potential for heavy vehicle and pedestrian interaction	10	107.6
12	Dock areas where crating and uncrating activities take place	28	300

Approved LED lights are to be used to achieve the desired lighting intensity for a given workspace.

- ANSI/IES LP-10-2020, Lighting Practice: Sustainable Lighting - An Introduction to the Environmental Impacts of Lighting
- ANSI/IES LP-11-2020, Lighting Practice: Environmental Considerations for Outdoor Lighting

- ANSI/IES LP-3-2020, Lighting Practice: Designing and Specifying Daylighting for Buildings
- ANSI/IES LP-4-2020, Lighting Practice: Electric Light Sources - Properties, Selection and Specification
- ANSI/IES LP-6-2020, Lighting Practice: Lighting Control Systems - Properties, Equipment and Specification
- ANSI/IES LP-7-2020, Lighting Practice: The Lighting Design and Construction Process
- ANSI/IES LP-8-2020, Lighting Practice: The Commissioning Process Applied to Lighting and Control Systems
- ANSI/IES RP-38-2017, Recommended Practice for Lighting Performance for Small-to-Medium-sized Videoconferencing Rooms
- ANSI/IES RP-41-2020, Recommended Practice: Lighting Theatre and Auditorium Spaces
- ANSI/IES RP-42-2020, Recommended Practice: Dimming and Control Method Designations
- ANSI/IES RP-6-2020, Recommended Practice: Lighting Sports and Recreational Areas
- ANSI/IES TM-32-2019, Lighting Practice: Building Information Management
- ISO 8995-1/CIE S 008, Lighting of work places — Part 1: Indoor
- ISO 30061/CIE S 020, Emergency lighting
- IEC 60598 (all parts), Luminaires
- ISO/CIE 20086:2019, Light and lighting — Energy performance of lighting in buildings
- ANSI C136.32-2020, Standard for Roadway and Area Lighting Equipment Enclosed Setback Luminaires and Directional Floodlights
- ISO/CIE 22012:2019, Light and lighting — Maintenance factor determination — Way of working

6.6.3 Temperature

When testing extreme temperatures, OSHA uses heat stress monitors to check temperature, humidity, air circulation, and the amount of heat radiating from heat sources. Meanwhile, freezing temperatures are much more easily spotted with a thermometer. Determining the safety of an extreme temperature is based on a worker's ability to maintain a safe body temperature. Therefore, the designer shall ensure that the climate in the work environment does not cause anyone's body temperature to exceed 100 (37.7^0C) degrees Fahrenheit or higher. As this will interfere with an employee's ability to perform his or her job.

- ANSI/ASHRAE 55-2013, Thermal Environmental Conditions for Human Occupancy

6.6.4 Ventilation and Indoor Air Quality

An effective ventilation system shall be designed and installed to safely evacuate hazardous material or hazardous chemical byproducts or fumes from tools or equipment.

Local exhaust ventilation may be used as a primary control if other engineering control systems are not feasible or cannot be included. Depending on the situation, the ventilation system shall meet the following criteria:

- Locally alarmed static pressure monitoring devices (e.g., Photohelic) should be installed on all primary and secondary ventilation control systems where the exhaust is required continuously to control exposure or an accidental release (i.e., gas cabinets, wet benches, etc.).
- At a minimum, a static pressure monitoring device (e.g., Magnehelic) shall be installed on exhaust systems where chemicals/hazardous materials are present only when personnel are using the exhausted equipment (i.e., lab hoods, and parts clean hoods etc.). In this case, the requirement for a local alarm may be replaced with administrative procedures and signage to require that the person

verify there is adequate exhaust ventilation by visually checking the monitoring device prior to starting work. Locally alarmed devices may be used and eliminate the need for administrative controls. Note: In some cases, the equipment may be delivered with a manufacturer-provided static pressure monitoring device. In this case, an installed device between the equipment and control damper may not be required as determined by site EHS.

- The monitoring device port shall be placed in the exhaust duct between the enclosure or hood and the first control damper. For static pressure, the port shall be at least one duct diameter from an inlet and shall not be placed in an elbow. If velocity pressure or flow is monitored for process reasons, the port must be at least five duct diameters from any inlet or elbow.
- The monitoring device for static pressure shall produce a local alarm (if alarm is required) at +/- 25% of design specifications.
- If a ventilation system failure could result in potential releases above the controlled substances threshold limit value, latched alarm with no reset is required. This would ensure that the process could not continue with inadequate exhaust. This does not apply to lab hoods where the hazard potential is present only when employees are present.
- All monitoring devices shall be labeled with the established set point, alarm settings and response procedure if the alarm sounds. Monitoring devices should be made as tamper-proof as possible to prevent inadvertent changes (i.e., set points cannot be changed or alarms disengaged without tools).

    - SEMI S6 - Environmental, Health, and Safety Guideline for Exhaust Ventilation of Semiconductor Manufacturing Equipment
    - ANSI/ASHRAE 62.1-2016, Ventilation for Acceptable Indoor Air Quality
    - ANSI/NFPA 90A-2021, Standard for the Installation of Air-Conditioning and Ventilating Systems
    - ANSI/NFPA 90B-2021, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems
    - ISO 16814:2008, Building environment design — Indoor air quality — Methods of expressing the quality of indoor air for human occupancy
    - ISO 16000-40:2019, Indoor air — Part 40: Indoor air quality management system

6.6.5 Noise

The workplace shall be so designed that the noise levels shall not exceed permissible exposure, this includes both occupational and also ambient noise, levels stipulated in the local legal requirements.

Micron and NIOSH Recommended Exposure Limits for occupational noise is 85 decibels, using the A-weighting frequency response (often written as dBA) over an 8-hour average, usually referred to as Time-Weighted Average (TWA). Exposures at or above this level is considered hazardous. As for the ambient noise level, the Environmental Protection Agency (EPA) has pegged permissible ambient noise levels in residential areas at 55 decibels (dB) during the day and 48 dB at night, for educational and health facilities it's 55 dB during the day and 50 dB at night.

Machinery, Equipment and Products purchased and placed within the workplace shall conform to ANSI/ASA S12.61-2020, Declaration and Verification of Noise Emission Values of Machinery, Equipment, and Products.

The General Contractor shall submit a Noise Assessment Report for the build facilities in conformance to

- ANSI/ASA S12.19-1996 (R2020), Measurement of Occupational Noise Exposure.
- ISO 15664:2001, Acoustics — Noise control design procedures for open plant

- ISO 17624:2004, Acoustics — Guidelines for noise control in offices and workrooms by means of acoustical screens
- ISO 22955:2021, Acoustics — Acoustic quality of open office spaces

6.7 Fall Prevention/Protection

The Designer is expected incorporate fall prevention systems into the building design. The fall prevention systems incorporated into the building design shall conform to the standards outlined below or other equivalent international standards. The fall prevention systems shall be clearly labelled with design load for ease of reference and use.

The Designer shall as far as reasonably practicable, place frequently used controls at ground level and within reach. Where this is not practical, a working platform complete with adequate toe board, handrails and access shall be provided.

Fall protection systems shall be incorporated into the design where the risk of fall cannot be eliminated. The fall protection system incorporated into the building system shall complement the fall prevention system.

There will be a need to install fall protection device above some of the manufacturing tools to facilitate tool maintenance. Manufacturing tools with such needs shall be identified and communicated to the designers. Upon receiving such information, the designers shall incorporate stronger structures that are capable of withstanding the force from a fall to anchor the SRLs. In addition, the designers shall ensure the process pipeline are routed safely to prevent it from being installed at locations where it would be exposed to potential damage when the fall protection device is deployed.

Where required, the building design shall consider potential dropped objects hazard and include safety nets or other appropriate engineering controls into the design.

- Global EHS - Work At Heights Standard
- ANSI ASSE Z359.15-2014, Safety Requirements for Single Anchor Vertical Lifelines & Fall Arrestors for Personal Fall Arrest Systems
- ANSI ASSE Z359.16-2016, Safety Requirements for Climbing Ladder Fall Arrest Systems
- ANSI ASSE Z359.6-2016, Specifications and Design Requirements for Active Fall Protection Systems
- ANSI/ASSE Z359.14-2014, Safety Requirements for Self-Retracting Devices for Personal Fall Arrest & Rescue Systems
- ANSI/ASSE Z359.18-2017, Safety Requirements for Anchorage Connectors for Active Fall Protection Systems
- ANSI/ASSE Z359.2-2017, Minimum Requirements for a Comprehensive Managed Fall Protection Program
- ANSI/ASSP Z359.1-2020, The Fall Protection Code
- ANSI/ASSP Z359.12-2019, Connecting Components for Personal Fall Arrest Systems
- ANSI/ASSE A10.32-2012, Fall Protection Systems for Construction and Demolition Operations
- ANSI/ISEA 121-2018, Dropped Object Prevention Solutions

6.7.1 Staircase

There shall be railing on both sides of the stairs for grip:

- Railing height shall be no less than 1100mm from FFL unless otherwise stated by local code,
- Railing shall be continuous with no break or vertical drop when turning a stair flight to ensure the user can have a firm grip on the railing even during fire/emergency where sight may be impeded by smoke/fire within the escape staircase,
- All balustrades should primarily be fitted with vertical members (instead of horizontal members) to avoid having climbable toehold between 250mm to 850mm from FFL,
- Spacing between balustrade shall be no more than 100mm center-to-center,
- There shall be continuous toe-guard of minimum 75mm from FFL along the entire path of the escape staircase (include landings and stair flight),
- There shall be adequate headroom clearance for the entire route along the escape staircase, no less than 2100mm clear. If the pitch of the stairs is steep, additional headroom shall be considered for safety. In case where additional headroom is not available, suitable warning sign shall be placed strategically to alert the user,
- The surface of the threads and landing shall be rendered anti-slip,
- Nosing installed on the staircase shall be flush and not present a trip hazard,
- Photoluminescent strips shall be included in the staircase design to ensure the staircase and the threads are visible to users when there is a power outage.

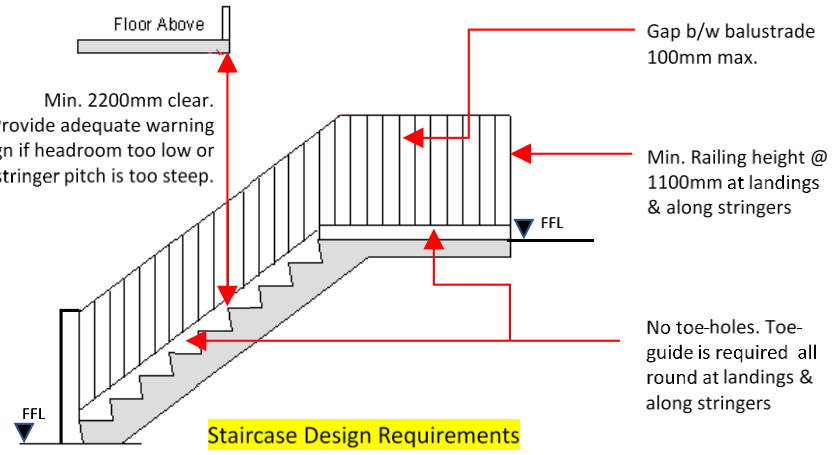


Figure 1 Staircase Design Requirements

6.7.2 Leading Edge Protection

Leading edge protection made of suitable material, which is structurally sound, shall be installed at areas where there is a potential for a person to fall e.g. elevator shaft opening, etc.

- ANSI/ASSE A10.18-2007 (R2012), Safety Requirements for Temporary Floors, Holes, Wall Openings, Stairways and Other Unprotected Edges in Construction and Demolition Operations

6.7.3 Floor Opening

Floor openings that present potential dropped object or fall hazard shall be adequately covered. The protection shall include:

- Pre-laid BRC of adequate strength to prevent materials or a man from falling through,
- Guardrail system, which includes top-rail, mid-rail, and a toe-board, of adequate strength,
- Suitable cover made of structurally sound material e.g. plywood,
- Warning signs shall be affixed on guardrail system as well as the cover,
- Such areas shall not be used as debris storage area where access or removal of such protection shall be through a permit-to-work system.

Safety nets to arrest falling objects shall be installed where there is a potential for objects to fall from gaps in the working platforms or from the working platforms.

Tools used by the workforce shall be fitted with lanyards and secured to the tool belt to prevent it from dropping down.

The safety net shall be used for falling objects protection and NOT fall protection.

Such safety nets shall be able to take the impact load of a tool and installed in a manner where the sag caused by the tools does not harm the workforce working directly underneath.

Where there is a need to join two safety nets, the seams must be secured in a way that it does not allow tools or materials pass through it.

- ANSI/ASSE A10.18-2007 (R2012), Safety Requirements for Temporary Floors, Holes, Wall Openings, Stairways and Other Unprotected Edges in Construction and Demolition Operations

6.7.4 Fixed Ladder Access

Cat ladder and corresponding access way complete with a guard rail system shall be installed at locations where access to monitor, service and maintain equipment or services installed in interstitial/ceiling space.

Where vertical ladders are installed to provide access to the catwalk, a vertical lifeline shall be installed to allow workers to access the catwalk safely.

Please refer to Global EHS - Work At Heights Standard for detail requirements for fixed ladder.

Figure 2 Fixed Ladder

Note: Ladder/Safety cage is not required if a horizontal lifeline is affixed to the vertical access ladder.

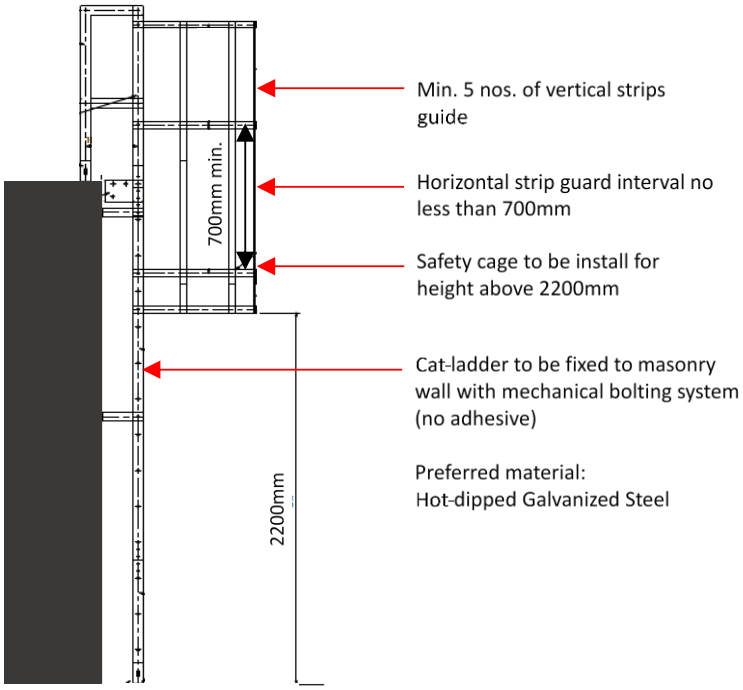


Figure 3 Cat-Ladder Design Requirements

6.8 Confined Space

As far as reasonably practical, confined spaces shall be eliminated from the building design. If this is not practical, the confined space shall be designed with the adequate:

- Safe access and egress,
- Mechanical ventilation,
- Space to facilitate rescue work, and
- Gas detection and monitoring

As far as reasonably practicable, pipes, drains or exhaust systems conveying hazardous substances or fume shall not be designed to pass through a confined space. Where this is not practicable, the following controls shall be designed and installed:

- Double containment system, and
- Hazardous substances conveyance system isolation,

Fall protection such as anchorage points shall be included in the design where work within the confined space will require the use of fall protection devices.

The labelling of confined spaces shall meet the requirements set out in the Global EHS – Confined Space Program Standard.

Following are considerations that the designer shall take into consideration when designing confined spaces:

Parameter	Requirements
Exiting and access	• Exiting distances consistent with code requirements for occupied areas, and • Occupational Safety & Health (OSHA)-compliant stairs for access/egress • Ensure that doorways are a minimum of 2.0m/80” high
Exhaust and ventilation	• Comply with criteria for occupied area, • Eliminate potential for a hazardous atmosphere, and • Inert gas (e.g. LN2) fill stations are located outside of and away from trenches
Deck over trench	• Prevent leaks/spills from entering trench, • Openings curbed to prevent spills from dripping into trench, and • Openings grated or railed to prevent large objects from dropping into trench
Life Safety Systems	• Evacuation alarms, PA system, emergency lighting, fire protection, safety showers consistent with Group B, F & H occupancy criteria, depending on the area within the facility
Lighting	• Lighting shall be provided in trench and pit areas requiring routine access. Illumination levels shall comply with local regulations
Drainage	• Adequate drainage to prevent safety hazard: flat floor with sumps provided at regular intervals to allow use of portable pumps for liquid removal
Electrical equipment, tools, and fittings	• Shall conform to area classification

Designers shall refer to the standards outlined below or other equivalent international standards for guidance in constructing a confined space.

- ANSI ASSE Z117.1-2016, Safety Requirements for Entering Confined Spaces
- ANSI/NFPA 350-2022, Guide for Safe Confined Space Entry and Work

6.9 Hazardous Energy

The Designer and the Project Management Team shall ensure that systems storing or conveying hazardous energies are equipped with lockable features that would enable it to be isolated in section and physically locked with a Lock-Out/Tag-Out device.

Facility piping, excluding fire protection water (e.g. chilled water, storm drain, etc.) shall not be routed over or within 0.3m (1 foot) of electrical, LSS, telecom, or FMS equipment where any mechanical joint (threaded or flanged) might leak onto the equipment.

Pressurized facility piping mechanical joints, excluding fire protection water, shall also be shielded to prevent any leak from spraying onto the electrical, LSS, telecom, FMS equipment or personnel in walkways or maintenance spaces. In addition, flexible mechanical connections (e.g. suction and discharge of pumps) within 6.0m (20 feet) of the above listed equipment must also be shielded to contain sprays.

The standards outlined below, or other equivalent international standards shall be referred to for guidance.

Lighting fixtures, power outlets/receptacles, motors and other electrical equipment shall be NRTL/CE/UL certified and appropriate to the hazardous area classification. Test reports from the accredited testing facilities shall be made available where applicable. Electrical installations in classified hazardous areas shall comply to the hazardous area installation requirements.

Refrigerators, freezers, chemical storage equipment using electrical power in classified hazardous areas must be rated and certified by NRTL / CE or national certification bodies. The protection class label shall be marked on the equipment with the explosion proof rating, type of protection and temperature class.

Ultra-cold freezers that store flammable liquids below their flashpoints, when installed in non-hazardous areas, are not required to be rated for Hazardous area protection. However, the equipment requires provisions to ensure that a flammable atmosphere cannot be developed during a power outage or other unplanned event (power monitoring, backup power or equivalent method). In cases where the Ultra cold Freezer is installed in a classified hazardous room, the freezer must comply to the hazardous area equipment protection and installation requirements.

Pls refer to the examples of typical labels:

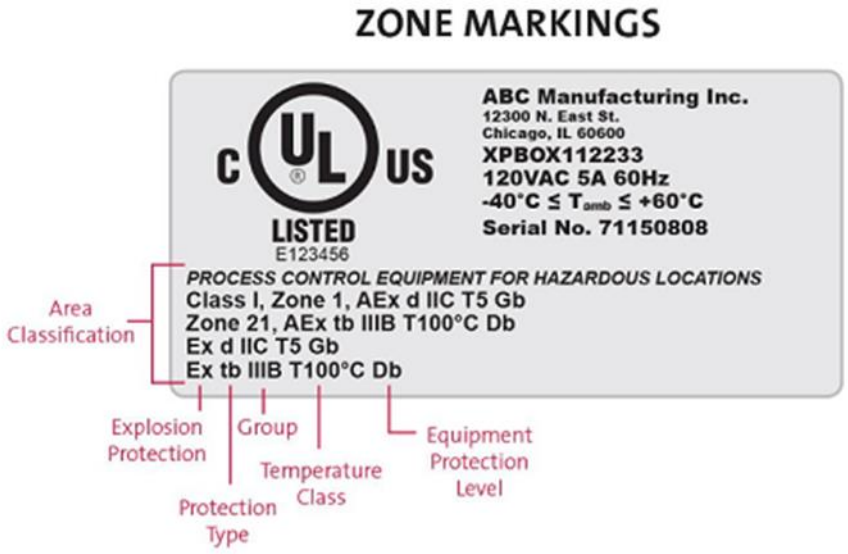


Figure 4 Safety Label - USA

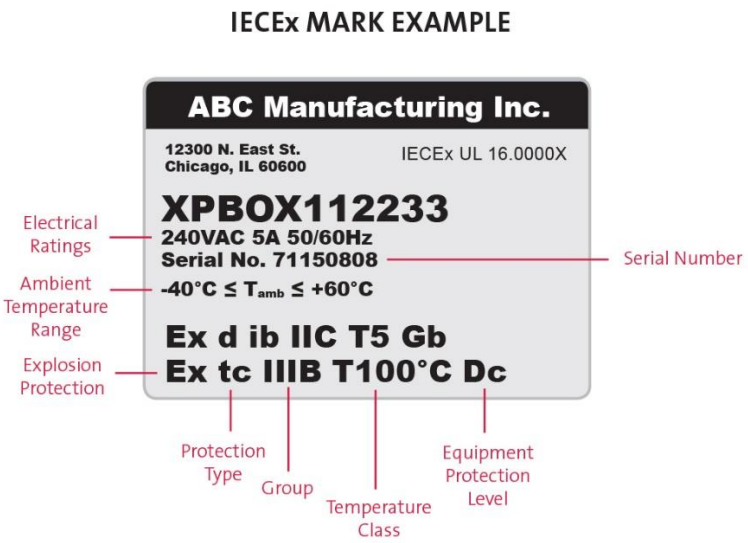


Figure 5 Safety Label - Europe

- SEMI S20 - Safety Guideline for Identification and Documentation of Energy Isolation Devices for Hazardous Energy Control
- ANSI/ASSE Z244.1-2016, The Control of Hazardous Energy Lockout, Tagout and Alternative Methods
- ANSI/NFPA 70E-2021, Standard for Electrical Safety in the Workplace
- ISO 14118:2017, Safety of machinery — Prevention of unexpected start-up
- ISO 4126-10:2010, Safety devices for protection against excessive pressure — Part 10: Sizing of safety valves for gas/liquid two-phase flow
- ISO 11933-5:2001, Components for containment enclosures — Part 5: Penetrations for electrical and fluid circuits

6.10 Uninterrupted Power Supply & Battery Charging Rooms

Ventilation of the battery room is required to prevent buildup of hydrogen.

The ventilation system shall be so configured that it limits hydrogen gas concentrations to less than 1% concentration by volume. Early gas and fire detection system shall be installed to detect incipient fire and to prevent hydrogen gas concentration from rising above 4%.

Continuous ventilation shall be provided at a rate of not less than 1 ft3/min/ft2 (5.1 L/sec/m2) of the floor area of the room or cabinet.

- ANSI/NFPA 505-2018, Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations
- ANSI/UL 583-2020, Standard for Safety for Electric-Battery-Powered Industrial Trucks
- ANSI/NECA 411-2014, Standard for Installing and Maintaining Uninterruptible Power Supplies
- ANSI/NECA 416-2016, Recommended Practice for Installing Stored Energy Systems
- ANSI/ATIS 0600003-2018, Battery Enclosure and Rooms/Areas

- ANSI/UL 1236-2016, Standard for Safety for Battery Chargers For Charging Engine-Starter Batteries
- ANSI/UL 1564-2020, Standard for Safety for Industrial Battery Chargers

6.11 Docks

Open dock areas and dock loading areas that are 4 feet (1.2 meters) or higher above the dock pad or adjacent areas are required to have guardrails. Fixed stairs shall be required for access from one level to another where operations necessitate daily travel. Ladders should not be installed at dock exit ways, where daily travel is required, or where the dock exit way may be used for evacuation purposes.

Light fixtures shall be designed to provide illumination (300 lux) on the pathways for movement on the dock and the dock apron. Special purpose light fixtures shall be provided at dock doors to permit illumination of the interiors of closed trucks or trailers, these fixtures shall be mounted to minimize the possibility of accidental damage.

Dock bumpers shall be provided at all docks.

A device that secures the truck to the dock through positive latching mechanism shall installed and used if approved by site EHS, but the use of such device shall not remove the need for wheel chocks. Arrangements shall be made for the chocks to be permanently tethered to the dock.

Permanent ramps shall be provided at each dock where powered lift trucks or other mechanical material handling equipment are required to operate on both the dock and apron levels. Such ramps shall have a maximum slope of 1 3/16 inch per foot. Curbs with fixed or removable handrails shall be provided.

Note: Protecting the open side of docks is not required for docks that are designed with a roll-up door or other barrier flush with the edge of the dock.

Power operated dock boards and lifts shall be designed and installed in accordance with the most recent revision international standards.

- ANSI MH30.1-2015, Performance and Testing Requirements for Dock Leveling Devices
- ANSI/MH32.1-2018, Stairs, Ladders, and Open-Edge Guards for Use with Material Handling Structures

6.12 Lightning

The Designer shall design the lightning protection system to ensure the building is adequately protected against lightning strike. The lightning protection or its component shall be designed to dissipate energy from a lightning strike effectively and not in any way expose the building occupants as well as the equipment/tools to lightning strikes.

- ANSI/NFPA 780-2020, Standard for the Installation of Lightning Protection Systems
- ANSI/UL 96-2016, Standard for Safety for Lightning Protection Components

6.13 Sustainability & Environment

Environmental sustainability is defined as responsible interaction with the environment to avoid depletion or degradation of natural resources and allow for long-term environmental quality. The designer shall take into consideration environmental sustainability into the building design to ensure that the needs of today's population are met without jeopardizing the ability of future generations to meet their needs.

- ASQ/ANSI/ISO 14006:2011, Environmental management systems - Guidelines for incorporating eco-design
- ISO 16813:2006, Building environment design — Indoor environment — General principles
- ISO 16817:2017, Building environment design — Indoor environment — Design process for the visual environment
- ISO 19454:2019, Building environment design — Indoor environment — Daylight opening design for sustainability principles in visual environment
- ISO 20887:2020, Sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements, and guidance
- ISO 14055-1:2017, Environmental management — Guidelines for establishing good practices for combatting land degradation and desertification — Part 1: Good practices framework
- ISO 26000:2010, Guidance on social responsibility
- ISO 20400:2017, Sustainable procurement — Guidance
- ISO 21930:2017, Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services
- ISO 14009:2020, Environmental management systems — Guidelines for incorporating material circulation in design and development
- ISO/TR 26368:2012, Environmental damage limitation from fire-fighting water run-off
- ISO 13315-6:2019, Environmental management for concrete and concrete structures — Part 6: Use of concrete structures
- ISO 13315-8:2019, Environmental management for concrete and concrete structures — Part 8: Environmental labels and declarations

6.13.1 Air Emissions

Air pollution caused by unabated emissions that contain contaminants or pollutant substances in the air has a potential to interfere with human health or welfare or produce other harmful environmental effects. Therefore, the designer shall incorporate effective air abatement systems that can remove pollutant substances to extend that it is in compliance with applicable local legal requirements or international standards.

- ANSI/NFPA 91-2020, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids
- ANSI/ASTM F1431-1992 (R2021), Specification for Water Trap for Diesel Exhaust

6.13.2 Energy

Sustainable energy is about finding clean, renewable sources of energy. Therefore, the designer shall consider several energy forms to render the building energy efficient.

- ISO 23045:2008, Building environment design — Guidelines to assess energy efficiency of new buildings

- ANSI/IREC 14732-2014, General Requirements for the Accreditation of Clean Energy Certificate Programs
- ISO 17772-1:2017, Energy performance of buildings — Indoor environmental quality — Part 1: Indoor environmental input parameters for the design and assessment of energy performance of buildings
- ISO/TR 17772-2:2018, Energy performance of buildings — Overall energy performance assessment procedures — Part 2: Guideline for using indoor environmental input parameters for the design and assessment of energy performance of buildings
- ISO 14009:2020, Environmental management systems — Guidelines for incorporating material circulation in design and development
- ANSI/ISO/MSE 50001-2011, Energy management systems - Requirements with guidance for use
- ISO/TR 16822:2016, Building environment design — List of test procedures for heating, ventilating, air-conditioning, and domestic hot water equipment related to energy efficiency
- ANSI/NFPA 900-2019, Building Energy Code
- ANSI/UL 9540-2016, Standard for Safety for Energy Storage Systems and Equipment

6.13.3 Waste Management

The goal of sustainable waste management is to reduce the amount of natural resources consumed, confirm that any materials that are taken from nature are reused as many times as possible and that the waste created is kept to a minimum. Therefore, the designer shall recommend the use of highest quality construction and demolition debris management, resource recovery and disposal services.

- ANSI/AWWA G510-2013, Wastewater Treatment Plant Operations and Management
- ANSI/AWWA G520-2017, Wastewater Collection System Operation and Management
- ANSI/AWWA J100-2020, Risk and Resilience Management of Water and Wastewater Systems
- ANSI/ASTM F917-2019, Specification for Commercial Food Waste Disposers
- ANSI Z245.30-2018, Waste Containers - Safety Requirements
- ANSI Z245.60-2018, Waste Containers - Compatibility Dimensions

6.14 Hazardous Substance

When hazardous substances are present in the workplace, it's very important the risks associated with in are properly recognized and dealt with to ensure the safety of all employees. The designer shall take the requirements outlined in the following standards to ensure safe hazardous substance conveyance and disposal.

This includes areas where there is a potential for hazardous substance spills, leaks, sprays, and splashes e.g. chemical loading/unloading docks (including waste) must be designed to prevent releases to the environment. Such design may include, blind sumps, lock-out valves, appropriate drain covers, plugs, etc.

Spill release devices (e.g., lock-out valves) must always be accessible e.g., dock equipment (e.g., levelers) must not be designed to block access to lock-out valves.

Emergency eyewash and shower installed at areas where hazardous substances are used shall be connected to an audio-visual alarm system, which activates at the vicinity as well as provides annunciation at the emergency control center.

- SEMI F6 - Guide for Secondary Containment of Hazardous Gas Piping Systems
- SEMI S5 - Safety Guideline for Sizing and Identifying Flow Limiting Devices for Gases
- SEMI S25 - Safety Guideline for Hydrogen Peroxide Storage and Handling Systems
- SEMI S29 - Guide for Fluorinated Greenhouse Gas (F-Ghg) Emission Characterization and Reduction
- SEMI S3 - Safety Guideline for Process Liquid Heating Systems
- ANSI/NFPA 400-2022, Hazardous Materials Code
- ANSI Z223.1/NFPA 54-2021, National Fuel Gas Code
- ANSI/NFPA 30-2021, Flammable and Combustible Liquids Code
- ANSI/NFPA 55-2020, Compressed Gases and Cryogenic Fluids Code
- ANSI/NFPA 58-2020, Liquefied Petroleum Gas Code
- ISO 10648-1:1997, Containment enclosures — Part 1: Design principles
- ISO 14123-1:2015, Safety of machinery — Reduction of risks to health resulting from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers
- ANSI/NFPA 497-2021, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
- ANSI/NFPA 499-2021, Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
- ANSI/ISA 12.10.02 (IEC 61241-0-2006) (R2015), Electrical Apparatus for Use in Zone 20, Zone 21, and Zone 22 Hazardous (Classified) Locations - General Requirements
- ANSI/ISA 61241-1 (12.10.03)-2007 (R2015), Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations - Protection by Enclosures "tD"
- ANSI/ISA 61241-11 (12.10.04)-2007 (R2015), Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations - Protection by Intrinsic Safety "iD"
- ANSI/ISA 61241-18 (12.10.07)-2007 (R2015), Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations - Protection by Intrinsic Safety "mD"
- ANSI/ISA 61241-2 (12.10.06)-2007 (R2015), Electrical Apparatus for Use in Zone 21 and Zone 22 Hazardous (Classified) Locations - Protection by Pressurization "pD"
- ANSI/UL 1203-2021, Standard for Safety for Explosion-Proof and Dust-Ignition Proof Electrical Equipment for Use in Hazardous (Classified) Locations
- ANSI/UL 122001-2009 (R2019), Standard for Safety for General Requirements for Electrical Ignition Systems for Internal Combustion Engines in Class I, Division 2 or Zone 2 Hazardous (Classified) Locations
- ANSI/UL 122701-2017, Standard for Safety for Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids
- ANSI/UL 2225-2020, Standard for Safety for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations
- ANSI/UL 674-2020, Standard for Safety for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
- ANSI/UL 698A-2018, Standard for Safety for Industrial Control Panels Relating to Hazardous (Classified) Locations
- ANSI/UL 844-2020, Standard for Safety for Luminaires for Use in Hazardous (Classified) Locations

- ANSI/UL 913-2019, Standard for Safety for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations
- ANSI/ISEA Z358.1-2020, Emergency Eyewash and Shower Equipment

6.15 Prohibited Materials

When designing and building facilities and facility systems, materials that are generally known to be carcinogenic or acutely hazardous, and which present a significant risk to people, the surrounding community or to the environment, are prohibited from use. These includes items listed in Micron's banned and restricted substances list, but are not limited to:

- Asbestos containing construction materials (i.e. insulation, ceiling tiles, fire resistant or retardant materials, etc.),
- Asbestos containing cement and adhesives,
- Materials, equipment or products containing poly-chlorinated bi-phenyls (e.g. transformers, ballasts in light fixtures),
- Materials, equipment or products containing or manufactured with any Class I ozone-depleting substance (e.g. chlorofluorocarbons, methyl chloroform, carbon tetrachloride),
- In the European Community, hydrochlorofluorocarbons (HCFC) listed in European Regulation 1005/2009 (or most recent version of the same).

Please refer to Micron's Product Content Specification for further details.

6.16 Traffic

The Designer shall consider the peak traffic flow for the given facility to eliminate or mitigate potential conflicts between pedestrian traffic, small and medium sized vehicular traffics, and large vehicular traffic. A Swept Path Analysis is required for determining the space required by large vehicular traffic when making a turn. The controls shall include, but not limited to, the following:

- Designated pedestrian walkways and crossings,
- Bollard's to prevent vehicular traffic from colliding into assets within the site,
- Segregated pathway for large vehicles,
- Well luminated pathways, access, and egress,
- Speed breakers,
- Higher road curbs, etc.

In addition to determining turning radius for large vehicular traffic, the Swept Path Analysis shall be used to test parking arrangements, loading areas, emergency access, or construction routes to determine the number and/or types of vehicles the site can logistically and safely accommodate.

- ISO 39001:2012, Road traffic safety (RTS) management systems - Requirements with guidance for use
- ISO 39002:2020, Road traffic safety — Good practices for implementing commuting safety management

Please refer to Appendix 10 for details of expected traffic controls.

6.17 Lifting

The designers shall ensure that the overhead and gantry cranes constructed and installed inside Micron's building shall meet the following design specifications.

- ANSI/ASME B30.2-2016, Overhead and Gantry Cranes
- ANSI/ASME NOG-1-2020, Rules for Construction of Overhead and Gantry Cranes
- ISO/TR 16880:2004, Cranes — Bridge and gantry cranes — International Standards for design and manufacturing requirements and recommendations
- ISO 11660-5:2001, Cranes — Access, guards, and restraints — Part 5: Bridge and gantry cranes
- ISO 10972-5:2006, Cranes — Requirements for mechanisms — Part 5: Bridge and gantry crane
- ISO 8686-5:2017, Cranes — Design principles for loads and load combinations — Part 5: Overhead travelling and portal bridge cranes
- ISO 10245-5:1995, Cranes — Limiting and indicating devices — Part 5: Overhead travelling and portal bridge cranes
- ISO/DIS 12210, Cranes — Anchoring devices for in-service and out-of-service conditions
- ISO 22986:2007, Cranes — Stiffness — Bridge and gantry cranes
- ISO 16881-1:2005, Cranes — Design calculation for rail wheels and associated trolley track supporting structure — Part 1: General
- ISO 17096:2015, Cranes — Safety — Load lifting attachments
- ISO 8566-5:2017, Cranes — Cabins and control stations — Part 5: Overhead travelling and portal bridge cranes
- ANSI/ASME NOG-1-2020, Rules for Construction of Overhead and Gantry Cranes

6.18 Tools

Tools purchased to manufacture semiconductors within the building shall be designed and constructed according to Semi S2 guidelines. Each tool shall be certified by a third-party accreditation body and accompanied by an assessment report for the end-user's reference.

- SEMI S2 - Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

6.19 Equipment

Equipment purchased to support the manufacturing of semiconductors within the building shall conform to local legal requirements or international standards. The equipment shall be accompanied product safety certification where applicable.

- ISO 12100:2010, Safety of machinery — General principles for design — Risk assessment and risk reduction
- ISO 13849-1:2015, Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design
- ISO 14120:2015, Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards

- ISO 14119, Safety of machinery — Interlocking devices associated with guards — Principles for design and selection
- ISO 14955-1:2017, Machine tools — Environmental evaluation of machine tools — Part 1: Design methodology for energy-efficient machine tools
- ISO 14159:2002, Safety of machinery — Hygiene requirements for the design of machinery
- ISO 13851:2019, Safety of machinery — Two-hand control devices — Principles for design and selection
- ISO 14119:2013, Safety of machinery — Interlocking devices associated with guards — Principles for design and selection
- ISO 15534-1:2000, Ergonomic design for the safety of machinery — Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery
- ISO 15534-2:2000, Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings
- ISO/TR 22100-3:2016, Safety of machinery — Relationship with ISO 12100 — Part 3: Implementation of ergonomic principles in safety standards
- ISO 19353:2019, Safety of machinery — Fire prevention and fire protection

6.20 Life Safety System

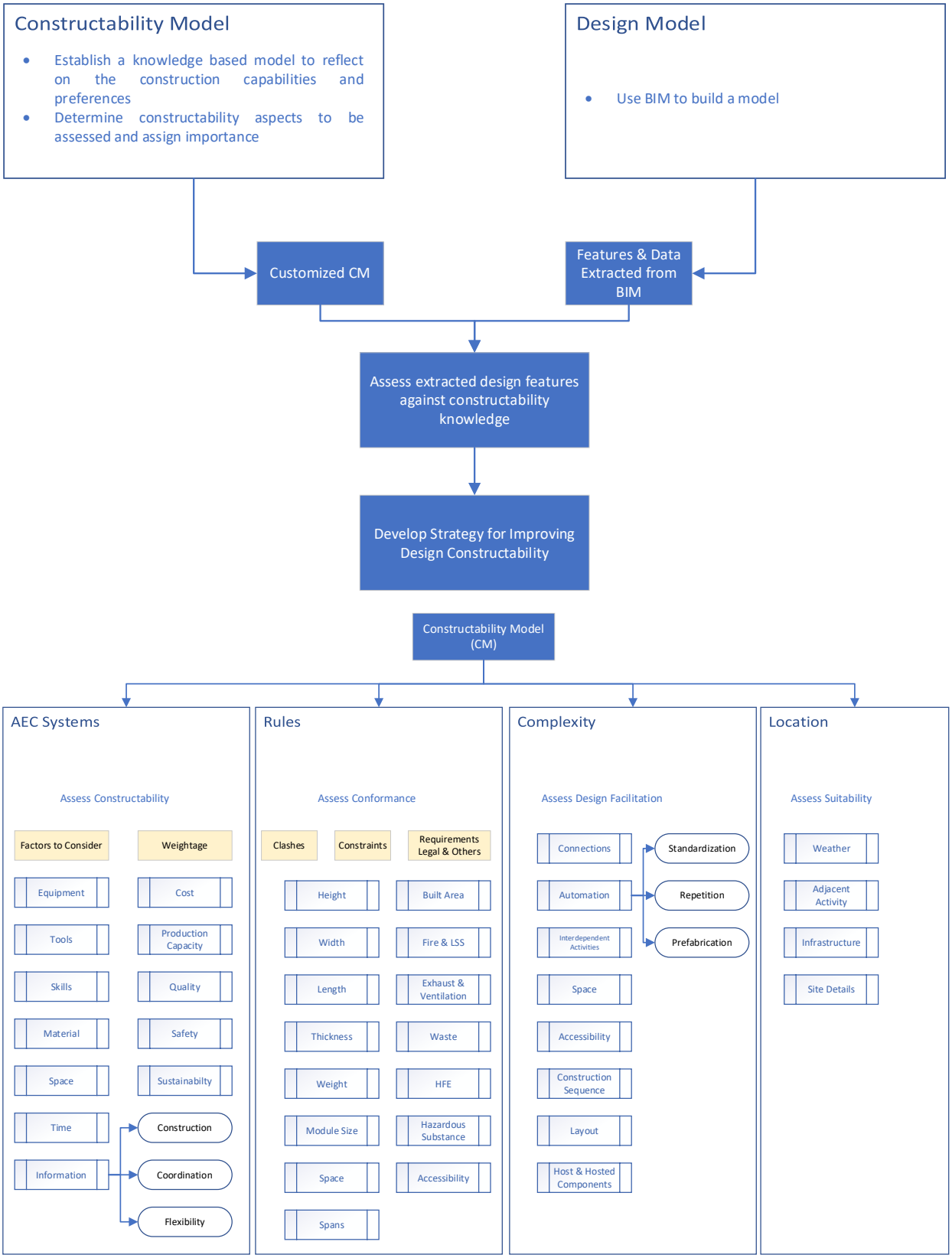
The designer shall ensure that any interior building element designed to protect and evacuate the building population in emergencies, including fires and earthquakes, and less critical events, such as power failures complies to the following standards in addition to local legal requirements.

- ANSI/NFPA 101-2021, Life Safety Code
- ANSI/NFPA 101A-2022, Guide on Alternative Approaches to Life Safety
- ANSI/NFPA 3-2021, Standard for Commissioning of Fire- Protection and Life Safety Systems
- ANSI/NFPA 4-2021, Standard for Integrated Fire Protection and Life Safety System Testing
- Requirements stipulated in Responsible Business Alliance (RBA) Guidelines

6.21 Construction Methodology & Constructability

Efficiency, both time use and cost, in building construction can be attained by applying the principles of constructability. Incorporating these principles into initial stages of design maximize outcomes for all stakeholders including designers, contractors, and Micron.

To be effective such a tool shall be deployed at the conceptual design stage so that constructability is factored into the design solution starting from its inception. Therefore, the designer shall use a BIM-based model with embedded information within the design environment to conduct the assessment. The modelling framework is composed of three key parts: The Constructability Model (CM) which formulates user-based knowledge; the BIM Design Model which provides required data for the assessment; and the Assessment Model (AM) which reasons with the formulated knowledge and the BIM Design Model.



- ISO 13824:2020, Bases for design of structures — General principles on risk assessment of systems involving structures
- ISO 10137:2007, Bases for design of structures - Serviceability of buildings and walkways against vibrations
- ISO 22111:2019, Bases for design of structures — General requirements
- ISO 21542:2011, Building construction — Accessibility and usability of the built environment
- ISO 13824:2020, Bases for design of structures — General principles on risk assessment of systems involving structures
- ANSI/ASHRAE/IES Standard 202-2013, Commissioning Process for Buildings and Systems
- ANSI/NFPA 5000-2021, Building Construction and Safety Code
- ANSI/ASSE A10.18-2007 (R2012), Safety Requirements for Temporary Floors, Holes, Wall Openings, Stairways and Other Unprotected Edges in Construction and Demolition Operations

6.22 Temporary Works

Temporary works relates to work activities undertaken during construction work or works to stabilize or protect an existing building or structure, neither works of which are intended or required to form part of the completed construction works e.g. scaffold erection/demolition, formwork installation/dismantling, etc. Such work activities are to be performed in accordance to approved design drawing provided by the professional engineer. The professional engineer is expected to provide on-side supervision and attestation to ensure the temporary works are carried out in accordance to the work method statement and approved design drawing.

- ISO 22966:2009, Execution of concrete structures
- ANSI/ASSP A10.8-2019, Scaffolding Safety Requirements
- ANSI/UL 1322-2017, Standard for Safety for Fabricated Scaffold Planks and Stages
- ANSI/UL 1323-2020, Standard for Scaffold Hoists
- ISO 10721-2:1999, Steel structures — Part 2: Fabrication and erection, Section 11.3

6.23 Fire Prevention and Protection

In addition to the safety of occupants with business continuity an ever-increasing issue, protection from fire is an integral aspect in reducing downtime at any facility. A combination of fire prevention and fire protection strategy can reduce hazards and maintain safety. Therefore, the designer shall ensure buildings are constructed in accordance with the version of the building code that is in effect when an application for a building permit is made.

- ANSI/NFPA 1-2021, Fire Code
- ISO 16732-1:2012, Fire safety engineering — Fire risk assessment — Part 1: General
- ISO 14520-1:2015, Gaseous fire-extinguishing systems — Physical properties and system design — Part 1: General requirements
- ISO 6183:2009, Fire protection equipment — Carbon dioxide extinguishing systems for use on premises — Design and installation
- ISO 20338:2019, Oxygen reduction systems for fire prevention — Design, installation, planning and maintenance

- ISO 7240-3:2020, Fire detection and alarm systems — Part 3: Audible alarm devices
- ISO 7240-14:2013, Fire detection and alarm systems — Part 14: Design, installation, commissioning and service of fire detection and fire alarm systems in and around buildings
- ISO 21927-5:2018, Smoke and heat control systems — Part 5: Powered smoke exhaust systems — Requirements and design
- ISO/TS 21805:2018, Guidance on design, selection and installation of vents to safeguard the structural integrity of enclosures protected by gaseous fire-extinguishing systems
- ISO 7240-19:2007, Fire detection and alarm systems — Part 19: Design, installation, commissioning, and service of sound systems for emergency purposes
- ISO 23932-1:2018, Fire safety engineering — General principles — Part 1: General
- ISO 24679-1:2019, Fire safety engineering — Performance of structures in fire — Part 1: General
- ISO/TR 16576:2017, Fire safety engineering — Examples of fire safety objectives, functional requirements, and safety criteria
- ISO 7240-16:2007, Fire detection and alarm systems — Part 16: Sound system control and indicating equipment
- ISO 7240-19:2007, Fire detection and alarm systems — Part 19: Design, installation, commissioning, and service of sound systems for emergency purposes
- ISO/DIS 20710-1, Fire safety engineering — Active fire protection systems — Part 1: General principles
- ISO 7240-16:2007, Fire detection and alarm systems — Part 16: Sound system control and indicating equipment
- ANSI/NFPA 318-2018, Standard for the Protection of Semiconductor Fabrication Facilities
- ANSI/NFPA 820-2020, Standard for Fire Protection in Wastewater Treatment and Collection Facilities
- ISO 14520-1:2015, Gaseous fire-extinguishing systems — Physical properties and system design — Part 1: General requirements
- ANSI/NFPA 13-2019, Standard for the Installation of Sprinkler Systems
- ANSI/NFPA 14-2019, Standard for the Installation of Standpipe and Hose Systems
- ANSI/NFPA 15-2022, Standard for Water Spray Fixed Systems for Fire Protection
- ANSI/NFPA 17-2021, Standard for Dry Chemical Extinguishing Systems
- ANSI/NFPA 17A-2021, Standard for Wet Chemical Extinguishing Systems
- ANSI/NFPA 1961-2020, Standard on Fire Hose
- ANSI/NFPA 1963-2019, Standard for Fire Hose Connections
- ANSI/NFPA 1964-2018, Standard for Spray Nozzles
- ANSI/NFPA 20-2022, Standard for the Installation of Stationary Pumps for Fire Protection
- ANSI/NFPA 2001-2018, Standard on Clean Agent Fire Extinguishing Systems
- ANSI/NFPA 2010-2020, Standard for Fixed Aerosol Fire-Extinguishing Systems
- ANSI/NFPA 204-2021, Standard for Smoke and Heat Venting
- ANSI/NFPA 214-2021, Standard on Water-Cooling Towers
- ANSI/NFPA 22-2018, Standard for Water Tanks for Private Fire Protection
- ANSI/NFPA 24-2022, Standard for the Installation of Private Fire Service Mains and Their Appurtenances
- ANSI/NFPA 3-2021, Standard for Commissioning of Fire Protection and Life Safety Systems
- ANSI/NFPA 45-2019, Standard on Fire Protection for Laboratories Using Chemicals

- ANSI/NFPA 497-2021, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
- ANSI/NFPA 499-2021, Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
- ANSI/NFPA 652-2019, Standard on the Fundamentals of Combustible Dusts
- ANSI/NFPA 67-2019, Guideline on Explosion Protection for Gaseous Mixtures in Pipe Systems
- ANSI/NFPA 68-2018, Standard on Explosion Protection by Deflagration Venting
- ANSI/NFPA 69-2019, Standard on Explosion Prevention Systems
- ANSI/NFPA 72-2019, National Fire Alarm and Signaling Code
- ANSI/NFPA 750-2019, Standard on Water Mist Fire Protection Systems
- ANSI/NFPA 77-2019, Recommended Practice on Static Electricity
- ANSI/NFPA 770-2021, Standard on Hybrid (Water and Inert Gas) Fire Extinguishing Systems
- ANSI/NFPA 80A-2022, Recommended Practice for Protection of Buildings from Exterior Fire Exposures
- ANSI/NFPA 92-2021, Standard for Smoke Control Systems
- ANSI/FM 3265-2017, Spark Detection and Extinguishing Systems
- ANSI/FM 5560-2017, Water Mist Systems
- ANSI/FMRC FM 3260-2004 (R2014), Radiant Energy-Sensing Fire Detectors for Automatic Fire Alarm Signaling
- ANSI/FM 4910-2013, Cleanroom Materials Flammability Test Protocol

6.24 Earthquake

At locations where earthquakes may undermine the operations of the building, the designer shall ensure the building structure is designed and constructed to the following international standards:

- ISO 2394:2015, General principles on reliability for structures
- ISO 13823:2008, General principles on the design of structures for durability
- ISO 22111:2019, Bases for design of structures — General requirements
- ISO 3010:2017, Bases for design of structures - Seismic actions on structures
- ISO 13822:2001, Bases for design of structures - Assessment of existing structures
- ISO 23469:2005, Bases for design of structures — Seismic actions for designing geotechnical works
- ISO/TR 22845:2020, Resilience of buildings and civil engineering works
- ISO 13033:2013, Bases for design of structures — Loads, forces, and other actions — Seismic actions on nonstructural components for building applications
- ISO 13824:2020, Bases for design of structures — General principles on risk assessment of systems involving structures
- ISO/TR 22845:2020, Resilience of buildings and civil engineering works
- ISO 13823:2008, General principles on the design of structures for durability
- ANSI/FM 1950-2016, Seismic Sway Brace Components for Automatic Sprinkler Systems

6.25 Safety Signs

Safety signs communicate hazards effectively. Therefore, the designer is required to specify suitable locations to place safety signs at the workplace. The safety signs installed at the workplace shall conform to the standards outlined below:

- ISO 3864-1:2011, Graphical symbols — Safety colors and safety signs — Part 1: Design principles for safety signs and safety markings
- ISO 3864-3:2012, Graphical symbols — Safety colors and safety signs — Part 3: Design principles for graphical symbols for use in safety signs
- ISO 7010:2019, Graphical symbols — Safety colors and safety signs — Registered safety signs
- ISO 20560-1:2020, Safety information for the content of piping systems and tanks — Part 1: Piping systems
- ANSI/NFPA 170-2021, Standard for Fire Safety and Emergency Symbols

Roles and Responsibilities for Safety Signs design and installation for new building:

Roles	Responsibilities
Design Manager	• Ensure that the Safety Signs design, placement and location are clearly indicated in the 100% design drawing • Communicated to the Construction Manager for purchase, fabrication and installation
Construction Manager	• Purchase, fabrication and installation for required Safety Signs before the site is handed over to Site Leadership and Facilities team • Ensure the Safety Signs conform to local standards/international standards and are installed according to the design drawing before handover to Micron

Roles and Responsibilities for Safety Signs design and installation for existing building:

Roles	Responsibilities
Site Facilities team	• Work with site EHS team and ensure that the Safety Signs design, placement and location are clearly indicated and determined • Purchase, fabrication and installation for required Safety Signs before the location is handed over respective department • Ensure the Safety Signs conform to local standards/international standards and are installed according to the design and requirements
Site EHS	• Provide advice on the design, placement and location of the Safety Signs • Verify with site Facilities team on the right installation during installation

6.26 Emergency Management

In addition to meeting relevant design codes for emergency management, the designer shall ensure the building design incorporates features and facilities that consider the capabilities of those with different capabilities. Examples are included in the following table:

Impairment	Enhancement
Vision	Marking on the floor for spatial recognition

	Color coding for color blindness
Hearing	Audio-visual aids e.g. strobe lights combined with emergency alarms
Hearing	Signboards in-addition to public announcement system to indicate evacuation routes

- ISO 30061:2007, Emergency lighting
- ISO/TS 18870:2014, Lifts (elevators) — Requirements for lifts used to assist in building evacuation
- ANSI/NFPA 110-2022, Standard for Emergency and Standby Power Systems
- ANSI/NFPA 111-2022, Standard on Stored Electrical Energy Emergency and Standby Power Systems
- ANSI/NFPA 1616-2020, Standard on Mass Evacuation, Sheltering, and Re-entry Programs
- ANSI/NFPA 704-2022, Standard System for the Identification of the Hazards of Materials for Emergency Response

6.26.1 Hazardous Material Spill

Where there is a potential for hazardous material spill, the designer shall design-in a secondary containment system to capture and channel the spill to a suitably constructed collection pit. The collection pit shall be suitable to collect and hold the spilled hazardous substance and shall be located away from other hazards, heavy vehicular and human traffic areas, and public.

6.26.2 Flood

In locations where there is a potential for flooding caused by rainwater or breach in process pipes conveying liquid, the designer shall incorporate adequate abatement equipment or system to prevent interruption to the building operations. This includes areas housing electrical equipment e.g. transformer room, switch rooms, etc.

- ANSI/FM 2510-2020, Flood Abatement Equipment

6.26.3 Evacuation & Assembly Area

During an emergency it is normal for the building occupants to be evacuated to an open area away from the impending emergency. Where possible the designer shall consider the provision of a covered area for emergency mustering to facilitate evacuation during inclement weather.

The designer shall consider the provision of safe refuge, an isolated area with positive pressure ventilation, where there is a potential for gas leak into work environments.

- ISO/TS 18870:2014, Lifts (elevators) — Requirements for lifts used to assist in building evacuation
- ISO/DIS 22578, Graphical symbols — Safety colors and safety signs — Natural disaster safety way guidance system
- ISO 16069:2017, Graphical symbols — Safety signs — Safety way guidance systems (SWGS)
- ANSI ASA S3.41-2015 (R2020), Audible Emergency, Evacuation (E2) and Evacuation Signals with Relocation Instructions
- ANSI/ASTM F1297-1999 (R2018), Guide for Location and Instruction Symbols for Evacuation and Lifesaving Equipment
- ANSI/RESNA ED-1-2019, RESNA Standard for Evacuation Devices – Volume 1: Emergency Stair Travel Devices Used by Individuals with Disabilities

7 Appendices

Appendix 1 Take 5 Form Preventing Hazard Through Design Purpose

This procedure sets out the engineering design Hazard Prevention by Design principles and methodology requirements. The purpose of the procedure is to identify, assess and control hazards associated with the construction, operability, and maintainability of a facility. It is based on the Risk Matrix from AS/NZS 4360:2004.

Risks are inherent in any human activity and cannot always be eliminated. The Hazard Prevention through Design process is based on identification of hazards and their associated causes in order to define the extent and likelihood of the potential loss. This shall be used to assign appropriate actions to the identified risk, to reduce the hazard to an acceptable level. This will have been achieved if the hazard has been reduced to As Low As Reasonably Practicable (ALARP). ALARP refers to a risk level that is tolerable only if further reduction is impracticable or if its cost is grossly disproportionate.

Traceability and Communication

The Hazard Register Sheet of this procedure when completed must be stored with each instance of design on a study or project as an integral part of the design report. Any item which requires cross discipline input to close out shall be raised with the lead engineer and project manager, who take joint responsibility for the close out of that risk.

Contents of this Procedure	**Notes on the application of this**
Information (This Sheet)	For information purposes only – not needed to be included in calculation pack
Hazard Register	To be completed, signed, and included in calculation pack or study report
Risk Assessment	For reference purposes only – not needed to be included in calculation pack.

Procedure

Scope

All works must incorporate a Hazard Prevention by Design risk assessment. A separate assessment must be undertaken for each facility, by each discipline (i.e. civil, structural, mechanical, electrical etc.). Assessments must be documented on the Hazard Register and included in the calculation pack or study report.

Any hazards identified with a high or very high residual risk must be highlighted to the Lead Engineer and the Project Manager for review and formal submission to the Client.

All disciplines must review all other disciplines Hazard Prevention by Design review forms as part of the safety in design process. Any hazards identified by one discipline which require the action of another discipline to lower the risk ranking must be communicated to the other discipline Lead Engineer, Design Engineer and their own Lead Engineer. These items must then appear in both disciplines' Hazard Registers. The Lead Engineers and Project Manager are responsible for coordination of this task.

Projects Resulting in New Equipment, Structures or Modifications to existing

Hazard Prevention by Design Risk assessments must be undertaken for projects that result in new equipment or structures or in modifications to existing plant, including sustaining capital projects. New facilities require a risk assessment for the complete facility. Where a project results in modifications to an existing facility, the risk assessment must cover the area(s) that have been modified. It must also cover any adjacent areas whose functionality, access/egress or maintainability has been affected by the new works. Other areas of the existing structure do not need to be assessed for risks. The premise is that existing structures will already have had a risk assessment undertaken for them by others, and/or that the Client is currently managing any existing risks for the particular facility.

Projects with no New Equipment, Structures or Modifications to existing

Projects that do not result in the construction of new structures, modifications to existing structures, or changes to the way that an existing structure is used do not typically require a Hazard Prevention by Design risk assessment to be undertaken. These works typically take the form of reviews of existing structures or facilities for increased production, or asset inspections.

The Process

The Hazard Prevention by Design process is not fixed and must be adapted to suit the task and/or facility. Prior to commencing the process, the following must be completed:

- Gain an understanding of the scope of works.
- Review the relevant standards applicable; and
- Review the construction, operations, and maintenance procedures applicable.

Hazard Identification

An initial assessment must be undertaken. Specific hazards must be identified and recorded on the Hazard Prevention by Design register by the Lead Engineer and/or Designer.

Initial Risk Ranking

Using the Qualitative Measures of Severity matrix and the Qualitative Measures of Likelihood matrix, determine the risk ranking of the hazard. The spreadsheet is automatically populated with the risk ranking once severity and likelihood are selected.

Controls

Using the hierarchy of controls, implement measures to reduce very high or high risks. If risks are low or medium, new controls may still be identified or existing controls adjusted to reduce the risks further provided that the controls are justifiable from a time and cost perspective.

Residual Risk

Close out of items is to be progressive during the design, with final assessment undertaken at completion. This assessment must be undertaken by the lead engineer and/or designer. The hazards initially identified must be reviewed with the new controls in place. The final design must also be reviewed for any new hazards that were not initially identified, or that have occurred because of the design process. Using the Qualitative Measures of Frequency matrix and the Qualitative Measures of Severity matrices, determine the residual ranking of the hazards.

Any hazards that cannot be reduced below a high ranking must be highlighted to the Project Manager for client discussion and resolution.

Hazards must not be signed off as closed out on the Hazard Register until they have been resolved or achieved a low or medium risk ranking.

Take 5 Form

Client:		Discipline:	
Project Name:		Facility:	
Project Number:		Document No:	

TAKE 5 HAZARD REGISTER

Current Risk (at initial assessment)				Initiated	Final Risk (progressive or at close out assessment				Close out	
Scenario	Severity (1 - 5)	Likelihood (A,B,C,D,E)	Risk Level	By / Date	Improvement Action	Severity (1 - 5)	Likelihood (A,B,C,D,E)	Risk Level	By / Date	Checked / Date
Gates not closed when walk way has been removed to change out pulleys	2	C	M	BRaman 2/2/16	Self closing, lockable gates. Input to client maintenance procedure	2	D	L		

Initial assessment undertaken by:	Date:	Initial assessment reviewed by:	Date:
PRINT NAME AND SIGN		PRINT NAME AND SIGN	
Close out assessment undertaken by:	Date:	Close out assessment reviewed by:	Date:
PRINT NAME AND SIGN		PRINT NAME AND SIGN	

Answer the Question: Can I complete or have I completed the design to a level where it can be built and operated with a residual HSEC risk that is As Low as Reasonable Practicable (ALARP)?

YES	Continue with the work but also continue to monitor the situation.	
NO	Discuss further with the Lead Discipline Engineer	

RISK ASSESSMENT AS PER AS/NZS 4360:2004

Qualitative Measures of Consequence or Impact:

Level	Consequence Types					
	Profit Reduction	Health and Safety	Natural Environment	Social / Cultural Heritage	Community / Government / Reputation / Media	Legal
1	<US$10k	No medical treatment required.	Minor effects on biological or physical environment.	Minor medium-term social impacts on local population. Mostly repairable.	Minor, adverse local public or media attention or complaints.	Minor legal issues, non-compliances and breaches of regulation.
2	US$10k-100k	Objective but reversible disability requiring hospitalisation.	Moderate, short-term effects but not affecting ecosystem functions.	On-going social issues. Permanent damage to items of cultural significance.	Attention from media and/or heightened concern by local community. Criticism by NGOs.	
3	US$100k-1M	Moderate irreversible disability or impairment (<30%) to one or more persons.	Serious medium term environmental effects.	On-going serious social issues. Significant damage to structures / items of cultural significance.	Significant adverse national media / public / NGO attention.	Serious breach of regulation with investigation or report to authority with prosecution and/or moderate fine possible.
4	US$1M-10M	Single fatality and/or severe irreversible disability or impairment (>30%) to one or more persons.	Very serious, long-term environmental impairment of ecosystem functions.		Serious public or media outcry (international coverage).	Major breach of regulation. Major litigation.
5	US$10M-100M	Multiple fatalities, or significant irreversible effects to > 50 persons.				Significant prosecution and fines. Very serious litigation including class actions.

Qualitative Measures of Likelihood:

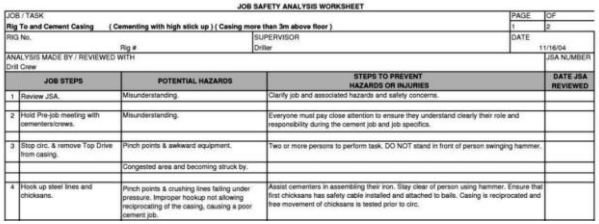
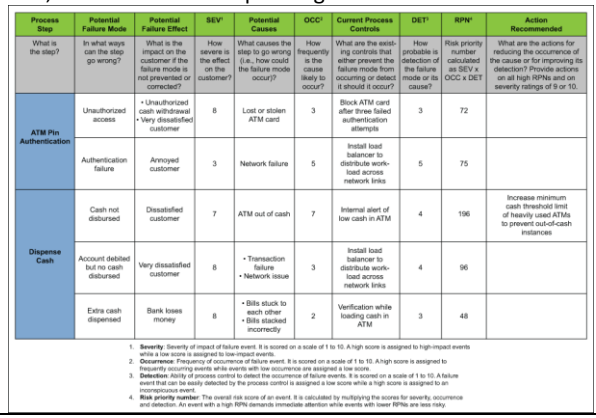
Level	Descriptor	Description	Indicative Frequency (expected to occur)
A	Almost certain	The event will occur on an annual basis.	Once a year or more frequently.
B	Likely	The event has occurred several times or more in your career.	Once every three years.
C	Possible	The event might occur once in your career.	Once every ten years.
D	Unlikely	The event does occur somewhere from time to time.	Once every thirty years.
E	Rare	Heard of something like this occuring elsewhere.	Once every 100 years.

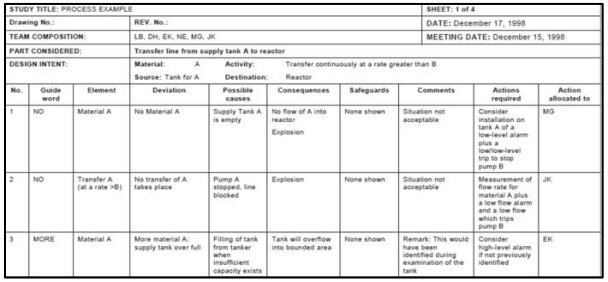
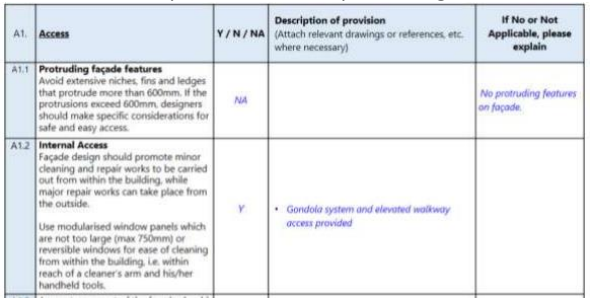
Level of Risk:

		Consequences				
	Likelihood	1	2	3	4	5
A	Almost Certain	M	H	H	VH	VH
B	Likely	M	M	H	H	VH
C	Moderate	L	M	H	H	H
D	Unlikely	L	L	M	M	H
E	Rare	L	L	M	M	H

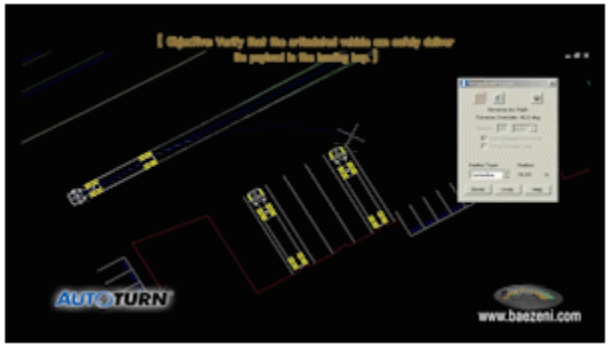
VH	**Very High Risks** are intolerable for HSEC. Do not commence or continue at this risk level. Implement control measures to ensure risk level is reduced
H	**High Risk** is undesirable. Verify and where possible, quantify the accuracy and certainty for the existing risk level. Implement control measures to ensure the risk level is reduced or is confirmed to be ALARP. Operation at this level on a project requires Project Management approval.
M	**Medium Risks** are only tolerable if examination proves them to be ALARP. Implement controls to minimise or prevent and/or mitigate the risk and monitor for change. Reduce to Low Risk is the benefits outweigh the cost of the additional controls. The Project Engineering Manager is responsible for monitoring these risks.
L	**Low Risks** are acceptable. These are managed by normal design and project processes. Review at next review interval.

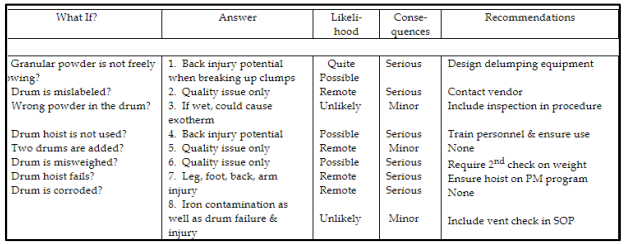
Appendix 2 Risk Assessment Tools

Tool	Description	Use
JHA/JSA	**Job Hazard / Safety Analysis** A risk assessment tools that enables users to discover potential hazards that exist in the workplace. It is used to find hazards that are specific to one task, to one job type, or even to an entire facility.	Used to identify the dangers involved in a specific task so that controls can be put in place to reduce the risk of injury to workers. 
HazID	**Hazard Identification** Hazard Identification (HAZID) is a brainstorming workshop with a multi-disciplinary team to identify potential hazards. HAZID studies may be broad in their scope and thus have a wide applicability. HAZID typically examines all reasonably possible sources of hazard during project design, construction, installation, and decommissioning activities, and for proposed changes to existing operations. The study considers the process and non-process hazards in a workplace.	• During the appraise stage or early select stage of a project as part of the selection process for conceptual design • During operations of existing facilities to update risk register, identify hazards associated with proposed change. 
FMEA	**Failure Mode Effects Analysis** A qualitative and systematic tool to help assessors anticipate what might go wrong with a product or process. In addition to identifying how a product or process might fail and the effects of that failure, FMEA also helps find the possible causes of failures and the likelihood of failures being detected before occurrence.	One of the best ways of analyzing potential reliability problems early in the development cycle, making it easier for manufacturers to take quick action and mitigate failure. The ability to anticipate issues early allows practitioners to design out failures and design in reliable, safe and customer-pleasing features. 

<table>
<tr>
<td>HazOp</td>
<td>Hazard and Operability
Hazard and Operability (HAZOP) is a systematic approach to determining potential problems that may be uncovered by reviewing the safety of designs and revisiting existing processes and operations in chemical, pharmaceutical, oil and gas, and nuclear industries.</td>
<td>Used to find potential situations that would cause an element to pose a hazard or limit the operability of the process.
 
<table>
<tr><td colspan="6">STUDY TITLE: PROCESS EXAMPLE</td><td colspan="4">SHEET: 1 of 4</td></tr>
<tr><td colspan="3">Drawing No.:</td><td colspan="3">REV. No.:</td><td colspan="4">DATE: December 17, 1998</td></tr>
<tr><td colspan="3">TEAM COMPOSITION:</td><td colspan="3">LB, DH, EK, NE, MG, JK</td><td colspan="4">MEETING DATE: December 15, 1998</td></tr>
<tr><td colspan="3">PART CONSIDERED:</td><td colspan="7">Transfer line from supply tank A to reactor</td></tr>
<tr><td colspan="3">DESIGN INTENT:</td><td colspan="7">Material: A Activity: Transfer continuously at a rate greater than B
Source: Tank for A Destination: Reactor</td></tr>
<tr><td>No.</td><td>Guide word</td><td>Element</td><td>Deviation</td><td>Possible causes</td><td>Consequences</td><td>Safeguards</td><td>Comments</td><td>Actions required</td><td>Action allocated to</td></tr>
<tr><td>1</td><td>NO</td><td>Material A</td><td>No Material A</td><td>Supply Tank A is empty</td><td>No flow of A into reactor
Explosion</td><td>None shown</td><td>Situation not acceptable</td><td>Consider installation on tank A of a low-level alarm plus a low/low-level trip to stop pump B</td><td>MG</td></tr>
<tr><td>2</td><td>NO</td><td>Transfer A (at a rate >B)</td><td>No transfer of A takes place</td><td>Pump A stopped, line blocked</td><td>Explosion</td><td>None shown</td><td>Situation not acceptable</td><td>Measurement of flow rate for material A plus a low flow alarm and a low flow which trips pump B</td><td>JK</td></tr>
<tr><td>3</td><td>MORE</td><td>Material A</td><td>More material A: supply tank over full</td><td>Filling of tank from tanker when insufficient capacity exists</td><td>Tank will overflow into bounded area</td><td>None shown</td><td>Remark: This would have been identified during examination of the tank</td><td>Consider high-level alarm if not previously identified</td><td>EK</td></tr>
</table></td>
</tr>
<tr>
<td>CHAZOP</td>
<td>Controls Hazards and Operability Analysis
A HAZard and OPerability study for instrument, control, and computer systems.</td>
<td>Used to assess the control loops—the set of instruments that operate the functions being controlled—are adequate for the process that they are applied to and at the same time evaluate whether the control system is properly integrated with the underlying process to prevent an unintended operational interference or obstruct the operation of another control system.</td>
</tr>
<tr>
<td>ALMOP</td>
<td>Access, Lifting, Maintainability & Operability
The practice of integrating operations and maintenance experience in the planning and design process to achieve safe operations throughout the life of an infrastructure. A lack of operability and maintainability considerations at the onset of a building project often creates avoidable operations and maintenance demands which can lead to higher upkeep costs and manpower needs.</td>
<td>Used during the appraise stage or early select stage of a project as part of the selection process for conceptual design.
 
<table>
<tr><th>A1.</th><th>Access</th><th>Y / N / NA</th><th>Description of provision (Attach relevant drawings or references, etc. where necessary)</th><th>If No or Not Applicable, please explain</th></tr>
<tr><td>A1.1</td><td>Protruding façade features
Avoid extensive niches, fins and ledges that protrude more than 600mm. If the protrusions exceed 600mm, designers should make specific considerations for safe and easy access.</td><td>NA</td><td></td><td>No protruding features on façade.</td></tr>
<tr><td>A1.2</td><td>Internal Access
Façade design should promote minor cleaning and repair works to be carried out from within the building, while major repair works can take place from the outside.

Use modularised window panels which are not too large (max 750mm) or reversible windows for ease of cleaning from within the building, i.e. within reach of a cleaner's arm and his/her handheld tools.</td><td>Y</td><td>• Gondola system and elevated walkway access provided</td><td></td></tr>
</table></td>
</tr>
<tr>
<td>CHAIR</td>
<td>Construction Hazard Assessment Implication Review
CHAIR (Construction Hazard Assessment Implication Review) is a tool to assist designers, constructors, clients, and other key stakeholders to come together to reduce construction, maintenance, repair and demolition safety risks associated with design.</td>
<td>Used during the appraise stage or early select stage of a project as part of the selection process for conceptual and detailed design.</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td>5. CHAIR-3 EXAMPLE ONLY
<table>
<tr><td colspan="4">DETAILED MAINTENANCE / REPAIR SAFETY IN DETAILED DESIGN (CHAIR-3) STUDY</td><td>Reference:</td></tr>
<tr><td>System: ROADWAY</td><td>Sub-System:</td><td colspan="2">Item/Component: DRAIN</td><td></td></tr>
<tr><td>Maintainability Aspect</td><td>Assessment</td><td>(Good, Fair, Poor, N/A) and WHY</td><td>Recommendation/Comment</td><td>Who/Date</td></tr>
<tr><td>POSTURE / MANUAL HANDLING</td><td>GOOD</td><td>Drain cover will have handles and should be lightweight</td><td>Satisfactory</td><td>—</td></tr>
<tr><td>SIZE / WIDTH</td><td>POOR</td><td>Construction vehicle may have limited shoulder space to stop on road</td><td>Widen shoulder width to allow for safe stopping during maintenance work</td><td>D.F.</td></tr>
<tr><td>ACCESS / EGRESS</td><td>POOR</td><td>Current drain design is that it is a confined space, and that confined space procedures need to be prepared</td><td>Drain design should avoid where possible the need to be classed as a confined space</td><td>D.F.</td></tr>
<tr><td>HEIGHTS / DROPPED OBJECTS</td><td>N/A</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>WEIGHT</td><td>FAIR</td><td>Drain cover could be too heavy</td><td>Ensure drain cover design such that it can be easily lifted</td><td>P.B.</td></tr>
<tr><td>DISCOMFORT / STRESS</td><td>FAIR</td><td>Do not expect long term drain maintenance</td><td>Satisfactory</td><td>—</td></tr>
<tr><td>PERSONNEL PROT. EQUIPMENT</td><td>N/A</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>VISIBILITY</td><td>N/A</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>SLIPS, TRIPS, FALLS</td><td>N/A</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>ROTATING / MOVING EQUIPMENT</td><td>N/A</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>IS REPAIR DIFFERENT?</td><td>NO</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>OTHERS THAT MAY APPLY (list below)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>None identified</td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>SPA</td><td>Swept Path Analysis
Refers to the analysis of the way a vehicle moves. A software is used to calculate and measure the exact path a vehicle takes when that vehicle does not move in a straight line but turns for instance.</td><td>Used to design roads specially to determine the path that vehicle will take and how much maneuvering space it requires to avoid any mishaps.
 
</td></tr>
<tr><td>LOPA</td><td>Layer of Protection Analysis
A risk assessment and hazard evaluation method which provides a simplified balance between qualitative process hazard analysis (PHA) and detailed and costly quantitative risk analysis. An identified accident scenario is established where some simplifying rules are used to allow for the analysis of the initiating event frequency, along with the independent layers of protection. This results in an estimate of risk by order of magnitude.</td><td>Used when companies are striving to achieve a specific risk target or to lower risk as low as reasonably practicable (ALARP). Using the LOPA method, the user can ascertain the level of risk that is associated with hazardous events in the workplace. The analysis is based on the severity of the event and the likelihood of it taking place.</td></tr>
</table>

<table>
<tr>
<td>What-If Analysis</td>
<td>What-If Analysis
It is a structured brainstorming method of determining what things can go wrong and judging the likelihood and consequences of those situations occurring. The answers to these questions form the basis for making judgments regarding the acceptability of those risks and determining a recommended course of action for those risks judged to be unacceptable.</td>
<td>Used to assess risks concerning a process or system.
 
<table>
<tr><th>What If?</th><th>Answer</th><th>Likeli-hood</th><th>Conse-quences</th><th>Recommendations</th></tr>
<tr><td>Granular powder is not freely owing?</td><td>1. Back injury potential when breaking up clumps</td><td>Quite Possible</td><td>Serious</td><td>Design delumping equipment</td></tr>
<tr><td>Drum is mislabeled?</td><td>2. Quality issue only</td><td>Remote</td><td>Serious</td><td>Contact vendor</td></tr>
<tr><td>Wrong powder in the drum?</td><td>3. If wet, could cause exotherm</td><td>Unlikely</td><td>Minor</td><td>Include inspection in procedure</td></tr>
<tr><td>Drum hoist is not used?</td><td>4. Back injury potential</td><td>Possible</td><td>Serious</td><td>Train personnel & ensure use</td></tr>
<tr><td>Two drums are added?</td><td>5. Quality issue only</td><td>Remote</td><td>Minor</td><td>None</td></tr>
<tr><td>Drum is misweighed?</td><td>6. Quality issue only</td><td>Possible</td><td>Serious</td><td>Require 2nd check on weight</td></tr>
<tr><td>Drum hoist fails?</td><td>7. Leg, foot, back, arm injury</td><td>Remote</td><td>Serious</td><td>Ensure hoist on PM program</td></tr>
<tr><td>Drum is corroded?</td><td>8. Iron contamination as well as drum failure & injury</td><td>Remote
Unlikely</td><td>Serious
Minor</td><td>None
Include vent check in SOP</td></tr>
</table></td>
</tr>
<tr>
<td>Facility Siting Analysis</td>
<td>Facility Siting Analysis
A facility siting study is a look at the spacing and placement of both permanent and temporary buildings and equipment in chemical processing plants. Its purpose is to make sure that buildings are located at safe distances in relation to process units.</td>
<td>A facility siting study will usually be initiated during an OSHA Process Hazard Analysis (PHA). The PHA is a more extensive study, completed every 5 years. Another time that a facility siting analysis could be initiated is when new buildings and equipment are added.</td>
</tr>
</table>

Appendix 3 Designer's Guide - Misconceptions Checklist

Designers' wrong beliefs	Explanation about the belief	Example
Active monitoring	The belief that contractors will seek information about the system condition whereas they are often passive recipients	Soil movement which required regular monitoring
Adaptive behavior	The belief that contractors will update their knowledge when they use new equipment – whereas they sometimes rely on knowledge acquired from using old ones	No cues provided on load handling characteristics to crane operators accustomed to different types of cranes
Benign conditions	The belief that operating conditions are benign or have little effect on the use of the system – or that operators use systems differently in difficult environments	Operating tower crane during inclement weather
Boundary knowledge	The belief that operators have good knowledge from experience about a system limit states – whereas operators cannot explore limit states because of the risks	Operating an excavator in a trench without understanding soil condition.
General practices	The belief that design practices for various operating environments are general – whereas operating environments are more varied than the design practices recognize.	Scaffold design for scaffold erected on cantilevered platform
Guaranteed operating procedures	The belief that operating procedures can avoid a harm that is inherent in the design – whereas procedures may be too general and are often violated	System left in hazardous state without indication after failure to observe permit-to-work procedures
Reliable aids	The belief that precautionary aids will increase system reliability – whereas operators will not routinely check and operate aids not in routine use.	Emergency stop buttons or windsocks
Specific emergency conditions	The belief that emergency conditions will only be of a particular kind - whereas emergency conditions are highly unpredictable by their nature	Evacuation system not taking into consideration gas density and wind direction
Sustained attention	The belief that operators will sustain high attention levels – whereas attention is degraded in a variety of conditions	Lack of device to alert sleeping operator to hazardous condition

Designers missing belief	Explanation about the belief	Example
Confounded goal	Not anticipating how the design could stop an operator meeting a reasonable goal and resorting to a hazardous behavior	Worker not able to secure fall protection device while working at height
Transmission mechanism	Not anticipating how a hazard could be quickly transmitted between locations in a complex system	Water drains carried burning hydrocarbons

Designers missing belief	Explanation about the belief	Example
Need for control	Not anticipating how the design requires operator to exercise control	Controls located out of view of affected operation
Need for cues	Not anticipating how the design fails to provide cues needed by operators	No visible indication of equipment in hazardous state
Need for precautionary instruction	Not anticipating how the design requires operator to perform precautionary actions	No service life stated for devices needing replacement
Activating a hazard	Not anticipating how the design allows operators to activate hazards	Operator fully opened wrong valve during start-up
Ambiguity during emergency	Not anticipating how the design is opaque to operators during emergency conditions	Layout was disorienting when filled with smoke
Information needed in emergency conditions	Not anticipating how the design requires operator to have particular information needs in emergency conditions	Lack of valve position indication during manual control
Biased information seeking	Not anticipating how the design is vulnerable to characteristic human biases in information seeking or processing	Operators are biased toward looking for hazards straight ahead
Component interference	Not anticipating how the design could be vulnerable to operators causing components to interfere	Interference between rope and chain caused rope to part
Gambling behavior	Not anticipating that the design is vulnerable to operators knowingly taking risks for some payoff	Safe work platform not provided to carry out maintenance causing workers to take shortcuts
Interrupted attention	Not anticipating that the design is vulnerable to operators suffering interruptions and hence lapses	System alarms and building alarms causing confusion
Over-dependence	Not anticipating that the design is vulnerable to operators depending on a system beyond its safe regime	CO2 total flooding system activating while operators working in protected area.
Repeated attempts	Not anticipating that the design is vulnerable to operators having to make multiple attempts to make it work	Docking system destroyed after repeated attempts
Unintended use	Not anticipating that the design appears to be capable of being used in unintended ways	Drain connections incorrectly used for depressuring causing low temperatures
Wrong-sense interpretation	Not anticipating that the design gives a display which can be interpreted in a wrong sense	Operator read emergency display as though it were the primary display

Appendix 4 General Hazard Management Prompts

1. General Requirements

1.1. Design Thought Process

Get the right……	▪ Information, Standards, Procedures and People
Think about……	▪ Existing plant/equipment/services/personnel ▪ Construction, Operations and Maintenance ▪ Special tools and Access requirements ▪ Regulators' requirements
Show…….	▪ Existing obstacles ▪ Services Access ways ▪ Equipment Clearances
Who needs to provide information?	▪ Operations, Maintenance, Vendors ▪ Electrical, mechanical, structural, disciplines, civil & earthworks

1.2. Hazard Identification

Visualise and be observant:

*Do not only **Look** but **See**: Look Close, Look Wide, Look Above, Look Below, Walk Through*

Will any of the following interaction create hazard?
Vehicle with Vehicle
Vehicle with personnel
Vehicle with environment
Vehicle with rail
Entanglement
Entrapment
Engulfment
Fire/explosion
Dropped objects – product
Dropped objects – tools/equipment
Cranes, Lifting, jacking
Spillage or overflow

Will the following exposure be hazardous to personnel?		
Working at heights	Crushing injury	Lack of signage/labelling
Working in confined spaces	Explosives	Lack of guarding
Lack of access	Fly rock	Chemicals
Dropped objects	Extreme weather	Vibration
Drowning	Wildlife	Noise
Stored Energy	Manual handling	Dust
Electrical energy	Poor lighting	Heat/cold
Electrical shock	Equipment/structural failure	

Is there exposure to the following and what are the controls?		
Leaks/discharges	Sacred sites	Dust generation
Effect on flora	Effect on fauna	Noise generation
Heritage sites	Land disturbance/clearing	Existing contamination

2. Control Measures

Discuss	Assess	Apply
With subject matter specialists	Alternative options	Hierarchy of Controls: See below for details
With other affected parties	Providing solutions	Standards

2.1 Hierarchy of Controls

Hazard elimination shall be given the priority.

If the hazard cannot be eliminated completely there are a number of control options that can be used to prevent or minimise exposure to the risk:

- **Substituting** a less hazardous material, process, or equipment
- **Redesigning** the equipment or work process
- **Isolating** the hazard through engineering – separating the worker from the hazard
- **Administrative** controls involve minimising exposure to a risk through the use of procedures or instruction
- **Personal Protective Equipment (PPE)** is used as a last resort when exposure to risk is not acceptable or cannot be minimised by other means.

3. Complete Design Review

Has the following been documented?	
Document on-going risk management procedures	Drawings to highlight methodologies
Training documentation	Produce/update procedures
Operations/maintenance manuals	Specific commissioning procedures
Construction sequence diagrams	

4. Construction Requirements

Does the design consider the following?	
Alignment with construction execution plan	Stability during construction/Deconstruction
Greenfield construction	Crane access, Monorail requirements
Brownfield construction	Minimise work in confined spaces
Modular construction	Traffic management plans
Flat pack construction	Designated laydown areas
Preassembly	Engineered lifting points
Underground services	Personnel respite areas
Above ground services	Construction fire protection
Personnel access/egress	Access to excavations

Emergency access/egress	Access to excavations equipment
Dust minimisation	Access to joints, splices etc.
Noise minimisation	Access – welding
Potential for engulfment	Access – piling rigs
Clearance for personnel to access bolts, nuts, splices	Access – concrete pumps
Stability of excavations	
Is design information required for the following?	
Erection methodology	Torque requirements for belt tightening
Lift studies	Pressure testing
Estimated weights	Pipe Pickling
Centre of gravity	Load testing requirements
Welding	Commissioning documents
Erection sequence	Construction verification
Personnel access	Test certificates
Deconstruction sequence	
Construction tolerances	

5. Operations and Maintenance

Has clearance and safe access been considered for?		
Personnel	Maintenance equipment	Cranes and removal of plant
Isolation of energy sources	Component change-out	Trucks
Purging	Maintenance lay-down	Manual handling
Bins and chutes	Sample and test points e.g. oil, vibration without removal of guards	Condition monitoring
Cleaning	HV Electrical Equipment	Lubrication access points
Moving equipment	Muster points	Lubrication storage
Drainage	Power lines clearance for vehicles and cranes and for safe maintenance access	Stockpiles and tunnels
Segregation of personnel/equipment		Escape / evacuation

Has the design considered provision of services for?	
Cleaning	Disposal of waste/spillage
Lighting	Uncontrolled discharge to the environment
Maintenance	Water
Lubrication	Air
Lift and pulling points	Power
Sampling	

Has the design considered the requirements of?		
Operations	Heavy vehicle access	Spare parts
Maintenance	Isolation	
Component change out	Rescue plans	Detailed work procedures
Disaster recovery	Training	Traffic Management Plans
Crane lift studies	Confined spaces	

Is protection required from?	
Equipment under load/overload	Slips, trips, falls
Removal of guarding	Flooding
Lack of guarding	Drowning
Explosion /Burst	Excessive weight (spillage)
Impact	Equipment failure
Equipment failure	Awkward lifting position
Lack of equipment protective devices	Ejected products/parts
No interlocks	Awkward object to lift
Interlock failure / bypass	Moving equipment
Vibration	Over-turning
Minimize confined space entry requirements	Dropped object

Appendix 5 Facility Siting Analysis

Facility Siting involves the assessment of the possible impacts of fire and explosion on life safety, structures, and equipment as well as the effects of releases of toxic substances and their ingress into buildings.

Traditionally, facility siting has a broad interpretation. OSHA's interpretation of facility siting includes the spatial relationship between the hazards of a process and the location(s) of people in the facility, particularly in occupied buildings such as control rooms.

Issues that should be addressed in a facility siting study include:

- Identifying hazardous scenarios that could have significant effects on occupied buildings
- Identifying vulnerable locations of control rooms, and other buildings that may be occupied by people
- Spacing between the hazards in a process and the locations of employees in occupied buildings,
- Spacing of process units and equipment,
- Spacing between potential sources of flammable releases and ignition sources,
- Domino effects, i.e.: the potential for an incident to propagate from one process area to another separate area,
- Emergency response issues, e.g.,
  - Availability of emergency equipment
  - Location of fire suppression systems
  - Accessibility for fire trucks
  - Accessibility of fire hydrants / monitors
  - Locations of emergency refuges and muster points
  - Ability of an occupied building to provide sheltering-in-place
  - Suitability of evacuation routes
- Adequacy of hazardous area classifications

Appendix 6 Typical EHS Design Management Plan Template

1. PURPOSE AND SCOPE
2. DEFINITIONS
3. REFERENCES
4. EHS IN DESIGN PHILOSOPHY
5. PROJECT EHS ORGANISATION AND RESPONSIBILITIES
   - 5.1 Project Sponsor
   - 5.2 Project Manager / Project Director (Tailor according to Project)
   - 5.3 Project Engineer / Engineering Manager (Tailor according to Project)
   - 5.4 Design Team
   - 5.5 Project EHS in Design Representative
   - 5.6 Project EHS Manager (Remove if EHS Manager not appointed in the design phase)
   - 5.7 National EHS in Design Coordinator
6. STANDARDS AND STATUTORY REQUIREMENTS
7. PROJECT EHS IN DESIGN PRINCIPLES & REQUIREMENTS
8. SITE VISITS
9. HAZARD IDENTIFICATION AND RISK MANAGEMENT
   - 9.1 Key Project EHS Risks
10. ENGINEERING DESIGN PRACTICES
11. KEY EHS ACTIVITIES & REVIEWS SPECIFIC FOR PROJECT
    - 11.1 EHS in Design Activities
    - 11.2 EHS in Design Reviews
12. EHS IN DESIGN TRAINING
13. EHS IN PROJECT MEETINGS & TOOLBOX TALKS
14. EHS IN DESIGN KPI'S
15. EHS IN DESIGN AUDITS
16. DELIVERABLE VERIFICATION REVIEW
17. OCCUPIED FACILITY SITING ANALYSIS
18. EHS IN DESIGN DELIVERABLES REGISTER
19. EXCLUSIONS

Appendix 7 Design for Safety Competency Matrix

Design for Safety Competency Matrix	Basic Skills						Technical Skills				Qualification & Experience		
	Induction - Design for Safety	Ability to understand and interpret Global EHS & Site EHS Standards and Procedures	Ability to understand and interpret EHS legal requirements, codes of practice, guidelines and international standards	Ability to understand and interpret Management Systems e.g. ISO14001, ISO45001 and RBA 7.0	Ability to use Microsoft Office Suit	Problem Solving Skills	Knowledge of Semiconductor Plant Design, Construction, Operation and Maintenance	Knowledge of Risk Management and Assessment Tools	Knowledge of MEP & CSA	Knowledge of BIM360 / ACC	Diploma/Degree in related engineering field with 3 to 5 years in Semiconductor Plant Design, Construction, Operation and Maintenance	Degree in related engineering field with 6 to 10 years in Semiconductor Plant Design, Construction, Operation and Maintenance	Degree in related engineering field with more than 10 years in Semiconductor Plant Design, Construction, Operation and Maintenance
Designer	■	■	■	■	□	■	■	■	■	■			■
Engineering Manager	■	■	■	■	□	■	■	■	■	■			■
Design Manager	■	□	□	□	□	■	■	■	■	■			■
Design Coordinator	■	■	■	■	□	■	■	■	■	■		■	
Construction Manager	■	□	□	□	□	■	■	■	■	■		■	
Project Manager	■	■	■	■	□	■	■	■	■	■		■	
EHS Engineers/Professionals	■	■	■	■	□	■	■	■	□	□		■	
MEP & CSA Engineers	■	□	□	□	□	■	■	□	■	■	□		

■ Has basic knowledge. Can do the task task independently.

■ Has the skills for independent task completion and quality that go beyond the basics

■ Has the skills for independent and qualitative task completion and can effectively pass this knowledge on

■ Has the skills for independent and qualitative task completion, Initiates optimization approaches, sources for error fix and solutions.

Appendix 8 Maintainability Guide

Use Instruction The designer should indicate “Y”, “N” or “NA” in the Y/N/NA column against the design recommendations.

Abbreviation	Denotes
Y	Yes – meet or exceed the design recommendation
N	No – does not meet the design recommendation
NA	Not Applicable – design recommendation is not applicable

The designer should provide a brief description of the provision. If the design recommendation is not met or not applicable, the designer should explain why the recommendation is not considered and whether alternative solution is proposed. Additional notes, references and drawings could be attached to this guide as supporting documents.

As the design objectives differ from one building to another, the recommendations of the guide may not comprehensively address the scope and specific maintenance requirements of a project. The designer should use this guide in conjunction with other applicable codes, regulations, and design guidelines.

An example of completed checklist is as follows:

A1.	**Access**	**Y / N / NA**	**Description of provision** (Attach relevant drawings or references, etc. where necessary)	**If No or Not Applicable, please explain**
A1.1	**Protruding façade features** Avoid extensive niches, fins and ledges that protrude more than 600mm. If the protrusions exceed 600mm, designers should make specific considerations for safe and easy access.	*NA*		*No protruding features on façade.*
A1.2	**Internal Access** Façade design should promote minor cleaning and repair works to be carried out from within the building, while major repair works can take place from the outside. Use modularised window panels which are not too large (max 750mm) or reversible windows for ease of cleaning from within the building, i.e. within reach of a cleaner's arm and his/her handheld tools.	*Y*	• *Gondola system and elevated walkway access provided*	
A1.3	Access to any part of the façade should not encroach on private spaces or require deconstruction of window units or other building components.	*Y*	• *No encroachment into private spaces*	
A1.4	**Building Maintenance Unit (BMU)** Where BMU is used for façade maintenance, ensure that the BMU is: a) electronically powered and programmable.	*N*		*No BMU system is used. See 'façade access strategy' described in the Maintenance Strategy Report*

1. Architecture

1.1. Access to facades

Objectives:

Provide safe and easy access to every part of a building's façade and all elements therein (e.g., sunshades, canopies, claddings, lights, signs, and other façade features) – for efficient cleaning and maintenance, and inspection.

1.	Access	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or Not Applicable, please explain
1.1	**Protruding façade features** Avoid extensive niches, fins and ledges that protrude more than 600mm. If the protrusions exceed 600mm, designers should make specific considerations for safe and easy access.			
1.2	**Internal Access** Façade design should promote minor cleaning and repair works to be carried out from within the building, while major repair works can take place from the outside. Use modularized window panels which are not too large (max 750mm) or reversible windows for ease of cleaning from within the building, i.e., within reach of a cleaner's arm and his/her handheld tools.			
1.3	Access to any part of the façade should not encroach on private spaces or require deconstruction of window units or other building components.			
1.4	**Building Maintenance Unit (BMU)** Where BMU is used for façade maintenance, ensure that the BMU is: a) Electronically powered and programmable. b) Designed to enable positioning/ suspension of working platforms to reach all exterior surfaces of the building. c) Easily accessible via common areas. d) Designed with suitable restraints and bumpers to address wind loads.			
1.5	**Suspended Working Platform** Where suspended working platform (gondola) is used for façade maintenance, ensure that: a) There are provisions for gondola to be safely affixed to the building (e.g., permanent installation points) as well as adequate anchor points for safety ropes and independent anchor for lifelines. b) The gondola is able to reach all parts of the building facade. c) Façade features do not obstruct the operation of the gondolas. Surfaces below protrusions/ cantilevered structures should be reachable and maintainable from the gondola. d) There are adequate safe launching/ landing places for the cradle/ working platform. e) The launching and landing spaces and the access routes to these spaces are located within common spaces and should avoid landing in landscaped areas.			

	f) There is provision of power supply for gondola operations and water supply for carrying out maintenance works. g) Ensure spacing between external walls/ structures of adjacent blocks is at least 1.2m to facilitate the safe use of gondolas.			
1.6	**Ground-based (Mobile Elevating Work Platform (MEWP))** Where MEWP is used for façade maintenance, ensure that: a) Unobstructed access route and working space are provided, b) Access route and working space should be level and designed to take the equipment's load.			
1.7	**Provision for use of ladders** Provide firm and level surface for use of ladders.			
1.8	**Safety of Maintenance Personnel** Provide safe working environment for the setting up and operation of access systems such as: a) Railing, b) Anchorage points and/ or lifelines for sliding safety harness, c) Eyebolt fixing for rope to secure ladder.			
1.9	**Air Conditioning (AC) Unit Service Ledge** Provide sufficient working space and safe working environment (e.g., anchorage for safety harness) for maintenance personnel.			
1.10	Where maintenance access to the service ledge is via windows or wall apertures, the size of the openings should allow safe and easy access for maintenance personnel carrying tools, equipment, and component parts. Maintenance activities should not require the dismantling of services and building elements.			
1.11	Provide safety barriers or guard rails (minimum height of 1m) around the service ledge.			

1.2. Choice of Materials & Finishes for Facades

Objectives:

Use appropriate materials and finishes that are resistant to deterioration and exposure to weather elements.

2.	**Materials & Finishes**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
2.1	Adopt materials and finishes that are readily available (i.e., does not require special procurement).			
2.2	**Paint Systems** Use paint systems that enhance weather protection and lengthen the cyclical period needed for façade re- painting (e.g., paint with anti-stain and self-cleansing properties).			
2.3	**Fastenings and Fixings** Use materials that are not prone to corrosion or rust e.g., stainless steel.			
2.4	**Outdoor Materials** Avoid materials that are prone to deterioration when exposed to weathering (e.g., plaster or calcium silicate board).			

2.5	**Sealants** Use sealants that are resistance to staining and bleeding.			

1.3. Design and detailing for facades

Objectives:

Provide effective design and detailing to promote efficient run-off on façade surfaces to minimize water ponding, penetration, and staining problems.

3.	**Design & Detailing**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
3.1	**External Walls** Provide drip edges to prevent streaks on exterior soffits, walls, and glazed surfaces.			
3.2	Grade all top surfaces of walls to fall away from external face of walls to minimize streaks on the facade. The coping should overhang the rear side of the walls and comes with drip control to mitigate streaks on the back walls.			
3.3	**Stone Panels** Stone panels should be mechanically fixed. Avoid the use of adhesive which are prone to efflorescence.			
3.4	Install stone panels in a way that allows for inspection of its concealed mechanical connections to pre-empt corrosion or defects (e.g., accessible for fiber-optics inspection).			
3.5	**Metal Cladding and Fixtures** Avoid metal cladding and wrapping around external building components where high pedestrian traffic is expected.			
3.6	Install metal cladding in a way that allows for inspection of its concealed mechanical connections to pre-empt corrosion, dilapidation and loose or defective fixings.			
3.7	**Glazed Surfaces** Avoid inclined glass surfaces, being prone to dirt and dust collection.			
3.8	Size up external glazing optimally such that glass panels can be transported by lifts to facilitate future replacement from within building.			
3.9	Avoid the use of non-planar or curvilinear glass surfaces which are difficult to maintain or not readily available in the market.			
3.10	Ensure that glass (e.g., glazed canopies) are able to withstand the loads imposed during maintenance.			
3.11	**Glass Parapets** Avoid extensive use of glass parapet walls at outdoor areas as weather stains on glass surfaces are more visible and require more frequent cleaning.			

3.12	**Weather Control Devices** Incorporate appropriate weather control devices (such as overhanging ledges, copings, and rain screens) to external openings to minimize rainwater ingress. Where wall openings/doors are subject to external weathering, incorporate details such as overhang at the top, and water-bar or threshold kerb at the bottom to minimize water ingress.			
3.13	**Joints** Provide movement joints to accommodate movement in large continuous areas, or between adjacent building components (e.g., brick wall and concrete column) and dissimilar substrates. The backer-rod material in the joint should be compatible with the sealant used.			
3.14	**Anti-Roosting Measures** Adopt designs that mitigate roosting of birds (e.g., use chamfered or steeply sloped surfaces).			
3.15	**Planter boxes** Planter boxes should be accessible for easy maintenance (e.g., located at windowsill level, along service balcony/ corridor).			
3.16	The location of drainage outlets of planters should not cause stains on building facade.			
3.17	**Loading/ Unloading Areas** Provide protection to beams and columns in loading/ unloading areas (e.g., rubberized sleeves).			

1.4. Roof Access

Objectives:

Design the roof space for safe and efficient movement of maintenance personnel carrying tools, equipment, and spare parts.

4.	**Access**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
4.1	**Direct Access** Provide at least one direct staircase access to main roof areas for maintenance purpose.			
4.2	**Safety** Provide safety barriers/guard rails (min height of 1.0m) or anchor points for safety harness along the roof perimeter and roof openings (such as skylights and air wells) to prevent fall from height.			
4.3	Provide minimum 1.5m clear working space (or larger as specified by M&E equipment supplier) between the building edge/parapet wall and M&E installations.			
4.4	Provide non-slip steps/platforms/catwalks over/along maintenance path to prevent stepping on rooftop services such as piping/ trunking/ conduit.			
4.5	Provide clear demarcation of maintenance boundaries and access at roof areas.			

4.6	Provide hoisting facilities and anchorages at the roof for hoisting of equipment after completion of the building.			
4.7	Where façade extends more than 5m above the roof, provide catwalk or other means of access at the internal side of the façade.			

1.5. Materials and finishes for roofs

Objectives:

Use appropriate materials and finishes that are resistant to deterioration and exposure to weather elements.

5.	**Materials and Finishes**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
5.1	Provide adequate waterproofing to roof surfaces			
5.2	Avoid extensive use of transparent and translucent roofing materials that are prone to discoloration and deterioration when exposed to weather elements.			
5.3	Use roofing materials/finishes that are able to withstand heavy maintenance works (e.g., removing of algae).			

1.6. Roof design and detailing

Objectives:

Provide effective design and detailing to ensure optimal run-off to avoid water ponding and penetration problems.

6.	**Design & Detailing**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
6.1	**Drainage** Grade all roof areas and open terraces to fall, with adequate gradients, so storm water is directed away from door openings and flow towards rainwater outlets/ floor waste outlets.			
6.2	Slope the RC roof slab and roof gutters at 1:50 or steeper to facilitate efficient run-off.			
6.3	Design two-directional fall to improve drainage and to reduce roof slab thickness.			
6.4	Provide drainage outlet with “debris trap” to prevent choking of the drainage system. Use leaf guards and overflow spouts to prevent water stagnation.			
6.5	**Expansion Joints** Incorporate adequate expansion joints to prevent cracking and support the vibration of plants and equipment on the roof. The expansion joints should be at regular intervals over large continuous roof areas due to continuous weather exposure.			

6.6	Fixtures of façade access equipment on the roof should not affect/damage the components of the lightning protection system.			

1.7. Building access, spaces, and elements

Objectives:

Ensure that access design and systems enable ease of maintenance to various building elements, vertical spaces, and services.

7.	**Access**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
7.1	**Air Well and Atrium** a) Avoid constricted areas, air wells and atrium which are difficult to access for maintenance. b) Provide suitable access system to maintain the façade/ glazed surfaces within air well/ atrium (e.g. maintenance tracks systems with suspended platforms around large voids and air wells). c)Avoid high volume voids or "soft storeys" with "flying" beams" which do not have easy means of access for maintenance.			
7.2	**Ceiling Spaces and Height** Avoid lobby areas with high ceiling spaces (e.g., > 5m) which are difficult to access for maintenance.			
7.3	Where ceilings exceed 5m in height, provide catwalks, elevated platforms and/or unobstructed access route for maintenance equipment and vehicles e.g., scissors lift and mobile elevated platforms.			
7.4	Provide a service lift of adequate capacity to transport the maintenance equipment and vehicles to for maintaining high ceiling spaces of sky terraces.			
7.5	**Outdoor Lightings** Lampposts should be safely and easily accessible for lamp replacement (e.g., areas should have firm surface to allow proper deployment of ladders).			

1.8. Materials and finishes for building access, spaces, and elements

Objectives:

Use appropriate materials and finishes to minimize the frequency of cleaning, repair and replacement.

8.	**Materials & Finishes**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
8.1	**Walls** Avoid spray textured finish on walls and columns where there is heavy pedestrian traffic.			
8.2	**Floors** Use stain resistant (e.g., mid tone colors) floor finishes in areas with heavy pedestrian traffic such as lift lobbies and common corridors.			
8.3	Avoid combining metal elements with natural stones to reduce risk of staining associated with metal corrosion.			

8.4	Use metal (e.g., aluminum-finished) fixtures or doors (with appropriate fire rating, where necessary) instead of timber in areas exposed to weather or damp conditions.			
8.5	**Exterior Ceiling** Use weather and wind resistant ceiling materials (e.g., metal panels) in areas exposed to weather elements.			
8.6	**External Signage** Use weather-resistant materials in semi-gloss finish for easy maintenance.			
8.7	**Vehicle Drop-off Areas** For vehicle drop-off areas, use oil-resistant surface (e.g. pavement or stone) to reduce permanent staining caused by vehicles. Avoid: i. porous, soft stone materials, ii. glossy surfaces, or iii. light-colored materials, in areas with heavy pedestrian traffic.			
8.8	**Driveway Paving** Avoid the use of rough stone paving for driveway as they are more prone to trapping dirt.			
8.9	**Timber** All timber finishes should be kiln-dried and well- seasoned to prevent shrinkage, splits and deformation. All timber finishes should be treated for fungi and insect attack, including anti-termite treatment, with an approved wood preservative.			
8.10	**Masonry, Stone and Tiles** Provide appropriate and compatible sealer/ impregnator to the sides, top and bottom surfaces of stone works.			
8.11	Where masonry/ stone finishes are used near wet areas, the stone should be appropriately treated (e.g., sealant, admixture, water repellent) and detailed to prevent efflorescence.			

1.9. Design and detailing for building access, spaces, and elements

Objectives:

Provide effective design & detailing for protection against weathering and enabling simple maintenance.

9.	**Design & Detailing**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
9.1	**Linkways and Drop-off Areas** Provide sufficient roof gradient (min 3˚ slope for flat roof) for efficient water run-off.			
9.2	Design of linkways, drop off porches, and external corridors should minimize ingress of rain, ensuring at least 50% dry covered passage, e.g. i. Provide drop panels and weatherproof louvers for high volume roof, ii. provide sheltered area or canopy with a depth of at least 2 times the entrance width.			

9.3	Design of linkways and drop-off porches should be modularized with demountable parts (no welded parts) for ease of maintenance, where required, and to facilitate access for maintenance vehicle.			
9.4	Provide concrete curb / collar at the base of metal columns to minimize contact with water and reduce corrosion.			
9.5	Floor slabs should come with removable panels for inspection and maintenance of concealed services.			
9.6	Grade all exposed floors and flat surfaces to fall so as to direct run-off to the external drains and scuppers.			
9.7	Avoid corners and cavities which are inaccessible to cleaning machines.			
9.8	Provide anchor points for safety harness on linkways and canopies for maintenance personnel.			
9.9	**Entrance to Building** Provide floor mats with integrated drainage system at the main entrance to reduce entry of water, dirt and dust into buildings. Floor mat should flush with the floor finishes to prevent tripping hazards.			
9.10	**Ceiling** Avoid monolithic ceiling design (joint-less with no access to internal services) which are more costly and tedious to repair and maintain.			
9.11	Use suspended modular ceiling panels that are easily demountable for its easy replacement and maintenance of embedded services.			
9.12	Where metal ceiling panels are used, they should be designed to prevent sagging and withstand wind loads. Panels should be sized such that they can be easily handled by one person.			
9.13	**Staircase** Provide appropriate nosing's to avoid chipping of edge of the steps.			
9.14	**Expansion Joints** Ensure that sufficient expansion joints are provided to external and internal finishes to prevent cracking, warping, etc.			
9.15	**Drainage** All concealed drainage, rainwater down pipes should have access openings.			
9.16	**Recessed Floor Lightings** Avoid the use of recessed floor lights that is prone to water damage. If such lights are used, provide drainage to prevent waterlogging.			
9.17	**Safety of Maintenance Personnel** Provide appropriate warning signs for maintenance crew to prevent stepping on ceiling boards and non- load bearing surfaces (e.g., in voids of service risers).			

1.10. Parking area access design

Objectives:

Provide adequate and unobstructed access for maintenance personnel and equipment.

10.	**Access**	Y / N / NA	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
10.1	Where services/ plant rooms are within car park, provide service route(s) with adequate headroom and sufficient working space for maintenance vehicle/ equipment. (e.g., access and maneuvering space for refuse collection truck).			
10.2	Car Park lots should not block the doors of M&E rooms.			

1.11. Materials and finishes for parking areas

Objectives:

Selection of materials and finishes should take into consideration stains and wear and tear due to vehicular traffic and exhaust fumes.

11.	**Materials & Finishes**	Y / N / NA	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
11.1	Provide epoxy coating on car park driveway and parking lot for greater durability. Use resilient material (e.g., thermoplastics) for directional and parking lot markings.			
11.2	The surface material of the driveway and walls should allow easy removal of oil and water stain as well as heavy-duty washing.			

1.12. Design and detailing parking areas

Objectives:

Provide effective design & detailing to protect against damages from vehicles and ensure optimal surface run-off to avoid water stagnation.

12.	**Design & Detailing**	Y / N / NA	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
12.1	**Guards and Wheel Stoppers** Use wheel stopper and crash guards to protect columns, walls, and exposed pipes and services near car park lots and driveways.			
12.2	**Ramps** Provide groove lines on access ramps to facilitate water discharge to the scupper drains on the side of ramps.			
12.3	**Drainage** Provide adequate drain outlets to prevent water stagnation (e.g., scupper drains in the vicinity of wheel stoppers).			
12.4	Provide cut-off drains with adequate depth and gradient at all areas of the car park that are exposed to weather including: i. the top and bottom of ramps. ii. open/partially exposed staircase (at intermediate landing and/or base of staircase).			

1.13. Materials and finishes for M&E rooms

Objectives:

Selection of materials and finishes for the floors and walls should take into consideration wear and tear and exposure to weather elements.

13.	**Materials & Finishes**	Y / N / NA	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
13.1	**Floors** Use darker tone epoxy topcoat for the floor finishes in service rooms and service corridors.			
13.2	**Walls** Provide metal chequered plate on walls (up to 1.2m high) for surface protection in service rooms and service corridors that are subject to frequent, heavy wheeled traffic.			
13.3	**Doors** Provide door kick plate for service rooms that are subject to frequent, heavy wheeled traffic.			
13.4	Use corrosion-resistant material (e.g., aluminum doors) for service doors exposed to weather or damp conditions.			

1.14. Design and detailing for M&E rooms

Objectives:

Provide effective design and detailing to prevent water ingress/egress problems and to enable simple maintenance.

14.	**Design & Detailing**	Y / N / NA	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
14.1	Avoid locating wet areas above critical service rooms (e.g., server rooms, LAN rooms, and electrical rooms). If this is not possible, provide double slab with access and adequate height between slabs for maintenance.			
14.2	Provide raised kerb at AHU room, water tank room and electrical rooms to prevent water ingress/ egress.			
14.3	**External AC Screens** Design the sound barriers/ visual screens for air- conditioning equipment in easily demountable, modularized units so as to facilitate easy access and maintenance.			
14.4	**Louvres** Provide at least 300mm overhang above louvre vents facing external or set back the louvre vents by 300mm from the building edge.			

1.15. Washroom access

Objectives:

The design and layout of toilet facilities should allow easy access for maintenance.

15.	Access	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or not applicable, please explain
15.1	**Cleaning Machines and Equipment** Provide at least one service lift to facilitate the transport and access for cleaning machines and equipment.			
15.2	The washroom entrance should be wide enough for cleaning machines and equipment.			
15.3	**Circulation** Adopt "doorless" or vestibule entry to facilitate ease of access and improve ventilation.			
15.4	The layout of toilet should minimize circulation space and adequately designed to handle the anticipated peak traffic.			

1.16. Materials and finishes for washroom

Objectives:

Use materials that are resistant to damp and chemical environments.

16.	Materials & Finishes	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or not applicable, please explain
16.1	Use moisture impervious, durable (e.g., ceramic tiles and phenolic panels) and cleanable materials for toilet wall and floor surfaces so as to facilitate cleaning and resource conservation (such as minimizing the use of water and cleaning agents).			
16.2	Provide slip-resistant flooring (e.g., slip resistant index of R11) for safety of maintenance workers.			
16.3	Use metal gratings of sufficient quality (e.g., Stainless Steel 304) to prevent rusting.			

1.17. Design and detailing of washrooms

Objectives:

Provide effective design and detailing to prevent water damages and to facilitate easy cleaning and maintenance.

17.	Detailing and Design	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or not applicable, please explain
17.1	**Fixtures** Provide wash basins of appropriate size and depth to reduce splashing and wetting of floors.			
17.2	Use modular and smaller basin mirrors instead of full- span wall mirrors for ease of cleaning.			
17.3	Use suspended cubicle partitions to facilitate floor cleaning and prevent partition panels from constant contact with damp floor.			

17.4	Use suitable hinge and lock for cubicle doors considering the material and weight of doors to prevent misalignment after prolonged use.			
17.5	Ensure that the size of recessed/ built-in trash bin can adequately meet the waste capacity demand.			
17.6	Provide a minimum of 25mm level difference between the corridor and the toilet floor.			
17.7	Use wall-mounted wash basins, urinal bowls, and water closets to facilitate floor cleaning.			
17.8	Door frame/architrave should be raised above the wet areas and terminate above the floor level. Consider installing sub-frames above the screed level to reduce the chance of water ingress from the wet floor through the masonry works.			
17.9	**Dispensers** Install dispensers' (soap/ hand towel) above the vanity top for ease of replacement/refill. Avoid installing the dispensers behind mirror/ feature.			
17.10	The dispenser should have a visual indicator (e.g., transparent window) to show the amount of soap/ towel in the dispenser to assist in timely refilling.			
17.11	Install dispensers (soap/hand towel) / hand dryer close to wash basin.			
17.12	**Waterproofing** Apply waterproofing membrane to the wall or substrate immediately adjacent or behind a washbasin, sink or similar fixture at a height of not less than 300mm above the fixture.			
17.13	Waterproofing membrane should be dressed up at pipe penetrations to the finished floor level and dressed down at least 50mm into the floor outlet. Waterproofing membrane should be applied at least 100mm horizontally around the pipe.			
17.14	Avoid laying tiles directly onto the waterproofing membrane. As a protective measure against damaging the membrane during tiling, a layer of screed should be laid over the membrane when it is cured.			
17.15	**Shower Facilities** Provide raised kerbs of at least 100mm at the base walls to act as barriers against lateral movement of water.			
17.16	Apply waterproofing membrane with an upturn of at least 300mm to create a minimum tanking protection against migration of water to spaces adjacent or below the wet area.			
17.17	Apply waterproofing membrane of at least 1800mm height and 1500mm width of the wall or the entire enclosure at bath and shower areas.			
17.18	**Supporting Facilities for Cleaners** Provide a janitor closet/ store on each level for storage of daily-use cleaning tools/equipment, chemicals, and supplies. Storerooms should come with a large sink for filling and emptying cleaning buckets.			
17.19	Provide a designated room of sufficient size for cleaners to rest and store personal belongings.			
17.20	Provide a central storeroom/area for storage of large cleaning machines (e.g., ride-on sweeper/scrubber). Access doors and aisles need to be large enough for the machines' movement.			

2. Mechanical and Electrical

2.1. Access to M&E installations on façade and roof

Objectives:

Provide safe and easy access for the inspection and maintenance of M&E installations.

2.1	Access	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or not applicable, please explain
2.11	**Air Conditioning Condenser Unit** Provide adequate working space around the condenser unit to accommodate maintenance and replacement.			
2.12	**Externally mounted M&E installations** Provide proper means of access for maintenance for externally mounted M&E installations: i. access to LPS installations (strike pads, down conductor tapes etc.) on façade, ii. replacement of lights on the façade as well as light fittings located in high volume spaces (canopy, drop-off porch, sky terrace, etc.), iii. maintenance of other externally mounted M&E installations (e.g., ACMV louver, CCTV, and PA/AV system, etc.).			
2.13	**Lifts** Service lift should preferably land at roof level. Lift should be designed with adequate capacity to transport equipment and parts for replacement and maintenance purposes.			
2.14	Provide designated access for motor room-less lift (e.g., 'knock-out wall panel') and hoisting beam for servicing and replacement of lift motor.			
2.15	**M&E Installations on Roof** Provide adequate working space (e.g., 600m) around and between M&E installations at the roof (cooling tower, generator, condenser unit, photovoltaic panels, etc.) to accommodate easy maintenance and replacement.			
2.16	**Lightning Protection System** Provide adequate means of access for workers to inspect and maintain air terminals and lightning tapes at edge of the building.			

2.2. Materials and finishes for M&E installations on façade and roof

Objectives:

External M&E services and equipment should be able to withstand exposure to weather elements.

2.2	Materials & Finishes	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or not applicable, please explain
2.21	Use weather-resistant material for all external signage with lighting.			

2.22	Use weather-proof material for outdoor M&E devices such as lightings, speakers, cameras, card reader: a) IP65 rated lightings and relevant accessories (transformers/controllers/drivers etc..), e.g., near green wall since exposed to dirt and irrigation. b) External access control equipment (cameras, card reader, etc.) should come with weatherproof covers and/or made of weather resistant materials c) Avoid locating fire alarm call points in weather- exposed areas. Alternatively, call points should be made of weatherproof material.			
2.23	Use corrosion-resistant material for pipes, ducts, louvers, cables, and trays (including their fixing accessories) that are exposed to weather.			
2.24	Use weatherproof materials for M&E services and equipment. Provide suitable cover/shelter to equipment or component (e.g., electrostatic filters for kitchen exhaust, inverters of photovoltaic installations) that do not come with weather-proof option.			

2.3. Design and detailing M&E installations for façade

Objectives:

Provide effective design and detailing to enable proper functioning and ease of maintenance for M&E equipment.

2.3	**Design & Detailing**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
2.31	**Lightning Protection System**Use natural down conductor (e.g., steel in reinforced concrete structures) instead of exposed lightning tape.			
2.32	Avoid mounting aluminum tape directly onto calcareous building surfaces (e.g., concrete limestone and plaster) to minimize aluminum corrosion.			
2.33	**External Air-conditioning Units** Avoid locating air-conditioning units in recesses or enclosed areas (e.g., basements) to mitigate the rejected heat from being recirculated into the equipment.			
2.34	**Lighting on Roof** Provide adequate lighting to access routes leading to M&E installations.			
2.35	**Cooling towers** Provide adequate water points and power points close to cooling towers to facilitate cleaning and top-up in the event of pump failure (serving make-up water tank).			
2.36	Provide effective cooling tower water treatment to prevent corrosion, fouling, and algae growth.			
2.37	**Photovoltaic (PV) Panels** Provide adequate water points for cleaning of PV panels.			

2.4. Access to M&E installations in common areas, plants, and equipment rooms

Objectives:

Provide safe and easy access to various M&E installations to enable efficient inspection, repair, and replacement.

2.4	**Access**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
2.41	**Overhead Services** Provide adequate maintenance access space to all M&E installations (light fittings, ventilation equipment, fire alarms, ELV equipment etc.) above the suspended ceiling.			
2.42	Provide ceiling access panels near floor traps, valves, water heater and air conditioning equipment to facilitate inspection/ maintenance of services.			
2.43	Provide multi-tier trays with at least 150mm access space in between for installation/ maintenance of services cables.			
2.44	Provide a minimum of 600mm clear depth between beam soffits and false ceilings for insulated chilled water pipes to pass below the beam. Provide a minimum of 400mm clear depth between beam soffits and false ceilings for insulated refrigerant pipes to pass below the beam.			
2.45	**Prefabricated MEP System** Where prefabricated MEP is used, provide a minimum workspace of 600mm along the center of the modules. The width of services on each side of the access space should be kept within one arm's length to allow easy reach to all the services.			
2.46	**Headroom** Provide minimum 2m clear headroom in M&E rooms and access walkways/ service corridors to facilitate safe access and ease of maintenance. Obstructions that result in reduced headroom should be clearly identified and marked.			
2.47	**High Volume Spaces** For easy access, provide signs and location indicators for services located above high ceiling areas.			
2.48	Provide permanent guarded ladders, catwalks, and hydraulic powered platforms for occasional access to high volume spaces. Such maintenance activities should not require dismantling of services and building elements.			
2.49	Provide scaffolding, staging and temporary ladders for infrequent access to high volume spaces. Ensure any fixtures below such spaces can be easily removed to make space for installation of temporary access systems.			

2.4.10	**Sanitary and Rainwater downpipes** Avoid casting sanitary pipes within wall structures. Sanitary waste stacks and downpipes should be easily accessible from common areas for maintenance.			
2.4.11	'Cleaning eye' for sanitary/waste piping system should be clear from obstruction and easily accessible for maintenance. Avoid placing 'cleaning eyes' at high and inaccessible areas.			
2.4.12	**Lightning Protection System** Provide adequate means of access to inspect and test the test-link panels and earth pits.			
2.4.13	**Working Space** Provide at least 600mm unobstructed space or larger (manufacturers' requirements) for maintenance around all M&E equipment for safe maintenance and replacement of components.			
2.4.14	Ensure adequate working space for the installation and removal of mechanical equipment (e.g. 2.5m unobstructed space at the back of chiller for replacement of chiller tube or unobstructed space to operate lifting equipment).			
2.4.15	**Plumbing & Sanitary** Provide access panel of minimum 600 x 600 mm for plumbing maintenance.			
2.4.16	Provide adequate working space within service shaft to allow access for maintenance.			
2.4.17	**Waste Management** Provide vehicle access to grease traps.			
2.4.18	**Safety for Maintenance Personnel** Provide adequate lightings along access walkways and in M&E rooms.			

2.5. Materials and finishes for M&E installations in common areas, plants, and equipment rooms

Objectives:

Use suitable materials that are resistant to deterioration and exposure to weather elements and dampness.

2.5	**Materials & Finishes**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
2.5.1	Use durable (e.g., metal clad) lighting switches and power sockets in M&E rooms			
2.5.2	**Waterproofing** Provide at least IP65 rated power sockets in wet areas (e.g., pantry, water dispenser, toilets, wash area and potential wet areas in M&E rooms).			
2.5.3	**Sanitary and Rainwater downpipes** Provide anti-corrosion material for piping and installations (e.g., UPVC pipes).			
2.5.4	**Fabric Ducting System** Use fabric ducting system for large spaces (e.g., atrium and auditorium) for ease of maintenance and replacement.			

2.6. Design and detailing M&E installations in common areas, plants, and equipment rooms

Objectives:

The design and placement of M&E installations should aim at minimizing maintenance interventions and enabling ease of repair and replacement.

2.6	**Design & Detailing**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
2.6.1	**Provisions for Maintenance** Provide switch socket outlets (each point to cover a radius of max. 15m) in common areas to allow use of powered equipment for maintenance.			
2.6.2	Provide sufficient water points and socket points to facilitate the use of electrical cleaning equipment in washrooms. Socket points should be provided with splash proof covers.			
2.6.3	Equip cleaners' storerooms with utilities supply for washing of cleaning tools and equipment, as well as drainage points and splash proof socket points to facilitate the charging of cleaning tools/equipment.			
2.6.4	**Condensation Treatment** Provide condensation treatment to air distribution outlets located in high humid areas.			
2.6.5	**Prefabricated MEP System** Adopt prefabricated Mechanical, Electrical, and Plumbing (MEP) systems for more productive replacement and installation.			
2.6.6	**Labelling** Provide labelling and color coding of piping and conduits consistent with industry standards (e.g., provide directional signs and valve status on pipes for ease of identification).			
2.6.7	Provide isolation valves and proper identification to all pipes and ductworks for easy maintenance.			
2.6.8	**High Volume Spaces** Use wall mounted lights and/or suspended lighting systems for rooms with high ceilings (e.g., atria, lecture theatres, reception or lobby areas and stairwells).			
2.6.9	**Parking Areas** Locate electrical services away from voids that are exposed to weather elements.			
2.6.10	Avoid locating electrical outlets on columns or walls adjacent to car park lots.			
2.6.11	Provide adequate water and power points at appropriate locations (each point to cover a radius of max. 15m) to facilitate washing and cleaning.			
2.6.12	**Sanitary and Rainwater downpipes** Avoid locating sanitary and waste pipe in areas with high pedestrian traffic (e.g., above escalators and within high voids above common staircases, food preparation area and water tank).			
2.6.13	Avoid concealing drainpipes in the screed of dry areas.			

2.6.14	**Manholes** Depending on their location, manhole covers should be designed to withstand the required loads. Manholes should be located away from high traffic areas to minimize risk to workers during maintenance.			
2.6.15	Where possible, manhole cover / cable trench cover/ grating should be moveable by one person. Where covers are too heavy to be lifted by one person, lifting tools must be provided.			
2.6.16	**Bin Centre** Provide water point and discharge point inside the bin center for regular cleaning purposes.			
2.6.17	**Lighting and Ventilation** Provide sufficient lighting and ventilation in M&E rooms and risers that houses heat emitting equipment (e.g., electrical panels, IT switches). Provide backup emergency lighting in event of power failure.			
2.6.18	**Flood Mitigation** Provide flood mitigation measures (such as sump pump) for M&E rooms located at basements.			
2.6.19	**Ductworks/ Pipes across Floor** Avoid ductworks/ pipe installations onto M&E room floors to minimize tripping hazards, and damage due to stepping.			
2.6.20	**Redundancy Systems** Shutdown maintenance of M&E installations should not affect building's daily operation. Provide redundancy systems and emergency power for shutdown maintenance.			
2.6.21	Provide at least 2 lifts for redundancy to avoid downtime during maintenance.			
2.6.22	**Lift Motor Room** Install lighting switches near entrances of lift motor rooms, preferably within an arm's length, so that the working space can be lit before entering.			
2.6.23	Provide a conducive environment for maintenance personnel in the lift motor room (e.g., well ventilated, provision of fans).			
2.6.24	Provide a minimum 1m overhang above lift motor room doors to prevent rainwater ingress.			
2.6.25	**Lift Well** Provide 2-way switch for lift well lighting between the lift well and the lift machine room.			
2.6.26	**Bulky MEP Equipment** Provide removable facade with hoisting platform for replacement of bulky MEP equipment if it cannot be transported via service lift.			
2.6.27	**AHU** Provide kerb up washing area with water point and floor trap in AHU rooms for maintenance of the filters. Proper mechanical ventilation in the AHU rooms should be provided for maintenance personnel.			
2.6.28	Locate water points at least 1m away from any electrical installations (e.g., control panel) in AHU rooms.			
2.6.29	Direct drainage pipe from AHU into the floor trap instead of terminating the pipe above the floor trap to avoid spillage.			

2.6.30	Avoid placing AHU/FCU directly above critical equipment (e.g., server rack, electrical panel, etc.).			
2.6.31	Provide auxiliary insulated drain pan with insulated drainpipe for ceiling mounted FCU in M&E rooms. The auxiliary installation must not affect proper operation of the FCU (e.g., hindrance to airflow of FCU).			
2.6.32	Provide dampers/ vibration isolators to equipment prone to vibration transmittance (e.g., ducted FCU)			
2.6.33	Provide suitable waterproofing for AHU rooms.			
2.6.34	**Chiller** Provide auto-tube cleaning system for condenser tube to avoid fouling.			
2.6.35	**Service Risers** Design service risers with adequate width and depth to allow ease of maintenance. (e.g. Minimum width of 600mm should be provided for access to services and components)			
2.6.36	Provide handles (recessed typed) for service riser doors			
2.6.37	Provide riser doors that can be opened from inside without the need of keys.			
2.6.38	Provide load bearing floor in risers that require access by maintenance personnel.			
2.6.39	**Uninterruptible Power Supply** (UPS) Provide by-pass for maintenance of UPS to prevent downtime.			

2.7. Facility Management

2.7	**Digital Readiness and Automation**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
2.7.1	**Building Management System (BMS)** Install appropriate computer-based BMS to control and monitor M&E equipment such as centralized air- conditioning system, ventilation, lighting, power system, fire protection services, plumbing, security system and landscape irrigation system.			
2.7.2	BMS should cater to specific operational needs of building instead of comprising generic specifications from the industry.			
2.7.3	Use BMS systems which have analytic features such as monitoring, charting, and trending reports for optimal maintenance planning.			
2.7.4	Include alarm notification options (such as SMS) for buildings not operating 24/7.			
2.7.5	Provide remote web-based monitoring.			
2.7.6	Provide common (BACnet, Modbus etc.) or non- proprietary protocol for the network backbone of the building management system (BMS). (This will enable standard compliant sensors or equipment to be easily added to the building and be monitored through the BMS)			
2.7.7	Use common file formats for automated and scheduled exported data from any chosen data points. (This will enable exchange of data between systems and allow such data to be analyzed by analytics or optimization software readily).			

2.7.8	**Sensors** Place sensors strategically with consideration to access, accuracy and operation.			
2.7.9	**Sub-metering** Divide sub-metering by energy loads and areas. (This will facilitate energy audit, identify maintenance needs and targets to reduce energy use).			
2.7.10	**Building Information Modelling (BIM)** Use BIM to facilitate integration of relevant information on facility and asset management and better coordinated documentation for maintenance operations.			
2.7.11	Adopt comprehensive digital building management through 3D building model integrated with sensors, video analytics and command center. (e.g., facial recognition, incident reporting, and crowd monitoring etc.)			
2.7.12	**Documentation** Prepare adequate documentation to ensure operational continuity from design to maintenance, comprising: Written description of all the systems operation and control actions to meet the functional requirements of the system, including control strategy and logic diagrams. Integration test results of air and hydronic systems and gases (CO & CO2). Network schematic of the BMS network, showing device locations and network addresses. Description of BMS point list including user adjustable points (IT/BMS), hard and derived points, and their respective controller and register addresses. Instruction's manuals and training guides and quick reference procedures/ checklist			
2.7.13	**Power and Data Provision** Provide adequate power and data provisions (LAN cables, Wi-Fi, network switches, server with spare capacity etc.) for future smart FM features.			

2.8. Security

2.8	**Access and Control**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
2.8.1	Locate central control console in areas with 24-hours manning.			
2.8.2	Locate the fire command center (FCC) and security center to oversee at least one main ingress/ egress point or critical area. Design the FCC such that the operator is able to view all alarm signage from his sitting position instead of having to turn round to see the alarm soundings.			
2.8.3	Use turnstile with proximity security access passes.			

2.8.4	**Remote monitoring/ CCTV** Use CCTV surveillance technology with motion sensing alert to reduce security personnel. Provide CCTV surveillance at all common and critical areas including but not limited to: • Car Park • Lift lobbies • Entries into staircases • Main lobbies • All exits of the building/ car park • Last landing of escape staircase staircases • Loading/unloading area • Essential plants and equipment rooms			
2.8.5	**Visitors Management System** Use computer-based Visitors Management System to record usage of facilities by specific visitors and provide documentation of visitor's whereabouts.			
2.8.6	**Natural Surveillance** Natural surveillance of a concealed or isolated route should be encouraged. For example, provide external- facing windows or openings for enclosed stairs or ramps such that they are visible from the surrounding properties.			

3. Landscape

3.1. Landscape access and maintenance

Objectives:

Provide appropriate access to planters, green walls, and other landscaped features to carry out pruning, maintenance, and replacement safely and efficiently.

3.1	**Access**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
3.1.1	**Access Route** Landscaped areas should have suitable access routes (e.g., pavement, gravel, mulch paths) of adequate width to facilitate maintenance access for workers, equipment, and materials.			
3.1.2	**Vertical Greenery** Frontal access to green walls (including its sub-system – such as substrate, drainage, irrigation pipelines, supporting sub-frames, gratings, etc.) For green walls that are less than 2m in height, allow maintenance access from the front via elevated work platforms (e.g. ladder stand platform, mobile tower scaffold, and pole pruner).			
3.1.3	For green wall that are more than 2m in height, provide an unobstructed, flat, stable surface of adequate structural capacity in front to allow safe and effective deployment of MEWPs (mobile elevated work platforms). Where the foreground is turfed, the latter should comprise supporting underlayers to withstand the load of MEWPs.			

3.1.4	Rear access to green wall (including its sub-system – such as substrate, drainage, irrigation pipelines, supporting sub-frames, gratings, etc.) Provide permanent rear access (e.g., walkways and platforms) with minimally 600mm clear width to all parts of the green wall. The rear access must be designed with edge protection to mitigate risks of fall-from-height.			
3.1.5	Mark and identify all designated access/inspection points for maintaining vertical greeneries.			
3.1.6	**Growth lights** Provide direct access to growth lights so as not to damage the greenery.			
3.1.7	**Sky Garden** Provide adequate access and workspace around trees and tall plants.			
3.1.8	**Large Turfed Surfaces/ Fields** Locate large, turfed surfaces near fire engine access way (with gates of adequate width, if fenced) to facilitate access of equipment e.g., turf mower.			
3.1.9	**Irrigation** Provide adequate access to irrigation systems for maintenance and replacement. This includes subsurface irrigation systems.			
3.1.10	Provide proper access (e.g., pavers, gravel or mulch paths) to sources of water supply.			
3.1.11	**Water Features** Provide safe and direct means of access for maintenance of water features (e.g., lightings in water feature).			
3.1.12	Provide adequate and safe access to pump room, balancing tanks and other pump equipment which serves the water features.			
3.1.13	**Storage** Provide adequate storage areas for landscape maintenance equipment and materials.			

3.2. Materials for landscape

Objectives:

Select appropriate plants species and landscape materials to minimize the frequency of maintenance interventions such as pruning, cleaning and replacement.

3.2	**Materials**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
3.2.1	**Plant selection** Select plant species in response to the expected environmental conditions (e.g., choose plants which are appropriate for sunny/ shady areas, waterlogged grounds, high pedestrian footfall areas, elevated edges, sloped terrain, wind conditions etc.). Avoid planting fruit trees next to walkways to reduce maintenance due to falling fruits.			

3.2.2	For vegetation abutting water features and water bodies, avoid selecting plant species with excessive shedding of leaves and blooms. Accumulated plant debris may end up choking the water systems.			
3.2.3	Avoid species with invasive roots system near non- suspended pavement, or for sky gardens and roof-top landscape. Provide root barriers in these areas to prevent them from penetrating into structures, weep holes, drains, and floor traps.			
3.2.4	In areas where plant inspection is infrequent and/or cannot be effectively conducted, avoid plants species (e.g., species of bromeliad, alocasia) with thick axils that trap water and require regular monitoring for signs of mosquito breeding.			
3.2.5	Plant ferns and hardy ground covers (instead of turf) on sloping grounds to prevent soil erosion and minimize the need of frequent maintenance.			
3.2.6	Use synthetic turf in areas with high pedestrian traffic or intensive activities (e.g., school fields), as well as areas with difficulty of access (e.g., green islands within pool/ water feature).			
3.2.7	**Test Plots** Prior to skyrise greenery installation, set up plant test plots (mock-up surfaces, etc.) in consultation with skyrise greenery consultants to ascertain the horticulture performance of selected greenery systems and species. The test plots will help to identify suitable species as well as inform building owners/ users on the maintenance needs and strategies.			
3.2.8	**Water Features** Use concealed bracket systems for stone claddings within water features to minimize the occurrence of efflorescence and stains on grouting.			
3.2.9	Avoid water features with rough edges and surfaces as they are prone to dirt accumulation and algae growth.			
3.2.10	Provide backwash for filters; Coarse screens shall be provided to keep dry leaves and rubbish getting into pump. Precautions to be taken in design to avoid pump overheating due to pump suction being choked with debris.			
3.2.11	Provide adequate lighting and ventilation to pump rooms.			

3.3. Design and detailing landscape features

Objectives:

Provide effective design and detailing to facilitate water drainage as well as to enable safe and ease of maintenance.

3.3	**Design & Detailing**	**Y / N / NA**	**Description of provision** *(Attach relevant drawings, references, etc. where necessary)*	**If No or not applicable, please explain**
3.3.1	Locate plants with similar water requirement within the same vicinity.			

3.3.2	**Planters** Provide sufficient soil depth for roots to grow. In general, groundcovers and shrubs require soil depths of between 300mm and 500mm, while small and medium trees (mature heights of 8m to 10m) require between 1m and 1.5m soil depth.			
3.3.3	**Planting on Ground** Planting should be carried out directly on ground wherever possible to reduce the use of planter boxes. If located on true ground, the planter boxes should be built on true ground and not on concrete surface to ensure proper drainage.			
3.3.4	**Un-edged Planting Areas** Planting soil should preferably be 50mm lower than unedged planters flushed in level to adjacent hardscape finishes, to reduce soil erosion and spillage onto common and public areas. These are applicable to areas such as true-ground planting, sunken e-deck, roof gardens.			
3.3.5	**Drainage** Landscaped footpaths should be at least 50mm higher than the drain for effective drainage. The footpaths should be sloped to fall effectively to the nearest drain.			
3.3.6	Ensure runoff from roofs does not fall directly onto landscape areas. Otherwise, provide materials to reduce impact (e.g., gravel).			
3.3.7	Provide appropriate drainage outlets for vertical greenery to avoid stains on façade or water ponding at the base of the installation (e.g., use drainage trays at the base of the installation).			
3.3.8	**Turfs** Avoid planting turf right up to the base of trees to minimize the risk of mechanical damage to tree barks during turf mowing.			
3.3.9	Avoid having isolated thin strips of turf or small grass patches that require frequent mowing.			
3.3.10	Grass surface should be at the same level or slightly higher than adjacent hard surfaces (e.g., pavements) to ease turf mowing.			
3.3.11	Provide buffer strips (e.g., gravel) between the turfed surfaces and pavements/footpaths to prevent soil erosion and spillage. Sub-soil drainage should be avoided.			
3.3.12	**Sky Gardens** Allow adequate exposure of plants to direct sunlight to avoid etiolation or leaning of trees beyond the edge of building in search of light.			
3.3.13	Where landscape is located near building edges, provide edge protection (e.g., guardrails, lifelines or anchor points) to mitigate risk of fall-from-heights.			
3.3.14	Trees should be adequately secured to withstand strong wind and mitigate risks of uprooting.			
3.3.15	Avoid planting shrubs beyond parapets so that maintenance personnel do not have to lean over the parapet to reach the foliage.			

3.3.16	The floor slab should be sloped towards the drainage outlet with silt control system. Waterproofing membrane should be properly installed around the drain opening so that water drains off from the waterproofing membrane to the roof outlet. Plants should not be allowed to grow into guttering.			
3.3.17	Provide adequate sources of water supply (e.g., taps) that are separated from the irrigation system in landscape areas.			
3.3.18	The finished level of sky gardens should be lower than adjoining indoor threshold to avoid rainwater ingress.			
3.3.19	In circumstances where sky gardens finished level is higher than the indoor finished level (e.g., retrofitted roof garden in an existing building), provide up-stand or cut-off drains with adequate capacity to minimize rainwater ingress.			
3.3.20	Provide adequate distance between tall plants and lamp posts to avoid damage to the lamp post by the roots.			
3.3.21	**Waterproofing** Provide adequate waterproofing system at landscaped areas and planters. Waterproofing should make to be root resistant and/or alongside a suitable root barrier.			
3.3.22	**Tree Wells & Gratings** Tree well gratings are to be durable and weather- resistant with effective drainage to avoid waterlogging issues. Gratings should be designed to prevent litter from entering the tree well, facilitate inspection access (i.e. designed with moveable modular segments, etc.) to the tree well and cater for installation of tree support system and future tree growth in girth.			
3.3.23	**Irrigation system** Adopt automatic-irrigation systems with rain sensors. Ensure that landscape under sheltered areas remain irrigated even on rainy days.			
3.3.24	Where water supply to the irrigation system comes from rain harvesting systems, effective strainers should be provided to prevent blockages and frequent maintenance to the irrigation network.			
3.3.25	**Water Features** Use concealed bracket systems for stone claddings within water features to minimize the occurrence of efflorescence and stains on grouting.			
3.3.26	Avoid water features with rough edges and surfaces as they are prone to dirt accumulation and algae growth.			
3.3.27	Provide backwash for filters; Coarse screens shall be provided to keep dry leaves and rubbish getting into pump. Precautions to be taken in design to avoid pump overheating due to pump suction being choked with debris.			
3.3.28	Provide adequate lighting and ventilation to pump rooms.			

4. Other good practices

4.1. Design collaboration

4.1	Design Collaboration	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or not applicable, please explain
4.1.1	**Design Brief** Provide a clear design brief for maintenance performance and operations.			
4.1.2	**Collaborate with FM and other stakeholders** Engage FM practitioners throughout the planning and design phase for their inputs and review of design drawings and specifications.			
4.1.3	Collaborate with relevant WSH consultants to review the necessary safety provisions for all areas that require maintenance access.			
4.1.4	**Virtual Reality** Conduct virtual walkthrough of the digital building model to identify potential maintenance issue during design.			

4.2. Documentation

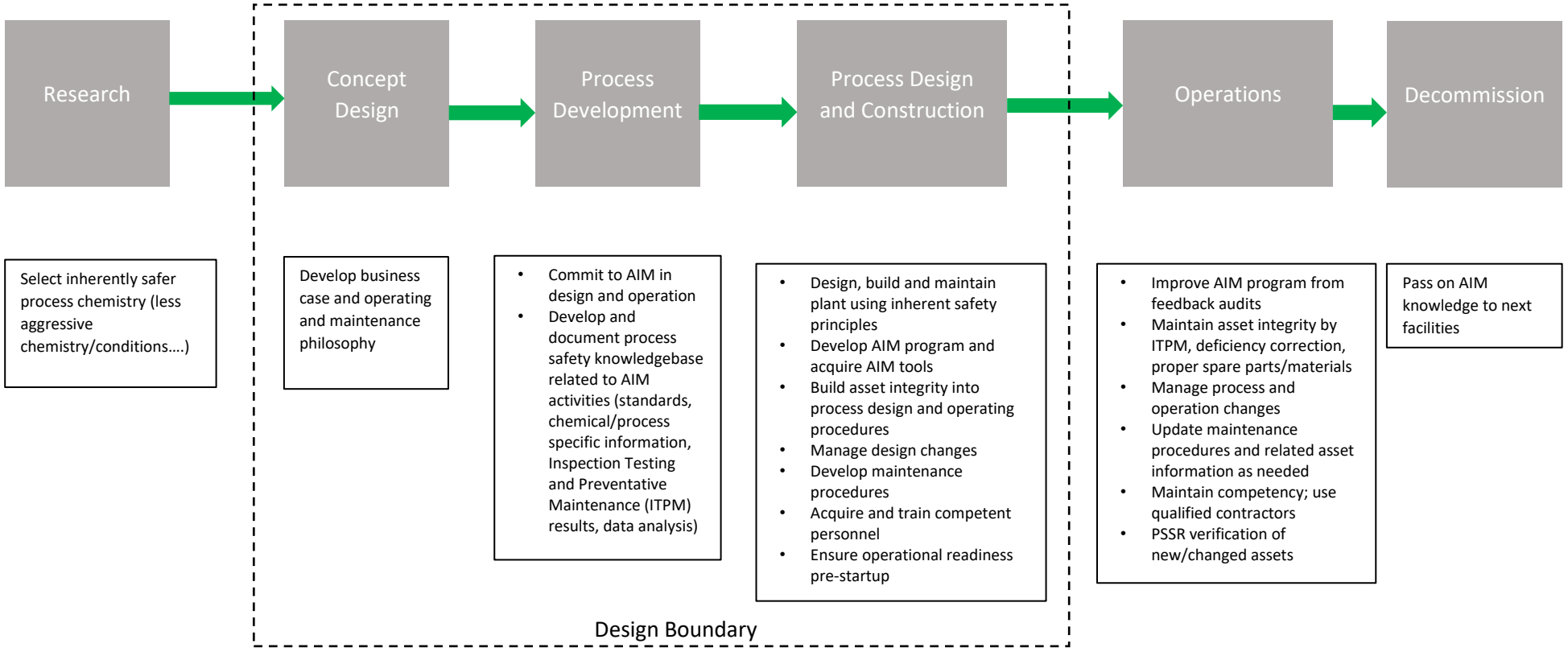
4.2.	Building Records	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or not applicable, please explain
4.2.1	Prepare as-built drawings (showing equipment layout, routing of M&E services, concealed services and landscape) and O&M manuals for end-users' future reference and maintenance purposes. These documentations should be regularly updated and kept for record purposes. All maintenance personnel should be made aware of such records. The records are preferably in both hard and soft copies, with proper dates of updating.			

4.3. Innovation

4.3	Innovation	Y / N / NA	Description of provision *(Attach relevant drawings, references, etc. where necessary)*	If No or not applicable, please explain
4.3.1	**Self-cleansing Facade** Adopt façade materials with self-cleansing properties (e.g., titanium dioxide coating) to reduce the frequency of façade cleaning.			
4.3.2	**Pneumatic Waste Conveyance System (PWCS)** Adopt PWCS to improve productivity in refuse collection and disposal. PWCS can be fitted with sensors to monitor waste disposal patterns and volume. The frequency of waste collection can thus be adjusted accordingly. Provide adequate openings to access PWCS piping's, especially when concealed underground.			

4.3.3	**Smart Lighting/Sensor** Adopt lighting with sensors to help understand human traffic patterns and optimize/reduce the provision of lighting in low traffic areas. This can help to reduce energy and maintenance.			
4.3.4	**Smart Bin** Adopt litter/ compactor bins with sensors to facilitate on demand refuse collector			
4.3.5	**Smart Toilet** Adopt autonomous systems with the use of sensors. Sensors can detect, monitor, and feedback any defects or situations (e.g., ammonia, people traffic, lighting levels, abnormal water usage, hand soap, hand towels, toilet paper and litter bins). Data gathered from sensors can use for analytics such as the determination of peak and off-peak usage and forecast cleaning regimes to optimize cleaning crew deployment.			
4.3.6	Use tiles, basins, urinals, and WCs that are infused/coated with anti-stain material or self-cleaning protective coatings (e.g., fluoropolymer coating) to facilitate cleaning efforts and eliminate the problem of tough stains and graffiti.			
4.3.7	Provide anti-odor tiles that are able to address foul smell such as urine spillage on the floor.			
4.3.8	**Digital Pest Control** Adopt smart surveillance/ monitoring systems to detect pests (e.g. rodent tracker)			
4.3.9	**Autonomous Cleaning** Adopt autonomous cleaning robots. Minimize level changes such as ramps and steps to enable its deployment.			
4.3.10	**Mobile Incident Reporting Management** Adopt mobile app-based incident reporting to facilitate efficient maintenance.			
4.3.11	**Lift Sensors Monitoring** Adopt autonomous systems with the use of sensors. Sensors can detect, monitor and feedback any predictive events and potential breakdowns (e.g. mislevelling of lift car, abnormal travelling speed of lift, abnormal performance of lift door, and condition of lift rope). Data gathered from sensors can be used for analytics such as determination of usages of lifts and forecast the necessary maintenance regimes. Lift mechanics can be dispatched effectively to rectify the abnormity, and prevent any faulty lift incidents). This can also be extended to escalators			

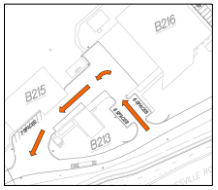
Appendix 9 Asset Integrity Management (AIM) - Life Cycle Activities



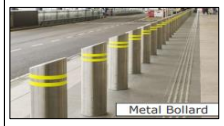
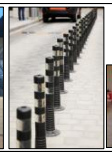
Source: Guidelines for Asset Integrity Management CCPS

Appendix 10 Micron Traffic Safety Checklist

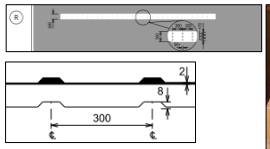
Traffic Safety Checklist for Micron Sites

Area	Recommendation/Consideration	Figure	Effect/Impact	Remarks:	☑
Road Width and Space	Ensure sufficient road width and space is provided for the all types of vehicles using the road i.e Large Car, 20 Footer Truck, Coach, 40 Footer Truck etc.				
	If insufficient road width and space for two way traffic circulation, consider:				
	One Way traffic circulation		•Improve traffic circulation in the carpark. •Minimise encroachment of opposing vehicle paths.		
	Cautionary road signs (list some examples)	 Speed limit	•Alerts driver of the direction of traffic ahead.	• Traffic signs used would differ based on the local traffic standards and regulations	
	At the turning corners, consider:				
	Convex Mirrors		• Improves visibility for drivers turning the corner. • Allows one vehicle to give way to another should there be insufficient space for two vehicles to turn the corner simultaneously.		
	Prohibitory signs for vehicle parking near corners		• Ensures sufficient space for vehicles to turn the corner without encroachment.	• Traffic signs used would differ based on the local traffic standards and regulations	

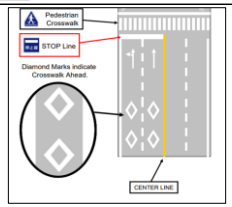
Traffic Safety Checklist for Micron Sites

Area	Recommendation/Consideration	Figure	Effect/Impact	Remarks:	☑
Bus-Stop/ Pick-Up/Drop-Off Point	Shuttle bus pick-up/drop off points should minimally incorporate marked out bus bays.		• Marked out bus bay will be more noticeable to pedestrians, avoiding potential conflict.		
	Separation of pedestrians from vehicle movements can be in the form of fixed concrete bollard, flexible bollard or metal bollards.	 	• Protect a barrier to separate pedestrian and vehicular traffic. • Improves safety and accessibility for pedestrians.		
	Shelters can be considered to further improve the accessibility for pedestrians.				
Loading/Unloading Docks	Loading docks to include: •Clear loading bay markings •Dedicated walkway for drivers/co-drivers.		•Dedicated pathway for drivers allows better management and flow of loading/unloading activity. •Avoid staff being in the path of vehicles reversing into loading docks.		
	To install barrier along the path leading to the doorway to ensure that pedestrians don't walk across the dock. •Barrier can be in the form of horseshoe bollard(U bollard) or reflective bollards. To install reflective road studs along proposed pathway for drivers.	  	•Minimise pedestrians walking across the loading dock. •Encourages pedestrians to use dedicated walkways and crosswalk. •Improves visibility of walkway especially for drivers.		
	If space is constraint at the loading docks, consider: •Beacon light warning system •Cautionary road signs	 	• Provide visual aid for both pedestrians and motorists that loading/unloading activity of larger vehicles are in progress. • Discourages pedestrians from using the walkway ahead when there is loading/unloading activity.	• Traffic signs used would differ based on the local traffic standards and regulations	

Traffic Safety Checklist for Micron Sites

Area	Recommendation/Consideration	Figure	Effect/Impact	Remarks:	☑
Pedestrian Walkway	Ensure pedestrian walkway is clearly painted and well connected throughout the site. •Carpark to lobby •Block to block	 	•Improves safety and accessibility for pedestrians throughout the development. •Encourages pedestrians to use designated external and internal walkways, minimising conflict with traffic circulation.		
	When walkway is adjacent to traffic circulation, consider:				
	Raised Profile Markings	 	• Raised profile line marking generates a noise and vibration when a vehicle's tyre rolls over it. • They are useful to alert drivers if they tend to drift too close to the left. In fog, when the line is less visible, they provide tactile and auditory feedback of the lane. • In wet weather at night they provide better visibility of the line.		
	Raised Walkway		• Raised pedestrian walkway allows clearer distinction between road and footpath. • Improves safety and accessibility for pedestrians.	• Raised pedestrian walkway would mean a decrease in accessibility for road users.	
	Reflective Bollard		• Provide a barrier to separate pedestrian and vehicular traffic. • Improves safety and accessibility for pedestrians.	• Reflective bollard would reduce uaseable road width and space for road users.	
	Footprint/Pedestrian Silhouette Marking	 	• Improves usage and accessibility for its users.		

Traffic Safety Checklist for Micron Sites

Area	Recommendation/Consideration	Figure	Effect/Impact	Remarks:	☑
Pedestrian/ Zebra Crossing	For pedestrian crossings, consider:				
	Reflective road studs. Installation of Belisha Beacon that flashes light to alert driver of pedestrian crossing ahead. "LOOK" painted on the two ends of the crossing.		• Improve visibility of the pedestrian crossing. • Alert pedestrians to look out for incoming vehicles. • Alert driver of pedestrian crossing ahead.		
	For traffic approaching pedestrian crossing, consider:				
	Road Hump		•Reduces speed of approaching vehicles and warn motorists of crosswalk ahead		
	Raised Crossing				
	Traffic Calming Measures: • Dragon's Teeth road marking • Peripheral Tranverse Lines • Diamond Road markings	  		• Approach to traffic calming measures would differ based on the local traffic standards and regulations	

STANDARD OPERATING PROCEDURES

Additional measures and Standard Operating Procedures (SOPs):

- Maintain a schedule for the usage of the loading/unloading bays,
- Avoid having vehicles stopping by the side of the road near demarcated pedestrian walkway,
- Deploy ground guide/traffic marshal to help regulate traffic flow when heavy vehicles are reversing into/out of loading/unloading bays. Ground guide will also help to guide drivers when reversing and look out for safety,
- Cautionary triple horns from driver prior to moving a stationary vehicle to warn pedestrians in the vicinity,
- As new staffs are likely unfamiliar with road signs. A group briefing might need to be conducted to increase the awareness of staff, and
- Pedestrian movements near loading/unloading points should be limited to related personnel.

8 Document Control

Items	Details
ECN Facility	CORP EHS
ECN Area	EHS CONST
Approval	This document is approved by: GLOBAL_EHS_SEAL_LT
Notification	Notification of changes to this document is managed through Micron's Engineering Change Notification (ECN) process to the following: **Leadership Team** • FLT • ATLT **EHS** • GLOBAL_EHS • GLOBAL_EHS_MANAGERS • GLOBAL_EHS_SEAL_LT • GLOBAL_EHS_TEAM_MEMBERS **Facilities** • GLOBAL_FAC_MANAGERS • GLOBAL_FAC_NOTIFY • GLOBAL_FAC_ALL_SITES_NOTIFY • GLOBAL_FAC_PM_MANAGERS • GLOBAL_FAC_CONSTRUCTION **GFTT / FCT Chem & Gas** • GFTT_GAS • GFTT_CHEM • FCT_GAS • FCT_CHEM **Procurement** • GP_ALL_LEADERS
Review	This document will be reviewed at least biennially (once per two years) by Global EHS / PSM through the Periodic Document Review (PDR) process.

9 Revision History