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1.0 GENERAL

1.1 Introduction

The purpose of this document is to provide initial planning and design guidance. The information provided below is based on PME regulations in place on 25 September 2017. As regulations are subject to change over time, please refer to Volume 6, Chapter 5, Section 9 for more information regarding the source of the requirements and be sure to use the most recent revision of all regulations.

Note that additional Environmental Site Studies and Assessments, such as the project EIA, Existing Site Condition Studies etc. may have design implications. Coordination with the Environmental Team will be necessary to ensure any design criteria identified is sufficiently captured in the design phase.

This document covers the following;

Air: Air Quality Standards, assessments, modeling and air pollution control.

Water and Wastewater Discharges: Types of discharges, the design and permit process for discharges, the minimization of environmental impact, modeling to predict impact and long-term monitoring.

Solid Waste Management and Recycling: Planning issues, waste generation type and volume predictions, reuse and recycling, energy recovery options, transportation, disposal options and landfill design.

Noise Management: Ambient noise levels, noise level limitations, techniques to mitigate and monitor noise during construction and operation.

1.2 Applicability

This Subsection applies to all projects within the Kingdom of Saudi Arabia.

1.3 Definitions

Definitions	Description
Ambient Air	Air on the external side of a pollutant source property boundary to which the public has access.
Ambient Noise	All-encompassing sound that is associated with a given environment, usually a composite of sounds from many sources near and far.
Background Noise	All-encompassing sound of a given environment without the sound source of interest.
Biological Oxygen Demand	An indirect measure of the concentration of biologically degradable material present in organic wastes.
Coastal Water	The area of surface water on the landward side of a line, every point of which is at a distance of two kilometers on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate to the outer limit of transitional waters.
Community Noise	Noise emitted from all sources except noise at the industrial or construction workplace.
Construction Noise	Noise emitted from building, demolition, refurbishment or directly associated activities.
Contaminant	A substance that is identified by the PME as having a Regulatory Standard outlined in the PME Regulations.
Decibel (dB)	A unit of measure of sound level.
Equivalent Continuous Level	When a noise varies over time, the LAeq is the equivalent continuous sound which would contain the same sound energy as the time varying sound.
Fugitive Emissions	A gas or vapor emission or pollutant due to leaks or other unintended releases.
Industrial Premises	Any site or facility that extracts, manufactures, stores, or processes any product or substance.

Definitions	Description
Landfill	A place, location, tract of land, area, or premises used for the disposal of solid wastes. The term is synonymous with 'solid waste disposal site' and is also known as garbage dump and trash dump.
Landfill Gas	The complex mixture of gases formed during the decomposition of biodegradable waste, primarily composed of methane and carbon dioxide, often with trace concentrations of a range of organic gases and vapors.
Leachate	Any liquid percolating through the deposited waste and emitted from or constrained within a landfill.
Life Cycle	A series of stages through which a material passes from the beginning of its existence to the end.
Life Cycle Assessment	An assessment that analyzes and quantifies the life cycle(s) of materials and energy of a facility or process.
Noise Barrier	A structure, or structure together with other material, that potentially alters the noise at a site from a *before* condition to an *after* condition.
Panel	The panel component of a noise barrier is that portion that, when joined together, produces a solid wall, typically spanning the distance between supports or posts.
Pollutant	A substance, condition, or energy introduced into the environment that has undesired effects, or adversely affects the usefulness of a resource.
Presidency of Meteorology and Environment (PME)	The agency designated as being responsible for the protection of the environment and the development of Environmental Protection Standards in the Kingdom of Saudi Arabia.
Recycling	Refers to a series of activities by which discarded materials are collected, sorted, processed, and converted into raw materials and used in the production of new products.
Reuse	The use of a product more than once in its same form for the same purpose or for different purposes.
Source	The point of emission or discharge of a pollutant or effluent.
Storm water	Runoff of rainwater mainly in urban settings during high intensity rainfall events. Storm water may enter and discharge to groundwater or other receptors through storm drains.
Waste Stream	The flow of solid waste from homes, businesses, institutions, manufacturing plants, and industries.
Wastewater	Water that (1) is or has been used in an industrial or manufacturing process, (2) conveys or has conveyed sewage, or (3) is directly related to manufacturing, processing, or raw materials storage areas at an industrial plant.
Working Face	The area of a waste deposit site that is currently being worked, where new refuse is being deposited and compacted into it. Once the working face is filled in and daily cover material is provided, it is no longer referred to as a working face, but rather is a completed or daily cell.

Refer Definitions and References (EPM-KE0-GL-000011) for all other definitions.

1.4 Abbreviations

Abbreviations	Description
BAT	Best Available Technique
BRE	Building Research Establishment
C&D	Construction and Demolition
CALPUFF	California Puff Model
CAMx	Comprehensive Air Quality Model with Extensions
CEMS	Continuous Emission Monitoring System
CFR	Code of Federal Regulations
CMAQ	Community Multi-scale Air Quality
CMB	Chemical Mass Balance
EIA	Environmental Impact Assessment
HAP	Hazardous Air Pollutant
LAeq	Equivalent Continuous Level

Abbreviations	Description
LCA	Life Cycle Assessment
LFG	Landfill Gas
PME	Presidency of Meteorology and Environment
PMF	Positive Matrix Factorization
ppm	Parts Per Million
REMSAD	Regional Modeling System for Aerosols and Deposition
SDS	Safety Data Sheet
UAM-V®	Urban Airshed Model Variable Grid
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound.
v/v	Volume Percent

Refer Definitions and References (EPM-KE0-GL-000011) for all other abbreviations.

1.5 General Requirements

Projects shall comply with all applicable requirements and regulations of the Presidency of Meteorology and Environment (PME).

1.6 Approvals

The PME has approval authority through the Environmental Permit Program.

2.0 AIR

2.1 General

Air emissions from new facilities constructed or existing facilities that are modified shall not exceed Air Pollutant Emission Standards. The proposed air pollutant sources shall be identified during the planning phase of the project. The Air Pollutant Emission Standards apply to both the construction phase and the operational phase of the project.

2.2 Ambient Air Quality Standards

The Presidency of Meteorology and Environment (PME) has established ambient Air Quality Standards that are protective of human health. These Standards are documented in PME Ambient Air Quality Standards. New or modified existing sources of air pollutants listed in the PME Ambient Air Quality Standards Tables must not cause these Standards to be exceeded.

2.3 Emission Modeling and Impact Assessment

2.3.1 Air Emission Inventory

- For projects involving a new facility or process or for modifications of an existing facility or process an inventory of the air pollution emissions anticipated during the construction phase of the project, facility start-up, and ongoing operations shall be prepared. This inventory must be prepared in accordance with the requirements of PME Control of Emissions to Air from Stationary Sources.
- Methods for determining an inventory of air emissions (as applicable) are detailed below, with the methods listed in preferred (most accurate) to less-preferred order.
    - Direct measurements of the concentration of air pollutants in the stack gas or a Continuous Emission Monitoring System (CEMS) are the most accurate methods of collecting actual emission data. CEMS requires proper calibration to produce accurate values, and when performed properly, are most accurate for an already-constructed facility.

- A mass balance estimates emissions by evaluating inputs of raw materials to an emitting process and accounting for all various outputs in the form of emissions to air, wastewater and hazardous waste, and/or the final product. All material inputs and outputs must be accounted for within the model for accuracy.
- Emission Factors are ratios that are based on the premise that a linear relationship exists between an activity level and the amount of air emissions produced by the activity. This method for estimation is often the most accurate prediction method available for a given process if all process variables have been accounted for. Emission factors have sometimes been developed from averaging sources that differed by factors of five or more.

2.3.2 Modeling

Air pollution emission dispersion and modeling may be required for certain projects as determined by the PME.

- When required by the PME, an appropriate air dispersion model such as AERMOD, CALPUFF, or another PME approved equivalent must be used to quantify the impact on ambient air quality beyond the fence line of the facility for all air pollutants listed in PME Control of Emissions to Air from Stationary Sources.
- In addition to air dispersion modeling, the PME may also require photochemical or receptor modeling.
    - Air quality models such as CMAQ, CAMx, REMSAD, and/or UAM-V® shall be used for photochemical modeling when required by the PME.
    - Air quality models such as CMB, UNMIX, and/or PMF shall be used for receptor modeling when required by the PME.
- Refer to PME Control of Emissions to Air from Stationary Sources for specific requirements to be incorporated in this modeling. The emissions modeled must meet the emission limits specified in PME Control of Emissions to Air from Stationary Sources.

2.3.3 Impact Assessment

Using the results of the modeling above, those emission sources causing Ambient Air Quality Standards beyond the fence line to be exceeded must identify additional measures to ensure that those Standards are met. See PME Control of Emissions to Air from Stationary Sources for more detailed requirements.

2.4 Air Pollution Control

2.4.1 General

All construction, start-up, commissioning, and ongoing operations must comply with the provisions of PME Ambient Air Quality Standards, PME Control of Emissions to Air from Stationary Sources, and PME General Environmental Regulations and Rules for Implementation.

2.4.2 Specific Source Emissions

Facilities that include the specific processes/operations must design air pollution control measures to meet the limitations listed in PME Control of Emissions to Air from Stationary Sources Tables.

2.4.3 General Point Source Emissions

All air emission points must comply with the provisions of PME Ambient Air Quality Standards, PME Control of Emissions to Air from Stationary Sources, and PME General Environmental Regulations and Rules for Implementation.

2.4.4 Mobile Point Source Emissions

All air emission points must comply with the provisions of PME Ambient Air Quality Standards, PME Standards for Control of Emissions from Mobile Sources, and PME General Environmental Regulations and Rules for Implementation.

2.4.5 Emissions Testing

PME Control of Emissions to Air from Stationary Sources (point sources) requires all facilities to undertake stack emission sampling for specific point sources. The requirements for such sampling are specified in PME Control of Emissions to Air from Stationary Sources.

2.4.6 Continuous Emissions Monitoring

Point sources must comply with the provisions of PME Control of Emissions to Air from Stationary Sources. This specifies what sources must have monitoring equipment and the quality assurance requirements for that instrumentation.

2.4.7 Fugitive Emissions

Certain volatile organic compounds (VOCs) and all hazardous air pollutants (HAPs) operations must comply with the requirements of PME Control of Emissions to Air from Stationary Sources.

3.0 WATER AND WASTEWATER DISCHARGES

3.1 General

Water is a critical resource for the Kingdom of Saudi Arabia. The resources include the Persian Gulf/Arabian Gulf, groundwater, and storm water runoff. Criteria have been established by the PME to minimize the impact on these water resources, the ecosystem and the community.

3.2 General Requirements

- Projects shall comply with all applicable requirements and regulations of the PME including but not limited to PME General Environmental Regulations and Rules for Implementation; PME Wastewater Discharge Standards for KSA.
- Discharge Characteristics and Impacts
    - The regulations are designed to control the discharge of various pollutants including those described in the following subdivisions.
    - Chemical
        - Risk of direct negative acute and chronic effects to organisms from organic, metal, chemical, and radioactive contaminants and the associated reduction in water and sediment quality.
    - Nutrients such as nitrogen, phosphates and derivatives
        - Risk of eutrophication, potentially resulting in changes in the species composition of phytoplankton communities, toxin-producing algae or harmful algal blooms. Risk of loss to submerged vegetation through shading, development of hypoxic conditions due to decomposition of excess plant biomass, changes in benthic community structure due to hypoxia or toxic algae, or fatalities of fauna due to oxygen deficiencies.
    - Organic Matter
        - Reduction of oxygen in water due to increase in Biological Oxygen Demand. Fatalities of fauna due to oxygen deficiencies and changes in benthic community structure.
    - Physical Including Thermal

        - Litter is a danger to wildlife from the risk of ingestion or entanglement. Temperature variations affect survivability of organisms in an ecosystem.

    - Biological

        - Un-stabilized fecal or related matter introduces pathogens harmful to ecosystems and public health.

- Sources of Discharge

    - Wastewater Treatment Plants

        - Treatment facilities that process water from sanitary sewers, industrial sources, storm sewers and other sources.

    - Industrial Facilities

        - Industrial sites where the facility processes utilize water for production and/or cooling operations.

    - Other Facilities

        - Other facilities that may not manufacture industrial products but still generate a water discharge.

- Design and Permitting
    - This section is intended to provide guidance for planning, designing, permitting, monitoring, and reporting of water and wastewater discharges. There should be continued coordination between design engineers and environmental specialist to complete design phases and reviews required for permit completions.
      Example of discharges:

        - Sanitary wastewater
        - Industrial wastewater
        - Seawater cooling water
        - Storm water runoff
        - Irrigation systems
        - Condensate/Boiler/Cooling tower blow-down

    - Planning/Permitting Discharges

        - Discharges are subject to pollutant concentration limits as detailed in the PME regulations. The Design Standard shall be that all discharges are segregated and connected to the appropriate central infrastructure systems where available (for example: sanitary wastewater shall be connected via lateral to the City's sanitary wastewater collection system). Note that in some cases pretreatment will be required to meet Water Quality Standards prior to discharge.
        - As part of the project planning and design, a narrative along with water balance diagrams shall be prepared which describe and show operations contributing to the discharges. This shall include flow rates at intakes, discharge locations and treatment units and provide water quality characteristics. Key monitoring points shall also be identified. This narrative and supporting information shall be included in the permit application package with sufficient detail, including calculations, baseline data, projections and justification of assumptions.
        - Assessing process materials is important to environmental protection and economic evaluation. Using environmentally-benign alternatives to industrial materials and chemicals is beneficial for reducing contaminant concentrations in discharges to the central wastewater treatment systems, coastal and marine environment, or other water resources. An effective review and use of alternatives shall be included in the project

concept development stage and approach to compliance with environmental Regulations and Standards.

- Reclamation and Reuse
  - Projects and processes shall be reviewed for opportunities to reclaim and reuse water to reduce demand and discharge volumes.
- Monitoring Provisions

- Water and wastewater discharges shall include appropriate provisions for flow monitoring and water quality sampling at key locations determined by the PME. Other internal monitoring points shall be considered as needed for process control and data collection. Monitoring locations shall be designed with safe access, proper hydraulic conditions for flow measurement, lighting/power, mounting/storage of sampling equipment and weather protection as needed.

3.3 Codes and Standards

Refer to PME Wastewater Discharge Standards for KSA, PME General Environmental Regulations and Rules for Implementation.

4.0 SOLID WASTE MANAGEMENT AND RECYCLING

4.1 General

This Subsection provides guidance for Design Standards related to solid waste management and recycling.

4.2 Codes and Standards

- Refer to PME General Environmental Regulations and Rules for Implementation
- Refer to the PME National Landfill Design and Operations Standard for KSA
- Refer to PME National Material Recovery and Recycling of Waste Guidelines Document for KSA
- Refer to PME Waste Acceptance Criteria Standard for KSA
- Refer to the PME Waste Classification Standard for KSA
- Refer to the National Best Practicable Environmental Options for Waste Disposal Guidance Note for KSA
- Refer to the National Waste Storage Standard for KSA
- Refer to the Waste RCC Standard for KSA
- Refer to the National Waste Transportation Standard for KSA
- Refer to the National Waste Training and Assessment of technical competence of operator's standard for KSA
- Refer to Geosynthetic Institute.
- USEPA Waste Transfer Stations: A Manual for Decision-Making" 2002, EPA530-R-02-002US 40 CFR 258 - Criteria for Municipal Solid Waste Landfills

4.3 Project Planning

4.3.1 Solid Waste Management

4.3.1.1 General

- Project planning shall include provisions for solid waste management and recycling (including waste avoidance and reuse). This must include determining waste types and volumes as well as requirements for handling, storage and disposal.
- The facility's solid waste management practices must be consistent with all PME policies and regulations.

4.3.1.2 Develop Profile of the Facility

- Include information on number of employees, material inputs, waste generating manufacturing processes, commercial, institutional, residential material outputs, along with estimated growth. Identify storage areas, storage containers, internal collection methods, and appropriate disposal landfills (onsite or offsite). Identify person(s) in charge of review, implementation, and execution of the solid waste management and recycling system for the facility.

4.3.2 Waste Generation

4.3.2.1 Waste Streams

- Waste surveys and/or projections shall be completed to evaluate facility processes and identify different types and classifications of wastes generated by the facility. Rates of generation must be estimated to help evaluate current storage and handling capacity.
    - There is a need to plan for construction and demolition (C&D) debris including excess sand. Estimates are to be provided to the PME as part of the engineering documentation when necessary.
    - To predict new construction waste generation rates, refer to the United Kingdom Department of Environment, Food, and Rural Affairs (DEFRA) funded BRE research on “Understanding and Predicting Construction Waste” (2008, WR0111). This research predicts waste generation rates for a variety of building types based on key performance indicators of either m2 floor area or project value.
        - Refer to the most recent construction waste benchmarking values from the United Kingdom as a standard. The designer is responsible for using the appropriate basis for project specific estimates.
- Waste generation rates and their source shall be included in a design basis report and justified based on material balances, current data for similar facilities, industry values, and/or independent studies. Include forecast of waste generation by type and volume for a minimum of 10 years.

4.3.2.2 Onsite Storage

- Segregation for types and classifications of wastes shall be provided to promote waste reuse, recovery, or efficient disposal. Waste shall be stored by methods and in labeled containers appropriate and compatible with the specific types of waste.
- Storage capacity shall be sufficient to comply with regulations and collection frequencies outlined in PME Waste Acceptance Criteria Standard for KSA, PME Waste Classification Standard for KSA, PME National Best Practicable Environmental Options for Waste Disposal Guidance Note for KSA, PME National Waste Storage Standard for KSA, Refer to the Waste RCC Standard for KSA where applicable.

4.3.2.3 Identification of Disposal Facilities

- The planning effort must identify the facilities at which waste will be disposed. These facilities may be KSA municipal landfills or other commercial facilities that may be accepting that type of waste.
- Onsite disposal and offsite transportation must adhere to applicable PME Waste Management guidelines and receive approval by the PME.

4.3.3 Material Reuse and Recycling

4.3.3.1 Material Evaluation

- Current or expected waste streams shall be evaluated to ascertain potential reuse and recycling in or outside the facility.
- Materials such as plastic, paper, metals, and glass must be recovered for recycling whenever possible.

4.3.3.2 Identification of Markets

- Recycling Facilities

- Survey and review existing recycling facilities for their acceptance of common materials such as plastic, aluminum, paper, and glass. Industrial recycling facilities may take other metals for separation and recycling.

- Other Businesses

  - Some manufacturing and other industrial businesses may offer to take waste streams for their own feedstock. These businesses may take solid wastes that would otherwise be landfilled.

4.3.4 Energy Recovery Options

4.3.4.1 General

- Certain segregated waste streams and wastewater sludge may be considered for energy recovery. These include biomass (including municipal solid waste), landfill gas and anaerobic digestion products such as biogas.

4.3.4.2 Biomass Electrical Generation

- Biomass refers to organically-derived materials from high quality feed stocks such as trees or grains and low quality feed stocks such as municipal solid waste. Burning biomass to recover energy is a common practice that can yield energy from what would otherwise be landfilled.
- Biomass used for energy generation shall only be for waste that has no other use. For example wood or paper products that can still be recycled to form other wood or paper products is more productive than energy generation.
- Burning biomass for electrical generation must adhere to regulations in PME air contaminant discharge levels and Waste Management regulations, for waste handling, storage, transportation, and disposal regulations.

4.3.4.3 Landfill Biogas

- Managed correctly, organic matter from municipal waste in landfills will degrade anaerobically and produce landfill gas (LFG) which generally contains at least 50% methane, the majority of the remaining LFG is CO2, and other trace gases. LFG has a higher global warming potential than carbon dioxide because it contains methane, and therefore shall be controlled and considered for energy recovery.
- A common method for electrical generation is to run the biogas through either modified compression ignition or modified spark ignition internal combustion engines. Biogas will not self-ignite in compression engines and thus a small amount of diesel fuel must also be injected for combustion. Spark ignition engines can run on 100% biogas. Both engines will run much hotter than normal and will need an efficient cooling system to prevent engine wear. Waste heat can be used for other purposes within the facility.

4.3.4.4 Anaerobic Digestion Biogas

- Anaerobic digestion is a process where microbes break down organic waste without the presence of oxygen. The microbes release methane and carbon dioxide as a gaseous waste product and stabilize the solid portion of the input waste. The biogas that can be captured and used to generate electricity, while the sludge effluent can be used as is, separated into liquid and solid portions, or disposed.
- The year-round warm climate in Saudi Arabia is ideal for energy and material production from anaerobic digestion. Current methods for anaerobic digestion use constant mesophilic or thermophilic conditions, where mesophilic conditions are between 30°C and 38°C and thermophilic conditions range from 49°C to 57°C.
- The anaerobic digestion process, the compatibility of feed stocks to produce methane, and the composition and frequency of expected waste sources shall be understood thoroughly to accurately assess digestion potential.
- Information about design and implementation of anaerobic digesters and associated equipment can be found at USEPA AgSTAR websites.
- Inputs, emissions, and effluents from anaerobic digestion must conform to PME regulations regarding water, air, and waste criteria as applicable.

4.3.5 Disposal Options

4.3.5.1 Landfilling

- Based on waste types, identify available disposal capacity at PME municipal or private facilities capable of handling expected project disposal needs. In project planning there shall be confirmation of disposal capacity and commitment from the facility to support the needs of the project.
- For on-site disposal facilities including landfills, these must meet current industry Standards for environmental regulation and protection.

4.4 Solid Waste Collection

4.4.1 Waste Collection Systems, Receptacles and Containers

- Noncombustible on-site collection systems and containers shall be provided for the immediate collection of waste generated during any municipal, industrial, construction, and/or demolition work. Due to the nature of refuse as a health and fire hazard, accumulation of waste outside of a waste receptacle or container shall not be allowed at any time.
- On-site collection systems and containers shall be of an adequate size for the volume of waste predicted to be generated per project planning guidelines.
- Collection systems and containers shall be constructed of material suitable for and nonreactive with the material to be stored within them and strong enough to withstand the physical methods used for the handling and transportation of the containers.
- Collection systems and containers must have tightly fitting or self-closing covers.
- Collection systems and containers must be labeled with the correct name and description of their contents. Additionally, hazardous waste bulk containers and transportation vehicles must be labeled and placarded, respectively.
- Separate containers shall be provided for material recycling and handling. Containers must be consistent with applicable PME regulations and policy.
- For additional municipal waste guidelines refer to referenced PME Waste Regulations

4.4.2 Waste Material Handling and Storage

4.4.2.1 All waste material must be removed from the immediate work area as the work progresses.

- Refer to PME National Waste Storage Standard for KSE for minimum collection and delivery frequency for such wastes, unless otherwise approved by the PME.

4.4.2.2 Waste material shall be segregated during storage, using the Safety Data Sheets (SDSs) to determine compatible materials. When there is more than one waste stored on site, all containers must be labeled to identify the container contents. Materials that must be segregated from general waste include the following:

- Combustibles
    - All containers and receptacles for combustible wastes shall be collected for removal at the end of each work day or at the end of each work shift.
    - This includes but is not limited to paper, wood, other natural fiber fabrics, oily or flammable materials.
    - Scrap lumber
        - Scrap lumber shall be placed in containers and not allowed to accumulate in work areas. Protruding nails shall be removed or bent over.
- Corrosive, caustic, reactive, radioactive or toxic materials.

4.4.2.3 Outdoor Storage

- Locations of power lines, egress or emergency equipment, and access shall be noted and recorded for submittal to the PME, should they be requested.
- Waste materials shall not be stored directly under power lines, blocking ingress or egress by emergency equipment, or so close together that there is less than five (5) meters of space to access a waste material.
- A firm waterproof base, protected from storm water and having an effective drainage system, shall drain to a waterproof spillage collection area where spillage shall be collected and treated should any leachate or spillage escape the waste material storage container.

4.4.2.4 Indoor Storage

- Locations of access, fire doors, and heating appliances shall be noted and recorded for submittal to the PME, should they be requested.
- Waste materials shall not be allowed to interfere with access to doorways, electrical panels, fire extinguishers, or hoistways.
- Storage of waste materials shall not make the aisle too narrow to be traversed by forklifts or firefighting equipment.
- A minimum of .75 meter clearance shall be maintained around fire door travel paths and a minimum of 1 meter clearance shall be maintained around unit heaters, space heaters, furnaces, and flues.

4.4.3 Site Provisions for Waste Collection

The Site Plan shall include provisions for storage and management of solid waste:

- Appropriate screening and fencing shall be provided to limit visual impacts as appropriate.
- Waste collection areas shall be paved with durable pavement to withstand solid waste collection vehicles.
- Solid waste collection structures shall be separate from general public use areas.
- Collection drains to sanitary sewer shall be provided.
- Access for collection vehicles intended to service the facility/site shall be provided.
- If food waste or other putrescible waste exists on site, provide odor control as needed.
- If food waste and/or other wastes exist on site that might attract insects, rodents, and/or other pests, and in any way lead to an increase in the pest population of the city, pest control shall be implemented.
- Solid waste activities shall be separated from noise sensitive areas and shall have noise barriers erected to mitigate noise from compacters, traffic, and other noisy equipment.

4.4.4 Facility and Transporter Permits

Prior to the transportation of waste material from the site of its generation a waste tracking form must be completed. All components to be included in the waste tracking form, along with all actions required for the transport of waste to a designated disposal facility shall be referenced in the PME National Waste Transportation Standard for KSA.

4.5 Transfer Station Design

4.5.1 Background

- As current landfills approach their capacity, new waste disposal sites are being created further from the main source of the waste generation due to both a lack of available land near city centers and due to general public disapproval of waste disposal facilities located near housing. A long-term waste collection plan requires the creation of waste transfer stations to decrease the cost of transporting waste further from its site of generation while reducing truck traffic.
- Following are several siting and design related topics for consideration involving waste transfer stations and the basic elements of each. For more in-depth and complete guidance refer to the USEPA Solid Waste and Emergency Response's guidance document titled "Waste Transfer Stations: A Manual for Decision-Making" (2002, EPA530-R-02-002)

4.5.2 Long Term Collection Plan

- The transfer station's break-even point (its optimal volume collected and area served) shall be calculated.
    - This calculation shall account for the cost to haul waste without a transfer station, to haul waste with a transfer station, and to build, operate, and maintain the transfer station.
- The capacity of storage shall be calculated by using variables including the size of waste collection vehicles delivering to the transfer station, the number of hours per day delivering to the site, and the length of time required to empty a waste collection vehicle, at minimum.

4.5.3 Siting Analysis for Individual Transfer Stations

When screening potential transfer station sites, the following areas of concern shall be considered, at a minimum:

- Community needs
- Landfill type
- Groundwater
- Alternative potential uses for the site
- Buffer distances
- Geology
- Hydrogeology
- Flora and fauna
- Infrastructure
- Surface water
- Impacts of future noise
- Impacts of possible odor
- Public concern and/or opposition
- The availability of an existing building for the transfer station
- The locations of environmental, historical, archeological, or cultural significance near the proposed site

4.5.4 Station Layout and Design

4.5.4.1 When designing a transfer station, the following considerations shall be addressed:

- Who the facility will receive waste from
- What types of waste will it receive
- Handling methods
- Sorting methods
- What types of technology will be utilized
- Any additional programs that will take place there (such as recovery programs or vehicle maintenance)
- What its anticipated peak flow of waste is
- How the local climate will affect all these functions

4.5.4.2 Other design considerations include but are not limited to:

- Types of structures
- Topography
- Size and shape of property area
- Surrounding land use
- Separations for utility, odor, and noise
- Drainage/sewage
- Vehicular access
- Site approvals

4.6 Landfill Design

4.6.1 Regulations

- Refer to US 40 CFR 258 - Criteria for Municipal Solid Waste Landfills as a general Standard for landfill design.
- Refer to Applicable PME Waste Regulations

4.6.2 Landfill Types

- Class I: Hazardous Landfills which may only accept Hazardous wastes which satisfy site specific acceptance criteria. Class I disposal sites must meet the minimum requirements detailed in PME Waste Classification Standard for KSA.
- Class II: Non- Hazardous Landfills which may accept any wastes which are considered to be non-hazardous including municipal waste, commercial waste, stable non-reactive hazardous waste, inert wastes and others as demonstrated through appropriate investigation and risk assessment. Class II disposal sites must meet the minimum requirements detailed in in PME Waste Classification Standard for KSA.
- Class III: Inert Landfills which may only accept waste which is known to be inert (that is, chemically or biologically unreactive). Class III disposal sites must meet the minimum requirements detailed in in PME Waste Classification Standard for KSA.

4.6.3 Siting Restrictions

- When determining the location of a landfill facility, ensure that the proposed landfill is built in a suitable location away from populated, environmental, or culturally sensitive areas.
- When screening potential landfill sites, the following areas of concern shall be considered, at a minimum:
    - Community needs
    - Landfill type
    - Size and shape of the property area
    - Local ecological aspects
    - Access and ease of transportation to the site
    - Groundwater
        - The landfill site shall be located a minimum of 2 meters from the water table.
    - Alternative potential uses for the site
    - Buffer distances (for odor, landfill gas, and bird impacts)
        - The site shall be located a minimum of 100 meters from surface water
        - The site shall be located at least 250 meters from other inhabited buildings or structures
        - The site shall be located a minimum of 3,300 meters from an airport for jet aircraft
    - Geology
        - The landfill site shall not be located within 100 meters of a fault line.
    - Flora and fauna
    - Surface water
        - The landfill site shall not be located in a floodplain.
    - Infrastructure
    - Public concern and/or opposition

4.6.4 Visual Considerations

The working face of the waste deposit site shall remain as small as practically possible to prevent attracting birds, scavenging animals, and vectors to avoid creating visual problems for passersby, and to contain windblown debris.

4.6.5 Groundwater Protection

- In order to confirm that the liner constructed below a landfill is not punctured or torn and allowing leachate to potentially impact groundwater below the landfill, routine groundwater testing is required for both Class I and Class II landfills. This groundwater monitoring shall be performed on a continued regular basis, per the PME regulations, during the operation of the landfill and for a recommended 30 years following the closure of a landfill site.
- As stated in the Sections referenced above, refer to the PME Hazardous, Non-Hazardous, Municipal, and Inert Waste Disposal Regulations, respectively for further information about groundwater protection in relation to Classes I, II, and III landfill sites.
- Refer to the Geosynthetic Research Institute's Specifications (GCL3, GS15, GT10, GT12, GT13, GM13, GM17, GM18, GM19, GM21, GM22, GM25, GM28), Guides (GCL4, GCL5, GN2, GS11), and Practices (GG4, GT7, GT11, GM29) for liner and cap design guidelines.

4.6.6 Landfill Cells

- Landfills shall be divided into cells for the purposes of active disposal locations and pollution management.
- Each cell should take less than two years to fill, after which they will be immediately closed and made ready for their proposed post closure use.
- Active cells shall be capped before starting new cells
- Leachate collection and leak detection monitoring shall be separated by cell/groups of cells to allow for isolating any liquid leakage problems.

4.6.7 Design and Performance Standards

4.6.7.1 Environmental Assessment

- The environmental design aspects of landfill design are derived from information gathered during the EIA and other environmental investigations.
- Refer to Volume 3, Chapter 5 for an overview of the EIA.
- Design considerations shall include, but are not limited to:

    - Meteorological data, including average rainfall and wind strength
    - Hydrogeological assessment in accordance with Hydrogeological Assessments, US EPA Publication 668
    - Water management information, including estimated storm water diversion dams, firefighting equipment, volume of leachate generated, and leachate collection, storage, and treatment systems
    - Landfill gas production volume and odor control
    - Noise assessment

4.6.7.2 Site Layout

- The landfill site shall be designed to minimize the following:

    - Potential risks to health and safety of landfill operators and the public
    - Inefficient use of on-site resources
    - Environmental impacts

- The landfill shall be designed with areas planned to be filled within 2 years, on a full trench or full cell basis.

4.6.7.3 Liner and Leachate Collection System

- Landfill liners are typically comprised of up to five components: sub-base, clay or geosynthetic clay layer, geomembrane and protection layer, drainage layer/leachate collection system, and/or geotextile. Final liner and leachate collection system design shall be submitted to the PME for approval prior to beginning liner and leachate collection system installation.
- Class I and II landfill liners must use BAT to control seepage to an amount not exceeding 1 x 10-9 m/s for hazardous sites and 1 x 10-5 m/s for nonhazardous sites.
- The sub-base shall consist of continuous, well consolidated, low permeability material. The subgrade must also offer the capacity to further attenuate contaminants that may potentially seep through the liner.
- The drainage layer/leachate collection system must act as a layer able to perform multiple functions within the landfill.
    - The drainage layer must sufficiently drain leachate such that the leachate head above the liner is minimized to less than 0.3 m.
    - The layer must resist chemical attack and biological, chemical, and physical clogging. This requires the hydraulic conductivity of the layer be greater than 1x10-3 m/s.
    - The layer must withstand the weight of waste and compaction equipment without damage from consolidation or compaction.
    - Consider use of recycled/reclaimed materials for alternative construction materials such as shredded tires as drainage and gas collection layers.

4.6.7.4 Construction Quality Assurance

- Construction quality assurance for landfills is required to demonstrate that the materials used in construction comply with specifications, that the design requirements have been met, and that the method of construction is appropriate for the landfill.
- For quality assurance practices and requirements refer to PME National Landfill Design and Operations Standard for KSA.

4.6.7.5 Water Management

- Management of storm water, leachate, and groundwater for landfills is critical to protecting the environment. Management systems shall be designed to protect the surrounding environment and groundwater. Design considerations shall include, but are not limited to:
- Storm water
    - Site
        - The site slopes and grading shall divert water away from the landfill and prevent onsite erosion to the landfill cover, roadways, and drainage ways.
        - Landfill site slopes shall be 1 vertical to 4 horizontal (for finished slopes) and temporary slopes between phases of a landfill of 1 vertical to a maximum of 3 horizontal.
        - Soil and drainage material onsite shall have low permeability to minimize infiltration and groundwater contamination.
    - Landfill Cap
        - Drainage structures (catch basins, ditches, culverts, storm water basins, check dams, swales, and diffusers) shall be present on the landfill cap to divert and consolidate storm water.
        - Structures shall be erected to prevent natural consolidation, preferential pathways, and erosion created by storm water runoff.
        - Rip-rap and check dams shall be used to line constructed preferential pathway structures to prevent erosion of such structures.
        - storm water runoff on the landfill cap shall be diverted away from the open sections of the landfill to minimize leachate generation.
    - Containment

- storm water generated onsite shall be contained onsite.
- Basins must only consist of storm water that has not permeated through waste.
  - Consideration must be given to the quantity (peak flow rate) of storm water generated.
  - Consideration must be given to the quality of the storm water generated.
- Water contained in storm water detention basins shall be tested and treated, and the results of tests and treatments are subject to all water discharge regulations, prior to discharge.

- Leachate
  - Leachate is generally a combination of two sources:
    - Liquid waste within the solid waste that has seeped out of the landfill, and
    - storm water infiltrating and migrating downward through the waste material that may have assimilated contamination.
  - The landfill shall be designed with an impermeable liner and a leachate collection system to prevent groundwater seepage.
  - Leachate volume shall be minimized using the following methodologies:
    - Sections of the landfill that have reached maximum capacity shall be capped; and
    - storm water shall be diverted away from open sections of the landfill.
  - Leachate containment basins shall be constructed onsite to temporarily hold leachate while disposal characterization analysis is performed. For example, large holding tanks that can hold a large volume of leachate may be necessary in case treatment systems are immediately overloaded or an emergency occurs that prohibits discharge of leachate.

    There shall be at least two holding tanks onsite for filling and testing. An example procedure for testing and discharge would be:
    - Allow leachate flow to Tank A
    - When Tank A reaches desired volume, switch flow to Tank B
    - Test Tank A for desired analytes and discharge when approval is received
    - When Tank B reaches desired volume, switch flow back to Tank A
    - Repeat as necessary.
  - Leachate containment tanks shall be sized according to estimates of liquid amounts inherent in the disposed waste, landfill size, and predicted rainfall.
  - Leachate shall be disposed of at an Industrial Wastewater Treatment Plant or, if deemed suitable by the PME, at a Sanitary Wastewater Treatment Plant. Refer below to Subsection Water Discharge for more information on the water discharge.

- Groundwater
  - Landfill liner systems must be constructed at least 2 meters above the highest elevation of groundwater as determined by a complete hydrogeological study.
  - The liner must be made of impermeable material that is free of cracks, holes, punctures, tears, breaches, or improperly constructed seams, and must be capable of withstanding designed waste loading.
  - Monitoring wells shall be installed around the landfill perimeter for monitoring the status of groundwater in the landfill vicinity. Monitoring wells must be located so that leaks in the landfill can be detected and mitigated quickly if they occur.
  - Wells shall be installed up-gradient and down-gradient of the landfill.
  - Periodic monitoring of the groundwater wells shall be performed to detect groundwater impacts in close proximity to the origin.

- Water Discharge

    - Water or leachate collected by the landfill must have adequate storage for accumulation of liquid.
    - storm water must be held onsite in a retention pond for testing before approval of discharge which is subject to all applicable PME requirements.
    - Leachate must also be held onsite for testing before approval of discharge and is subject to all applicable PME requirements.
    - Testing and analysis requirements must be met for PME Standards for the discharge destination.

4.6.7.6 Air Quality

- Landfill gas

    - As landfill cells are completed and capped, and the conditions under the cap become anaerobic, the breakdown of organic waste generates biogas. This biogas is typically around 50% carbon dioxide and 50% methane. Proper venting must be installed to prevent gas pressure buildup.
    - A venting system that allows the gas to escape without water entering shall be installed.
    - A capture system integrated with the venting system on the landfill cap shall be installed for landfills with capped cells.
    - The capture system shall draw the gas out of the landfill vents at a slight vacuum (matching the landfill gas generation rate with the extraction rate).
    - Capturing and combusting landfill gas shall be considered to meet Air Emission Control Requirements.
    - If utilized, gas shall be combusted at the same rate as it is being drawn out of the landfill. Consider combusting gas in this way as a beneficial source of electrical and heat generation for a facility.
    - Landfill gas shall be sampled before and after it is combusted to establish the contaminant reduction benefits combustion will have on the landfill gas. Final emission contaminant levels are subject to PME requirements and regulations.

- Monitoring

    - When planning the landfill gas monitoring, the following items shall be considered:

        - The type of wastes deposited at the site
        - The composition and generation rate of landfill gas
        - The possible pathways of gas migration
        - The possible effects the gas may have on receptors

    - Landfill gas monitoring shall include testing at the following locations around the landfill, at a minimum:
        - The landfill surface, where the action level is 100 ppm
        - The subsurface geology, where the action level is 1% Volume Percent (v/v) methane and 1.5% v/v carbon dioxide above background
        - Interior air in buildings on and adjacent to the site, where the action level is 0.5% v/v methane and carbon dioxide above background
        - Landfill gas combustion equipment, such as flares and engines, where the action level is 98% destruction efficiency

    - Written procedures must be in place for handling, investigating, communicating, and reporting actual or potential non-compliance with operating procedures.

- Management

    - Landfill gas management tactics vary on a site-specific basis due to the varying amount of landfill gas produced from any site. Therefore, the management plan must be verified by the PME prior to its instillation when applicable
    - Methods of managing landfill gas are listed below from most preferable management methods to least preferable:

        - Combined heat and power generation
        - Substitute fuel
        - Power generation
        - Intermittent use and off-time flaring
        - Constant (high-temperature or low-calorific) flaring
        - Treatment (via oxidation) and discharge
        - Discharge

- Odor
    - Care must be taken to protect people and areas within close proximity of the landfill from odor, particularly when the surrounding areas include residential, educational, health care or other sensitive facilities.
    - A landfill gas extraction and venting system shall act to partially control odor via negative pressure for the landfill once the system is installed.
    - Waste disposed of each day shall be covered daily with cover material to reduce odor, deter birds from scavenging, and stabilize the landfill. The contents of the daily cover material must adhere to PME criteria waste associated with landfill classes. The daily cover material could come from the existing site or be imported from offsite.
        - Given the large volume of sand that is often landfilled, it is recommended that the sand be separated at the time of disposal to the extent practicable and be used as the daily waste cover.

- Particulate emissions
    - When planning particulate emission controls, the following variables shall be considered:
        - The type and size of the landfill operation
        - The speed and direction of the prevailing winds
        - The use of lands adjacent to the landfill site
        - The existence of natural and/or constructed wind breaks on or adjacent to the site
        - The occurrence of other wind-abatement buffers
    - Dust suppression must be provided including the availability of browsers and water supplies. Leachate must not be used for dust suppression in areas outside the working landfill area, although it may be suitable for use for dust suppression within the working face.
    - Other long-term measures that must be considered for use to suppress particulates include vegetating or mulching exposed areas, sealing roads that are used regularly, and using water or other particulate suppressants on roads and/or stockpiles.

4.6.7.7 Noise

- Landfill sites can be a high source of noise to the surrounding community. Noises that shall be mitigated include, but are not limited to, that of trucks (i.e. engines, exhaust, and/or back-up alarms), other mobile equipment and machinery (such as concrete crushing equipment), external telephone bells, and public address announcements.
- The landfill may have to avoid certain operations at night depending on its vicinity to residential, educational, healthcare, or other noise-sensitive facilities. This will be determined on a case-by-case basis by the PME.
- An acoustics specialist shall model the noise levels generated by the landfill at structures adjacent to the landfill and recommend noise controls per Subsection Noise Management.
    - Due to vehicular traffic in and around the landfill site, noise barriers may be recommended to reduce vehicle noise. These barriers double as security and visual barriers in addition to noise.
    - Earthen berms and depressions may be constructed to provide similar noise control.

4.6.7.8 Traffic considerations

- Landfills typically have high-volume truck traffic. This can increase the amount of noise, dust, safety concerns, dirt on surrounding roads and cost of road maintenance inflicted on the surrounding areas. Design controls to limit the above concerns include the following:

    - Limiting access routes and speeds of vehicles while en-route to and from the site
    - Limiting the hours of operation of the site
    - Arranging the landfill site interior such that the entrance and weigh station, as well as parking, are away from adjacent sensitive land users
    - Traffic islands or merging lanes external to the entrance of the landfill in order to shorten the vehicle queues on public roads
    - Wheel wash or equivalent wheel and undercarriage wash at the exit of the site to minimize dirt accumulation on public roads

- The above recommendations apply not only to vehicles regularly delivering waste, but also to those importing cover material and removing leachate.

4.6.7.9 Site Security

- Security at the facility is necessary to prevent unauthorized dumping and salvaging in the landfill, as well as any unauthorized access to the landfill.

    - Fencing; the facility must be secured to prevent free access to the site.
    - The gates to the fence shall be locked outside operational hours.
    - Any areas of the landfill site that are particularly dangerous, such as leachate ponds shall be posted with signs to indicate the respective dangers.

5.0 NOISE MANAGEMENT

5.1 General

- Noise generation from new facilities that are constructed, existing facilities that are modified, and sites of construction and/or demolition shall not cause Environmental Noise Standards to be exceeded. The likely noise sources shall be identified during the planning phase of the project. The Environment Noise Standards apply to the construction, operational, and demolition phase of any given project.
- Management tactics vary on a site-specific basis due to the varying amount of noise produced from any site. Therefore, the management objectives that may exceed regulated noise limits must be reviewed by the PME prior to their initiation.

5.2 Codes and Standards

For Noise Standard, refer to PME - General Environmental Regulations and Rules for Implementation.

5.3 Ambient Noise Levels

5.3.1 Objective

- To design new projects to be compliant with acceptable ambient noise standards.
- To provide a suitable noise management such that the indoor ambient noise levels in buildings adjacent to the site (1) during the day allow for clear communication of speech between two individuals three or more feet apart and (2) at night allow for continuous undisturbed sleep cycles of the building occupants.

5.4 Maximum Allowable Noise Levels

5.4.1 Community Noise

- Noise levels will vary depending on the amount of residential, recreational, and commercial facilities in a given area. They will also vary depending on the time of day.

- Noise generated in the community shall remain below values specified in the PME General Environmental Standard for Noise.
- When the values specified in this regulation are likely to be, or are currently continually, breached, a Noise Permit will be required.

5.4.2 Industrial Area Noise

- Noise levels will vary depending on the category in which the industrial premises fall under, specifically retail, warehousing, or light, medium, or heavy industrial. Refer to PME General Environmental Standard for Noise for definitions of each industrial premise.
- Noise generated in industrial areas shall remain below those stated in the PME General Environmental Standard for Noise. When the values specified are likely to be, or are currently continually, breached, a Noise Permit will be required to continue the industrial processes.

5.4.3 Construction Noise

- Noise levels shall vary depending on the classification of the areas adjacent to construction sites. Refer to the PME General Environmental Standard for Noise, for the noise area classifications and permissible façade noise limits for each of the described noise areas.
- Noise levels generated in Construction areas shall be less than those stated in the PME's Environmental Standard 3 Article VI, Noise from Construction Activities. When the values specified in Article VI are likely to be, or are currently continually, breached, a Noise Permit will be required to continue the construction work.

5.4.4 Vehicular Noise

- Noise generated by vehicles, including motorcycles, shall remain less than that stated in the PME's Environmental Standard 3 Article VII, Noise from Vehicles.

5.4.5 Outdoor Equipment Noise

- Noise generated by equipment used outdoors shall remain less than the noise levels stated in the PME's Environmental Standard 3 Article VIII, Noise from Equipment Used Outdoors. When the values specified in Article VIII are likely to be, or are currently continually, breached, noise permit will be required.

5.5 Noise Prevention Mitigation

5.6 Noise Barriers

5.6.1 Objectives

- A noise barrier or other noise mitigation system shall be designed such that it fits with its surroundings while performing its intended acoustical and structural functions at a reasonable life-cycle cost.
- Noise barriers reduce the sound which enters a community by absorbing it, reflecting it back at the source of the sound, or forcing it to take a longer path. Refer to the US Department of Transportation Federal Highway Administration's Noise Barrier Design Handbook Section 3.4, Noise Barrier Basics (2011) for detail on predicting noise reduction via each of the above-listed methods.
    - Temporary noise barriers are those intended for construction activities and equipment that will be removed from the site.
    - Permanent noise barriers are those placed along areas that will experience noise throughout the project life.

5.6.2 Acoustical Considerations

5.6.2.1 Barrier Design Goals

- Noise barriers shall be designed such that they decrease the sound attenuation by 10 dB(A), at a minimum, at the noise receptor.
    - A noise barrier that blocks the receiving location's line of sight from the sound source blocks around 5 dB(A), with every additional meter in height above the line of sight blocking an additional 1.5 dB(A).

5.6.2.2 Placement

- The barrier shall be placed near the source or near the receiver, not near the midpoint between them.
- The barrier shall be kept as far away as possible from any reflecting surfaces in the vicinity of the source and receiver.

5.6.2.3 Materials

- The side of the barrier facing the noise source shall be coated or covered with sound-absorbing materials.
- Reflecting surfaces in the vicinity of the source and receiver shall be coated or topped with sound-absorbing materials.
- The barrier must be free of holes or orifices and shall be as airtight as possible.

5.6.2.4 Barrier Length

- A sound barrier shall be tall enough and long enough so that only a small fraction of the sound emitted by the source is diffracted down its entire length and around the barrier's edges.
- The length from the sound receiver and the end of the sound barrier shall be 4 times the perpendicular distance from the sound receiver to the barrier immediately nearest the receiver, unless a smaller length is agreed upon by the PME.
    - If the above specification is not achievable, the ends of the sound barrier shall be curved in towards the sound receiver to minimize attenuation into the community.

5.6.2.5 Reflective versus Absorptive

- All noise barriers shall have an absorptive layer or treatment to its surface to mitigate sound reflection.
- A solution of erecting parallel noise barriers may degrade both barriers' performance due to the multitude of diffractions that take place between their surfaces. To avoid this phenomenon, the distance between two parallel barriers shall be at least 10 times their average height.

5.6.3 Noise Barrier Types

- Refer to the US Department of Transportation Federal Highway Administration's Noise Barrier Design Handbook Section 4, Noise Barrier Types (2011) for details on ground-mounted and structure-mounted noise barrier designs.
- The use of natural noise barriers such as natural berms, tree lines, topography, etc. shall be considered.
- Refer to the US Department of Transportation Federal Highway Administration's Noise Barrier Design Handbook Section 5, Noise Barrier Material and Surface Treatments (2011) for details on noise barrier construction materials and surface treatments.
- Wall versus Berm
- The consideration of whether a wall or berm noise barrier is more appropriate depends on the given area, materials available, costs of materials, aesthetics, and concerns of the community.
- Generally, a berm provides between 1 to 3 dB(A) more sound attenuation than a wall of similar height and placement; however, that difference is barely perceptible to the human ear.

5.7 Sound Insulation

5.7.1 New structures

- Site specifics shall be evaluated to determine the need to add sound insulation systems for sites adjacent to potential noise sources.
- Construct fewer windows and doorways facing the source of the noise.
- Insulate exterior walls, and use siding that acts to reflect or absorb sound rather than simply allowing it to pass through.
- Avoid penetrations into the building or house.
- Consider additional vegetation around the building perimeter to act as an additional noise barrier.

5.8 Equipment Enclosures

5.8.1 Structure

- Equipment shall be mounted on isolators or on concrete pads with sound attenuated enclosures completely surrounding the base of the unit.
- Gaskets shall be used to prevent noise leakages through gaps in an uneven base surface.
- Rigid couplings for pipes and electrical connectors shall be utilized.
- Flexible or isolated connections shall be used to prevent transmission of sound or vibrations.
- Select and apply manufacturer's noise reduction accessories and enclosures to any location or noise source as a default.

5.8.2 Materials

- All penetrations through enclosure walls shall be sealed with flexible, non-hardening mastic, for example, silicone caulk.
- Acoustical absorbing materials shall be used to line the interior surfaces of the enclosure.
    - A splash barrier, such as 1-mil thick plastic coating shall be used to cover the acoustical absorbing material lining the interior enclosure surfaces.

5.9 Other Mitigation Techniques

5.9.1 Techniques for the noise-producing site to consider

- Selecting equipment with lower sound power levels
- Installing silencers for fans
- Installing suitable mufflers on engine exhausts and compressor components
- Installing vibration isolation for mechanical equipment
- Relocating noise sources to areas of the site further from adjacent noise-sensitive receptors, to take advantage of distance and natural shielding
- Developing a mechanism to record and respond to noise complaints submitted by inhabitants of adjacent facilities.