Environmental, Health, and Safety General Guidelines

Introduction

The Environmental, Health, and Safety (EHS) Guidelines (the EHS Guidelines) are technical reference documents designed to assist a wide range of users, including project developers, financiers, facility managers, and other decision makers, by providing relevant industry background and technical information. This information supports actions aimed at avoiding, minimizing, and controlling environmental, health, and safety impacts during the construction, operation, and decommissioning phase of a project or facility.

How to Use This Document

The Environmental, Health, and Safety General Guidelines (henceforth '**General EHS Guidelines'**) are organized to capture common themes that are applicable to any industry sector and project. The **General EHS Guidelines** and the **Industry Sector EHS Guidelines** (henceforth '**EHS Guidelines'**) are designed to be used jointly. On complex projects, multiple industry-sector guidelines may be useful. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities at reasonable costs using existing technology. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets with an appropriate timetable for achieving them. The applicability of the EHS Guidelines may need to be established for each project based on the results of an environmental assessment where site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

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**Note: Attribution of all references, including verification for completeness and accuracy, will be completed in the final draft of the General EHS Guidelines document.*

General Approach to the Management of EHS Hazards at the Facility or Project Level

Effective management of environmental, health, and safety (EHS) hazards entails the inclusion of EHS considerations into corporate- and facility-level business processes in an organized, hierarchical approach that includes the following steps:

- Identifying EHS risks and impacts as early as possible in the project cycle, including the incorporation of EHS considerations into the site selection process, product design process, engineering planning process for capital requests, engineering work orders, facility modification authorizations, or layout and process change plans.
- Involving EHS professionals, who are experienced in assessing and managing EHS impacts and risks, in project engineering and financial decisions.
- Understanding the likelihood and magnitude of EHS risks and impacts, based on:
    - The nature of the project activities, such as whether the project involves significant quantities of emissions and effluents, or hazardous materials or processes;
    - The potential consequences to workers, the community, or the environment if hazards are not adequately managed, which may depend on the proximity of project activities to people or to the environmental resources on which they depend.
- Prioritizing risk management strategies with the objective of achieving an overall reduction of risk to human health and the environment, focusing on the prevention of irreversible or significant impacts.
- Favoring avoidance strategies that eliminate the cause of the risk or impact at its source, for example, by selecting less hazardous materials or processes that avoid the need for EHS controls.
- When avoidance is not feasible, incorporating engineering and management controls into the facility or project to reduce or minimize the possibility and magnitude of undesired consequences, such as may be the case with the application of pollution controls to reduce the levels of emitted contaminants to the worker or overall environments.
- Preparing workers and the community to respond to accidents, including provision of technical and financial resources to effectively and safely control such events, and restoring the working and community environments to a safe and healthy condition.
- Improving EHS performance through a combination of ongoing monitoring of facility performance and effective accountability of all levels of corporate and facility management.

1.1 Air Emissions and Ambient Air Quality

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Applicability and Approach

This guideline applies to projects which generate emissions to air at any stage of the project life-cycle. It complements the industry-specific emissions guidance presented in IFC's Industry Sector Environmental, Health, and Safety (EHS) Guidelines by providing additional information about common techniques for air emissions management that may be applied to a range of industry sectors. This guideline provides an approach to the management of significant sources of emissions, including specific guidance for assessment and monitoring of impacts. It is also intended to provide additional information on approaches to emissions management in projects located in areas of poor air quality, where it may be necessary to establish project-specific emissions standards.

Emissions of air pollutants can occur from a wide variety of activities during the construction, operation, and decommissioning phases of a project. These activities can be categorized based on the spatial characteristic of the source, namely point sources, fugitive sources, and mobile sources, and further, by process, such as combustion, materials storage, or other industry sector-specific processes.

Projects should avoid, minimize, and control adverse impacts to human health, safety, and the environment from emissions to air. The generation and release of emissions of any type should be managed through a combination of:

- Energy use efficiency
- Process modification
- Selection of fuels or other materials whose transformation may result in less polluting emissions
- Application of emission control techniques

The selected prevention and control techniques may include one or more methods of treatment depending on:

- Significance of the source
- Location of the emitting facility relative to other sources, existing ambient air quality, and potential for degradation of the airshed from a proposed project
- Technical feasibility and cost effectiveness of the available options for prevention, control, and release of emissions

Ambient Air Quality

General Approach

Projects with significant[1] [2] sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, the current WHO Air Quality Guidelines[4] (see Table 1.1.1), or other internationally recognized sources in the absence of nationally legislated standards;
- Emissions do not represent a significant portion of the relevant ambient guidelines or standards. As a general rule, this would be defined as 1percent of the long-term air quality standards and 20 percent or the short-term air quality standards.

Impacts should be estimated through qualitative or quantitative assessments by the use of baseline air quality assessments and atmospheric dispersion models to assess potential ground level concentrations. Local atmospheric, climatic, and air quality data should be applied when modeling dispersion, protection against atmospheric downwash, wakes, or eddy effects of the source, nearby[5] structures, and terrain features. The dispersion model applied should be internationally recognized, or comparable. Examples of acceptable emission estimation and dispersion modeling approaches for point and fugitive sources are included in Annex 1.1.1. These approaches include simple screening models for single source evaluations (SCREEN3 or AIRSCREEN), as well as more complex and refined models (AIRMOD OR ADMS). Model selection is dependent on the complexity and geophysical siting of the project (i.e. mountainous terrain, urban or rural area).

Table 1.1.1: WHO Ambient Air Quality Guidelines[3]

	Averaging Period	Guideline value in mg/m³
Sulfur dioxide (SO_2)	1-year 24-hours 10-minutes	50 125 500
Nitrogen dioxide (NO_2)	1-year 1-hour	40 200
Particulate Matter **PM_{10}** **PM_{10}**	 1-year 24-hours	 20 50
Ozone	8-hour daily maximum	100

Projects Located in Degraded Airsheds or Ecologically Sensitive Areas

Facilities located within poor quality airsheds[6], and within or next to areas established as ecologically sensitive (e.g. national parks), should ensure that any increase in pollution levels are kept as small as feasible, and generally amount to a fraction of the applicable short-term and annual average air quality guidelines. Suitable measures may also include the location of significant sources of emissions outside the airshed in question, application

1 Significant sources of point and fugitive emissions are considered to be general sources which, for example, can contribute a net emissions increase of one or more of the following pollutants within a given airshed: PM10: 50 tons per year (tpy); NOx: 500 tpy; SO2: 500 tpy; or as established through national legislation; and combustion sources with an equivalent heat input of 50 MWth or greater. The significance of emissions of inorganic and organic pollutants should be established on a project-specific basis taking into account toxic and other properties of the pollutant.

2 United States Environmental Protection Agency, Prevention of Significant Deterioration of Air Quality, 40 CFR Ch. 1 Part 52.21; other references for establishing significant emissions include the European Commission. 2000, http://www.eper.cec.eu.int/eper/documents/ eper_en.pdf; Canada Gazette – Part I", February 2005, and; Australian Government. 2004. http://www.npi.gov.au/handbooks/pubs/npiguide.pdf

3 WHO – Guidelines for Air Quality, Geneva 2000, except for PM10 and Ozone values which are from WHO – Air Quality Guidelines Global Update 2005. PM10 24-hour value is the 99th percentile.

4 WHO. http://www.who.int/en

5 "Nearby" generally considers an area within a radius of up to 20 times the stack height.

6 An airshed should be classified as having poor air quality if nationally legislated air quality standards or the WHO Air Quality Guidelines are exceeded significantly.

of cleaner fuel and technology, application of comprehensive pollution control measures, offset provisions at installations controlled by the project sponsor and at other facilities within the same airshed, and buy-down of emissions within the same airshed.

Specific provisions for minimizing emissions and impacts in poor air quality or ecologically sensitive airsheds should be established on a project-by-project or industry-specific basis. Offset provisions, outside the immediate control of the project sponsor, and buy-downs should be monitored and enforced by the local agency responsible for granting and managing emission permits. Such provisions should be in place prior to final commissioning of the project.

Point Sources

Point sources are discrete, stationary, identifiable sources of emissions that release pollutants into the atmosphere. They are typically located in manufacturing or production plants. Within a given point source, there may be several emission points that comprise the point source.[7]

Point sources are characterized by the release of general air pollutants typically associated with the combustion of fossil fuels, such as nitrogen oxides (NOx), sulfur dioxide (SO_2), carbon monoxide (CO), and particulate matter (PM), as well as hazardous air pollutants (HAPs) including certain volatile organic compounds (VOCs) and metals, which may also be associated with a wide range of industrial activities.

Emissions from point sources should be avoided and controlled according to good international industry practice (GIIP) applicable to the relevant industry sector, depending on ambient conditions, through the combined application of process modifications and emissions controls as described in Table 1.1.2. Additionally, recommendations regarding stack height and emissions from small combustion facilities are provided below.

Stack Height

The stack height for all point sources of emissions, whether above or below the significance threshold, should be designed according to GIIP (see Annex 1.1.2) to avoid excessive ground level concentrations due to downwash, wakes, and eddy effects, and to ensure reasonable diffusion to minimize impacts. For projects where the combustion facility is not the only source of emissions, stack heights should be established with due consideration to emissions from all other project sources—point and fugitive. Smaller sources of emissions, including small combustion sources,[8] should also use GIIP in stack design.

Small Combustion Facilities Emissions Guidelines

Small combustion processes are systems designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type, with a total, rated heat input capacity of between three Megawatt thermal (MWth) and 50 MWth. Smaller processes should follow these guidelines to the extent practical; processes larger than 50 MWth should conform to IFC's Thermal Power Guideline.

The emissions guidelines in Table 1.1.3 are applicable to small combustion process installations operating more than 500 hours per year, and those with an annual capacity utilization of more than 30 percent. Plants firing a mixture of fuels should compare

[7] Emission points refer to a specific stack, vent, or other discrete point of pollution release. This term should not be confused with point source, which is a regulatory distinction from area and mobile sources. The characterization of point sources into multiple emissions points is useful for allowing more detailed reporting of emissions information.

[8] Small combustion sources are those with a total rated heat input capacity of 50MWth or less.

Table 1.1.2: Illustrative Point Source Air Emissions Prevention and Control Technologies

Principal Sources and Issues	General Prevention / Process Modification Approach	Control Options	Reduction Efficiency (%)	Gas Condition	Comments
Particulate Matter (PM)					
Main sources are the combustion of fossil fuels and numerous manufacturing processes which collect PM through air extraction and ventilation systems. Volcanoes, ocean spray, forest fires and blowing dust (most prevalent in dry and semiarid climates) contribute to background levels.	Fuel switching (e.g. selection of lower sulfur fuels) or reducing the amount of fine particulates added to a process.	Fabric Filters	99 - 99.7%	Dry gas, temp <400F	Applicability depends on flue gas properties including temperature, chemical properties, abrasion and load. Typical air to cloth ratio range of 2.0 to 3.5 cfm/ft^2 Achievable outlet concentrations of 23 mg/Nm3
		Electrostatic Precipitator (ESP)	97 – 99%	Varies depending of particle type	Precondition gas to remove large particles. Efficiency dependent on resistivity of particle. Achievable outlet concentration of 23 mg/Nm^3.
		Cyclone	74 – 95%	None	Most efficient for large particles. Achievable outlet concentrations of 30 - 40 mg/Nm3
		Wet Scrubber	93 – 95%	None	Wet sludge may be a disposal problem depending on local infrastructure. Achievable outlet concentrations of 30 - 40 mg/Nm3
SO2					
Mainly produced by the combustion of fuels such as oil and coal and as a by-product from some chemical production or wastewater treatment processes.	Control system selection is heavily dependent on the inlet concentration. For SO2 concentrations in excess of 10%, the stream is passed through an acid plant to not only lower the SO2 emissions but to also generate high grade sulfur for sale. Levels below 10% are not rich enough for this process; absorption or scrubbing where SO2 molecules are captured into a liquid phase; and, adsorption where SO2 molecules are captured on the surface of a solid adsorbent.	Fuel Switching	>90%		Alternate fuels may include low sulphur coal, light diesel or natural gas with consequent reduction in particulate emissions related to sulphur in the fuel. Fuel cleaning or beneficiation of fuels prior to combustion is another viable option but may have economic consequences.
		Sorbent Injection	30% - 70%		Calcium or lime is injected into the flue gas and the SO_2 is adsorbed onto the sorbent
		Dry Flue Gas Desulfurization	70%-90%		Can be regenerable or throwaway.
		Wet Flue Gas Desulfurization	>90%		Produces gypsum as a by-product

Table 1.1.2: Illustrative Point Source Air Emissions Prevention and Control Technologies (continued)					
NOx		Percent Reduction by Fuel Type			
Associated with combustion of fuel. May occur in several forms of nitrogen oxide; namely nitric oxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O) which is also a greenhouse gas. The term NOx serves as a composite between NO and NO_2 and emissions are usually reported as NOx. Here the NO is multiplied by the ratio of molecular weights of NO_2 to NO and added to the NO_2 emissions. Means of reducing NOx emissions are based on the modification of operating conditions such as minimizing the resident time at peak temperatures, reducing the peak temperatures by increasing heat transfer rates or minimizing the availability of oxygen.	**Combustion modification** (Illustrative of boilers)	**Coal**	**Oil**	**Gas**	These modifications are capable of reducing NOx emissions by 50 to 80%. The method of combustion control used depends on the type of boiler and the method of firing fuel.
	Low-excess-air firing	10–30	10–30	10–30	
	Staged Combustion	20–50	20–50	20–50	
	Flue Gas Recirculation	N/A	20–50	20–50	
	Water/Steam Injection	N/A	10–50	N/A.	
	Low-NOx Burners	30–40	30–40	30–40	
	Flue Gas Treatment	**Coal**	**Oil**	**Gas**	Flue gas treatment is more effective in reducing NOx emissions than are combustion controls. Techniques can be classified as SCR, SNCR, and adsorption. SCR involves the injection of ammonia as a reducing agent to convert NOx to nitrogen in the presence of a catalyst in a converter upstream of the air heater. Generally, some ammonia slips through and is part of the emissions. SNCR also involves the injection of ammonia or urea based products without the presence of a catalyst.
	Selective Catalytic Reduction	60–90	60–90	60–90	
	Selective Non-Catalytic Reduction	N/A	30–70	30–70	

Table 1.1.3 - Small Combustion Facilities Emissions Guidelines (in mg/Nm3 or as indicated)				
Combustion Technology/ Fuel	PM	SO2	NOx	Dry Gas O2 Content O2
Engine				
Gas	N/A	N/A	200	15%
Liquid	50 or 0.15 g/kWh	860 or 1.5%S A: 570 or 1%S B: 280	1460 A: 740 B: 300 or 1.6 g/kWh	15%
Turbine				
Gas =3MWth to < 15MWth	N/A	N/A	42 ppm (Electric generation) 100 ppm (Mechanical drive)	15%
Gas =15MWth to < 50MWth	N/A	N/A	25 ppm	15%
Liquid =3MWth to < 15MWth	N/A	0.5% S or 225 ngSO2/J A: 0.2% S or 90 ngSO2/J	96 ppm (Electric generation) 150 ppm (Mechanical drive)	15%
Liquid =15MWth to < 50MWth	N/A	0.5% S or 225 ngSO2/J A: 0.2% S or 90 ngSO2/J	74 ppm	15%
Boiler				
Gas	N/A	N/A	320	3%
Liquid	150 A: 100 B: 50	2000 A: 900 B: 300	460	3%
Solid	250 A: 100 B: 50	2000 A: 900 B: 300	650	6%

Notes:
- N/A/ - no emissions guideline.
- A and B figures are higher performance levels applicable to facilities located in urban / industrial areas with degraded airsheds or close to ecologically sensitive areas where more stringent emissions controls may be needed. Level B should be applied if Level A may not be sufficient for site-specific circumstances.
- MWth is heat input on HHV basis.
- Solid fuels include biomass.

emissions performance with these guidelines based on the sum of the relative contribution of each applied fuel[9]. Lower emission values may apply if the proposed facility is located in an ecologically sensitive airshed, or airshed with poor air quality, to address potential cumulative impacts from the installation of more than one small combustion plant as part of a distributed generation project.

Fugitive Sources

Fugitive sources are air emissions that are distributed spatially over a wide area and not confined to a specific discharge point. They originate in operations where exhausts are not captured and passed through a stack. Fugitive emissions have the potential for much greater ground-level impacts per unit emission than stationary emissions since they are emitted and dispersed close to the ground. The two main types of fugitive emissions are Volatile Organic Compounds (VOCs) and particulate matter (PM). Other contaminants (NOx, SO2 and CO) are mainly associated with combustion processes, as described above. Projects with potentially significant fugitive sources of emissions should conduct an estimate to establish the need for ambient quality assessment and monitoring practices.

Open burning of any amount of solid wastes, whether hazardous or non-hazardous, is not considered good practice and should be avoided, as the generation of polluting emissions from this type of source can not be controlled effectively.

Volatile Organic Compounds (VOCs)

The most common sources of fugitive VOC emissions are associated with industrial activities which produce, store, and use VOC-containing liquids or gases where the material is under

[9] The contribution of a fuel is the percentage of heat input (LHV) provided by this fuel multiplied by its limit value.

pressure, exposed to a lower vapor pressure, or displaced from an enclosed space. Specific types of sources include equipment leaks, open vats and mixing, storage tanks, and accidental releases. Equipment leaks include valves, fittings, elbows, etc., which are subject to leaks under pressure. The recommended prevention and control techniques for VOC emissions associated with equipment leaks include:

- Equipment modifications, as described in Table 1.1.4
- Implementing a leak detection and repair (LDAR) program which reduces fugitive emissions by periodic monitoring to detect leaks and implementing repairs within a predefined time period[10]

For VOC emissions associated with handling of chemicals in open vats and mixing processes, the recommended prevention and control techniques include:

- Substitution of less volatile substances, such as aqueous solvents, where feasible
- Collection of vapors through air extractors and subsequent treatment of gas stream by removing VOCs with control devices such as condensers or activated carbon absorption
- Collection of vapors through air extractors and subsequent treatment with destructive control devices such as:
  - Catalytic Incinerators: Used to reduce VOCs from process exhaust gases exiting paint spray booths, ovens, and other process operations
  - Thermal Incinerators: Used to control VOC levels in a gas stream by passing the stream through a combustion chamber where the VOCs are burned in air at temperatures between 700º C to 1,300º C
  - Enclosed Oxidizing Flares: Used to convert VOCs into CO_2 and H_2O by way of direct combustion

Table 1.1.4 – VOC Emissions Controls

Equipment Type	Modification	Approximate Control Efficiency (%)
Pumps	Seal-less design	100[11]
	Closed-vent system	90[12]
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the pumped fluid	100
Compressors	Closed-vent system	90
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the compressed gas	100
Pressure Relief Devices	Closed-vent system	Variable[13]
	Rupture disk assembly	100
Valves	Seal-less design	100
Connectors	Weld together	100
Open-ended Lines	Blind, cap, plug, or second valve	100
Sampling Connections	Closed-loop sampling	100

- Use of floating roofs on storage tanks to help reduce emissions by eliminating the headspace that is present in conventional storage tanks

Particulate Matter (PM)

The most common pollutant involved in fugitive emissions is dust or particulate matter (PM). This is released during certain

10 LDAR. http://www.ldar.net/

11 Seal-less equipment can be a large source of emissions in the event of equipment failure.
12 Actual efficiency of a closed-vent system depends on percentage of vapors collected and efficiency of control device to which the vapors are routed.
13 Control efficiency of closed vent-systems installed on a pressure relief device may be lower than other closed-vent systems.

operations, such as transport and open storage of solid materials, and from exposed soil surfaces, including unpaved roads. Principal means for prevention and control of these emissions sources include:

- Use of dust control methods, such as covers, water suppression, or increased moisture content for open materials storage piles; or controls, including air extraction and treatment through a baghouse or cyclone for material handling sources, such as conveyors and bins;
- Use of sweeping or water suppression for control of loose materials on paved or unpaved road surfaces. Additional control options for unpaved roads include those summarized in Table 1.1.5.

Table 1.1.5 – Fugitive PM Emissions Controls

Control Type	Control Efficiency
Chemical Stabilization	0% - 98%
Hygroscopic salts Bitumens/adhesives	60% - 96%
Surfactants	0% - 68%
Wet Suppression – Watering	12% - 98%
Speed Reduction	0% - 80%
Traffic Reduction	Not quantified
Paving (Asphalt / Concrete)	85% - 99%
Covering with Gravel, Slag, or "Road Carpet"	30% - 50%
Vacuum Sweeping	0% - 58%
Water Flushing/Broom Sweeping	0% - 96%

Mobile Sources – Land-based

Similar to other combustion processes, emissions from vehicles include CO, NOx, SO2, PM and VOCs. The potential cumulative impact on an airshed of emissions from land-based mobile sources, owned or operated by single entities, are typically less than the impact associated with significant stationary or fugitive sources. The potential impact may depend on a number of variables, including, but not limited to: the size of the fleet; the type of engine; the quality of the locally available fuel; equipment age; local environment (including traffic congestion and climate); and operators' driving habits. Emissions from on-road and off-road vehicles may be regulated through national or regional programs. In the absence of these, the following approach should be considered:

- Regardless of the fleet size or type of vehicles, fleet owners or operators should implement the equipment manufacturers' recommended engine maintenance, along with the mechanical maintenance for the safe operation of the vehicle, including proper tire pressure. Drivers should also be instructed on the benefits of driving practices which reduce both the risk of accidents and fuel consumption, including measured acceleration and driving within safe speed limits.
- Operators with fleets of 120 or more units of heavy duty vehicles (buses and trucks), or 540 or more light duty vehicles[14] (cars and light trucks) within an airshed, should consider additional ways to reduce potential impacts including:
  - Replacing older vehicles with newer, more fuel efficient alternatives.
  - Converting high-use vehicles to cleaner fuels, where feasible.
  - Installing and maintaining control devices, such as catalytic converters.

[14] The selected fleet size thresholds are assumed to represent potentially significant sources of emissions based on individual vehicles traveling 100,000 km/yr using average emission factors.

Monitoring

Emissions and air quality monitoring programs provide information that can be used to assess the effectiveness of emissions management strategies. With this objective in mind, emissions and ambient air quality monitoring program should be developed, while taking into account the following factors:

- *Indicator parameters*: The monitoring parameters selected should reflect the pollutants of concern considered to be associated with project processes. For combustion processes, indicator parameters may include, or be limited to, the quality of inputs, such as the sulfur content of fuel.
- *Monitoring type and frequency*: Data on emissions quality generated through the monitoring program should be representative of the emissions discharged by the project over time. Examples of time-dependent variations in the manufacturing process include batch process manufacturing and seasonal process variations. Emissions from highly variable processes may need to be sampled more frequently or through composite methods. Emissions monitoring frequency and duration may also range from continuous for some combustion process operating parameters or inputs, including the quality of fuel, to less frequent, monthly, quarterly or yearly stack tests.
- *Data quality*: Monitoring programs should apply internationally approved methods for sample collection and analysis. Sampling should be conducted by, or under, the supervision of trained individuals. Analysis should be conducted by entities permitted or certified for this purpose. Sampling and analysis Quality Assurance / Quality Control (QA/QC) plans should be applied and documented to ensure that data quality is adequate for the intended data use (e.g., method detection limits are below levels of concern). Monitoring reports should include QA/QC documentation.

Monitoring of Small Combustion Plants Emissions

- Additional recommended monitoring approaches for ***boilers***:

  Boilers with capacities between =3 MWth and < 20 MWth:
  - Annual Stack Emission Testing: SO_2, NOx and PM
  - For gaseous fuel-fired boilers, only NOx
  - SO_2 can be calculated based fuel quality certification if no SO_2 control equipment is used
  - Emission Monitoring: None

  Boilers with capacities between =20 MWth and < 50 MWth
  - Annual Stack Emission Testing: SO_2, NOx and PM. For gaseous fuel-fired boilers, only NOx. SO_2 can be calculated based on fuel quality certification, (if no SO_2 control equipment is used)
  - Emission Monitoring: SO_2. Plants with SO_2 control equipment: Continuous. NOx: Continuous monitoring of either NOx emissions or indicative NOx emissions using combustion parameters. PM: Continuous monitoring of either PM emissions, opacity, or indicative PM emissions using combustion parameters / visual monitoring.
- Additional recommended monitoring approaches for ***turbines***:
  - Annual Stack Emission Testing: NOx and SO_2 (NOx only for gaseous fuel-fired turbines)
  - Emission Monitoring: NOx: Continuous monitoring of either NOx emissions or indicative NOx emissions using combustion parameters. SO_2: Continuous monitoring if SO_2 control equipment is used.
- Additional recommended monitoring approaches for ***engines***:
  - Annual Stack Emission Testing: NOx ,SO_2 and PM (NOx only for gaseous fuel-fired diesel engines)

- o Emission Monitoring: NOx: Continuous monitoring of either NOx emissions or indicative NOx emissions using combustion parameters. SO_2: Continuous monitoring if SO_2 control equipment is used. PM: Continuous monitoring of either PM emissions or indicative PM emissions using operating parameters.

Energy Conservation

Reduced energy consumption is one of the most effective ways of reducing the emission of all pollutants associated with fossil fuel-based power generation. Projects should implement energy management programs commensurate with the magnitude of energy use with the objective to promote a continuous improvement in energy efficiency, both through management control of ongoing operations, and the identification and implementation of energy efficiency investment projects.

Energy Management Programs

The most effective energy management programs are integrated into companies' Total Quality Management (TQM) systems, and consider efficient energy use to be just one indicator of high-quality operations. Energy management programs may also be operated in isolation, or within an Environmental and Social Management System (ESMS). Whichever implementation methodology is adopted, the energy management program should include the following elements:

- Identification, and regular measurement and reporting of principal energy flows within a facility
- Definition and regular review of energy performance targets, which are adjusted to account for changes in major influencing factors on energy use—most likely to be production quantity and climate
- Regular comparison and reporting of energy flows with performance targets to identify where action should be taken to reduce energy use
- Regular review of targets, which may include comparison with benchmark data, to confirm that targets are set at appropriate levels

Energy Efficiency in Industry and Commerce

The majority of energy use in industry and commerce is accounted for by process heating and cooling; process and auxiliary systems, such as motor, pump, and fans; compressed air systems and heating, ventilation and air conditioning systems (HVAC); and lighting systems.

For any energy-using system, a systematic analysis of energy efficiency improvements and cost reduction opportunities should include a hierarchical examination of opportunities to**:**

- Reduce loads on the energy system
- Reduce losses in energy distribution
- Improve energy conversion efficiency
- Exploit energy purchasing opportunities
- Use lower-carbon fuels

Common opportunities in each of these areas are summarized below.[15]

[15] Additional guidance on energy efficiency is available from sources such as Natural Resources Canada (NRCAN http://oee.nrcan.gc.ca/commercial/financial-assistance/new-buildings/mnecb.cfm?attr=20); the European Union (EUROPA. http://europa.eu.int/scadplus/leg/en/s15004.htm), and United States Department of Energy (US DOE, http://www.eere.energy.gov/consumer/industry/process.html).

Process and Building Heating

Process heating is vital to many manufacturing processes, including heating for fluids, calcining, drying, heat treating, metal heating, melting, melting agglomeration, curing, and forming[16].

In process heating systems, a system heat and mass balance will show how much of the system's energy input provides true process heating, and quantify fuel used to satisfy energy losses caused by excessive parasitic loads, distribution, or conversion losses. Examination of savings opportunities should be directed by the results of the heat and mass balance, though the following techniques are often valuable and cost-effective.

General recommendations for process heating efficiency improvements are listed below.

Heating Load Reduction

- Ensure adequate insulation to reduce heat losses through furnace/oven etc. structure
- Recover heat from hot process or exhaust streams to reduce system loads
- In intermittently-heated systems, consider use of low thermal mass insulation to reduce energy required to heat the system structure to operating temperature
- Control process temperature and other parameters accurately to avoid, for example, overheating or overdrying
- Examine opportunities to use low weight and/or low thermal mass product carriers, such as heated shapers, kiln cars etc.
- Review opportunities to schedule work flow to limit the need for process reheating between stages
- Operate furnaces/ovens at slight positive pressure, and maintain air seals to reduce air in-leakage into the heated system, and therefore reduce the energy required to heat unnecessary air to system operating temperature
- Reduce radiant heat losses by sealing structural openings and keep viewing ports closed when not in use
- Where possible, use the system for long runs close to or at operating capacity
- Consider use of high emissivity coatings of high temperature insulation, and consequent reduction in process temperature

Heat Distribution Systems

Heat distribution in process heating applications typically takes place through steam, hot water, or thermal fluid systems. Losses can be reduced through the following actions:

- Promptly repair distribution system leaks
- Avoid steam leaks despite a perceived need to get steam through the turbine. Electricity purchase is usually cheaper overall, especially when the cost to treat turbine-quality boiler feed water is included. If the heat-power ratio of the distribution process is less than that of power systems, opportunities should be considered to increase the ratio, for example, by using low-pressure steam to drive absorption cooling systems rather than using electrically-driven vapor-compression systems.
- Regularly verify correct operation of steam traps in steam systems, and ensure that traps are not bypassed. Since steam traps typically last around 5 years, 20% of them should be replaced or repaired annually
- Insulate distribution system vessels, such as hot wells and deaerators, in steam systems and thermal fluid or hot water storage tanks
- Insulate all steam, condensate, hot water and thermal fluid distribution pipework, down to and including 1" (25 mm) diameter pipe, in addition to insulting all hot valves and flanges

[16] US DOE. http://www.eere.energy.gov/consumer/industry/process.html

- In steam systems, return condensate to the boiler house for re-use, since condensate is expensive boiler-quality water and valuable for use beyond its heat content alone
- Use flash steam recovery systems to reduce losses due evaporation of high-pressure condensate
- Consider steam expansion through a back-pressure turbine rather than reducing valve stations
- Eliminate distribution system losses by adoption of point-of-use heating systems

Energy Conversion System Efficiency Improvements

The following efficiency opportunities should be examined for process furnaces or ovens, and utility systems, such as boilers and fluid heaters:

- Regularly monitor carbon monoxide and oxygen or carbon dioxide content of flue gases to verify that combustion systems are using the minimum practical excess air volumes
- Consider combustion automation using oxygen-trim controls
- Minimize the number of boilers or heaters used to meet loads. It is typically more efficient to run one boiler at 90% of capacity than two at 45%. Minimize the number of boiler kept at hot–standby
- Use flue dampers to eliminate ventilation losses from hot boilers held at standby
- Maintain clean heat transfer surfaces; in steam boilers, flue gases should be no more than 20 K above steam temperature)
- In steam boiler systems, use economizers to recover heat from flue gases to pre-heat boiler feed water or combustion air
- Consider reverse osmosis or electrodialysis feed water treatment to minimize the requirement for boiler blowdown
- Adopt automatic (continuous) boiler blowdown
- Recover heat from blowdown systems through flash steam recovery or feed-water preheat
- Do not supply excessive quantities of steam to the deaerator
- With fired heaters, consider opportunities to recover heat to combustion air through the use of recuperative or regenerative burner systems
- For systems operating for extended periods (> 6000 hours/year), cogeneration of electrical power, heat and /or cooling can be cost effective

Process and Building Cooling

The general methodology outlined above should be applied to process cooling systems. Commonly used and cost-effective measures to improve process cooling efficiency are described below.

Load Reduction

- Ensure adequate insulation to reduce heat gains through cooling system structure and to below-ambient temperature refrigerant pipes and vessels
- Control process temperature accurately to avoid overcooling
- Operate cooling tunnels at slight positive pressure and maintain air seals to reduce air in-leakage into the cooled system, thus reducing the energy required to cool this unnecessary air to system operating temperature
- Examine opportunities to pre-cool using heat recovery to a process stream requiring heating, or by using a higher temperature cooling utility
- In cold and chill stores, minimize heat gains to the cooled space by use of air curtains, entrance vestibules, or rapidly opening/closing doors. Where conveyors carry products into chilled areas, minimize the area of transfer openings, for example, by using strip curtains

- Quantify and minimize “incidental” cooling loads, for example, those due to evaporator fans, other machinery, defrost systems and lighting in cooled spaces, circulation fans in cooling tunnels, or secondary refrigerant pumps (e.g. chilled water, brines, glycols)
- Do not use refrigeration for auxiliary cooling duties, such as compressor cylinder head or oil cooling
- While not a thermal load, ensure there is no gas bypass of the expansion valve since this imposes compressor load while providing little effective cooling
- In the case of air conditioning applications, energy efficiency techniques include:
  - Placing cool air intakes and air-conditioning units in cool, shaded locations
  - Improving building insulation including seals, vents, windows, and doors
  - Planting trees as thermal shields around buildings Installing timers and/or thermostats and/or enthalpy-based control systems
  - Installing timers and/or thermostats and/or enthalpy-based control systems
  - Installing ventilation heat recovery systems[17]

[17] More information on HVAC energy efficiency can be found at the British Columbia Building Corporation (Woolliams, 2002. http://www.greenbuildingsbc.com/new_buildings/pdf_files/greenbuild_strategies_guide.pdf), NRCAN's EnerGuide (http://oee.nrcan.gc.ca/equipment/english/index.cfm?PrintView=N&Text=N) and NRCAN's Energy Star Programs (http://oee.nrcan.gc.ca/energystar/english/consumers/heating.cfm?text=N&printview=N#AC), and the US Energy Star Program (http://www.energystar.gov/index.cfm?c=guidelines.download_guidelines).

Energy Conversion

The efficiency of refrigeration service provision is normally discussed in terms of Coefficient of Performance (“COP”), which is the ratio of cooling duty divided by input power. COP, hence system efficiency, is maximized by effective refrigeration system design, maximization of refrigerant compression efficiency, and minimization of the temperature difference through which the system works, and of auxiliary loads (i.e. those in addition to compressor power demand) used to operate the refrigeration system.

System Design

- If process temperatures are above ambient for all, or part, of the year, use of ambient cooling systems, such as provided by cooling towers or dry air coolers, may be appropriate, perhaps supplemented by refrigeration in summer conditions.
- Most refrigeration systems are electric-motor driven vapor compression systems using positive displacement or centrifugal compressors. The remainder of this guideline mainly relates to vapor-compression systems. However, when a cheap or free heat source is available (e.g. waste heat from an engine-driven generator—low-pressure steam which has passed through a back-pressure turbine), absorption refrigeration may be appropriate.
- Exploit high cooling temperature range: precooling by ambient and/or ‘high temperature’ refrigeration before final cooling can reduce refrigeration capital and running costs. High cooling temperature range also provides an opportunity for countercurrent (cascade) cooling, which reduces refrigerant flow needs.
- Keep ‘hot’ and ‘cold’ fluids separate, for example, do not mix water leaving the chiller, with water returning from cooling circuits.

- In low-temperature systems where high temperature differences are inevitable, consider two-stage or compound compression, or economized screw compressors, rather than single-stage compression.

Minimizing Temperature Differences

A vapor-compression refrigeration system raises the temperature of refrigerant from somewhat below the lowest process temperature (the evaporating temperature) to provide process cooling, to a higher temperature (the condensing temperature), somewhat above ambient, to facilitate heat rejection to the air or cooling water systems. Increasing evaporating temperature typically increases compressor cooling capacity without greatly affecting power consumption. Reducing condensing temperature increases evaporator cooling capacity and substantially reduces compressor power consumption.

Elevating Evaporating Temperature

- Select a large evaporator to permit relatively low temperature differences between process and evaporating temperatures. Ensure that energy use of auxiliaries (e.g. evaporator fans) does not outweigh compression savings. In air-cooling applications, a design temperature difference of 6-10 K between leaving air temperature and evaporating temperature is indicative of an appropriately sized evaporator. When cooling liquids, 2K between leaving liquid and evaporating temperatures can be achieved, though a 4K difference is generally indicative of a generously-sized evaporator.
- Keep the evaporator clean. When cooling air, ensure correct defrost operation. In liquid cooling monitor refrigerant/process temperature differences and compare with design expectations to be alert to heat exchanger contamination by scale or oil.
- Ensure oil is regularly removed from the evaporator, and that oil additions and removals balance.
- Avoid the use of back-pressure valves.
- Adjust expansion valves to minimize suction superheat consistent with avoidance of liquid carry-over to compressors.
- Ensure that an appropriate refrigerant charge volume is present.

Reducing Condensing Temperature

- Consider whether to use air-cooled or evaporation-based cooling (e.g. evaporative or water cooled condensers and cooling towers). Air-cooled evaporators usually have higher condensing temperatures, hence higher compressor energy use, and auxiliary power consumption, especially in low humidity climates. If a wet system is used, ensure adequate treatment to prevent growth of *legionella* bacteria.
- Whichever basic system is chosen, select a relatively large condenser to minimize differences between condensing and the heat sink temperatures. Condensing temperatures with air cooled or evaporative condensers should not be more than 10K above design ambient condition, and a 4K approach in a liquid-cooled condenser is possible.
- Avoid accumulation of non-condensable gases in the condenser system. Consider the installation of refrigerated non-condensable purgers, particularly for systems operating below atmospheric pressure.
- Keep condensers clean and free from scale. Monitor refrigerant/ambient temperature differences and compare with design expectations to be alert to heat exchanger contamination.
- Avoid liquid backup, which restricts heat transfer area in condensers. This can be caused by installation errors such

as concentric reducers in horizontal liquid refrigerant pipes, or "up and over" liquid lines leading from condensers.

- In multiple condenser applications, refrigerant liquid lines should be connected via drop-leg traps to the main liquid refrigerant line to ensure that hot gases flow to all condensers.
- Avoid head pressure control to the extent possible. Head pressure control maintains condensing temperature at, or near, design levels. It therefore prevents reduction in compressor power consumption, which accompanies reduced condensing temperature, by restricting condenser capacity (usually by switching off the condenser, or cooling tower fans, or restricting cooling water flow) under conditions of less severe than design load or ambient temperature conditions. Head pressure is often kept higher than necessary to facilitate hot gas defrost or adequate liquid refrigerant circulation. Use of electronic rather than thermostatic expansion valves, and liquid refrigerant pumps can permit effective refrigerant circulation at much reduced condensing temperatures.
- Site condensers and cooling towers with adequate spacing so as to prevent recirculation of hot air into the tower.

Refrigerant Compression Efficiency

- Some refrigerant compressors and chillers are more efficient than others offered for the same duty. Before purchase, identify the operating conditions under which the compressor or chiller is likely to operate for substantial parts of its annual cycle. Check operating efficiency under these conditions, and ask for estimates of annual running cost. Note that refrigeration and HVAC systems rarely run for extended periods at design conditions which are deliberately extreme. Operational efficiency under the most commonly occurring off-design conditions is likely to be most important.
- Compressors lose efficiency when unloaded. Avoid operation of multiple compressors at part-load conditions. Note that package chillers can gain coefficient of performance (COP) when slightly unloaded, as loss of compressor efficiency can be outweighed by the benefits of reduced condensing and elevated evaporating temperature. However, it is unlikely to be energy efficient to operate a single compressor-chiller at less than 50% of capacity.
- Consider turndown efficiency when specifying chillers. Variable speed control or multiple compressor chillers can be highly efficient at part loads.
- Use of thermal storage systems (e.g., ice storage) can avoid the need for close load-tracking and, hence, can avoid part-loaded compressor operation.

Refrigeration System Auxiliaries

Many refrigeration system auxiliaries (e.g. evaporator fans and chilled water pumps) contribute to refrigeration system load, so reductions in their energy use have a double benefit. General energy saving techniques for pumps and fans, listed in the next section of these guidelines, should be applied to refrigeration auxiliaries.

Additionally, auxiliary use can be reduced by avoidance of part-load operation and in plant selection (e.g. axial fan evaporative condensers generally use less energy than equivalent centrifugal fan towers).

Under extreme off-design conditions, reduction in duty of cooling system fans and pumps can be worthwhile, usually when the lowest possible condensing pressure has been achieved.

Compressed Air Systems

Compressed air is the most commonly found utility service in industry, yet in many compressed air systems, the energy contained in compressed air delivered to the user is often 10% or less of energy used in air compression. Savings are often possible through the following techniques:

Load reduction

- Examine each true user of compressed air to identify the air volume needed and the pressure at which this must be delivered.
- Do not mix high volume low pressure and low volume high pressure loads. Decentralize low volume high-pressure applications or provide dedicated low-pressure utilities, for example, by using fans rather than compressed air.
- Review air use reduction opportunities, for example:
    - Use air amplifier nozzles rather than simple open-pipe compressed air jets
    - Consider whether compressed air is needed at all
    - Where air jets are required intermittently (e.g. to propel product), consider operating the jet via a process-related solenoid valve, which opens only when air is required
    - Use manual or automatically operated valves to isolate air supply to individual machines or zones which are not in continuous use
    - Implement systems for systematic identification and repair of leaks
    - All condensate drain points should be trapped. Do not leave drain valves continuously 'cracked open'
    - Train workers never to direct compressed air against their bodies or clothing to dust or cool themselves down.

Distribution

- Monitor pressure losses in filters and replace as appropriate
- Use adequately sized distribution pipework designed to minimize pressure losses

Annex 1.1.1 – Air Emissions Estimation and Dispersion Modeling Methods

The following is a partial list of documents to aid in the estimation of air emissions from various processes and air dispersion models:

Australian Emission Estimation Technique Manuals
http://www.npi.gov.au/handbooks/

Atmospheric Emission Inventory Guidebook, UN / ECE / EMEP and the European Environment Agency
http://www.aeat.co.uk/netcen/airqual/TFEI/unece.htm

Emission factors and emission estimation methods, US EPA Office of Air Quality Planning & Standards
http://www.epa.gov/ttn/chief

Guidelines on Air Quality Models (Revised), US Environmental Protection Agency (EPA), 2005
http://www.epa.gov/scram001/guidance/guide/appw_05.pdf

Frequently Asked Questions, Air Quality Modeling and Assessment Unit (AQMAU), UK Environment Agency
http://www.environment-agency.gov.uk/subjects/airquality/236092/?version=1&lang=_e

OECD Database on Use and Release of Industrial Chemicals
http://www.olis.oecd.org/ehs/urchem.nsf/

Annex 1.1.2 - Good Engineering Practice (GEP) Stack Height

(Based on United States 40 CFR, part 51.100 (ii)).

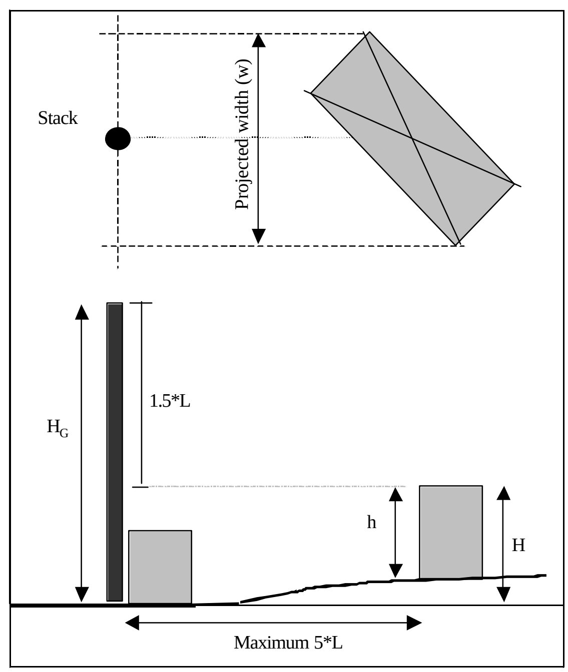
$H_G = H + 1.5L$; where

H_G = GEP stack height measured from the ground level elevation at the base of the stack

H = Height of nearby structure(s) above the base of the stack.

L = Lesser dimension, height (h) or width (w), of nearby structures

"Nearby structures" = Structures within/touching a radius of 5L but less than 800 m.



1.2 Wastewater and Ambient Water Quality

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Applicability and Approach

This guideline applies to projects that have either direct or indirect discharge of wastewater or stormwater to the environment. It provides information on common techniques for wastewater management, water conservation, and reuse that can be applied to a wide range of industry sectors. This guideline is meant to be complemented by the industry-specific effluent guidelines presented in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines. Projects with the potential to generate industrial process wastewater, sanitary (domestic) sewage, or stormwater should incorporate the necessary precautions to avoid, minimize, and control adverse impacts to human health, safety, or the environment.

As an overall strategy for managing different types of wastewater streams, facilities should:

- Understand the quality, quantity, and source locations of liquid effluents in its installations. This includes knowledge about the locations and routes of internal drainage systems and discharge points
- Plan and implement the segregation of liquid effluents principally along industrial, sanitary, and stormwater categories, in order to limit the volume of water requiring specialized treatment

Additionally, the generation and discharge of wastewater of any type should be managed through a combination of:

- Water use efficiency to reduce the amount of wastewater generation
- Process modification, including waste minimization, and reducing the use of hazardous materials to reduce the load of pollutants requiring treatment
- If needed, application of wastewater treatment techniques to further reduce the load of contaminants prior to discharge, taking into consideration potential impacts of cross-media transfer of contaminants during treatment (e.g., from water to air or land)

When wastewater treatment is required prior to discharge, the level of treatment should be based on:

- Good International Industry Practice (GIIP) for the relevant industry sector
- Whether wastewater is being discharged to a sanitary sewer system, or to surface waters
- Intended use of the receiving water body (e.g. as a source of drinking water, recreation, irrigation, navigation, or other)
- Presence of sensitive receptors (e.g., endangered species) or habitats

- Assimilative capacity of the receiving water for the load of contaminant being discharged

General Liquid Effluent Quality

Discharge to Surface Water

Guidelines on the quality of process or stormwater effluents discharged to surface waters are provided in the relevant IFC Industry Sector Guidelines. Projects for which there are no industry-specific guidelines should reference the effluent quality guidelines of an industry sector with suitably analogous processes and effluents. In addition, discharges to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria or, in the absence of local criteria, other sources of ambient water quality.[18] Receiving water use[19] and assimilative capacity[20], taking other sources of discharges to the receiving water into consideration, should also influence the acceptable pollution loadings and effluent discharge quality.

Discharge to Sanitary Sewer Systems

Discharges of industrial wastewater or stormwater into public or private wastewater treatment systems should:

- Meet the effluent quality and monitoring requirements of the sewer treatment system into which it discharges.
- Not interfere, directly or indirectly, with the operation and maintenance of the collection and treatment systems, or pose a risk to worker health and safety.
- Be discharged into wastewater treatment system that has adequate capacity to meet local regulatory requirements for the treatment of wastewater generated from the project.

Land Application of Treated Effluent

The quality of treated industrial wastewater or stormwater discharged on land, including wetlands, should be established based on local regulatory requirements or, in their absence, on a case-specific assessment of potential impact on soil, groundwater, and surface water. Where the ultimate receptor is surface water, water quality guidelines for surface water discharges specific to the industry sector process should apply. The quality of discharges to groundwater should be established based on the potential or actual use of groundwater resources.[21]

Discharge to Septic Systems

Septic systems use a combination of anaerobic treatment and soil absorption, and are designed to remove suspended solids, bacteria, and nutrients. Therefore, septic systems should only be used for disposal and treatment of sanitary sewage. When septic systems are the selected form of wastewater disposal and treatment, they should be:

- Properly designed and installed in accordance with local regulations and guidance to prevent any hazard to public health or contamination of surface or groundwater at the point of use.
- Installed in areas with sufficient soil percolation for the design wastewater loading rate.
- Installed in areas of stable soils that are nearly level, well drained, and permeable, with enough separation between the

[18] An example is the US EPA National Recommended Water Quality Criteria http://www.epa.gov/waterscience/criteria/wqcriteria.html

[19] Examples of receiving water uses as may be designated by local authorities include: drinking water (with some level of treatment), recreation, aquaculture, irrigation, general aquatic life, ornamental, and navigation.

[20] Assimilative capacity may vary depending on the volume, salinity, and flow/flushing rate of the receiving waters. More localized factors include the morphology of receiving water body at the effluent discharge point, time in the annual hydrologic cycle, and temperature gradients of the water column.

[21] Based on whether groundwater resources are or have the potential to produce water of a quality and quantity for drinking, irrigation, or other community uses.

drain field and the groundwater table or other receiving waters.

Wastewater Management

Wastewater discharges to ambient waters may require different levels of on-site treatment to meet the ambient quality objectives described above. The levels of wastewater treatment typically applied to sanitary, and some industrial wastewater streams directly discharged to ambient waters, are summarized below.

Industrial Wastewater Treatment

Industrial wastewater generated from industrial operations includes process wastewater, non-contact cooling water, runoff from process and materials staging areas, and miscellaneous activities. The major impacts of industrial wastewater result from the presence of oxygen depleting substances (e.g., Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD)), suspended solids, excess nutrients, synthetics and organics (e.g., phenols), and heavy metals (e.g., copper, lead, zinc, and chromium), as well as from the thermal characteristics of the discharge (e.g., elevated temperature). Transfer of pollutant to another phase, such as air, soil, or the sub-surface, should be avoided.

Technologies typically used in the treatment of industrial wastewater, and level of expected performance, are summarized in Table 1.2.1. While the choice of treatment technology is driven by wastewater characteristics, performance of the selected technology is largely dependent on process design, equipment selection, and proper operation and maintenance of the facilities. One or more treatment technologies may be used to achieve the desired effluent quality and maintain consistent compliance with regulatory requirements.

Stormwater Management

Stormwater includes any surface runoff and flows resulting from drainage. Typically stormwater runoff contains suspended sediments, metals, hydrocarbons, Polycyclic Aromatic Hydrocarbons (PAHs), coliform, etc. Rapid runoff, even of uncontaminated stormwater, also degrades the quality of the receiving water by eroding stream beds and banks. In order to reduce the need for stormwater treatment, the following principles should be applied:

- Stormwater should be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge
- Surface runoff from process areas or potential sources of contamination should be prevented
- Where this approach is not practical, runoff from process and storage areas should be segregated from potentially less contaminated runoff
- Runoff from areas without potential sources of contamination should be minimized (e.g. by minimizing the area of impermeable surfaces) and the peak discharge rate should be reduced (e.g. by using vegetated swales and retention ponds)
- Where stormwater treatment is deemed necessary to protect the quality of receiving water bodies, priority should be given to managing and treating the first flush of stormwater runoff where the majority of potential contaminants tend to be present
- When water quality criteria allow, stormwater should be managed as a resource, either for groundwater recharge or for meeting water needs at the facility

Table 1.2.2 – Examples of Industrial Wastewater Treatment Approaches		
Pollutant/Parameter	**Control Options**	
	Principle	**Common End of Pipe Control Technology**
pH	Chemical, Equlaization	Acid/Base addition, Flow equalization
Oil and Grease / TPH	Phase separation	Dissolved Air Floatation, oil water separator
TSS - Settleable	Settling, Size Exclusion	Sedimentation basin, clarifier, centrifuge, screens
TSS - Non-Settleable	Floatation, Filtration - traditional and tangential	Dissolved air floatation, Multimedia filter, sand filter, fabric filter, ultrafiltration, microfiltration
Hi - BOD (>0.2 Kg/m^3)	Biological - Anaerobic	Suspended growth, attached growth, hybrid
Lo - BOD (<0.2 Kg/m^3)	Biological - Aerobic, Facultative	Suspended growth, attached growth, hybrid
COD - Non-Biodegradable	Oxidation, Adsorption, Size Exclusion	Chemical oxidation, Thermal oxidation, Activated Carbon, Membranes
Metals - Particulate and Soluble	Coagulation, flocculation, precipitation, size exclusion	Flash mix with settling, filtration - traditional and tangential
Inorganics / Non-metals	Coagulation, flocculation, precipitation, size exclusion, Oxidation, Adsorption	Flash mix with settling, filtration - traditional and tangential, Chemical oxidation, Thermal oxidation, Activated Carbon, Membranes, Evaporation
Organics - VOCs and SVOCs	Biological - Aerobic, Anaerobic, Facultative; Adsorption, Oxidation	Biological : Suspended growth, attached growth, hybrid; Chemical oxidation, Thermal oxidation, Activated Carbon
Nutrients	Biological Nutrient Removal, Chemical, Physical, Adsorption	Aerobic/Anoxic biological treatment, air stripping, chlorination, ion exchange
Color	Biological - Aerobic, Anaerobic, Facultative; Adsorption, Oxidation	Biological Aerobic, Chemical oxidation, Activated Carbon
Temperature	Cooling	Surface Aerators, Flow Equalization
TDS	Concentration, Size Exclusion	Evaporation, crystallization, Reverse Osmosis
Active Ingredients/Emerging Contaminants	Adsorption, Oxidation, Size Exclusion, Concentration	Chemical oxidation, Thermal oxidation, Activated Carbon, Ion Exchange, Reverse Osmosis, Evaporation, Crystallization
Radionuclides	Adsorption,Size Exclusion, Concentration	Ion Exchange, Reverse Osmosis, Evaporation, Crystallization
Pathogens	Disinfection, Sterilization	Chlorine, Ozone, Peroxide, UV, Thermal
Whole Effluent Toxicity	Adsorption, Oxidation, Size Exclusion, Concentration	Chemical oxidation, Thermal oxidation, Activated Carbon, Evaporation, crystallization, Reverse Osmosis

Water Conservation

Project sponsors should implement water management programs, commensurate with the magnitude and cost of water use. Program objectives should promote a continuous reduction in water consumption, both through management control of ongoing operations, and identification and implementation of water-saving projects. When municipal water is used, conservation projects are often highly cost-effective. If river or groundwater is used, water conservation projects reduce the cost of water treatment and pumping, and in many cases heat energy is also saved when water use is reduced. Reduced water use also reduces the physical volume of water treatment systems and can reduce water disposal costs. The true value of saving water is often much more than the volumetric cost of water abstraction, and should be evaluated carefully.

Examples of successful water conservation measures are outlined below, including general water monitoring and management techniques and guidance on water saving methods that have been applied successfully in industrial processes, utility systems, and commercial applications.

Water Monitoring and Management

Water use should be managed using the same techniques as described in Section 1.1: Energy Management. The essential elements of a water management program are:

- Identification and regular measurement and reporting of principal flows within a facility
- Definition and regular review of performance targets, adjusted to account for changes in major influencing factors on water use, most likely to be production quantity
- Regular comparison and reporting of water flows with performance targets to identify where action should be taken to reduce use
- Regular review of targets, which may include comparison with benchmark data to confirm that they are set at appropriate levels

Metering data will identify areas of greatest water use, and since water savings often come about through system adjustment, metering and monitoring routines should be established to ensure that savings made through system adjustment are not lost with time. Data should be reviewed for completeness. For example, large 'unaccounted' use could indicate leaks, which are common in many facilities.

Process Water Reuse and Recycling

Opportunities for water savings in industrial processes are highly industry-specific. However, the following techniques have all been used successfully, and should be considered in conjunction with the development of the metering system described above.

- *Washing Machines:* Many washing machines use large quantities of hot water. Use can increase as nozzles become enlarged due to repeated cleaning and /or wear. Monitor machine water use, compare with specification, and replace nozzles when water and heat use reaches levels warranting such work.

- *Water reuse:* Common water reuse applications include countercurrent rinsing, for example in multi-stage washing and rinsing processes, or reusing waste water from one process for another with less exacting water requirements. For example, using bleaching rinse water for textile washing, or bottle-washer rinse water for bottle crate washing, or even washing the floor. More sophisticated reuse projects requiring treatment of water before reuse are also sometimes practical.

- *Water jets/sprays:* If processes use water jets or sprays (e.g. to keep conveyors clean or to cool product) review the accuracy of the spray pattern to prevent unnecessary water loss.
- *Flow control optimization:* Industrial processes sometimes require the use of tanks, which are refilled to control losses. It is often possible to reduce the rate of water supply to such tanks, and sometimes to reduce tank levels to reduce spillage. If the process uses water cooling sprays, it may be possible to reduce flow while maintaining cooling performance. Testing can determine the optimum balance.
    - o If hoses are used in cleaning, use flow controls to restrict wasteful water flow
    - o Consider the use of high pressure, low volume cleaning systems rather than using large volumes of water sprayed from hosepipes
    - o Using flow timers and limit switches to control water use
    - o Using 'clean-up' practices rather than hosing down

Building Facility Operations

Consumption of building and sanitary water is typically less than that used in industrial processes. However, savings can readily be identified, as outlined below:

- Compare daily water use per employee to existing benchmarks taking into consideration the primary use at the facility, whether sanitary or including other activities such as showering or catering
- Regularly maintain plumbing, and identify and repair leaks
- Shut off water to unused areas
- Install self-closing taps, automatic shut-off valves, spray nozzles, pressure reducing valves, and water conserving fixtures (e.g. low flow shower heads, faucets, toilets, urinals; and spring loaded or sensored faucets)
- Operate dishwashers and laundries on full loads, and only when needed
- Install water-saving equipment in lavatories, such as low-flow toilets

Cooling Systems

Water conservation opportunities in cooling systems include:

- Use of closed circuit cooling systems with cooling towers rather than once-through cooling systems
- Limiting condenser or cooling tower blowdown to the minimum required to prevent unacceptable accumulation of dissolved solids
- Use of air cooling rather than evaporative cooling, although this may increase electricity use in the cooling system
- Use of treated waste water for cooling towers
- Reusing/recycling cooling tower blowdown

Heating Systems

Heating systems based on the circulation of low or medium pressure hot water (which do not consume water) should be closed. If they do consume water, regular maintenance should be conducted to check for leaks. However, large quantities of water may be used by steam systems, and this can be reduced by the following measures:

- Repair of steam and condensate leaks, and repair of all failed steam traps
- Return of condensate to the boilerhouse, and use of heat exchangers (with condensate return) rather than direct steam injection where process permits
- Flash steam recovery

- Minimizing boiler blowdown consistent with maintaining acceptably low dissolved solids in boiler water. Use of reverse osmosis boiler feed water treatment substantially reduces the need for boiler blowdown
- Minimizing deaerator heating

Monitoring

Wastewater and water quality management should include a monitoring program to provide information on an appropriate management strategy, as well as the proper operation and effectiveness of selected management techniques. With this objective, a wastewater and water quality monitoring program should be developed taking into account the following factors:

- *Indicator parameters*: The monitoring parameters selected should be indicative of the pollutants of concern considered to be associated with the project processes.
- *Monitoring type and frequency*: Data on wastewater quality generated through the monitoring program should be representative of the effluents discharged by the project over time. Examples of time-dependent variations in the manufacturing process include batch process manufacturing and seasonal process variations. Effluents from highly variable processes may need to be sampled more frequently or through composite methods. Effluent monitoring frequency may be daily-to-weekly to compute mass loadings discharge, and to assure safe effluent discharge to surface water. Grab samples or, if automated equipment permits, composite samples may offer more insight on average quality over a 24-hour period. Composite samplers may not be appropriate where analytes of concern are short lived (e.g., quickly degraded or volatile).
- *Monitoring locations*: The monitoring location should be selected with the objective of providing representative monitoring data. Effluent sampling stations may be located at final discharge, as well as at strategic upstream points prior to merging of different effluents. Process effluents should not be diluted prior or after treatment with the objective of avoiding necessary treatment, or for the purpose of defeating the objective of the monitoring program.

Data quality: Monitoring programs should apply internationally approved methods for sample collection and analysis. Sampling should be conducted by, or under, the supervision of trained individuals. Analysis should be conducted by entities permitted or certified for this purpose. Sampling and analysis Quality Assurance/Quality Control (QA/QC) plans should be applied and documented to ensure that data quality is adequate for the intended data use (e.g., method detection limits are below levels of concern). QA/QC documentation should be included in monitoring reports. 1.3 Hazardous Materials and Oil Management

1.3 Hazardous Materials and Oil Management

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Applicability and Approach

These guidelines apply to projects that use, store, or handle any quantity of hazardous materials (Hazmats), defined as materials that represent a risk to human health, safety, or the environment due to their physical or chemical characteristics. Materials (including mixtures and solutions) subject to these guidelines can be classified according to the hazard they present including: explosives; compressed gases, including toxic or flammable gases; flammable liquids; flammable solids; oxidizing substances; toxic and infectious substances; radioactive material; corrosive substances; and miscellaneous dangerous materials.

When a hazardous material is no longer usable for its original purpose and is intended for disposal, but still has hazardous properties, it is considered a *hazardous waste*.

This guidance is intended to be applied in conjunction with traditional occupational health and safety and emergency preparedness programs which are included in Section 2.0 on Occupational Health and Safety Management, and Section 3.7 on Emergency Preparedness and Response. Guidance on the Transport of Hazardous Materials is provided in Section 3.5.

This section is divided into two main subsections:

General Hazardous Materials Management: Guidance applicable to all projects or facilities that handle or store any quantity of hazardous materials.

Management of Major Hazards: Additional guidance for projects or facilities that store or handle hazardous materials at, or above, threshold quantities, and thus require special treatment to prevent accidents such as fire, explosions, leaks or spills, and to prepare and respond to emergencies.

The overall objective of hazardous materials management is the responsible manufacture, handling, and use of such materials that avoids releases and accidents to protect human health and the environment. The general approach to achieve this objective should consistently include the following steps:

- Establish hazardous materials management priorities based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts. This can be achieved through a hazard assessment or risk screening process which evaluates potential hazards

- Where practicable, avoid or minimize the use of hazardous materials
- Where hazardous materials are manufactured, handled, or used, implement measures to:
  - o Prevent uncontrolled releases to the environment or uncontrolled reactions such as fire and explosions
  - o Respond and control non-routine and emergency situations
- Apply engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of the hazard
- Apply management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures

General Hazardous Materials Management

A main objective of projects involving hazardous materials should be the prevention and control of releases and accidents. This should be addressed by integrating prevention and control measures, management actions, and procedures into day-to-day business activities. Application of these management systems should be documented in a written *Hazardous Materials Management Plan* that includes the following elements.

Hazard Assessment

Projects which manufacture, handle, use, or store hazardous materials should establish management programs that are commensurate with the potential risks present. The level of risk should be established through an on-going assessment process based on:

- The types and amounts of hazardous materials present in the project. This information should be recorded and should include a summary table with the following information:
  - o Substance name and description
  - o Substance code, class or division
  - o Regulatory threshold quantity or national equivalent[22]
  - o Quantity used per month
  - o Characteristics which makes it hazardous (e.g. flammability, toxicity)
  - o Hazard level (low to high)
- Analysis of potential spills and releases, including assessment of potential for uncontrolled reactions such as fire and explosions
- Analysis of potential consequences based on the physical-geographical characteristics of the project site, including aspects such as its distance to populated areas, and to water resources and other environmentally sensitive areas
- Review of available industry statistics on spills and accidents

This analysis should be performed by specialized professionals and based on formal, internationally accepted methodologies, such as Hazardous Operations Analysis (HAZOP), Failure Mode and Effects Analysis (FMEA), and Hazard Identification (HAZID).

Management Actions

The Hazardous Materials Management Plan should include the necessary management actions to complement prevention and control measures as described below.

[22] Threshold quantities should be those established for emergency planning purposes such as provided in the US Environmental Protection Agency. *Protection of Environment* (Title 40 CFR Parts 300-399 and 700 to 789).

Release Prevention and Control Planning

Where there is a risk of uncontrolled releases of hazardous materials, facilities should prepare a spill control plan as a specific component of their Emergency Preparedness and Response plan (described in more detail in Section 3.7). The plan should be tailored to the hazards associated with the project, and include:

- Training of operators on release prevention, including drills specific to hazardous materials as part of emergency preparedness response training
- Implementation of inspection programs to maintain the mechanical integrity and operability of pressure vessels, tanks, piping systems, relief and vent valve systems, containment infrastructure, emergency shutdown systems, controls and pumps, and associated process equipment
- Monitoring procedures for filling and transfer operations by personnel trained in the safe transfer and filling of the hazardous material, and in spill prevention and response
- Written methods and procedures for the management of secondary containment structures, specifically the removal of any accumulated fluid, such as rainfall, to ensure that the intent of the system is not accidentally or willfully defeated
- Identifying locations of hazardous materials and associated activities on an emergency plan site map
- Documentation of availability of specific personal protective equipment and training needed to respond to the emergency
- Documentation of availability of spill response equipment sufficient to handle at least initial stages of a spill and a list of external resources for equipment and personnel, if necessary, to supplement internal resources
- Description of response activities in the event of a spill, release, or other chemical emergency including:
    - Internal and external notification procedures
    - Specific responsibilities of individuals or groups
    - Decision process for assessing severity of the release, and determining appropriate actions
    - Facility evacuation routes
    - Post-event activities such as clean-up and disposal, incident investigation, employee re-entry, and restoration of spill response equipment.

Occupational Health and Safety

The Hazardous Materials Management Plan should address applicable, essential elements of occupational health and safety management as described in Section 2.0 on Occupational Health and Safety, including:

- Job safety analysis to identify specific potential occupational hazards and industrial hygiene surveys, as appropriate, to monitor and verify chemical exposure levels, and compare with applicable occupational exposure standards[23]
- Hazard communication and training programs to prepare workers to recognize and respond to workplace chemical hazards. Programs should include aspects of hazard identification, safe operating and materials handling procedures, safe work practices, basic emergency procedures, and special hazards unique to their jobs. Training should incorporate information from Material Safety Data Sheets[24] (MSDSs) for hazardous materials being handled. MSDSs should be readily accessible to employees in their local language.

[23] Including: Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®), American Conference of Governmental Industrial Hygienists (ACGIH), http://www.acgih.org/TLV/; U.S. National Institute for Occupational Health and Safety (NIOSH), http://www.cdc.gov/niosh/npg/; Permissible Exposure Limits (PELs), U.S. Occupational Safety and Health Administration (OSHA), http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992; Indicative Occupational Exposure Limit Values, European Union, http://europe.osha.eu.int/good_practice/risks/ds/oel/; and other similar sources.

[24] MSDSs are produced by the manufacturer, but might not be prepared for chemical intermediates that are not distributed in commerce. In these cases, employers still need to provide workers with equivalent information.

- Definition and implementation of permitted maintenance activities, such as hot work or confined space entries
- Provision of suitable personal protection equipment (PPE) (footwear, masks, protective clothing and goggles in appropriate areas), emergency eyewash and shower stations, ventilation systems, and sanitary facilities
- Monitoring and record-keeping activities, including audit procedures designed to verify and record the effectiveness of prevention and control of exposure to occupational hazards, and maintaining accident and incident investigation reports on file for a period of at least five years

Process Knowledge and Documentation

The Hazardous Materials Management Plan should include a prevention plan covering:

- Written process safety parameters (i.e., hazards of the chemical substances, safety equipment specifications, safe operation ranges for temperature, pressure, and other applicable parameters, evaluation of the consequences of deviations, etc.)
- Written operating procedures
- Compliance audit procedures

Preventive Measures

Hazardous Materials Transfer and Use

Uncontrolled releases of hazardous materials may occur from small cumulative events, or more significant equipment failure associated with manual or mechanical transfer between storage systems or process equipment. Recommended practices to prevent hazardous materials releases include:

- Use of transfer equipment that is compatible and suitable for the characteristics of the materials transferred and designed to ensure safe transfer
- Use of dedicated fittings, pipes, and hoses specific to materials in tanks (e.g., all acids use one type of connection, all caustics use another), and maintaining procedures to prevent addition of hazardous materials to incorrect tanks
- Provision of drip trays or other overflow and drip containment measures, for hazardous materials containers at connection points or other possible overflow points.

Overfill Protection

Overfills of any volume should be prevented as they are among the most common causes of soil and groundwater contamination, and among the easiest to prevent. Recommended overfill protection measures include:

- Use of dripless hose connections for vehicle tank and fixed connections with storage tanks
- Provision of automatic fill shutoff valves on storage tanks to prevent overfilling
- Use of a catch basin around the fill pipe
- Use of piping connections with automatic overfill protection (float valve)
- Pumping less volume than available capacity into the tank or vessel by ordering less material than its available capacity
- Provision of overfill or over pressure vents that allow controlled release to a capture point

Reaction, Fire, and Explosion Prevention

Reactive, flammable, and explosive materials should also be managed to avoid uncontrolled reactions or conditions. Recommended practices to prevent fires and explosions include:

- Storage of incompatible materials (acids, bases, flammables, oxidizers, reactive chemicals) in separate areas, and with containment facilities separating material storage areas
- Provision of material-specific storage for extremely hazardous or reactive materials

- Use of flame arresting devices on vents from flammable storage containers
- Provision of grounding and lightning protection for tank farms, transfer stations, and other equipment that handles flammable materials
- Selection of materials compatible with products stored for all parts of storage and delivery systems, and avoiding reuse of tanks for different products without checking material compatibility
- Storage of hazardous materials in an area of the facility separated from the main production works. Where proximity is unavoidable, physical separation should be provided using structures designed to prevent fire, explosion, spill, and other emergency situations from affecting facility operations
- Prohibition of all sources of ignition from areas near flammable storage tanks

Control Measures

Secondary Containment (Liquids)

A critical aspect for controlling accidental releases of liquid hazardous materials during storage and transfer is the provision of secondary containment. It is not necessary for secondary containment methods to meet long term material compatibility as with primary storage and piping, but their design and construction should hold released materials effectively until they can be detected and safely recovered. Appropriate measures include:

- Use of impervious, chemically resistant material;
- Berms, dikes, or walls capable of containing the larger of 110 percent of the largest tank or 25% percent of the combined tank volumes in areas with above-ground tanks with a total storage volume equal or greater than 1,000 liters
- Means for preventing contact between incompatible materials

Other secondary containment measures that should be applied depending on site-specific conditions include:

- Transfer of hazardous materials from vehicle tanks to storage in areas with impervious surfaces sloped to a collection or a containment structure
- Where it is not practical to provide permanent, dedicated containment structures for transfer operations, one or more alternative forms of spill containment should be provided, such as portable drain covers (which can be deployed for the duration of the operations), automatic shut-off valves on storm water basins, or shut off valves in drainage or sewer facilities, combined with oil-water separators
- Storage of drummed hazardous materials with a total volume equal or greater than 1,000 liters in areas with impervious surfaces that are sloped or bermed to contain a minimum of 25 percent of the total storage volume
- Provision of secondary containment for components (tanks, pipes) of the hazardous material storage system, to the extent feasible
- Conducting periodic (e.g. daily or weekly) reconciliation of tank contents, and inspection of visible portions of tanks and piping for leaks;
- Use of double-walled storage and piping systems with a means of detecting leaks between the two walls, particularly in the use of underground storage tanks (USTs) and underground piping

Storage Tank and Piping Leak Detection

Leak detection may be used in conjunction with secondary containment, particularly in high-risk locations[25]. Leak detection is especially important in situations where secondary containment is

[25] High-risk locations are places where the release of product from the storage system could result in the contamination of drinking water source or those located in water resource protection areas as designated by local authorities.

not feasible or practicable, such as in long pipe runs. Acceptable leak detection methods include:

- Use of automatic pressure loss detectors on pressurized or long distance piping
- Use of approved or certified integrity testing methods on piping or tank systems, at regular intervals

Underground Storage Tanks (USTs)

Although there are many environmental and safety advantages of underground storage of hazardous materials, including reduced risk of fire or explosion, and lower vapor losses into the atmosphere, leaks of hazardous materials can go undetected for long periods of time with potential for soil and groundwater contamination. Techniques to manage these risks include:

- Avoiding use of USTs for storage of highly soluble organic materials, where feasible
- Assessing local soil corrosion potential, and installing and maintaining cathodic protection (or equivalent rust protection) for steel tanks, where appropriate
- For new installations, installing impermeable liners or structures (e.g., concrete vaults) under and around tanks and lines that direct any leaked product to monitoring ports at the lowest point of the liner or structure
- Monitoring the surface above any tank for indications of soil movement
- Reconciling tank contents by measuring the volume in store with the expected volume, given the stored quantity at last stocking, and deliveries to and withdrawals from the store
- Testing integrity by volumetric, vacuum, acoustic, tracers, or other means on all tanks at regular intervals[26]
- Monitoring groundwater quality down gradient of locations where multiple USTs are in use

Management of Major Hazards

In addition to the application of the above-referenced guidance on prevention and control of releases of hazardous materials, projects involving production, handling, and storage of hazardous materials *at or above threshold limits*[27] should prepare a Hazardous Materials Risk Management Plan containing all of the elements presented below.[28] The objective of this guidance is the prevention and control of catastrophic releases of toxic, reactive, flammable, or explosive chemicals which may result in toxic, fire, or explosion hazards.[29]

Management Actions

- *Management of Change:* These procedures should address:
  - The technical basis for changes in processes and operations
  - The impact of changes on health and safety
  - Modification to operating procedures
  - Authorization requirements
  - Employees affected
  - Training needs
- *Compliance Audit*: A compliance audit is a way to evaluate compliance with the prevention program requirements for each process. A compliance audit covering each element of

[26] Recommended for tanks with a capacity equal or greater than 1,000 liters at a frequency of once every three years.

[27] Threshold quantities should be those established for emergency planning purposes such as provided in the US Environmental Protection Agency. *Protection of Environment* (Title 40 CFR Parts 300-399 and 700 to 789).

[28] For further information and guidance, please refer to International Finance Corporation (IFC) Hazardous Materials Risk Management Manual. Washington, D.C. December 2000.

[29] The approach to the management of major hazards is largely based on an approach to Process Safety Management developed by the American Institute of Chemical Engineers.

the prevention measures (see below) should be conducted at least every three years and should include:

- Preparation of a report of the findings
- Determination and documentation of the appropriate response to each finding
- Documentation that any deficiency has been corrected

- *Incident Investigation:* Incidents can provide valuable information about site hazards and the steps needed to prevent accidental releases. Incident investigation procedures should require:
  - Initiation of the investigation promptly
  - Summarizing the investigation in a report
  - Addressing the report findings and recommendations
  - A review of the report with staff and contractors
- *Employee Participation:* A written plan of action should describe an active employee participation program for the prevention of accidents.
- *Contractors:* Procedures should require that contractors are:
  - Provided with safety performance procedures and safety and hazard information
  - Observe safety practices
  - Act responsibly
  - Have access to appropriate training for their employees
  - Ensure that their employees know process hazards and applicable emergency actions
  - Prepare and submit training records for their employees
  - Inform their employees about the hazards presented by their work
  - Assess trends of repeated similar incidents
  - Develop and implement procedures to manage repeated similar incidents
- *Training*: Good training programs on operating procedures should provide employees with the information needed to understand how to operate safely and why safe operations are needed. A training program should include:
  - A list of employees to be trained
  - Specific training objectives
  - Mechanisms to achieve the objectives (i.e., hands-on workshops, videos, etc.)
  - The means to determine whether the training program is effective
  - Training procedures for new hires and refresher courses for existing employees

Preventive Measures

The purpose of preventive measures is to ensure that safety-related aspects of the process and equipment are considered, limits to be placed on the operations are well known, and accepted standards and codes are adopted, where they apply.

- *Process Safety Information:* Procedures should be prepared for each hazardous materials that include:
  - Compilation of Material Safety Data Sheets (MSDS)
  - Identification of maximum intended inventories and safe upper/lower parameters
  - Documentation of equipment specifications and of codes and standards used to design, build and operate the process
- *Operating Procedures:* Procedures should be prepared for the use of hazardous materials during each operation phase including initial startup, normal operations, temporary operations, emergency shutdown, emergency operations, normal shutdown, and start-up following a normal or emergency shutdown or major change.

Other procedures to be developed include impacts of deviations, steps to avoid deviations, prevention of chemical exposure, exposure control measures, and equipment inspections.

- *Mechanical Integrity:* Procedures should be prepared to maintain the mechanical integrity of process equipment. The procedures should be developed for pressure vessels and storage tanks, piping systems, relief and vent systems and devices, emergency shutdown systems, controls, and pumps. This requirement includes:
  - Developing written procedures
  - Conducting training
  - Developing inspection and testing procedures
  - Identifying and correcting equipment deficiencies
  - Establishing a quality assurance plan for equipment, maintenance materials, and spare parts
- *Hot Work Permit:* Procedures should be prepared to cover the issuance of a hot work permit, identifying the object on which the hot work will be conducted, and implementing the necessary preventive measures.
- *Pre-Start Review:* Procedures should be prepared to carry out pre-start reviews when a modification is significant enough to require a change in safety information under the management of change procedure. The procedures should:
  - Confirm that the new or modified construction and/or equipment meet design specifications
  - Ensure that procedures for safety, operation, maintenance, and emergency are adequate
  - Include a process hazard assessment, and resolve or implement recommendations for new process
  - Ensure that training for all affected employees is being conducted

Emergency Preparedness and Response

When handling hazardous materials, procedures and practices should be developed allowing for quick and efficient responses to accidents that could result in human injury or damage to the environment. An Emergency Preparedness and Response Plan should be prepared to cover the following:

- *Planning Coordination:* Procedures should be prepared for:
  - Informing the public and emergency response agencies
  - Documenting first aid and emergency medical treatment
  - Taking emergency response actions
  - Reviewing and updating the emergency response plan to reflect changes, and ensuring that employees are informed of such changes
- *Emergency Equipment:* Procedures should be prepared for using, inspecting, testing, and maintaining the emergency response equipment.
- *Training:* Employees and relevant parties should be trained on appropriate procedures.

Community Involvement and Awareness

When hazardous materials are in use above threshold quantities, the management plan should include a system for community involvement and awareness commensurate with the potential risks of the project, as identified in the hazard assessment. This should include an assessment of worst-case scenarios that informs the potentially affected community and provides a means for public feedback. Community involvement activities should include:

- Availability of general information to the potentially affected community on the nature, extent, and potential off-site effects to human health or the environment, including property, and possible major accidents at planned or existing hazardous installations (e.g. in writing or through meetings)

- Specific and timely information on appropriate behavior and safety measures to be adopted, disseminated both as a routine practice and in the event of an accident
- Access to other information necessary to understand the nature of the possible effect of an accident and an opportunity to contribute effectively, as appropriate, to decisions concerning hazardous installations and the development of community emergency preparedness plans.
- Record keeping of complaints and responses.

1.4 Solid and Hazardous Waste Management

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Applicability and Approach

These guidelines apply to projects which generate, store, or handle any quantity of waste across a range of industry sectors. It is not intended to apply to projects or facilities where the main business is the collection, transportation, treatment, or disposal of wastes. Specific guidance for these types of facilities is presented in IFC's Environmental Health and Safety (EHS) Guidelines for Waste Management Facilities.

A *waste* is any solid, liquid, or contained gaseous material that is being discarded by disposal, recycling, burning or incineration. It can be byproduct of a manufacturing process or an obsolete commercial product that can no longer be used for intended purpose and requires disposal. Residuals directly recycled or reused at the place of generation generally are not considered a waste. Neither are the discharges of permitted effluents or emissions.

Solid (non-hazardous) wastes generally include any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility, and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial operations or community activities. Examples of such waste include domestic trash and garbage; inert construction / demolition materials; refuse, such as metal scrap and empty containers; and residual waste from industrial operations, such as boiler slag, clinker, and fly ash.

Hazardous waste shares the properties of a hazardous material (e.g. ignitability, corrosivity, reactivity, or toxicity), or other physical, chemical, or biological characteristics which may pose a potential risk to human health or the environment if improperly managed. Wastes may also be defined as "hazardous" by local regulations or international conventions, based on the origin of the waste and its inclusion in hazardous waste lists, or based in its characteristics.

The overall approach to waste management should consistently include the following steps:

- Establishing waste management priorities based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts
- Avoiding or minimizing the generation of hazardous and non-hazardous waste materials, as far as practicable
- Where waste generation cannot be avoided but has been minimized, recovering and reusing waste
- Where waste can not be recovered or reused, treating, destroying, and disposing of it in an environmentally sound manner

General Waste Management

The following guidance applies to the management of non-hazardous and hazardous waste. Additional guidance specifically applicable to hazardous wastes is presented below.

Waste Management Planning

Waste streams should be characterized according to their sources, types of wastes produced, generation rates and composition, or according to local regulatory requirements. Effective planning and implementation of waste management strategies should include:

- Review of new waste sources during planning, siting, and design activities, including during equipment modifications and process alterations, to identify expected waste generation, pollution prevention opportunities, and necessary treatment, storage, and disposal infrastructure
- Collection of data and information about the process and waste streams in existing facilities, including characterization of waste streams by type, quantities, and potential use/disposition
- Establishment of priorities based on a risk analysis that takes into account the potential EHS risks during the waste cycle and the availability of infrastructure to manage the waste in an environmentally sound manner
- Definition of opportunities for source reduction, as well as reuse and recycling
- Definition of procedures and operational controls for on-site storage
- Definition of options / procedures / operational controls for final disposal

Waste Prevention

Processes should be designed and operated to prevent, or minimize, the quantities and toxicities of wastes generated in accordance with the following strategy:

- Substituting raw materials or inputs with less hazardous or toxic materials, or with those where processing generates lower waste volumes
- Applying manufacturing process that convert materials efficiently, providing higher product output yields, including modification of design of the production process, operating conditions, and process controls[30]
- Instituting good housekeeping and operating practices, including inventory control to reduce the amount of waste resulting from materials that are out-of-date, off-specification, contaminated, damaged, or excess to plant needs
- Waste segregation to prevent the commingling of non-hazardous and hazardous waste, thus minimizing the volume of hazardous waste

Recycling and Reuse

In addition to the implementation of waste prevention strategies, the total amount of waste may be significantly reduced through the implementation of recycling plans, which should consider the following elements:

- Evaluation of waste production processes and identification of potentially recyclable materials
- Identification and recycling of products that can be reintroduced into the manufacturing process or industry activity at the site

[30] Examples of waste prevention strategies include the concept of Lean Manufacturing found at http://www.epa.gov/epaoswer/hazwaste/minimize/lean.htm

- Investigation of external markets for recycling by other industrial processing operations located in the neighborhood or region of the facility (e.g., waste exchange)
- Establishing recycling objectives and formal tracking of waste generation and recycling rates
- Providing training and incentives to employees in order to meet objectives

Treatment and Disposal

If waste materials are generated after the exploration and implementation of feasible waste reduction, reuse, and recycling measures, waste materials should be treated and disposed of avoiding or minimizing the impact to human health and the environment. Selected management approaches should be consistent with the characteristics of the waste and local regulations, and may include one or more of the following:

- On-site or off-site biological, chemical, or physical treatment of the waste material to render it non-hazardous prior to final disposal
- Treatment or disposal at permitted facilities specially designed to receive the waste. Examples include: composting operations for organic non-hazardous wastes; properly designed and operated landfills; permitted, controlled, incineration designed and operated for the respective type of waste; or other methods known to be effective in the safe, final disposal of waste materials.

Hazardous Waste Management

If generation of hazardous waste can not be prevented through the implementation of the above general waste management practices, its management should focus on the prevention of harm to health, safety, and the environment, according to the following additional principles:

- Understanding potential impacts and risks associated with the management of any generated hazardous waste during its complete life cycle
- Ensuring that contractors handling, treating, and disposing of hazardous waste are reputable and legitimate enterprises, licensed by the relevant regulatory agencies

Waste Storage

Hazardous waste should be stored so as to prevent or control accidental releases to soil and water resources in an area where:

- Waste is stored in a manner that prevents the commingling or contact between incompatible wastes, and allows for inspection between containers to monitor leaks or spills. Examples include sufficient space between incompatibles or physical separation such as walls or containment curbs.
- The base material, side walls, pits, trenches and sumps for secondary containment are sealed with materials appropriate for the contents of the containment area to prevent seepage.
- Secondary containment is included wherever wastes are stored in volumes greater than 220 liters. The available volume of secondary containment should be at least 110 percent of the largest storage container, or 25 percent of the total storage capacity (whichever is greater), in that specific area.

Hazardous waste storage activities should also be subject to special management actions, conducted by employees who have received specific training in handling and storage of hazardous wastes:

- Provision of readily available information on chemical compatibility to employees, including labeling each container to identify its contents
- Limiting access to hazardous waste storage areas to employees who have received proper training

- Clearly identifying and marking of the area, including documentation of its location on a facility map or site plan
- Conducting periodic inspections of waste storage areas and documenting the findings
- Preparing and implementing spill response and emergency plans to address their accidental release (additional information on Emergency Plans in provided in Section 3 of this document)
- Avoiding underground storage tanks and underground piping of hazardous waste

Transportation

On-site transportation of waste should be conducted so as to prevent or minimize spills, releases, and exposures to employees and the public. All waste containers designated for off-site shipment should be secured and labeled with the contents and associated hazards, and be properly loaded on the transport vehicles before leaving the site, consistent with the guidance on Hazardous Materials Management provided in Section 3. 4 on the Transport of Hazardous Materials.

Treatment and Disposal

The treatment and final disposal of hazardous wastes requires careful, expert evaluation of potential risks and impacts to workers, public health and safety, and the environment on a case-specific basis. In addition to the recommendations for treatment and disposal applicable to hazardous and non-hazardous wastes, the following issues specific to hazardous wastes should be considered:

Commercial or Government Waste Contractors

Project sponsors that use commercial or government-owned waste transportation, treatment, storage, disposal, and recycling facilities should ensure that these facilities:

- Have the technical capability to manage the waste in a manner that reduces immediate and future impact to the environment
- Have all required permits, certifications, and approvals, of applicable government authorities
- Have been secured through the use of formal procurement agreements

In the absence of qualified commercial or government-owned waste vendors (taking into consideration proximity and transportation requirements), project sponsors should consider using:

- Alternative processes that do not generate problem waste
- Installing on-site waste treatment or recycling processes
- As a final option, implementing long-term storage on-site until external commercial options become available

Small Quantities of Hazardous Waste

Projects may generate potentially hazardous materials in relatively small quantities, primarily from equipment and building maintenance activities that are not related to the main commercial activity. Examples of these types of wastes include: spent solvents and oily rags from mechanical maintenance activities; used lubricating oil; batteries (such as nickel-cadmium or lead acid); and lighting equipment, such as lamps or lamp ballasts, which may respectively contain limited quantities of mercury and Polychlorinated Biphenyls (PCBs).

These types of wastes should not be mixed and disposed of with general non-hazardous wastes. Their generation should be minimized, and their final treatment and disposal should follow the guidance provided in the above sections.

Monitoring

Monitoring activities associated with the management of hazardous and non-hazardous waste should include:

- Regular visual inspection of all waste storage collection and storage areas for evidence of accidental releases and to verify that wastes are properly labeled and stored. When significant quantities of hazardous wastes are generated and stored on site, monitoring activities should include:
    - Inspection of vessels for leaks, drips or other indications of loss
    - Identification of cracks, corrosion, or damage to tanks, protective equipment, or floors
    - Verification of locks, emergency valves, and other safety devices for easy operation (lubricating if required and employing the practice of keeping locks and safety equipment in standby position when the area is not occupied)
    - Checking the operability of emergency systems
    - Documenting results of testing for integrity, emissions, or monitoring stations (air, soil vapor, or groundwater)
    - Documenting any changes to the storage facility, and any significant changes in the quantity of materials in storage
- Regular audits of waste segregation and collection practices
- Tracking of waste generation trends by type and amount of waste generated, preferably by facility departments
- Characterizing waste at the beginning of generation of a new waste stream, and periodically documenting the characteristics and proper management of the waste, especially hazardous wastes
- Keeping manifests or other records which document the amount of waste generated and its destination
- Periodic auditing of third party transport, treatment, and disposal services when significant quantities of hazardous wastes are managed by third parties. Whenever possible, audits should include site visits to the treatment storage and disposal location
- Inspection of third party hazardous waste transport vehicles on a continuous basis at the time of waste collection
- Monitoring records for hazardous waste collected, stored, or shipped should include:
    - Name and identification number of the material(s) composing the hazardous waste
    - Physical state (i.e., solid, liquid, gaseous or a combination of one, or more, of these)
    - Quantity (e.g., kilograms or liters)
    - Method and date of storing, repacking, treating, or disposing at the facility, cross-referenced to specific manifest document numbers applicable to the hazardous waste
    - Location of each hazardous waste within the facility, and the quantity at each location

1.5 Noise

Applicability

This section addresses impacts of noise beyond the property boundary. Worker exposure to noise is covered in Section 2.0 on Occupational Health and Safety.

Prevention and Control

Noise prevention and mitigation measures should be applied where predicted or measured noise impacts from a project facility or operations exceed the applicable noise level guideline at the most sensitive point of reception.[31] The preferred method for controlling noise from stationary sources is to implement noise control measures at source.[32] Methods for prevention and control of sources of noise emissions depend on the source and proximity of receptors. Options include:

- Selecting equipment with lower sound power levels
- Installing silencers for fans
- Installing mufflers for engine exhausts
- Installing acoustic enclosures for equipment casing radiated noise
- Improving the acoustic performance of constructed buildings
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective
- Installing vibration isolation for mechanical equipment
- Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas
- Re-locating noise sources to less sensitive areas to take advantage of distance and shielding

Noise Level Guidelines

Noise impacts should not exceed the levels presented in Table 1.5.1, nor result in a maximum increase in background levels of 3 dB at the nearest receptor location.

Table 1.5.1- Noise Level Guidelines		
	One Hour L_{Aeq} (dBA)[33]	
Time of Day	Urban	Rural
0700 – 2200	55	50
2200 – 0700	45	40

Noise level limits for rural receptors have been reduced to account for reduced human activity in these areas. In general, the noise level limit is represented by the background or ambient noise levels that would be present in the absence of the facility or noise source(s) under investigation. Highly intrusive noises, such as noise from aircraft flyovers and passing trains, should not be included when establishing background noise levels.

31 A point of reception or receptor may be defined as any point on the premises occupied by persons where extraneous noise and/or vibration are received. Examples of receptor locations may include: permanent or seasonal residences; hotels / motels; schools and daycares; hospitals and nursing homes; places of worship; and parks and campgrounds.

32 At the design stage of a project, equipment manufacturers should provide design or construction specifications in the form of *"Insertion Loss Performance"* for silencers and mufflers, and *"Transmission Loss Performance"* for acoustic enclosures and upgraded building construction.

33 People hear high frequency noise much better than low frequency noise. Noise measurement readings can be adjusted to correspond to this peculiarity of human hearing. An A-weighting filter used on noise-monitoring equipment de-emphasizes low frequencies or pitches. Decibels measured using this filter are A-weighted and are called dB(A). A-weighted noise-monitoring equipment is most commonly used when conducting a community noise study.

For stationary noise sources, the sound level limit should be expressed as the one hour, A-weighted equivalent sound level (1-Hr L_{Aeq}) that results from road traffic or other activity in the vicinity of the receptor location.

Monitoring

Noise monitoring[34] may be carried out for the purposes of establishing the existing ambient noise levels in the area of the proposed or existing facility, or for verifying operational phase noise levels.

Noise monitoring programs should be designed and conducted by trained specialists. Typical monitoring periods may last 48 hours with the use of noise monitors that should be capable of logging data continuously over this time period, or hourly, or more frequently, as appropriate. The type of acoustic indices recorded depends on the type of noise being monitored, as established by a noise expert. Monitors should be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface (e.g., wall). In general, the noise level limit is represented by the background or ambient noise levels that would be present in the absence of the facility or noise source(s) under investigation.

[34] Noise monitoring should be carried out using a Type 1 or 2 sound level meter meeting all appropriate IEC standards.

1.6 Contaminated Land

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Applicability and Approach

This section provides a summary of management approaches for land contamination due to anthropogenic releases of hazardous materials, wastes, or oil, including naturally occurring substances. Releases of these materials may be the result of historic or current site activities, including, but not limited to, accidents during their handling and storage, or due to their poor management or disposal.

Land is considered contaminated when it contains hazardous materials or oil concentrations above background or naturally occurring levels.

Contaminated lands may involve surficial soils or subsurface soils, which, through leaching and transport, may affect groundwater, surface water, and adjacent sites. Where subsurface contaminant sources include volatile substances, soil vapor may also become a transport and exposure medium, and create potential for contaminant infiltration of indoor air spaces of buildings.

Contaminated land is a concern due to:

- The potential for human and ecological health risk it may pose, for example, risk of cancer or other human health effects, ecological risks of mortality, or impairment of growth and reproduction, and associated resource loss.
- The business liability that it may pose to the polluter, investors (e.g., remedial cost, business reputation, regulatory compliance), or affected parties (e.g., affected local property owners).

Minimizing or avoiding release of hazardous materials or oil to prevent contamination of land should be a main objective. When land contamination is suspected or confirmed during any project phase, the cause of the release should be identified and corrected if it is on-going to avoid further releases and potential impacts.

Irrespective of the cause, land contamination should be managed to address the risk to human health and ecological receptors. In doing so, it is good practice to include among the risk mitigation strategies a component that causes net improvement in the site through some level of contaminant reduction. Risk mitigation achieved solely by prevention of exposure without reduction of contamination is less desirable.

To determine whether risk management actions are warranted, the following risk paradigm should be applied to assess whether the three risk factors of 'Contaminants', 'Receptors', and 'Exposure Pathways' co-exist, or are likely to co-exist, at the project site under current or possible future land use:

- *Contaminant(s)*: Presence of hazardous materials, waste, or oil in any environmental media at potentially hazardous concentrations
- *Receptor(s)*: Actual or likely presence of humans, wildlife, plants, and other living organisms
- *Exposure pathway(s)*: A combination of the route of migration of the contaminant from its point of release (e.g., leaching into potable groundwater) and exposure routes (e.g., ingestion,

transdermal absorption), which would allow receptor(s) to come into actual contact with contaminants

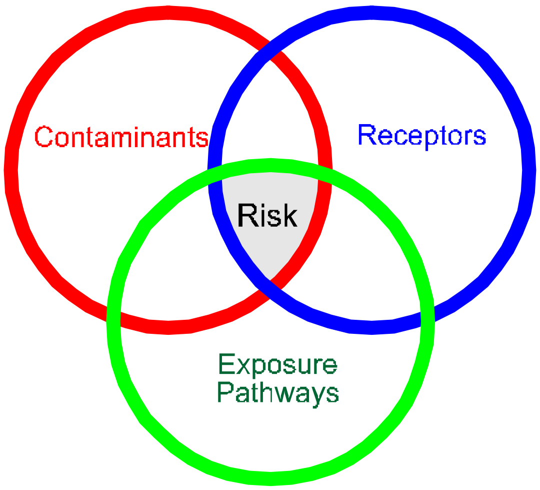

FIGURE 1.6.1: Inter-Relationship of Contaminant Risk Factors

When the three risk factors are considered to be present (in spite of limited data) under current or foreseeable future conditions, the following approach should be followed:

- Risk Screening
- Interim Risk Management
- Detailed Quantitative Risk Assessment
- Permanent Risk Reduction Measures

Risk Screening

Risk Screening is also known as "Problem Formulation" for environmental risk assessment. Where there is potential evidence that contamination is present, the following steps are recommended:

- Identifying location of suspected highest level of contamination through a combination of visual and historical operational information
- Sampling and testing the contaminated media (e.g., soil, sediment, soil vapor, groundwater, or surface water) according to established technical methods applicable to suspected type of contaminant[35,36]
- Evaluating analytical results against local or national contaminated sites regulations. In the absence of such regulations or environmental standards, other sources of risk-based standards or guidelines should be consulted to obtain a comprehensive list of screening soil concentrations for common polluting substances [37]
- Verifying potential human and/or ecological receptors and exposure pathways relevant to the site in question

The outcome of risk-screening may reveal that there is no overlap between the three risk-factors as the contaminant levels identified are below those considered to pose a risk to human health or the environment. Alternatively, interim or permanent risk reduction measures may need to be taken with, or without, more detailed risk assessment activities, as described below.

[35] BC MOE. http://www.env.gov.bc.ca/epd/epdpa/contam_sites/guidance

[36] Massachusetts Department of Environment. http://www.mass.gov/dep/cleanup

[37] These may include the USEPA Region 3 Risk-Based Concentrations (RBCs). http://www.epa.gov/reg3hwmd/risk/human/index.htm. These RBCs are considered acceptable for specific land use and contaminant exposure scenarios as they have been developed by governments using risk assessment techniques for use as general targets in the site remediation. Separate PRGs have been developed or adopted for soil, sediment or groundwater, and often a distinction is made between land uses (as noted earlier) because of the need for more stringent guidelines for residential and agricultural versus commercial/industrial landuse. The RBC Tables contains Reference Doses (RfDs) and Cancer Slope Factors (CSFs) for about 400 chemicals. These toxicity factors have been combined with "standard" exposure scenarios to calculate RBCs--chemical concentrations corresponding to fixed levels of risk (i.e., a Hazard Quotient (HQ) of 1, or lifetime cancer risk of 1E-6, whichever occurs at a lower concentration) in water, air, fish tissue, and soil for individual chemical substances. The primary use of RBCs is for chemical screening during baseline risk assessment (see EPA Regional Guidance EPA/903/R-93-001, "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening"). Additional useful soil quality guidelines can also be obtained from Lijzen et al. 2001.

Interim Risk Management

Interim risk management actions should be implemented at any phase of the project life cycle if the presence of land contamination poses an "imminent hazard", i.e., representing an immediate risk to human health and the environment if contamination were allowed to continue, even a short period of time. Examples of situations considered to involve imminent hazards include, but are not restricted to:

- Presence of an explosive atmosphere caused by contaminated land
- Accessible and excessive contamination for which short-term exposure and potency of contaminants could result in acute toxicity, irreversible long term effects, sensitization, or accumulation of persistent biocumulative and toxic substances
- Concentrations of pollutants at concentrations above the Risk Based Concentrations (RBCs) or drinking water standards in potable water at the point of abstraction

Appropriate risk reduction should be implemented as soon as practicable to remove the condition posing the imminent hazard.

Detailed Quantitative Risk Assessment

As an alternative to complying with numerical standards or Preliminary Remediation Goals, and depending on local regulatory requirements, a detailed site-specific, environmental risk assessment may be used to develop strategies that yield acceptable health risks, while achieving low level contamination on-site. An assessment of contaminant risks needs to be considered in the context of current and future land use, and development scenarios (e.g., residential, commercial, industrial, and urban parkland or wilderness use).

A detailed quantitative risk assessment builds on the screening risk (problem formulation) efforts previously described. First, a detailed site investigation should be performed to identify the scope of contamination.[38] Site investigation programs should apply quality assurance/quality control (QA/QC) measures to ensure that data quality is adequate for the intended data use (e.g., method detection limits are below levels of concern). The site investigation in turn should be used to develop a *conceptual site model* of how and where contaminants exist, how they are transported, and where routes of exposure occur to organisms and humans. The risk factors and conceptual site model provide a framework for assessing contaminant risks.

Human or ecological risk assessments facilitate risk management decisions at contaminated sites. Specific risk assessment objectives include:

- Identifying relevant human and ecological receptors (e.g., children, adults, fish, wildlife)
- Determining if contaminants are present at levels that pose potential human health and/or ecological concerns (e.g., levels above applicable regulatory criteria based on health or environmental risk considerations)
- Determining how human or ecological receptors are exposed to the contaminants (e.g., ingestions of soil, dermal contact, inhalation of dust)
- Identifying the types of adverse effects that might result from exposure to the contaminants (e.g., effect on target organ, cancer, impaired growth or reproduction)
- Quantifying the magnitude of health risks to human and ecological receptors based on a quantitative analysis of

[38] Examples include processes defined by the American Society of Testing and Materials (ASTM) Phase II ESA Process; the British Columbia Ministry of Environment Canada (BC MOE http://www.env.gov.bc.ca/epd/epdpa/contam_sites/guidance); and the Massachusetts Department of Environment http://www.mass.gov/dep/cleanup.

contaminant exposure and toxicity (e.g. calculate lifetime cancer risk or ratios of estimated exposure rates compared to safe exposure rates)

- Determining how current and proposed future land use influence the predicted risks (e.g., consider if residential land and parkland will have more sensitive receptors, such as children, compared to industrial lands)
- Quantifying the potential environmental and/or human health risks from off-site contaminant migration (e.g., consider if leaching and groundwater transport, or surface water transport results in exposure for adjacent lands/receptors)
- Determining if the risk is likely to remain stable, increase, or decrease with time in the absence of any remediation (e.g., consider if contaminant is reasonably degradable and likely to remain in place, or be transported to other media)

Addressing these objectives provides a basis to develop and implement risk reduction measures (e.g., clean-up, on-site controls) at the site. If such a need exists, the following additional objectives become relevant:

- Determining where, and in what conceptual manner, risk reduction measures should be implemented
- Identifying the preferred technologies needed to implement the conceptual risk reduction measures
- Developing a monitoring plan to ascertain whether risk reduction measures are effective

Permanent Risk Reduction Measures

The *risk factors* and *conceptual site model* within the contaminant risk approach described also provide a basis to manage and mitigate environmental contaminant health risks. The underlying principle is to reduce, eliminate, or control any or all of the three risk factors illustrated in Figure 1.6.1. A short list of examples of risk mitigation strategies is provided below, although actual strategies should be developed based on site-specific conditions, and the practicality of prevailing factors and site constraints. Regardless of the management options selected, the action plan should include, whenever possible, *contaminant source reduction* (i.e., net improvement of the site) as part of the overall strategy towards managing health risks at contaminated sites, as this alone provides for improved environmental quality.

Figure 1.6.2 presents a schematic of the inter-relationship of risk factors and example strategies to mitigate contaminant health risk by modifying the conditions of one or more risk factors to ultimately reduce contaminant exposure to the receptor. Example risk mitigation strategies for contaminant source and exposure concentrations include:

- Soil, sediment, and sludge:
  - In situ biological treatment (aerobic or anaerobic)
  - In situ physical/chemical treatment (e.g., soil vapor extraction with off-gas treatment, chemical oxidation)
  - In situ thermal treatment (e.g., steam injection, 6-phase heating)
  - Ex situ biological treatment (e.g., excavation and composting)
  - Ex situ physical/chemical treatment (e.g., excavation and stabilization)
  - Ex situ thermal treatment (e.g., excavation and thermal desorption or incineration)
  - Containment (e.g. landfill)
  - Other treatment processes
- Groundwater, surface water, and leachate:
  - In situ biological treatment (aerobic and/or aerobic)
  - In situ physical/chemical treatment (e.g., air sparging, zero-valent iron permeable reactive barrier)
  - Ex situ biological, physical, and or chemical treatment (i.e., groundwater extraction and treatment)

- Containment (e.g., slurry wall or sheet pile barrier)
- Other treatment processes

- Soil vapor intrusion:
  - Soil vapor extraction to reduce VOC contaminant source in soil
  - Installation of a sub-slab depressurization system to prevent migration of soil vapor into the building
  - Creating a positive pressure condition in buildings
  - Installation (during building construction) of an impermeable barrier below the building and/or an alternative flow pathway for soil vapor beneath building foundations (e.g., porous media and ventilation to shunt vapors away from building)

Example risk mitigation strategies for receptors include:

- Limiting or preventing access to contaminant by receptors (actions targeted at the receptor may include signage with instructions, fencing, or site security)
- Imposing health advisory or prohibiting certain practices leading to exposure such as fishing, crab trapping, shellfish collection
- Educating receptors (people) to modify behavior in order to reduce exposure (e.g., improved work practices, and use of protective clothing and equipment)

Example risk mitigation strategies for exposure pathways include:

- Providing an alternative water supply to replace, for example, a contaminated groundwater supply well
- Capping contaminated soil with at least 1m of clean soil to prevent human contact, as well as plant root or small mammal penetration into contaminated soils
- Paving over contaminated soil as an interim measure to negate the pathway of direct contact or dust generation and inhalation
- Using an interception trench and pump, and treat technologies to prevent contaminated groundwater from discharging into fish streams

Occupational Health and Safety Considerations

Investigation and remediation of contaminated lands requires that workers be mindful of the occupational exposures that could arise from working in close contact with contaminated soil or other environmental media (e.g., groundwater, wastewater, sediments, and soil vapor). Occupational health and safety precautions should be exercised to minimize exposure, as described in Section 2 on Occupational Health and Safety. In addition, workers on contaminated sites should receive special health and safety training specific to contaminated site investigation and remediation activities.[39]

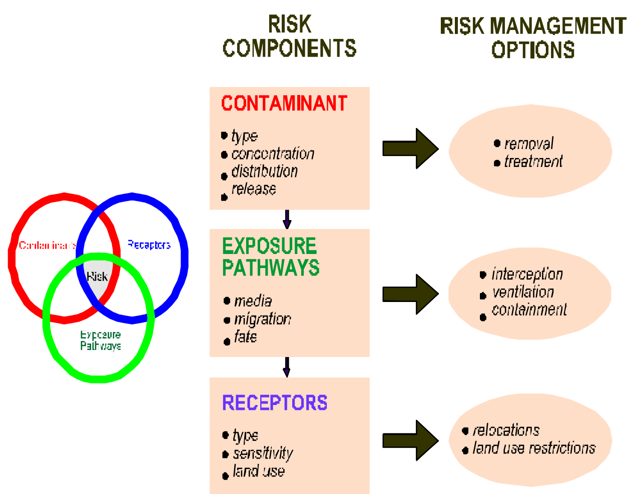

FIGURE 1.6.2: Inter-Relationship of Risk Factors and Management Options

[39] For example, US Occupational Safety and Health Agency (OSHA) regulations found at 40 CFR 1910.120. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9765

1.7 Construction and Decommissioning

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Applicability and Approach

This section provides additional, specific guidance on prevention and control of environmental impacts which are most common during construction or decommissioning activities. Construction and decommissioning activities may occur during new project development, at the end of the project life-cycle, or due to expansion or modification of existing project facilities. Construction activities vary in aerial extent and complexity, but typically include:

- Land clearing for site preparation and access routes
- Excavation, blasting, and filling
- Transportation of supply materials, fuels and chemicals
- Building foundations, involving excavation and placement of concrete
- Installing buildings of varying heights, process facilities, utilities, or storage facilities
- Operating heavy equipment in close quarters
- Operating cranes for unloading, and installing equipment
- Working with temporary utilities
- Commissioning new equipment

Noise and Vibration

During construction, noise and vibration may be caused by the operation of pile drivers, earth moving and excavation equipment, concrete mixers, and materials transport and delivery equipment. During decommissioning, noise sources may include earth moving and structural wrecking equipment, among others. Although it is generally accepted that noise emissions from construction activities are difficult and, at times, not feasible to mitigate, some recommended prevention and control strategies include:

- Planning activities with the potential to generate the greatest levels of noise and vibration, such as pile driving, earth moving, and materials deliveries, in consultation with local communities or during periods of the day when disturbance to potentially affected communities can be minimized.
- Using noise control devices, such as deflectors for impact and blasting activities, and exhaust muffling devices for combustion engines.

Soil Erosion

Soil erosion may be caused by exposure of soil surfaces to rain and wind during site clearing, earth moving, and excavation activities. The mobilization and transport of soil particles may, in turn, result in sedimentation of surface drainage networks, which may impact on water quality and biodiversity. Recommended methods to avoid, minimize, or control soil erosion and stream sedimentation include:

Sediment mobilization and transport

- Reducing exposure of sediment generating materials to wind or water by providing proper placement, minimizing bare areas, and covering highly erodible soils

- Reducing or preventing erosion by:
  - Avoiding areas with sensitive soils
  - Scheduling to avoid heavy rainfall periods (i.e., during the dry season)
  - Phasing construction areas and times
  - Contouring and minimizing length and steepness of slopes
  - Mulching to stabilize exposed areas
  - Re-vegetating areas promptly
  - Designing channels and ditches for post-construction flows
  - Lining steep channel and slopes
- Reducing or preventing off-site sediment transport through use of settlement ponds, silt fences, and water treatment, and suspending activities during extreme rainfall

Clean runoff management

- Segregating or diverting clean runoff to prevent it mixing with dirty water, which typically results in larger volumes of water needing treatment prior to release

Road design

- Limiting access road gradients to reduce runoff-induced erosion
- Providing adequate road drainage based on road width, surface material, compaction, and maintenance

Disturbance to water bodies

- Installing free-spanning structures (e.g., single span bridges) for road watercourse crossings
- Restricting the duration and timing of in-stream activities to lower flow periods, and avoiding periods critical to biological cycles of valued flora and fauna (e.g. migration, spawning, etc.)
- For in-stream works, using isolation techniques such as berming or diversion during construction to limit the exposure of disturbed sediments to moving water
- Using trenchless technology for pipeline crossings (e.g., suspended crossings) or installation by directional drilling

Structural (slope) stability

- Providing effective short term measures for slope stability until long term measures for the operational phase can be implemented
- Providing adequate drainage systems to minimize and control infiltration

Air Quality

Construction and decommissioning activities may generate emission of fugitive dust caused by a combination of on-site excavation and movement of earth materials, contact of construction machinery with bare soil, and exposure of bare soil and soil piles to wind. A secondary source of emissions may include exhaust from diesel engines of earth moving equipment, as well as from open burning of solid waste on-site. Techniques for preventing and controlling fugitive dust emissions at construction and decommissioning sites include:

- Minimizing dust from material handling sources, such as conveyors and bins, by using covers and/or control equipment (water suppression, bag house, or cyclone)
- Minimizing dust from open area sources, including storage piles, by using control measures such as installing enclosures and covers, and increasing the moisture content
- Controlling dust from paved/unpaved roads by sweeping or using water suppressants

- Selectively removing potential hazardous air pollutants, such as asbestos, from existing infrastructure prior to demolition
- Managing emissions from mobile sources according to Section 1.1
- Avoiding open burning of solid waste through segregation and recycling, and through disposal according to solid waste management guidance in Section 1.4

Solid Waste

Non-hazardous solid waste generated at construction and decommissioning sites includes excess fill materials from grading and excavation activities, scrap wood and metals, and small concrete spills. Other non-hazardous solid wastes include office, kitchen, and dormitory wastes when these types of operations are part of construction project activities. *Hazardous solid waste* includes contaminated soils, which could potentially be encountered on-site due to previous land use activities, or small amounts of machinery maintenance materials, such as oily rags, used oil filters, and used oil, as well as spill cleanup materials from oil and fuel spills. Techniques for preventing and controlling non-hazardous and hazardous construction site solid waste include:

- Segregating recyclable materials for further sale or distribution to recycling entities
- Making scrap wood and other potentially reusable, non-hazardous materials available to local residents
- Securing site from contaminant migration or public access, if necessary, to isolate future environmental impacts
- Managing any other non-hazardous, solid wastes and hazardous or potentially hazardous solid wastes according to the recommendations in Section 1.4

Hazardous Materials

Construction and decommissioning activities may pose the potential for release of petroleum based products, such as lubricants, hydraulic fluids, or fuels during their storage, transfer, or use in equipment. Additionally, the potential for releases of these materials during decommissioning activities may include their presence in building components or industrial process equipment. Techniques for prevention, minimization, and control of these impacts include:

- Providing temporary secondary containment for portable storage tanks and for temporary storage of new and used lubricating fluids, including the use of portable impervious systems for lubricating oil and fuel storage and transfer areas
- Training workers on the correct transfer and handling of petroleum products and response to spills
- Providing portable spill containment and cleanup equipment
- Assessing the contents of hazardous materials and petroleum-based products in building systems and process equipment and removing them prior to initiation of decommissioning activities, and managing their treatment and disposal according to Sections 1.3 and 1.4 on Hazardous Materials and Hazardous Waste Management, respectively
- Assessing the presence of hazardous substances in or on building materials (e.g., polychlorinated biphenyls absorbed into concrete, asbestos-containing flooring or insulation) and decontaminating or properly managing contaminated building materials

Wastewater Discharges

Construction and decommissioning activities may include the generation of sanitary wastewater discharges in varying quantities depending on the number of workers involved. Sanitary wastewater should be managed according to the significance and location of the discharges so as to address the potential risk of water-borne disease transmission and impacts to receiving water quality. The following types of alternatives should be considered:

- Discharging directly into a sanitary sewage network, if one is available
- Use of portable sanitary facilities serviced by a provider permitted by competent authorities for the off-site management of sanitary wastewater
- Installing and operating on-site sanitary wastewater management systems according to the guidance provided in Section 1.2

Contaminated Land

Land contamination may be encountered in sites under construction or decommissioning due to known or unknown historical releases of hazardous materials or oil, or due to the presence of abandoned infrastructure formerly used to store or handle these materials, including underground storage tanks. Actions to manage the risk from contaminated land will depend on factors such as the level and location of contamination, the type and risks of the contaminated media, and the intended land use. However, a basic management strategy should include:

- Managing contaminated media with the objective of protecting the safety and health of occupants of the site, the surrounding community, and the environment post construction or post decommissioning
- Understanding the historical use of the land with regard to the potential presence of hazardous materials or oil prior to initiation of construction or decommissioning activities
- Preparing plans and procedures to respond to the discovery of contaminated media to minimize or reduce the risk to health, safety, and the environment consistent with the approach for Contaminated Land in Section 1.6
- Managing obsolete, abandoned, hazardous materials or oil consistent with the approach to hazardous waste management described in Section 1.4

Threats to Environment

Depending on the nature of the ambient environment, including the temporary or permanent reduction or displacement of species due to land conversion, presence of worker camps, noise emissions and degradation of air and water quality (noise, air and water issue have been addressed in other subsections). In addition to the air, water, and noise-related guidelines in Sections 1.1, 1.2 and 1.5 respectively, recommended approaches to prevent, minimize, or control threats to the environment include:

- Maximizing the use of previously disturbed land for both the access and siting of new facilities
- Identifying habitat critical for the survival of critically endangered and endangered flora and fauna, and avoiding or minimizing impacts accordingly
- Minimizing the disturbed footprint by:
  - Optimizing development layouts for buildings, roads, and facilities
  - Building vertically as opposed to horizontally, where possible
  - Minimizing disturbance to vegetation and soils
  - Minimizing habitat fragmentation by providing migration corridors
  - Implementing buffer zones
  - Implementing soil conservation measures, such as segregation, proper placement, and stockpiling of clean soils and overburden material for existing site remediation
- Precluding site workers from hunting, harvesting, or trading in flora or fauna

- Avoiding the use of foreign, potentially invasive, species in site reclamation and landscaping activities after construction or decommissioning, and restoring natural habitat to the extent practical
- Addressing existing land contamination, if present, and its potential for short- and long-term off-site migration into terrestrial or aquatic environments

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Applicability and Approach

Employers and supervisors are obliged to implement all reasonable precautions to protect the health and safety of workers. This section provides guidance and examples of reasonable precautions to implement in managing principal risks to occupational health and safety. Although the focus is placed on the operational phase of projects, much of the guidance also applies to construction and decommissioning activities.

Preventive and protective measures should be introduced according to the following order of priority:

- *Eliminating the hazard* by removing the activity from the work process. Examples include substitution with less hazardous chemicals, using different manufacturing processes, etc;
- *Controlling the hazard* at its source through use of engineering controls. Examples include local exhaust ventilation, isolation rooms, machine guarding, acoustic insulating, etc;
- *Minimizing the hazard* through design of safe work systems and administrative or institutional control measures. Examples include job rotation, training safe work procedures, lock-out and tag-out, workplace monitoring, limiting exposure or work duration, etc.

- *Providing appropriate personal protective equipment (PPE)* in conjunction with training, use, and maintenance of the PPE.

The application of prevention and control measures to occupational hazards should be based on comprehensive job safety or job hazard analyses. The results of these analyses should be prioritized as part of an action plan based on the likelihood and severity of the consequence of exposure to the identified hazards. An example of a qualitative risk ranking or analysis matrix to help identify priorities is described in Table 2.1.1. A qualified OHS officer or risk assessor would assign a predefined likelihood and consequence category to each work activity/work zone of interest to derive the risk category and resolve whether risk reduction actions are warranted.

Table 2.1.1. Risk Ranking Table to Classify Worker Scenarios Based on Likelihood and Consequence

Likelihood	Consequences				
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catas-trophic 5
A. Almost certain	L	M	E	E	E
B. Likely	L	M	H	E	E
C. Moderate	L	M	H	E	E
D. Unlikely	L	L	M	H	E
E. Rare	L	L	M	H	H

Legend

E: extreme risk; immediate action required

H: high risk; senior management attention needed

M: moderate risk; management responsibility must be specified

L: low risk; manage by routine procedures

2.1 General Facility Design and Operation

Integrity of Workplace Structures

Permanent and recurrent places of work should be designed and equipped to protect OHS:

- Surfaces, structures and installations should be easy to clean and maintain, and not allow for accumulation of hazardous compounds.
- Buildings must be structurally safe, provide appropriate protection against the climate, and have acceptable light and noise conditions.
- Fire resistant, noise-absorbing materials should, to the extent feasible, be used for cladding on ceilings and walls.
- Floors should be level, even, and non-skid.
- Heavy oscillating, rotating or alternating equipment should be located in dedicated buildings or structurally isolated sections.

Severe Weather and Facility Shutdown

- Work place structures should be designed and constructed to withstand the expected elements for the region and have an area designated for safe refuge, if appropriate.
- Standard Operating Procedures (SOPs) should be developed for project or process shut-down, including an evacuation plan. Drills to practice the procedure and plan should also be undertaken annually.

Workspace and Exit

- The space provided for each worker, and in total, should be adequate for safe execution of all activities, including transport and interim storage of materials and products.
- Passages to emergency exits should be unobstructed at all times. The number and capacity of emergency exits should be sufficient for safe and orderly evacuation of the greatest number of people present at any time, and there should be a minimum two exits from any work area.

Fire Precautions

The workplace should be designed to prevent the start of fires through the implementation of fire codes applicable to industrial settings. Other essential measures include:

- Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. The equipment should be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present.
- Provision of manual firefighting equipment that is easily accessible and simple to use
- Fire and emergency alarm systems that are both audible and visible

The IFC Life and Fire Safety Guideline should apply to buildings accessible to the public (See Section 5.4.6).

Lavatories and Showers

- Adequate lavatory facilities (toilets and washing areas) should be provided for the number of people expected to work in the facility and allowances made for segregated facilities, or for indicating whether the toilet facility is "In Use" or "Vacant". Toilet facilities should also be provided with adequate supplies of hot and cold running water, soap, and hand drying devices.
- Where workers may be exposed to substances poisonous by ingestion and skin contamination may occur, facilities for showering and changing into and out of street and work clothes should be provided.

Potable Water Supply

- Adequate supplies of potable drinking water should be provided from a fountain with an upward jet or with a sanitary means of collecting the water for the purposes of drinking
- Water supplied to areas of food preparation or for the purpose of personal hygiene (washing or bathing) should meet drinking water quality standards

Clean Eating Area

- Where there is potential for exposure to substances poisonous by ingestion, suitable arrangements are to be made for provision of clean eating areas where workers are not exposed to the hazardous or noxious substances

Lighting

- Workplaces should, to the degree feasible, receive natural light and be supplemented with sufficient artificial illumination to promote workers' safety and health, and enable safe equipment operation. Supplemental 'task lighting' may be required where specific visual acuity requirements should be met.
- Emergency lighting of adequate intensity should be installed and automatically activated upon failure of the principal artificial light source to ensure safe shut-down, evacuation, etc.

Safe Access

- Passageways for pedestrians and vehicles within and outside buildings should be segregated and provide for easy, safe, and appropriate access
- Equipment and installations requiring recurrent servicing and cleaning should have permanent means of access
- Hand, knee and foot railings should be installed on stairs, fixed ladders, platforms, permanent and interim floor openings, loading bays, ramps, etc.
- Openings should be sealed by gates or removable chains
- Covers should, if feasible, be installed to protect against falling items
- Measures to prevent unauthorized access to dangerous areas should be in place

First Aid

- The employer should ensure that qualified first-aid can be provided at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work
- Eye-wash stations and/or emergency showers should be provided close to all workstations where immediate flushing with water is the recommended first-aid response
- Where the scale of work or the type of activity being carried out so requires, dedicated and appropriately equipped first-aid room(s) should be provided. First aid stations and rooms should be equipped with gloves, gowns, and masks for protection against direct contact with blood and other body fluids
- Remote sites should have written emergency procedures in place for dealing with cases of trauma or serious illness up to the point at which patient care can be transferred to an appropriate medical facility.

Air Supply

- Sufficient fresh air should be supplied for indoor and confined work spaces. Factors to be considered in ventilation design include physical activity, substances in use, and process-related emissions. Air distribution systems should be designed so as not to expose workers to draughts
- Mechanical ventilation systems should be maintained in good working order. Point-source exhaust systems required for maintaining a safe ambient environment should have local indicators of correct functioning.
- Re-circulation of contaminated air is generally not acceptable. Air inlet filters should be kept clean and free of dust and microorganisms. Heating, ventilation and air conditioning (HVAC) and industrial evaporative cooling systems should be equipped, maintained and operated so as to prevent growth and spreading of disease agents (e.g. *Legionnella pneumophilia*) or breeding of vectors (e.g. mosquitoes and flies) of public health concern.

Work Environment Temperature

- The temperature in work, rest room and other welfare facilities should, during service hours, be maintained at a level appropriate for the purpose of the facility.

2.2 Communication and Training

OHS Training

- Provisions should be made to provide OHS orientation training to all new employees to ensure they are apprised of the basic site rules of work at / on the site and of personal protection and preventing injury to fellow employees.
- Training should consist of basic hazard awareness, site-specific hazards, safe work practices, and emergency procedures for fire, evacuation, and natural disaster, as

appropriate. Any site-specific hazard or color coding in use should be thoroughly reviewed as part of orientation training.

Visitor Orientation

- If visitors to the site can gain access to areas where hazardous conditions or substances may be present, a visitor orientation and control program should be established to ensure visitors do not enter hazard areas unescorted.

New Task Employee Training

- The employer should ensure that workers, prior to commencement of new assignments, have received adequate training and information enabling them to understand work hazards and to protect their health from hazardous ambient factors that may be present.
  The training should adequately cover:
  - Knowledge of materials, equipment, and tools
  - Known hazards in the operations and how they are controlled
  - Potential risks to health
  - Precautions to prevent exposure
  - Hygiene requirements
  - Wearing and use of protective equipment and clothing
  - Appropriate response to operation extremes, incidents and accidents

Basic OHS Training

- A basic occupational training program and specialty courses should be provided, as needed, to ensure that workers are oriented to the specific hazards of individual work assignments. Training should generally be provided to management, supervisors, workers, and occasional visitors to areas of risks and hazards.
- Workers with rescue and first-aid duties should receive dedicated training so as not to inadvertently aggravate exposures and health hazards to themselves or their co-workers. Training would include the risks of becoming infected with blood–borne pathogens through contact with bodily fluids and tissue.
- Through appropriate contract specifications and monitoring, the employer should ensure that service providers, as well as contracted and subcontracted labor, are trained adequately before assignments begin.

Area Signage

- Hazardous areas (electrical rooms, compressor rooms, etc), installations, materials, safety measures, and emergency exits, etc. should be marked appropriately.
- Signage should be in accordance with international standards and be well known to, and easily understood by workers, visitors and the general public as appropriate.

Labeling of Equipment

- All vessels that may contain substances that are hazardous as a result of chemical or toxicological properties, or temperature or pressure, should be labeled as to the contents and hazard, or appropriately color coded.
- Similarly, piping systems that contain hazardous substances should be labeled with the direction of flow and contents of the pipe, or color coded whenever the pipe passing through a wall or floor is interrupted by a valve or junction device.

Communicate Hazard Codes

- Copies of the hazard coding system should be posted outside the facility at emergency entrance doors and fire emergency connection systems where they are likely to come to the attention of emergency services personnel.

- Information regarding the types of hazardous materials stored, handled or used at the facility, including typical maximum inventories and storage locations, should be shared proactively with emergency services and security personnel to expedite emergency response when needed.
- Representatives of local emergency and security services should be invited to participate in periodic (annual) orientation tours and site inspections to ensure familiarity with potential hazards present.

2.3 Physical Hazards

Physical hazards represent potential for accident or injury or illness due to repetitive exposure to mechanical action or work activity. Single exposure to physical hazards may result in a wide range of injuries, from minor and medical aid only, to disabling, catastrophic, and/or fatal. Multiple exposures over prolonged periods can result in disabling injuries of comparable significance and consequence.

Rotating and Moving Equipment

Injury or death can occur from being trapped, entangled, or struck by machinery parts due to unexpected starting of equipment or unobvious movement during operations. Appropriate protective measures include:

- Designing machines to eliminate trap hazards and ensuring that extremities are kept out of harm's way under normal operating conditions. Examples of proper design considerations include two-hand operated machines to prevent amputations or the availability of emergency stops dedicated to the machine and placed in strategic locations. Where a machine or equipment has an exposed moving part or exposed pinch point that may endanger the safety of any worker, the machine or equipment should be equipped with, and protected by, a guard or other device that prevents access to the moving part or pinch point. Guards should be designed and installed in conformance with appropriate machine safety standards.[40]
- Turning off, disconnecting, isolating, and de-energizing (Locked Out and Tagged Out) machinery with exposed or guarded moving parts, or in which energy can be stored (e.g. compressed air, electrical components) during servicing or maintenance, in conformance with a standard such as CSA Z460 Lockout or equivalent ISO or ANSI standard
- Designing and installing equipment, where feasible, to enable routine service, such as lubrication, without removal of the guarding devices or mechanisms

Noise

Noise limits for different working environments are provided in Table 2.3.1.

- No employee should be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).
- The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB(A), the peak sound levels reach 140 dB(C), or the average maximum sound level reaches 110dB(A). Hearing protective devices provided should be capable of reducing sound levels at the ear to at least 85 dB(A).
- Although hearing protection is preferred for any period of noise exposure in excess of 85 dB(A), an equivalent level of protection can be obtained, but less easily managed, by limiting the duration of noise exposure. For every 3 dB(A)

[40] For example: CSA Z432.04 Safe Guarding of Machinery, CSA Z434 Robot Safety, ISO 11161 Safety of Machinery – Integrated Manufacturing Systems or ISO 14121 Safety of Machinery – Principals of Risk Management or equivalent ANSI standard.

increase in sound levels, the 'allowed' exposure period or duration should be reduced by 50 percent.[41]

- Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible.

Table 2.3.1. Noise Limits for Various Working Environments

Location /activity	Equivalent level $LA_{eq},8h$	Maximum LA_{max},fast
Heavy Industry (no demand for oral communication)	85 dB(A)	110 dB(A)
Light industry (decreasing demand for oral communication)	50-65 dB(A)	110 dB(A)
Open offices, control rooms, service counters or similar	45-50 dB(A)	-
Individual offices (no disturbing noise)	40-45 dB(A)	-
Classrooms, lecture halls	35-40 dB(A)	-
Hospitals	30-35 dB(A)	40 dB(A)

Vibration

Exposure to hand-arm vibration from equipment such as hand and power tools, or whole-body vibrations from surfaces on which the worker stands or sits, should be controlled through choice of equipment, installation of vibration dampening pads or devices, and limiting the duration of exposure. Limits for vibration and action values, (i.e. the level of exposure at which remediation should be initiated) are provided by the ACGIH[42]. Exposure levels should be checked on the basis of daily exposure time and data provided by equipment manufacturers.

Electrical

Exposed or faulty electrical devices, such as circuit breakers, panels, cables, cords and hand tools, can pose a serious risk to workers. Overhead wires can be struck by metal devices, such as poles or ladders, and by vehicles with metal booms. Vehicles or grounded metal objects brought into close proximity with overhead wires can result in arcing between the wires and the object, without actual contact. Appropriate actions include:

- Marking all energized electrical devices and lines with warning signs
- Locking out (de-charging and leaving open with a controlled locking device) and tagging-out (warning sign placed on the lock) devices during service or maintenance
- Checking all electrical cords, cables, and hand power tools for frayed or exposed cords and following manufacturer recommendations for maximum permitted operating voltage of the portable hand tools
- Double insulating / grounding all electrical equipment used in environments that are, or may become, wet; using equipment with ground fault interrupter (GFI) protected circuits
- Protecting power cords and extension cords against damage from traffic by shielding or suspending above traffic areas
- Appropriate labeling of service rooms housing high voltage equipment ('electrical hazard') and where entry is controlled or prohibited (see also Section 3 on Planning, Siting, and Design).
- Establishing "No Approach" zones around or under high voltage power lines in conformance with Table 2.3.2

[41] The American Conference of Governmental Industrial Hygienists (ACGIH), 2005

[42] ACGIH, 2005

Table 2.3.2. No Approach Zones for High Voltage Power Lines	
Nominal phase-to-phase voltage rating	Minimum distance
750 or more volts, but no more than 150,000 volts	3 meters
More than 150,000 volts, but no more than 250,000 volts	4.5 meters
More than 250,000 volts	6 meters

- Rubber tired construction or other vehicles that come into direct contact with, or arcing between, high voltage wires may need to be taken out of service for periods of 48 hours and have the tires replaced to prevent catastrophic tire and wheel assembly failure, potentially causing serious injury or death.

Eye Hazards

Solid particles from a wide variety of industrial operations, and / or a liquid chemical spray may strike a worker in the eye causing an eye injury or permanent blindness. Recommended measures include:

- Use of machine guards or splash shields and/or face and eye protection devices, such as safety glasses with side shields, goggles, and/or a full face shield. Specific Safe Operating Procedures (SOPs) may be required for use of sanding and grinding tools and/or when working around liquid chemicals. Frequent checks of these types of equipment prior to use to ensure mechanical integrity is also good practice. Machine and equipment guarding should conform to standards published by organizations such as CSA, ANSI and ISO (see also Section 2.3 on Rotating and Moving Equipment and 2.7 on Personal Protective Equipment).
- Moving areas where the discharge of solid fragments, liquid, or gaseous emissions can reasonably be predicted (e.g. discharge of sparks from a metal cutting station, pressure relief valve discharge) away from places expected to be occupied or transited by workers or visitors. Where machine or work fragments could present a hazard to transient workers or passers-by, extra area guarding or proximity restricting systems should be implemented, or PPE required for transients and visitors.

Welding / Hot Work

Welding creates an extremely bright and intense light that may seriously injur a worker's eyesight. In extreme cases, blindness may result. Additionally, welding may produce noxious fumes to which prolonged exposure can cause serious chronic diseases. Appropriate measures include:

- Provision of proper eye protection such as welder goggles and/or a full-face eye shield for all personnel involved in, or assisting, welding operations. Additional methods may include the use of welding barrier screens around the specific work station (a solid piece of light metal, canvas, or plywood designed to block welding light from others). Devices to extract and remove noxious fumes at the source may also be required.
- Special hot work and fire prevention precautions and Standard Operating Procedures (SOPs) should be implemented if welding or hot cutting is undertaken outside established welding work stations, including 'Hot Work Permits, stand-by fire extinguishers, stand-by fire watch, and maintaining the fire watch for up to one hour after welding or hot cutting has terminated. Special procedures are required for hotwork on tanks or vessels that have contained flammable materials.

Industrial Vehicle Driving and Site Traffic

Poorly trained or inexperienced industrial vehicle drivers have increased risk of accident with other vehicles, pedestrians, and equipment. Industrial vehicles and delivery vehicles, as well as private vehicles on-site, also represent potential collision scenarios. Industrial vehicle driving and site traffic safety practices include:

- Training and licensing industrial vehicle operators in the safe operation of specialized vehicles such as forklifts, including safe loading/unloading, load limits
- Equipping site vehicles with back-up alarms to help warn other workers in the vicinity of the moving vehicle
- Establishing rights-of-way, site speed limits, vehicle inspection requirements, operating rules and procedures (e.g. prohibiting operation of forklifts with forks in down position), and control of traffic patterns or direction
- Restricting the circulation of delivery and private vehicles to defined routes and areas, giving preference to 'one-way' circulation, where appropriate

Working Environment Temperature

Exposure to hot or cold working conditions in indoor or outdoor environments can result temperature stress-related injury or death. Use of personal protective equipment (PPE) to protect against other occupational hazards can accentuate and aggravate heat-related illnesses. Extreme temperatures in permanent work environments should be avoided through implementation of engineering controls and ventilation. Where this is not possible, such as during short-term outdoor work, temperature-related stress management procedures should be implemented which include:

- Monitoring weather forecasts for outdoor work to provide advance warning of extreme weather and scheduling work accordingly
- Adjustment of work and rest periods according to temperature stress management procedures provided by ACGIH[43], depending on the temperature and workloads
- Providing temporary shelters to protect against the elements during working activities or for use as rest areas
- Use of protective clothing
- Providing easy access to adequate hydration such as drinking water or electrolyte drinks, and avoiding consumption of alcoholic beverages

Ergonomics, Repetitive Motion, Manual Handling

Injuries due to ergonomic factors, such as repetitive motion, over-exertion, and manual handling, take prolonged and repeated exposures to develop, and typically require periods of weeks to months for recovery. These OHS problems should be minimized or eliminated to maintain a productive workplace. Controls may include:

- Use of mechanical assists to eliminate or reduce exertions required to lift materials, hold tools and work objects, and requiring multi-person lifts if weights exceed thresholds
- Selecting and designing tools that reduce force requirements and holding times, and improve postures
- Providing user adjustable work stations
- Incorporating rest and stretch breaks into work processes, and conducting job rotation
- Implementing quality control and maintenance programs that reduce unnecessary forces and exertions

Working at Heights

Fall prevention and protection measures should be implemented whenever a worker is exposed to the hazard of falling more than two meters; into operating machinery; into water or other liquid; into hazardous substances; or through an opening in a work

[43] ACGIH, 2005

surface. Fall prevention / protection measures may also be warranted on a case-specific basis when there are risks of falling from lesser heights. Fall prevention may include:

- Installation of guardrails with mid-rails and toe boards at the edge of any fall hazard area
- Proper use of ladders and scaffolds by trained employees
- Use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard area, or fall protection devices such as full body harnesses used in conjunction with shock absorbing lanyards or self-retracting inertial fall arrest devices attached to fixed anchor point or horizontal life-lines
- Appropriate training in use, serviceability, and integrity of the necessary PPE
- Inclusion of rescue and/or recovery plans, and equipment to respond to workers after an arrested fall

Table 2.3.3. Minimum Limits For Workplace Illumination Intensity

Location / Activity	Light Intensity
Emergency light	10 lux
Outdoor non working areas	20 lux
Simple orientation and temporary visits (machine storage, garage, warehouse)	50 lux
Workspace with occasional visual tasks only (corridors, stairways, lobby, elevator, auditorium, etc.)	100 lux
Medium precision work (simple assembly, rough machine works, welding, packing, etc.)	200 lux
Precision work (reading, moderately difficult assembly, sorting, checking, medium bench and machine works, etc.), offices.	500 lux
High precision work (difficult assembly, sewing, color inspection, fine sorting etc.)	1,000 – 3,000 lux

Illumination

Work area light intensity should be adequate for the general purpose of the location and type of activity, and should be supplemented with dedicated work station illumination, as needed. The minimum limits for illumination intensity for a range of locations/activities appear in Table 2.3.3.

Controls should include:

- Use of energy efficient light sources with minimum heat emission
- Undertaking measures to eliminate glare / reflections and flickering of lights
- Taking precautions to minimize and control optical radiation including direct sunlight. Exposure to high intensity UV and IR radiation and high intensity visible light should also be controlled
- Controlling laser hazards in accordance with equipment specifications, certifications, and recognized safety standards. The lowest feasible class Laser should be applied to minimize risks.

2.4 Chemical Hazards

Chemical hazards represent potential for illness or injury due to single acute exposure or chronic repetitive exposure to toxic, corrosive, sensitizing or oxidative substances. They also represent a risk of uncontrolled reaction, including the risk of fire and explosion, if incompatible chemicals are inadvertently mixed. Chemical hazards can most effectively be prevented through a hierarchical approach that includes:

- Replacement of the hazardous substance with a less hazardous substitute
- Implementation of engineering and administrative control measures to avoid or minimize the release of hazardous substances into the work environment keeping the level of

exposure below internationally established or recognized limits

- Keeping the number of employees exposed, or likely to become exposed, to a minimum
- Communicating chemical hazards to workers through labeling and marking according to national and internationally recognized requirements and standards, including the International Chemical Safety Cards (ICSC), Materials Safety Data Sheets (MSDS), or equivalent. Any means of written communication should be in an easily understood language and be readily available to exposed workers and first-aid personnel
- Training workers in the use of the available information (such as MSDSs), safe work practices, and appropriate use of PPE

Air Quality

Poor air quality due to the release of contaminants into the work place can result in possible respiratory irritation, discomfort, or illness to workers. Employers should take appropriate measures to maintain air quality in the work area. These include:

- Maintaining levels of contaminant dusts, vapors and gases in the work environment, to the extent feasible, at concentrations below those recommended by local authorities. Where these are not available, levels should be below those recommended by the ACGIH[44] as TWA-TLV's (threshold limit value)—concentrations to which most workers can be exposed repeatedly (8 hours/day, 40 hrs/week, week-after-week), without sustaining adverse health effects.
- Developing and implementing work practices to minimize release of contaminants into the work environment including:
    - Direct piping of liquid and gaseous materials
    - Minimized handling of dry powdered materials;
    - Enclosed operations
    - Local exhaust ventilation at emission / release points
    - Vacuum transfer of dry material rather than mechanical or pneumatic conveyance
    - Indoor secure storage, and sealed containers rather than loose storage
- Where ambient air contains several materials that have similar effects on the same body organs (additive effects), taking into account combined exposures using calculations recommended by the ACGIH[45]
- Where work shifts extend beyond eight (8) hours, calculating adjusted workplace exposure criteria recommended by the ACGIH[46]

Fire and Explosions

Fires and or explosions resulting from ignition of flammable materials or gases can lead to loss of property as well as possible injury or fatalities to project workers. Prevention and control strategies include:

- Storing flammables away from ignition sources and oxidizing materials. Further, flammables storage area should be:
    - Remote from entry and exit points into buildings
    - Away from facility ventilation intakes or vents
    - Have natural or passive floor and ceiling level ventilation and explosion venting
    - Use spark-proof fixtures
    - Be equipped with fire extinguishing devices and self-closing doors, and constructed of materials made to withstand flame impingement for a moderate period of time
- Providing bonding and grounding of, and between, containers and additional mechanical floor level ventilation if

[44] ACGIH, 2005

[45] ACGIH, 2005.

[46] ACGIH, 2005.

materials are being, or could be, dispensed in the storage area
- Where the flammable material is mainly comprised of dust, providing electrical grounding, spark detection, and, if needed, quenching systems
- Defining and labeling fire hazards areas to warn of special rules (e.g. prohibition in use of smoking materials, cellular phones, or other potential spark generating equipment)
- Providing specific worker training in handling of flammable materials, and in fire prevention or suppression

Corrosive, oxidizing, and reactive chemicals

Corrosive, oxidizing, and reactive chemicals present similar hazards and require similar control measures as flammable materials. However, the added hazard of these chemicals is that inadvertent mixing or intermixing may cause serious adverse reactions. This can lead to the release of flammable or toxic materials and gases, and may lead directly to fires and explosions. These types of substances have the additional hazard of causing significant personal injury upon direct contact, regardless of any intermixing issues. The following controls should be observed in the work environment when handling such chemicals:

- Corrosive, oxidizing and reactive chemicals should be segregated from flammable materials and from other chemicals of incompatible class (acids vs. bases, oxidizers vs. reducers, water sensitive vs. water based, etc.), stored in ventilated areas and in containers with appropriate secondary containment to minimize intermixing during spills
- Workers who are required to handle corrosive, oxidizing, or reactive chemicals should be provided with specialized training and provided with, and wear, appropriate PPE (gloves, apron, splash suits, face shield or goggles, etc).
- Where corrosive, oxidizing, or reactive chemicals are used, handled, or stored, qualified first-aid should be ensured at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work, and eye-wash stations and/or emergency showers should be provided close to all workstations where the recommended first-aid response is immediate flushing with water

2.5 Biological Hazards

Biological agents represent potential for illness or injury due to single acute exposure or chronic repetitive exposure. Biological hazards can be prevented most effectively by implementing the following measures:

- If the nature of the activity permits, use of any harmful biological agents should be avoided and replaced with an agent that, under normal conditions of use, is not dangerous or less dangerous to workers. If use of harmful agents can not be avoided, precautions should be taken to keep the risk of exposure as low as possible and maintained below internationally established and recognized exposure limits.
- Work processes, engineering, and administrative controls should be designed, maintained, and operated to avoid or minimize release of biological agents into the working environment. The number of employees exposed or likely to become exposed should be kept at a minimum.
- The employer should review and assess known and suspected presence of biological agents at the place of work and implement appropriate safety measures, monitoring, training, and training verification programs.
- Measures to eliminate and control hazards from known and suspected biological agents at the place of work should be designed, implemented and maintained in close co-operation with the local health authorities and according to recognized international standards.

Biological agents should be classified into four groups:

- ***Group 1:*** Biological agents unlikely to cause human disease, and consequently only require controls similar to those required for hazardous or reactive chemical substances;
- ***Group 2:*** Biological agents that can cause human disease and are thereby likely to require additional controls, but are unlikely to spread to the community;
- ***Group 3***: Biological agents that can cause severe human disease, present a serious hazard to workers, and may present a risk of spreading to the community, for which there usually is effective prophylaxis or treatment available and are thereby likely to require extensive additional controls;
- ***Group 4:*** Biological agents that can cause severe human disease, are a serious hazard to workers, and present a high risk of spreading to the community, for which there is usually no effective prophylaxis or treatment available and are thereby likely to require very extensive additional controls.

The employer should at all times encourage and enforce the highest level of hygiene and personal protection, especially for activities employing biological agents of Groups 3 and 4 above. Work involving agents in Groups 3 and 4 shall be restricted only to those persons who have received specific verifiable training in working with and controlling such materials.

Areas used for the handling of Groups 3 and 4 biological agents should be designed to enable their full segregation and isolation in emergency circumstances, include independent ventilation systems, and be subject to SOPs requiring routine disinfection and sterilization of the work surfaces.

HVAC systems serving areas handling Groups 3 and 4 biological agents should be equipped with High Efficiency Particulate Air (HEPA) filtration systems. Equipment should readily enable their disinfection and sterilization, and maintained and operated so as to prevent growth and spreading of disease agents, amplification of the biological agents, or breeding of vectors e.g. mosquitoes and flies of public health concern.

Table 2.6.1. Acceptable Effective Dose Limits for Workplace Radiological Hazards

Exposure	Workers (min.19 years of age)	Apprentices and students (16-18 years of age)
Five consecutive year average – effective dose	20 mSv/year	
Single year exposure – effective dose	50 mSv/year	6 mSv/year
Equivalent dose to the lens of the eye	150 mSv/year	50 mSv/year
Equivalent dose to the extremities (hands, feet) or the skin	500 mSv/year	150 mSv/year

2.6 Radiological Hazards

Radiation exposure can lead to potential discomfort, injury or serious illness to workers. Prevention and control strategies include:

- Places of work involving occupational and/or natural exposure to ionizing radiation should be established and operated in accordance with recognized international safety standards and guidelines.[47] The acceptable effective dose limits appear Table 2.6.1.
- Exposure to non-ionizing radiation (including static magnetic fields; sub-radio frequency magnetic fields; static electric fields; radio frequency and microwave radiation; light and

[47] International Basic Safety Standard for protection against Ionizing Radiation and for the Safety of Radiation Sources and its three interrelated Safety Guides. IAEA. http://www-ns.iaea.org/standards/documents/default.asp?sub=160 and its three interrelated Safety Guides.

near-infrared radiation; and ultraviolet radiation) should be controlled to limits recommended by the ACGIH[48].

- In the case of both ionizing and non-ionizing radiation, the preferred method for controlling exposure is shielding and limiting the radiation source. Personal protective equipment is supplemental only or for emergency use. Personal protective equipment for near-infrared, visible and ultraviolet range radiation can include appropriate sun block creams, with or without appropriate screening clothing.

2.7 Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) provides additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems.

PPE is considered to be a last resort that is above and beyond the other facility controls and provides the worker with an extra level of personal protection. Table 2.7.1 presents general examples of occupational hazards and types of PPE available for different purposes. Appropriate measures for use of PPE in the workplace include:

- Active use of PPE if alternative technologies, work plans or procedures cannot eliminate, or sufficiently reduce, a hazard or exposure
- Identification and provision of appropriate PPE that offers adequate protection to the worker, co-workers, and occasional visitors, without incurring unnecessary inconvenience to the individual
- Proper maintenance of PPE, including cleaning when dirty and replacement when damaged or worn out. Proper use of PPE should be part of the recurrent training programs for employees

Table 2.7.1. Summary of Recommended Personal Protective Equipment According to Hazard

Objective	Workplace Hazards	Suggested PPE
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation.	Safety Glasses with side-shields, protective shades, etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords.	Plastic Helmets with top and side impact protection.
Hearing protection	Noise, ultra-sound.	Hearing protectors (ear plugs or ear muffs).
Foot protection	Falling or rolling objects, pointed objects. Corrosive or hot liquids.	Safety shoes and boots for protection against moving & falling objects, liquids and chemicals.
Hand protection	Hazardous materials, cuts or lacerations, vibrations, extreme temperatures.	Gloves made of rubber or synthetic materials (Neoprene), leather, steel, insulating materials, etc.
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapours.	Facemasks with appropriate filters for dust removal and air purification (chemicals, mists, vapours and gases). Single or multi-gas personal monitors, if available.
	Oxygen deficiency	Portable or supplied air (fixed lines). On-site rescue equipment.
Body/leg protection	Extreme temperatures, hazardous materials, biological agents, cutting and laceration.	Insulating clothing, body suits, aprons etc. of appropriate materials.

- Selection of PPE should be based on the hazard and risk ranking described earlier in this section, and selected according to criteria on performance and testing established by recognized organizations[49].

[48] ACGIH, 2005.

[49] American National Standards Institute (ANSI), http://www.ansi.org/; National Institute for Occupational Safety and Health[49] (NIOSH),

2.8 Special Hazard Environments

Special hazard environments are work situations where all of the previously described hazards may exist under unique or especially hazardous circumstances. Accordingly, extra precautions or rigor in application of precautions is required.

Confined Space

A confined space is defined as a wholly or partially enclosed space not designed or intended for human occupancy and in which a hazardous atmosphere could develop as a result of the contents, location or construction of the confined space or due to work done in or around the confined space. Confined spaces can occur in enclosed or open structures or locations. Serious injury or fatality can result from inadequate preparation to enter a confined space or in attempting a rescue from a confined space.

- Engineering measures should be implemented to eliminate, to the degree feasible, the existence and adverse character of confined spaces. Unavoidable confined spaces should be provided with permanent safety measures for venting, monitoring, and rescue operations, to the extent possible. The area adjoining an access to a confined space should provide ample room for emergency and rescue operations.
- Prior to entry into a confined space:
  - Process or feed lines into the space should be disconnected or drained, and blanked and locked-out.
  - Mechanical equipment in the space should be disconnected, de-energized, locked-out, and braced, as appropriate.
  - The atmosphere within the confined space should be tested to assure the oxygen content is between 19.5 precent and 23 percent, and that the presence of any flammable gas or vapor does not exceed 25 percent of its respective Lower Explosive Limit (LEL).
  - If the atmospheric conditions are not met, the confined space must be ventilated until the target safe atmosphere is achieved, or entry is only to be undertaken with appropriate and additional PPE.
- Safety precautions should include Self Contained Breathing Apparatus (SCBA), life lines, and safety watch workers stationed outside the confined space, with rescue and first aid equipment readily available.
- Before workers are required to enter a confined space, adequate and appropriate training in confined space hazard control, atmospheric testing, use of the necessary PPE, as well as the serviceability and integrity of the PPE should be verified. Further, adequate and appropriate rescue and / or recovery plans and equipment should be in place before the worker enters the confined space.

Lone and Isolated Workers

A lone and isolated worker is a worker out of verbal and line of sight communication with a supervisor, other workers, or other persons capable of providing aid and assistance, for continuous periods exceeding one hour. The worker is therefore at increased risk should an accident or injury occur.

- Where workers may be required to perform work under lone or isolated circumstances, Standard Operating Procedures (SOPs) should be developed and implemented to ensure all PPE and safety measures are in place before the worker starts work. SOPs should establish, at a minimum, verbal contact with the worker at least once every hour, and ensure the worker has a capability for summoning emergency aid.
- If the worker is potentially exposed to highly toxic or corrosive chemicals, emergency eye-wash and shower facilities should

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http://www.cdc.gov/niosh/homepage.html; Canadian Standards Association[49] (CSA), http://www.csa.ca/Default.asp?language=english; Mine Safety and Health Administration[49] (MSHA), http://www.msha.gov.

be equipped with audible and visible alarms to summon aid whenever the eye-wash or shower is activated by the worker and without intervention by the worker.

2.9 Construction and Decommissioning

Applicability and Approach

This section provides additional, specific guidance on prevention and control of environmental impacts which are most common during construction or decommissioning activities. Construction and decommissioning activities may occur during new project development, at the end of the project life-cycle, or due to expansion or modification of existing project facilities.

Construction and decommissioning sites provide potentially significant occupational hazards due to the dynamic conditions of the workplace. Significant occupational health and safety hazards during construction and decommissioning are often similar. However, decommissioning may also involve potential exposure to hazardous materials and wastes present in structural components or accumulated during operational activities.

Over-exertion

Over-exertion, and ergonomic injuries and illnesses, such as repetitive motion, over-exertion, and manual handling, are among the most common causes of lost time in construction and decommissioning sites. Recommendations for their prevention and control include:

- Training of workers in lifting and materials handling techniques in construction and decommissioning projects, including the placement of weight limits above which mechanical assists or two-person lifts are necessary
- Planning work site layout to minimize the need for manual transfer of heavy loads
- Selecting tools and designing work stations that reduce force requirements and holding times, and which promote improved postures, including, where applicable, user adjustable work stations
- Implementing administrative controls into work processes, such as job rotations and rest or stretch breaks

Work in Heights

Falls from elevation associated with working with ladders, scaffolding, and partially built or demolished structures are among the most common cause of fatal or permanent disabling injury at construction or decommissioning sites. If fall hazards exist, a fall protection plan should be in place which includes one or more of the following aspects, depending on the nature of the fall hazard[50]:

- Training and use of temporary fall prevention devices, such as rails or other barriers able to support a weight of 200 pounds, when working at heights equal or greater than two meters or at any height if the risk includes falling into operating machinery, into water or other liquid, into hazardous substances, or through an opening in a work surface
- Training and use of personal fall arrest systems, such as full body harnesses and energy absorbing lanyards able to support 5000 pounds (also described in this section in Working at Heights above), as well as fall rescue procedures to deal with workers whose fall has been successfully arrested. The tie in point of the fall arresting system should also be able to support 5000 pounds
- Use of control zones and safety monitoring systems to warn workers of their proximity to fall hazard zones, as well as

[50] Additional information on identification of fall hazards and design of protection systems can be found in the United States Occupational Health and Safety Administration's (US OSHA) web site: http://www.osha.gov/SLTC/fallprotection/index.html

securing, marking, and labeling covers for openings in floors, roofs, or walking surfaces

Slips and Falls

Slips and falls on the same elevation associated with poor housekeeping, such as excessive waste debris, loose construction materials, liquid spills, and uncontrolled use of electrical cords and ropes on the ground, are also among the most frequent cause of lost time accidents at construction and decommissioning sites. Recommended methods for the prevention of slips and falls from, or on, the same elevation include:

- Implementing good house-keeping practices, such as the sorting and placing loose construction materials or demolition debris in established areas away from foot paths
- Cleaning up excessive waste debris and liquid spills regularly
- Locating electrical cords and ropes in common areas and marked corridors

Struck By Objects

Construction and demolition activities may pose significant hazards related to the potential fall of materials or tools, as well as ejection of solid particles from abrasive or other types of power tools which can result in injury to the head, eyes, and extremities. Techniques for the prevention and control of these hazards include:

- Using a designated and restricted waste drop or discharge zones, and/or a chute for safe movement of wastes from upper to lower levels
- Conducting sawing, cutting, grinding, sanding, chipping or chiseling with proper guards and anchoring as applicable
- Maintaining clear traffic ways to avoid driving of heavy equipment over loose scrap
- Use of temporary fall protection measures in scaffolds and out edges of elevated work surfaces, such as hand rails and toe boards to prevent materials from being dislodged
- Evacuating work areas during blasting operations, and using blast mats or other means of deflection to minimize fly rock or ejection of demolition debris if work is conducted in proximity to people or structures
- Wearing appropriate PPE, such as safety glasses with side shields, face shields, hard hats, and safety shoes

Moving Machinery

Vehicle traffic and use of lifting equipment in the movement of machinery and materials on a construction site may pose temporary hazards, such as physical contact, spills, dust, emissions, and noise. Heavy equipment operators have limited fields of view close to their equipment and may not see pedestrians close to the vehicle. Center-articulated vehicles create a significant impact or crush hazard zone on the outboard side of a turn while moving. Techniques for the prevention and control of these impacts include:

- Planning and segregating the location of vehicle traffic, machine operation, and walking areas, and controlling vehicle traffic through the use of one-way traffic routes, establishment of speed limits, and on-site trained flag-people wearing high-visibility vests or outer clothing covering to direct traffic
- Ensuring the visibility of personnel through their use of high visibility vests when working in or walking through heavy equipment operating areas, and training of workers to verify eye contact with equipment operators before approaching the operating vehicle
- Ensuring moving equipment is outfitted with audible back-up alarms

- Using inspected and well-maintained lifting devices that are appropriate for the load, such as cranes, and securing loads when lifting them to higher job-site elevations.

Dust

- Dust suppression techniques should be implemented, such as applying water or non-toxic chemicals to minimize dust from vehicle movements
- PPE, such as dusk masks, should be used where dust levels are excessive

Confined Spaces and Excavations

Confined spaces are locations not meant for human habitation, with limited means of access and egress, which can result in physical entrapment or compromised air quality. Examples of confined spaces that may be present in construction or demolition sites include: silos, vats, hoppers, utility vaults, tanks, sewers, pipes, and access shafts. Ditches and trenches may also be considered a confined space when access or egress is limited[51]. Occupational hazards associated with confined spaces and excavations in construction and decommissioning sites should be prevented according to the following recommendations:

- Institution of a permit-based confined space entry program that includes training of all workers in recognition of the confined space, restricted access to essential and trained workers, explicit authorization by supervisors for entry of properly trained workers, pre-entry and periodic air quality testing (including for oxygen atmospheres), installation of ventilation or air supplies when needed, and a rescue plan with properly equipped and trained personnel.
- Controlling site-specific factors which may contribute to excavation slope instability including, for example, the use of excavation dewatering, side-walls support, and slope gradient adjustments that eliminate or minimize the risk of collapse, entrapment, or drowning
- Providing safe means of access and egress from excavations, such as graded slopes, graded access route, or stairs and ladders
- Avoiding the operation of combustion equipment for prolonged periods inside excavations areas where other workers are required to enter

Other Site Hazards

Construction and decommissioning sites may pose a risk of exposure to dust, chemicals, hazardous or flammable materials, and wastes in a combination of liquid, solid, or gaseous forms, which should be prevented through the implementation of project-specific plans and other applicable management practices, including:

- Use of specialized trained personnel to identify and remove waste materials from tanks, vessels, processing equipment or contaminated land as a first step in decommissioning activities to allow for safe excavation, construction, dismantling or demolition
- Use of specialized trained personnel to identify and selectively remove potentially hazardous materials in building elements, including insulation or structural elements containing asbestos and Polychlorinated Biphenyls (PCBs), electrical components containing mercury, prior to dismantling or demolition[52]
- Use of waste-specific PPE based on the results of an occupational health and safety assessment, including respirators, clothing/protective suits, gloves and eye protection

[51] Canadian Center for Occupational Health and safety http://www.ccohs.ca/oshanswers/hsprograms/confinedspace_intro.html

[52] Additional information on the management and removal of asbestos containing building materials can be found in ASTM Standard E2356 and E1368 [note to Golder to find and complete these references]

2.10 Monitoring

Occupational health and safety monitoring programs should verify the effectiveness of prevention and control strategies. The selected indicators should be representative of the most significant occupational, health, and safety hazards, and the implementation of prevention and control strategies. The occupational health and safety monitoring program should include:

- *Safety inspection, testing and calibration:* This should include regular inspection and testing of all safety features and hazard control measures focusing on engineering and personal protective features, work procedures, places of work, installations, equipment, and tools used. The inspection should verify that issued PPE continues to provide adequate protection and is being worn as required. All instruments installed or used for monitoring and recording of working environment parameters should be regularly tested and calibrated, and the respective records maintained.

- *Surveillance of the working environment:* Employers should document compliance using an appropriate combination of portable and stationary sampling and monitoring instruments. Monitoring and analyses should be conducted according to internationally recognized methods and standards. Monitoring methodology, locations, frequencies, and parameters should be established individually for each project following a review of the hazards. Generally, monitoring should be performed during commissioning of facilities or equipment and at the end of the defect and liability period, and otherwise repeated according to the monitoring plan.

- *Surveillance of workers health:* When extraordinary protective measures are required (for example, against biological agents Groups 3 and 4, and/or hazardous compounds), workers should be provided appropriate and relevant health surveillance prior to first exposure, and at regular intervals thereafter. The surveillance should, if deemed necessary, be continued after termination of the employment.

- *Training:* Training activities for employees and visitors should be adequately monitored and documented (curriculum, duration, and participants). Emergency exercises, including fire drills, should be documented adequately. Service providers and contractors should be contractually required to submit to the employer adequate training documentation before start of their assignment.

Accidents and Diseases monitoring

- The employer should establish procedures and systems for reporting and recording:
  - Occupational accidents and diseases
  - Dangerous occurrences and incidents

  These systems must enable workers to report immediately to their immediate supervisor any situation they believe presents a serious danger to life or health.

- The systems and the employer should further enable and encourage workers to report all:
  - Occupational injuries and near misses
  - Suspected cases of occupational disease
  - Dangerous occurrences and incidents
- All reported occupational accidents, occupational diseases, dangerous occurrences, and incidents together with near misses must be investigated with the assistance of a competent person. The investigation should:
  - Establish what happened
  - Determine the cause of what happened
  - Identify measures necessary to prevent a recurrence
- Occupational accidents and diseases should, at a minimum, be classified according to Table 2.9.1. Distinction is made

between fatal and non-fatal injuries. The two main categories are divided into three sub-categories according to time of death or duration of the incapacity to work. The total number of man-days and hours worked during the reporting period must be stated.

Table 2.9.1. Occupational Accident and Disease Reporting

a. Fatalities (number)	**b. Non-fatal injuries** (number) [53]	**c. Total time lost** non-fatal injuries (days)
a.1 Immediate	**b.1** Less than one day	
a.2 Within a month	**b.2** Up to 3 days	**c.1** Category b.2
a.3 Within a year	**b.3** More than 3 days	**c.2** Category b.3

[53] The day on which an incident occurs is not included in b.2 and b.3.

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This section complements the guidance provided in the preceding environmental and occupational health and safety sections, specifically addressing some aspects of project activities taking place outside of the traditional project boundaries, but nonetheless related to the project operations, as may be applicable on a project basis. These issues may arise at any stage of a project life cycle.

3.1 Water Quality and Availability

Groundwater and surface water represent essential sources of drinking and irrigation water in developing countries, particularly in rural areas where piped water supply may be limited or unavailable and where available resources are collected by the consumer with little or no treatment. Project activities involving wastewater discharges, water extraction, diversion or impoundment should prevent adverse impacts to the quality and availability of groundwater and surface water resources.

Water Quality

Drinking water sources, whether public or private, should at all times be protected so that they meet or exceed applicable national acceptability standards and the current edition of WHO Guidelines for Drinking-Water Quality. Air emissions, wastewater effluents, oil and hazardous materials, and wastes should be managed according to the guidance provided in the respective sections of the General EHS Guidelines with the objective of protecting soil and water resources.

Where the project includes the delivery of water to the community or to users of facility infrastructure (such as hotel hosts and hospital patients), where water may be used for drinking, cooking, washing, and bathing, water quality should be consistent with WHO Drinking Water Guidelines. Water quality for more sensitive well-being-related demands such as water used in health care facilities or food production may require more stringent, industry-specific guidelines or standards, as applicable.

Water Availability

The potential effect of groundwater or surface water abstraction for project activities should be properly assessed through a combination of field testing and modeling techniques, accounting for seasonal variability and projected changes in demand in the project area.

Project activities should not compromise the availability of water for personal hygiene needs and should take account of potential future increases in demand. The overall target should be the availability of 100 liters per person per day although lower levels may be used to meet basic health requirements.[54] Water volume requirements for well-being-related demands such as water use in health care facilities may need to be higher.

3.2 Structural Safety of Project Infrastructure

Hazards posed to the public while accessing project facilities may include:

- Physical trauma associated with failure of building structures
- Burns and smoke inhalation from fires
- Injuries suffered as a consequence of falls or contact with heavy equipment
- Respiratory distress from dust, fumes, or noxious odors
- Exposure to hazardous materials

Reduction of potential hazards is best accomplished during the design phase when the structural design, layout and site modifications can be adapted more easily. The following issues should be considered and incorporated into the planning, siting, and design phases of a project:

- Inclusion of buffer strips or other methods of physical separation around project sites to protect the public from major hazards associated with hazardous materials incidents or process failure, as well as nuisance issues related to noise, odors, or other emissions
- Incorporation of siting and safety engineering criteria to prevent failures due to natural risks posed by earthquakes, tsunamis, wind, flooding, landslides and fire. To this end, all project structures should be designed in accordance with engineering and design criteria mandated by site-specific risks, including but not limited to seismic activity, slope stability, wind loading, and other dynamic loads
- Application of locally regulated or internationally recognized building codes[55] to ensure structures are designed and constructed in accordance with sound architectural and engineering practice, including aspects of fire prevention and response
- Engineers and architects responsible for designing and constructing facilities, building, plants and other structures should certify the applicability and appropriateness of the structural criteria employed.

International codes, such as those compiled by the International Code Council (ICC)[56], are intended to regulate the design, construction, and maintenance of a built environment and contain detailed guidance on all aspects of building safety, encompassing methodology, best practices, and documenting compliance. Depending on the nature of a project, guidance provided in the ICC or comparable codes should be followed, as appropriate, with respect to:

- Existing structures

[54] World Health Organization (WHO) defines 100 liters/capita/day as the amount required to meet all consumption and hygiene needs. Additional information on lower service levels and potential impacts on health are described in "Domestic Water Quantity, Service Level and Health" 2003. http://www.who.int/water_sanitation_health/diseases/wsh0302/en/index.html

[55] ILO-OSH, 2001. http://www.ilo.org/public/english/protection/safework/cops/english/download/e000013.pdf

[56] ICC, 2006.

- Soils and foundations
- Site grading
- Structural design
- Specific requirements based on intended use and occupancy
- Accessibility and means of egress
- Types of construction
- Roof design and construction
- Fire-resistant construction
- Flood-resistant construction
- Construction materials
- Interior environment
- Mechanical, plumbing and electrical systems
- Elevators and conveying systems
- Fire safety systems
- Safeguards during construction
- Encroachments into public right-of-way

Although major design changes may not be feasible during the operation phase of a project, hazard analysis can be undertaken to identify opportunities to reduce the consequences of a failure or accident. Illustrative management actions, applicable to hazardous materials storage and use, include:

- Reducing inventories of hazardous materials through inventory management and process changes to greatly reduce or eliminate the potential off-site consequences of a release
- Modifying process or storage conditions to reduce the potential consequences of an accidental off-site release
- Improving shut-down and secondary containment to reduce the amount of material escaping from containment and to reduce the release duration
- Reducing the probability that releases will occur through improved site operations and control, and through improvements in maintenance and inspection
- Reducing off-site impacts of releases through measures intended to contain explosions and fires, alert the public, provide for evacuation of surrounding areas, establish safety zones around a site, and ensure the provision of emergency medical services to the public

3.3 Life and Fire Safety (L&FS)

Applicability and Approach

All new buildings accessible to the public and financed by IFC should be designed, constructed, and operated in full compliance with local building codes, local fire department regulations, local legal/insurance requirements, and in accordance with an internationally acceptable life and fire safety (L&FS) standard. There are diverse international L&FS codes and standards acceptable to IFC. The Life Safety Code[57], which provides extensive documentation on life and fire safety provisions, is one example and may be used to document compliance with IFC Life and Fire Safety objectives. With regard to these objectives:

- Project sponsors' architects and professional consulting engineers should demonstrate that affected buildings meet these life and fire safety objectives.
- Life and fire safety systems and equipment should be designed and installed using appropriate prescriptive standards and/or performance based design, and sound engineering practices.
- Life and fire safety design criteria for all existing buildings must incorporate all local building codes and fire department regulations.

These guidelines apply to all IFC-financed buildings that are accessible to the public. Examples of such buildings include:

[57] US NFPA. http://www.nfpa.org/catalog/product.asp?category%5Fname=&pid=10106&target%5Fpid=10106&src%5Fpid=&link%5Ftype=search

- Health and education facilities
- Hotels, convention centers, and leisure facilities
- Retail and commercial facilities
- Airports, other public transport terminals, transfer facilities
- Any other project, upon request from IFC's Investment Officer or IFC management

Specific Requirements for New Buildings

The nature and extent of life and fire safety systems required will depend on the building type, structure, construction, occupancy, and exposures. Sponsors should prepare a Life and Fire Safety Master Plan identifying major fire risks, applicable codes, standards and regulations, and mitigation measures. The Master Plan should be prepared by a suitably qualified professional acceptable to IFC, and adequately cover, but not be limited to, the issues addressed briefly in the following points. The suitably qualified professional selected to prepare the Master Plan is responsible for a detailed treatment of the following illustrative, and all other required, issues.

Fire Prevention

Fire prevention addresses the identification of fire risks and ignition sources, and measures needed to limit fast fire and smoke development. These issues include:

- Fuel load and control of combustibles
- Ignition sources
- Interior finish flame spread characteristics
- Interior finish smoke production characteristics
- Human acts, and housekeeping and maintenance

Means of Egress

Means of Egress includes all design measures that facilitate a safe evacuation by residents and/or occupants in case of fire or other emergency, such as:

- Clear, unimpeded escape routes
- Accessibility to the impaired/handicapped
- Marking and signing
- Emergency lighting

Detection and Alarm Systems

These systems encompass all measures, including communication and public address systems needed to detect a fire and alert:

- Building staff
- Emergency response teams
- Occupants
- Civil defense

Compartmentation

Compartmentation involves all measures to prevent or slow the spread of fire and smoke, including:

- Separations
- Fire walls
- Floors
- Doors
- Dampers
- Smoke control systems

Fire Suppression and Control

Fire suppression and control includes all automatic and manual fire protection installations, such as:

- Automatic sprinkler systems

- Manual portable extinguishers
- Fire hose reels

Emergency Response Plan

An Emergency Response Plan is a set of scenario–based procedures to assist staff and emergency response teams during real life emergency and training exercises. This chapter of the Fire and Life Safety Master Plan should include an assessment of local fire prevention and suppression capabilities.

Operation and Maintenance

Operation and Maintenance involves preparing schedules for mandatory regular maintenance and testing of life and fire safety features to ensure that mechanical, electrical, and civil structures and systems are at all times in conformance with life and fire safety design criteria and required operational readiness.

L&FS Master Plan Review and Approval

- A suitably qualified professional acceptable to IFC will submit the Life and Fire Safety (L&FS) Master Plan, including preliminary drawings and specifications, and certify to IFC and to the project sponsor that the design meets the requirements of these L&FS guidelines. The findings and recommendations of the review will be used as the basis for acceptance by IFC, or used to establish the conditions of a Corrective Action Plan and a mutually acceptable time frame for implementing the changes.
- The suitably qualified professional acceptable to IFC will conduct a review as part of the project completion test at the time of life and fire safety systems testing and commissioning, and certify to IFC and to the project sponsor that construction of these systems has been carried out in accordance with the accepted design. The findings and recommendations of the review will be used as the basis for establishing project completion or to establish the conditions of a Pre-Completion Corrective Action Plan and a mutually acceptable time frame for implementing the changes.

Specific Requirements for Existing Buildings

- All life and fire safety guideline requirements for new buildings apply to existing buildings programmed for renovation. A suitably qualified professional acceptable to IFC will conduct a complete life and fire safety review of existing buildings slated for renovation. The findings and recommendations of the review will be used as the basis to establish the scope of work of a Corrective Action Plan and a mutually acceptable time frame for implementing the changes.
- If it becomes apparent to IFC that life and fire safety conditions are deficient in an existing building that is not part of the IFC project or that has not been programmed for renovation, IFC may request a life and fire safety review of the building by a suitably qualified professional acceptable to IFC. The findings and recommendations of the review will be used as the basis to establish the scope of work of a Corrective Action Plan and a mutually acceptable time frame for implementing the changes.

Other Hazards

- Facilities, buildings, plants, and structures should be situated to minimize potential risks from forces of nature (e.g. earthquakes, tsunamis, floods, windstorms, and fires from surrounding areas).
- All such structures must be designed in accordance with the criteria mandated by situation-, climatic-, and geology-specific location risks (e.g. seismic activity, wind loading, and other dynamic loads).

- Structural engineers and architects responsible for facilities, buildings, plants and structures must certify the applicability and appropriateness of the design criteria employed.
- National or regional building regulations typically contain fire safety codes and standards[58] or these standards are found in separate Fire Codes.[59,60] Generally, such codes and regulations incorporate further compliance requirements with respect to methodology, practice, testing, and other codes and standards[61]. Such nationally referenced material constitutes the acceptable fire life safety code.

3.3 Traffic Safety

Traffic accidents have become one of the most significant causes of injuries and fatalities among members of the public worldwide. Traffic safety should be promoted by all project personnel during displacement to and from the workplace, and during operation of project equipment on private or public roads. Prevention and control of traffic related injuries and fatalities should include the adoption of safety measures that are protective of project workers and of road users, including those who are most vulnerable to road traffic accidents[62]. Road safety initiatives proportional to the scope and nature of project activities should include:

- Adoption of best transport safety practices across all aspects of project operations with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public. Measures should include:
    - Emphasizing safety aspects among drivers
    - Improving driving skills and requiring licensing of drivers
    - Adopting limits for trip duration and arranging driver rosters to avoid overtiredness
    - Avoiding dangerous routes and times of day to reduce the risk of accidents
    - Use of speed control devices (governors) on trucks, and remote monitoring of driver actions
- Procurement of vehicles with design features, such as deformable bumpers and deflectable mirrors, to minimize harm to pedestrians and other road users in case of collisions. Additional desirable features in modern vehicles include daytime running lights to increase vehicle visibility; fuel cells to minimize fire and leakage of hazardous materials from collisions; and better egress for rescue of injured occupants.
- Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or premature failure.

Where the project may contribute to a significant increase in traffic along existing roads, or where road transport is a significant component of a project, appropriate measures should include:

- Collaboration with local communities and responsible authorities to improve signage, visibility and overall safety of roads, particularly along stretches located near schools or other locations where children may be present[63]
- Coordination with emergency responders to ensure that appropriate first aid is provided in the event of accidents

3.4 Transport of Hazardous Materials

General Hazardous Materials Transport

- Projects should have procedures in place that ensure compliance with international requirements applicable to the

58 For example, Australia, Canada, South Africa, United Kingdom
59 Réglementation Incendie [des ERP]
60 USA NFPA, 2006.
61 Prepared by National Institutes and Authorities such as ASTM, BS, DIN, and NF
62 Additional information on vulnerable users of public roads in developing countries is provided by Peden et al., 2004.
63 Additional sources of information for implementation of road safety measures is available at WHO, 1989, Carson and Hedman, 1990, Ross et al., 1991, Tsunokawa and Hoban, 1997, and OECD, 1999

transport of hazardous materials, regardless of the quantities transported, including:

- IATA requirements[64] for air transport
- IMDG Code[65] sea transport
- UN Model Regulations[66] of other international standards as well as local requirements for land transport

- The procedures for transportation of hazardous materials (Hazmats) should include:
  - Proper labeling of containers, including the identify and quantity of the contents, hazards, and shipper contact information
  - Ensuring that the volume, nature, integrity and protection of packaging and containers used for transport are appropriate for the type and quantity of hazardous material and modes of transport involved
  - Ensuring adequate transport vehicle specifications
  - Training employees involved in the transportation of hazardous materials regarding proper shipping procedures and emergency procedures
  - Using labeling and placarding (external signs on transport vehicles), as required
  - Providing the necessary means for emergency response on call 24 hours/day

Major Transportation Hazards

Guidance related to major transportation hazards should be implemented in addition to measures presented in the preceding section for preventing or minimizing the consequences of catastrophic releases of hazardous materials, which may result in toxic, fire, explosion, or other hazards during transportation.

In addition to these aforementioned procedures, projects which transport hazardous materials *at or above the threshold quantities*[67] should prepare a Hazardous Materials Transportation Plan containing all of the elements presented below[68].

Hazard Assessment

The hazard assessment should identify the potential hazard involved in the transportation of hazardous materials by reviewing:

- The hazard characteristics of the substances identified during the screening stage
- The history of accidents, both by the company and its contractors, involving hazardous materials transportation
- The existing criteria for the safe transportation of hazardous materials, including environmental management systems used by the company and its contractors

This review should cover the management actions, preventive measures and emergency response procedures described below. The hazard assessment helps to determine what additional measures may be required to complete the plan.

Management Actions

- *Management of Change:* These procedures should address:
  - The technical basis for changes in hazardous materials offered for transportation, routes and/or procedures
  - The potential impact of changes on health and safety
  - Modification required to operating procedures
  - Authorization requirements
  - Employees affected
  - Training needs

64 IATA, 2005. www.iata.org
65 IMO. www.imo.org/safety
66 United Nations. Transport of Dangerous Goods - Model Regulations. 14th Revised Edition. Geneva 2005. http://www.unece.org/trans/danger/publi/unrec/rev14/14files_e.html
67 Threshold quantities for the transport of hazardous materials are found in the UN – Transport of Dangerous Goods – Model Regulations cited above.
68 For further information and guidance, please refer to International Finance Corporation (IFC) Hazardous Materials Transportation Manual. Washington, D.C. December 2000.

- *Compliance Audit:* A compliance audit evaluates compliance with prevention requirements for each transportation route or for each hazardous material, as appropriate. A compliance audit covering each element of the prevention measures (see below) should be conducted at least every three years. The audit program should include:
  - Preparation of a report of the findings
  - Determination and documentation of the appropriate response to each finding
  - Documentation that any deficiency has been corrected.
- *Incident Investigation:* Incidents can provide valuable information about transportation hazards and the steps needed to prevent accidental releases. The implementation of incident investigation procedures should ensure that:
  - Investigations are initiated promptly
  - Summaries of investigations are included in a report
  - Report findings and recommendations are addressed
  - Reports are reviewed with staff and contractors
- *Employee Participation:* There should be a written plan of action regarding the implementation of active employee participation in the prevention of accidents be developed.
- *Contractors:* The plan should include procedures to ensure that:
  - The contractor is provided with safety performance procedures and safety and hazard information
  - Contractors observe safety practices
  - Verify that the contractor acts responsibly

  The plan should also include additional procedures to ensure the contractors will:
  - Ensure appropriate training for their employees
  - Ensure their employees know process hazards and applicable emergency actions
  - Prepare and submit training records
  - Inform employees about the hazards presented by their work
- *Training:* Good training programs on operating procedures will provide the employees with the necessary information to understand how to operate safely and why safe operations are needed. The training program should include:
  - The list of employees to be trained
  - Specific training objectives
  - Mechanisms to achieve objectives (i.e. hands-on workshops, videos, etc.)
  - Means to determine the effectiveness of the training program
  - Training procedures for new hires and refresher programs

Preventive Measures

The plan should include procedures to implement preventive measures specific to each hazardous material offered for transportation, including:

- Classification and segregation of hazardous materials in warehouses and transport units
- Packaging and packaging testing
- Marking and labeling of packages containing hazardous materials
- Handling and securing packages containing hazardous materials in transport units
- Marking and placarding of transport units
- Documentation (e.g. bills of lading)
- Application of special provisions, as appropriate

Emergency Preparedness and Response

It is important to develop procedures and practices for the handling of hazardous materials that allow for quick and efficient responses to accidents that may result in injury or environmental damage. The sponsor should prepare an Emergency Preparedness and Response Plan that should cover:

- *Planning Coordination:* This should include procedures for:
  - Informing the public and emergency response agencies
  - Documenting first aid and emergency medical treatment
  - Taking emergency response actions
  - Reviewing and updating the emergency response plan to reflect changes and ensuring that the employees are informed of such changes
- *Emergency Equipment:* The plan should include procedures for using, inspecting, testing, and maintaining emergency response equipment.
- *Training:* Employees should be trained in any relevant procedures

3.5 Disease Prevention

In addition to construction phase disease prevention measures, long-term interventions can minimize the incidence and prevalence of communicable diseases during project operations. Good international industry practice for solid waste management, water drainage, and sanitary wastewater management are effective in reducing communicable diseases. Uninformed social interaction among project personnel and local community residents can lead to increased incidence of sexually transmitted diseases (STDs).

Recommended interventions at the project level include:

- Adopting best practices to prevent or minimize the potential for project activities to contribute to increases in communicable diseases
- Providing health services to workers and their families
- Collaborating with local authorities to enhance public health

Typical measures undertaken to reduce communicable disease incidence involve[69]:

- Providing surveillance and thorough treatment of workers and their families
- Preventing illness among workers and their families and in local communities by:
  - Undertaking health awareness and education initiatives
  - Training health workers in disease treatment
  - Conducting immunization programs in local communities to improve health and guard against infection
- Providing treatment through standard case management in on-site or community health care facilities.

Long-term control of STDs among permanent workers and in local communities is best achieved through interventions that reinforce measures already implemented during the project construction phase. STDs are a major cause of acute and chronic illness and disability. HIV/AIDS, in particular, is a major cause of death. Prevention and treatment of STDs should be a core component of health service delivery.

Reducing the impact of vector-borne disease on the long-term health of workers and in local communities is best accomplished through implementation of diverse interventions aimed at eliminating the factors that lead to disease. Project sponsors, in close collaboration with community health authorities, can implement an integrated control strategy for mosquito and other arthropod-borne diseases that might involve:

- Prevention of larval and adult propagation through sanitary improvements and elimination of breeding habitats close to human settlements
- Elimination of unusable impounded water
- Increase in water velocity in natural and artificial channels

[69] Additional sources of information on disease prevention include IFC, 2006; UNDP, 2000, 2003; Walley et al., 2000; Kindhauser, 2003; Heymann, 2004.

- Application of residual insecticide to dormitory walls
- Implementation of integrated vector control programs
- Use of chemoprophylaxis drugs to eradicate disease reservoirs
- Promoting use of repellents, clothing, netting, and other barriers to prevent insect bites
- Monitoring and treatment of circulating and migrating populations to prevent disease reservoir spread
- Collaboration and exchange of in-kind services with other control programs in the project area to maximize beneficial effects
- Educating project personnel and area residents on risks, prevention, and available treatment
- Monitoring communities during high-risk seasons to detect and treat cases
- Distributing appropriate education materials

3.6 Emergency Preparedness and Response

An emergency is an unplanned event when a project operation loses control, or could lose control, of a situation that may result in risks to human health, property, or the environment, either within the facility or in the local community. Emergencies do not normally include safe work practices for frequent upsets or events that are covered by occupational health and safety.

All projects should have an Emergency Preparedness and Response Plan that is commensurate with the risks of the facility and that includes the following basic elements:

- Administration (policy, purpose, distribution, definitions, etc)
- Organization of emergency areas (command centers, medical stations, etc)
- Roles and responsibilities
- Communication systems
- Emergency response procedures
- Emergency resources
- Training and updating
- Checklists (role and action list and equipment checklist)
- Business Continuity and Contingency

Additional information is provided for key components of the emergency plan, as follows below.

Communication Systems

Worker notification and communication

Alarm bells, visual alarms, or other forms of communication should be used to reliably alert workers to an emergency. Related measures include:

- Testing warning systems at least annually (fire alarms monthly), and more frequently if required by local regulations, equipment, or other considerations
- Installing a back-up system for communications on-site with off-site resources, such as fire departments, in the event that normal communication methods may be inoperable during an emergency

Community Notification

If a local community may be at risk from a potential emergency arising at the facility, the company should implement communication measures to alert the community, such as:

- Audible alarms, such as fire bells or sirens
- Fan out telephone call lists
- Vehicle mounted speakers
- Communicating details of the nature of the emergency
- Communicating protection options (evacuation, quarantine)
- Providing advise on selecting an appropriate protection option

Media and Agency Relations

Emergency information should be communicated to the media through:

- A trained, local spokesperson able to interact with relevant stakeholders, and offer guidance to the company for speaking to the media, government, and other agencies
- Written press releases with accurate information, appropriate level of detail for the emergency, and for which accuracy can be guaranteed

Emergency Resources

Finance and Emergency Funds

- A mechanism should be provided for funding emergency activities.

Fire Services

- The company should consider the level of local fire fighting capacity and whether equipment is available for use at the facility in the event of a major emergency or natural disaster. If insufficient capacity is available, fire fighting capacity should be acquired that may include pumps, water supplies, trucks, and training for personnel.

Medical Services

- The company should provide first aid attendants for the facility as well as medical equipment suitable for the personnel, type of operation, and the degree of treatment likely to be required prior to transportation to hospital.

Availability of Resources

Appropriate measures for managing the availability of resources in case of an emergency include:

- Maintaining a list of external equipment, personnel, facilities, funding, expert knowledge, and materials that may be required to respond to emergencies. The list should include personnel with specialized expertise for spill clean-up, flood control, engineering, water treatment, environmental science, etc., or any of the functions required to adequately respond to the identified emergency
- Providing personnel who can readily call up resources, as required
- Tracking and managing the costs associated with emergency resources
- Considering the quantity, response time, capability, limitations, and cost of these resources, for both site-specific emergencies, and community or regional emergencies
- Considering if external resources are unable to provide sufficient capacity during a regional emergency and whether additional resources may need to be maintained on-site

Mutual Aid

Mutual aid agreements decrease administrative confusion and provide a clear basis for response by mutual aid providers.

- Where appropriate, mutual aid agreements should be maintained with other organizations to allow for sharing of personnel and specialized equipment.

Contact List

- The company should develop a list of contact information for all internal and external resources and personnel. The list should include the name, description, location, and contact details (telephone, email) for each of the resources, and be maintained annually.

Training and Updating

The emergency preparedness facilities and emergency response plans require maintenance, review, and updating to account for changes in equipment, personnel, and facilities. Training programs and practice exercises provide for testing systems to ensure an adequate level of emergency preparedness. Programs should:

- Identify training needs based on the roles and responsibilities, capabilities and requirements of personnel in an emergency
- Develop a training plan to address needs, particularly for fire fighting, spill response, and evacuation
- Conduct annual training, at least, and perhaps more frequent training when the response includes specialized equipment, procedures, or hazards, or when otherwise mandated
- Provide training exercises to allow personnel the opportunity to test emergency preparedness, including:
  - Desk top exercises with only a few personnel, where the contact lists are tested and the facilities and communication assessed
  - Response exercises, typically involving drills that allow for testing of equipment and logistics
- Debrief upon completion of a training exercise to assess what worked well and what aspects require improvement
- Update the plan, as required, after each exercise. Elements of the plan subject to significant change (such as contact lists) should be replaced
- Record training activities and the outcomes of the training

Business Continuity and Contingency

Measures to address business continuity and contingency include:

- Identifying replacement supplies or facilities to allow business continuity following an emergency. For example, alternate sources of water, electricity, and fuel are commonly sought.
- Using redundant or duplicate supply systems as part of facility operations to increase the likelihood of business continuity.
- Maintaining back-ups of critical information in a secure location to expedite the return to normal operations following an emergency.

3.7 Construction and Decommissioning

Applicability and Approach

This section provides additional, specific guidance on prevention and control of community health and safety impacts that most commonly occur during construction or decommissioning activities. Construction and decommissioning activities may occur during new project development, at the end of the project life-cycle, or due to expansion or modification of existing project facilities.

The nature and potential risk to the health and safety of community members from construction and decommissioning sites depends on a number of factors, including the proximity of settled areas and site access. Potential risks should be clearly identified during the impact assessment process prior to initiation of construction and decommissioning activities, considering the factors presented in this section and other potential risks applicable to project-specific circumstances.

General Site Hazards

Projects should implement risk management strategies to protect the community from physical, chemical, or other hazards associated with sites under construction and decommissioning. Risks may arise from inadvertent or intentional trespassing, including potential contact with hazardous materials, contaminated soils and other environmental media, buildings that are vacant or under construction, or excavations and structures which may pose falling and entrapment hazards. Risk management strategies may include:

- Restricting access to the site, through a combination of institutional and administrative controls, with a focus on high risk structures or areas depending on site-specific situations, including fencing, signage, and communication of risks to the local community
- Removing hazardous conditions on construction sites that cannot be controlled affectively with site access restrictions, such as covering openings to small confined spaces, ensuring means of escape for larger openings such as trenches or excavations, or locked storage of hazardous materials
- Permanently removing hazardous conditions during site decommissioning that are likely remain after site abandonment
- Managing the transport, treatment, and disposal of any encountered hazardous materials according to recommendations provided in Section 1.3 and 1.4 of this document on Hazardous Materials and Hazardous Waste Management

The use of security forces to protect access to construction or decommissioning sites should be conducted only in a way that is consistent with the requirements of IFC Performance Standard 4 on Community Health and Safety.[70]

Vector-Borne Diseases

Increased incidence of vector-borne diseases attributable to construction activities represents a potentially serious health threat to project personnel and residents of local communities. Vector-borne diseases that are especially prevalent in developing countries include malaria, dengue, and African trypanosomiasis. Standing water accumulating in quarries, in roadside borrow pits, and on construction sites provide ideal mosquito breeding environments. Similarly, insect- and rodent-vectors can thrive on unsanitary work sites and work camps. Vector-disease control programs intended to prevent or minimize vector breeding, and, in turn, reduce human-vector contact during project construction, typically combine best management practices and chemical control. Additional considerations relevant to long-term vector control programs that may be needed during project operations are considered in Section 3.5 on Disease Prevention.

Practices and chemical control for managing risks of vector-borne diseases include:

- Minimizing standing water at construction sites
- Minimizing large-scale land clearing in previously undisturbed areas
- Implementing programs to maintain a sanitary work place
- Using pesticide treated bed nets
- Using larvicides to treat household water supply
- Implementing residual and space spraying programs using less hazardous pesticide classes such as organophosphates and pyrethroids
- Following safety guidelines for the storage, transport, and distribution of pesticides to minimize the potential for misuse, spills, and accidental human exposure

Communicable Diseases

Communicable diseases pose a significant public health threat worldwide. Health hazards typically associated with large development projects are those relating to poor sanitation and living conditions, sexual transmission and vector-borne infections. Communicable diseases of most concern during the construction phase are sexually-transmitted diseases (STDs), such as HIV/AIDS. The destabilizing effect of widespread diseases such as diarrhea, malaria, and tuberculosis in rural communities can be

[70] http://www.ifc.org/enviro

amplified if new diseases, such as HIV/AIDS, are introduced as a result of project development.

Development projects usually involve labor mobility, particularly during the construction phase when large numbers of temporary workers from surrounding communities may be employed as laborers. Such mobile populations pose a heightened risk of contracting STDs through person-to-person contact. Additionally, they represent a disease vector, leading to the spread of STDs such as HIV/AIDS when workers return to their own communities. Recognizing that no single measure is likely to be effective in the long term, successful initiatives typically involve a combination of behavioral and environmental modifications. These include:

- Promoting individual protection, and protecting others from infection, by encouraging condom use
- Addressing systemic factors that can influence individual behavior
- Ensuring ready access to medical treatment, confidentiality and appropriate care, particularly with respect to migrant workers
- Increasing awareness and knowledge of risks posed by STDs and their transmission, recognizing that awareness is typically lower in developing countries
- Implementing an information strategy to reinforce person-to-person counseling

Traffic Safety

Upgrading existing roads and construction of new roads to service large projects has the potential to cause significant environmental and human health impacts. Once constructed, access roads would typically be heavily utilized for the mobilization of equipment and material to a project site and sourcing of materials from borrow pits and quarries. Such activities may result in a significant increase in traffic, thus increasing the risk of traffic-related accidents and injuries to workers and local communities. The incidence of road accidents involving project vehicles during construction should be minimized through a combination of education and awareness-raising, and the adoption of procedures including:

- Using locally sourced construction materials, whenever possible, to minimize transport distances
- Locating worker camps close to project sites and arranging worker bus transport to minimizing external traffic
- Minimizing pedestrian interaction with construction vehicles
- Employing safe traffic control measures, including road signs and flag persons to warn of dangerous conditions
- Establishing a safe driver work environment, including self regulating maximum project vehicle speeds, regular testing of driving skills, alcohol control measures, and regular rest stops
- Providing public education and traffic safety awareness programs aimed at vulnerable road users and at children through the regular school curriculum
- Ensuring good maintenance of construction vehicles to minimize breakdowns
- Employing dust prevention and road maintenance measures to improve visibility and minimize road hazards
- Implementing emergency response communication and transportation systems

Air Emissions, Noise and Vibration

During project construction, heavy equipment and trucks using project access roads inevitably cause a temporary increase in noise and diffuse emissions of air pollutants for residents situated along these roads. Noise, vibration, and air quality hazards from the construction site may also impact the community. Particular attention should be given to:

- Reducing ground level air pollution emissions, particularly particulates and sulfur from diesel trucks, through improved vehicle maintenance, use of fuel-efficient vehicles, and installation of catalytic control devices

- Adopting dust suppression measures, including frequent wetting of road surfaces
- Applying noise and vibration abatement measures, as described in Section 1.5 on Noise
- Avoiding roads that pass schools and hospitals
- Implementing traffic controls, such as prohibiting certain types of vehicles and restricting traffic to certain times of the day

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** Attribution of all references, including verification for completeness and accuracy, are to be completed for the final draft of the General EHS Guidelines document.*

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