CHEMINFO

Best Practices for the Reduction of Air Emissions From Construction and Demolition Activities

March, 2005

Prepared by:

Cheminfo Services Inc.
315 Renfrew Dr., Suite 302
Markham, Ontario
L3R 9S7

In conjunction with the
Construction and Demolition Multi-stakeholder Working Group

Prepared for:

Environment Canada
Transboundary Issues Branch

Table of Contents

CHEMINFO

CHEMINFO

Glossary of Terms

Actions to Reduce Emissions - Any applications of technologies or practices that contribute to reducing pollutant releases to the environment.

Active Operation - activity capable of generating fugitive dust, including any open storage pile, earthmoving activity, construction/demolition activity, disturbed surface area, and non-emergency movement of motor vehicles on unpaved roadways and parking lots.

Anemometer – device used to measure wind speed and direction.

Apron – material (e.g., asphalt, gravel) that covers a distance of the path travelled by construction vehicles at the entry/exit points from construction sites.

Asphalt – a brownish-black solid or semisolid mixture of bitumen obtained from native deposits or as a petroleum by-product and used in roofing and road building.

Bulk Material - any material including but not limited to earth, rock, silt, sediment, sand, gravel, soil, fill, aggregate less than 2 inches in length or diameter, dirt, mud, demolition debris, trash, cinders, pumice, saw dust and dry concrete, which are capable of producing fugitive dust at a construction site.

Coal Tar Pitch – a thick, dark, and sticky substance obtained from the distillation residue of coal tar.

Construction Activities – any on-site activities preparatory to or related to the building, alteration, rehabilitation or improvement of property, including, but not limited to the following activities: grading, excavation, trenching, loading, vehicular travel, crushing, blasting, cutting, planning, shaping, breaking, equipment staging/storage areas, weed abatement activities or adding or removing bulk materials from storage piles.

Cutback Asphalt – asphalt cement that has been liquefied by blending with petroleum solvents (diluents). Upon exposure to atmospheric conditions, the diluents evaporate, leaving the asphalt cement to perform its function.

Demolition Activities – the wrecking or taking out of any load-supporting structural member of a structure or building and related handling operations or the intentional burning of any structure or building.

Disturbed Surface Area – portion of the earth's surface having been physically moved, uncovered, destabilized, or otherwise modified from its undisturbed natural condition, thereby increasing the potential for emission of fugitive dust. Disturbed surface area does not include areas restored to a natural state with vegetative ground cover and soil characteristics similar to adjacent natural conditions.

Dust Emissions - Releases to air of fine particulate matter (usually PM_{10}, $PM_{2.5}$)

Dust Generating Operation - any activity capable of generating fugitive dust, including but not limited to, land clearing, earthmoving, weed abatement by discing or blading, excavating, construction, demolition, material handling, storage and/or transporting operations, vehicle use and movement, the operation of any outdoor equipment or unpaved parking lots.

Dust Suppressant – water, hygroscopic materials, or non-toxic chemical stabilizers used as soil treatment to reduce fugitive dust emissions.

Earthmoving Operation – the use of any equipment for an activity which may generate fugitive dust, such as, but not limited to, cutting and filling, grading, levelling, excavating, trenching, loading or unloading of bulk materials, demolishing, blasting, drilling, adding to or removing bulk materials from open storage piles, back filling, soil mulching, landfill operations, or weed abatement by discing or blading.

Emulsified Asphalt – an emulsion of asphalt cement and water that contains a small amount of an emulsifying agent. It is a heterogeneous system containing two normally immiscible phases (asphalt and water) in which the water forms the continuous phase of the emulsion and minute globules of asphalt form the discontinuous phase.

Freeboard - the vertical distance between the top edge of a cargo container area and the highest point at which the bulk material contacts the sides, front and back of the container.

Fugitive Dust – any particulate matter becoming airborne, other than being emitted from an exhaust stack, directly or indirectly as a result of human activity.

Gravel Pad - a layer of washed gravel, rock or crushed rock which is at least one inch or larger in diameter, maintained at the point of intersection of a paved public roadway and a work site or source entrance to dislodge mud, dirt and/or debris from the tire of the motor vehicles or haul trucks prior to leaving the work site.

Grizzly - a device maintained at the point of intersection of a paved public roadway and a work site or source entrance to dislodge mud, dirt and/or debris from the tires of the motor vehicles or haul trucks prior to leaving the work site.

Haul Truck - any fully or partially open-bodied self propelled vehicle including any non-motorized attachments, such as but not limited to trailers or other conveyances which are connected to or propelled by the actual motorized portion of the vehicle used for transporting bulk material.

High Wind Conditions – when instantaneous wind speeds exceed 25 mph (40 kph).

Inactive Disturbed Surface Area – any disturbed surface area upon which active operations have not occurred or are not expected to occur for a period of 10 consecutive days.

Microgram (µg) – a metric unit of mass equal to one-millionth of a gram.

Micron - a metric unit of length equal to one millionth of a meter or 1/100th the width of a human hair.

Off-road Vehicle - any self-propelled conveyance specifically designed for off-road use, including not limited to, bulldozers, loaders, excavators, graders, off-road trucks, forklifts, all-terrain vehicles, utility vehicles, snow blowers and portable generator sets. A complete list of off-road vehicles and equipment can be found at the following website:
www.ec.gc.ca/transport/offroad2004/offRoad_full_listing_e.htm

Opacity - the degree to which emissions reduce the transmission of light and obscure the view of an object in the background.

Open Storage Pile – any accumulation of bulk material with 5% or greater silt content not fully enclosed, covered or chemically stabilized, and attaining a height of three feet or more and a total surface area of 500 or more square feet.

Particulate Matter (PM) – the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. Some particles are large or dark enough to be seen as dust or smoke. Others are so small that individually they can only be detected with an electron microscope.

PM_{10}, - particulate matter that is less than 10 microns in diameter.

$PM_{2.5}$ - particulate matter that is less than 2.5 microns in diameter.

Power Take-off Equipment - an accessory that is mounted onto a transmission, allowing power to be transferred outside the transmission to a shaft or a driveline. Some examples of vehicles with power take-off equipment are cement mixers, trucks with hydraulic winches, car carriers, mobile cranes and sewer cleaning trucks.

Porosity –the fabric or materials of the fence/barrier will be greater than 50% of the entire surface area. The holes in the fence/barrier will be less than 50% of the entire surface area.

Practice for Emission Reduction - a pre-emptive or concurrent technique, or procedure to minimize the generation, emission, entrainment, suspension, and/or airborne transport of fugitive dust. Example: Driving slowly over unpaved road.

Public Roadway - any roadways that are open to public travel.

Road Construction - the use of any equipment for the paving or new construction of a road surface, street or highway.

Roofing Kettle – A device used to heat and melt asphalt or coal tar pitch so that the asphalt or coal tar pitch can be applied onto a rooftop to provide a protective coating.

Silt – any bulk material with a particle size less than 75 microns in diameter that passes through a Number 200 sieve as determined by the American Society of Testing Materials (ASTM) Test Method C136.

Stabilized – a condition where the soil surface is wet, crusted, covered or otherwise secured, so that dust particles do not become airborne even in high wind.

Stabilized Surface – any previously disturbed surface area or open storage pile which, through the application of dust suppressants, shows visual or other evidence of surface crusting and is resistant to wind-driven fugitive dust and is demonstrated to be stabilized.

Surfactant – a compound or element that reduces the surface tension of a liquid. The term is used in this document to describe wetting and spray adjuvants designed to promote the economical application of water to hydrophobic soils. Surfactants prevent drifting, decrease run-off, increase the penetrating and wetting properties, and promote more even, consistent spray patterns.

Technology For Emission Reduction – a piece of equipment, substance, device or related contrivance that serves to reduce emissions through its utilization. Example: application of dust suppressants on unpaved roads.

Trackout/Carryout – any and all bulk materials that adhere to and agglomerate on the exterior surface of motor vehicles, haul trucks, and/or equipment (including tires) and that have fallen onto a paved roadway. Material can be removed by a vacuum sweeper or a broom sweeper under normal operating conditions.

Trackout Control Device - a gravel pad, grizzly, wheel wash system, or a paved area, located at the point of intersection of an unpaved area and a paved roadway that controls or prevents vehicular trackout.

Transfer Point – a point in a conveying operation where an aggregate or other similar material is transferred to or from a belt conveyor, except where the material is being transferred to a stockpile.

Unpaved Road – any straight or curved length of well-defined travel way for motor vehicles not covered by one of the following: concrete, asphaltic concrete, or asphalt.

Wind Barrier - any structure put up along a source's boundaries to reduce the amount of wind blown dust leaving the site. Creating a wind barrier includes but is not limited to installing wind fencing, construction of berms, planting trees, or parking on-site equipment so that it blocks the wind.

Wind Fencing - a 1 to 1.5 metre (3 to 5 foot) barrier with 50% or less porosity located adjacent to roadways or urban areas.

Work Practices - a technique or operational procedure used to minimize the generation, emission, entrainment, suspension, and/or airborne transport of fugitive dust.

Wheel Shaker – a device capable of spreading the tread on tires and shaking the wheels and axles of vehicles for the purpose of releasing mud, soil and rock from the tires and undercarriage to prevent tracking those materials onto paved surfaces.

Wheel Washer – a station or device, either temporary or permanent, that utilizes a bath or spray of water for the purpose of cleaning mud, soil, and rock from the tires and undercarriage of vehicles to prevent tracking those materials onto paved surfaces.

List of Acronyms

CAC	Criteria Air Contaminants (PM, PM_{10}, $PM_{2.5}$, SOx, NOx, CO, VOC, Ammonia)
CCME	Canadian Council Of Ministers Of The Environment
C&D	Construction and Demolition
CEPA-99	Canadian Environmental Protection Act-1999
C&DWG	Construction and Demolition Multi-stakeholder Working Group
CO	Carbon Monoxide
COH	Coefficient of Haze
CWS	Canada-Wide Standard
EC	Environment Canada
EIA	Environmental Impact Assessment
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse Gas
HEPA	High Efficiency Particulate Arrestor
HVLP	High Volume Low Pressure (Coating spray equipment)
JIA	Joint Initial Actions
kph	Kilometers per hour
KCAC	Keeping Clean Areas Clean
mph	Mile per hour
NOx	Nitrogen Oxides
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
PM_{10}	Particulate Matter Less Than or Equal to 10 Microns in Diameter
$PM_{2.5}$	Particulate Matter Less Than or Equal to 2.5 Microns in Diameter
ppb	Parts Per Billion
ppm	Parts Per Million
SO_2	Sulphur Dioxide
VOC	Volatile Organic Compounds
TPM	Total Particulate Matter
TSP	Total Suspended Particulates
$\mu g/m^3$	Micrograms Per Cubic Meter (A microgram is one-millionth of a gram)
µm	Micron (one-millionth of a meter)

1. Introduction

1.1 Background

Construction and demolition activities emit pollutants that contribute to poor air quality and ground level ozone formation. The major pollutants emitted are particulate matter (PM), volatile organic compounds (VOCs), nitrogen oxides (NO_x) and sulphur dioxide (SO_2). Current emission estimates prepared by Environment Canada show that construction activities represent approximately 20% of total PM_T emissions and 15% of total PM_{10} emissions in Canada. Information on Canada's PM and other Criteria Air Contaminant (CAC) emissions inventories can be found at: http://www.ec.gc.ca/pdb/cac/cac_home_e.cfm.

Extensive scientific studies indicate that there are significant health and environmental effects associated with emissions of PM and other criteria air contaminants. As a result, the Canada-wide Standards (CWS) for PM and Ozone were signed in June 2000 by the Canadian Council of Ministers of the Environment (CCME). The CWS for $PM_{2.5}$ is 30 µg/m^3 averaged over 24 hours, to be achieved by 2010. The CWS for ozone is 65 ppb averaged over 8 hours, to be achieved by 2010.

Provinces, the territories, and the federal government are committed to emissions reduction in order to achieve all aspects of the CWS in Canada. As a result, the federal government is seeking the assistance of the construction and demolition sector in contributing their share to the emission reductions that have to be achieved in order to meet the CWS in 2010.

Included within the CWS are a series of Joint Initial Actions aimed at reducing PM emissions as well as precursor emissions to PM and ground level ozone. The Joint Initial Action for the construction and demolition sector included the development of a document that reflected the best current dust minimization and suppression methods available for use across Canada by authorities involved with construction and demolition activities.

Since construction and demolition activities are common to most jurisdictions and affect many communities across Canada, Environment Canada established the Construction and Demolition Multi-stakeholder Working Group to assist in the development of this Best Practices document.

1.2 Scope and Applicability

Technologies and work practices contained in this Best Practices document can be applied to reduce emissions from construction and demolition activities. These technologies and practices cover the full spectrum of construction project phases including design, site preparation, fabrication, landscaping, demolition and deconstruction, and renovation.

The focus of the document is on actions that can achieve reductions in PM and VOC emissions. This Best Practices document provides descriptions of a large number of technologies and practices that can address emissions of PM/VOCs, as well as some practices that may lead to reductions in sulphur oxides, nitrogen oxides and greenhouse gas emissions. These technologies/practices include both pollution prevention practices as well as options that control pollution after it has been generated. In the hierarchy of emissions reduction, pollution prevention practices are generally preferable and typically result in lower costs (or higher savings) than control options.

There are issues to take into consideration with respect to implementing the various technologies/practices to achieve PM and VOC emission reductions. These issues can include cost to implement, environmental consequences, and other factors that should be evaluated prior to selecting and implementing emission reduction options. For example, some of the practices to reduce PM emissions (e.g., application of water, dust suppressants) can facilitate the occurrence of other (just as serious) environmental issues. These are discussed further in Chapter 4.

This document should be useful to project owners, designers, managers, foremen, supervisors, contractors, and equipment operators interested in minimizing PM, VOC and other pollutant emissions at project sites. Provincial, municipal as well as federal government authorities concerned with minimizing potential emissions from construction and demolition activities can also use this document as a source of information to identify project-specific options that can be outlined in tender documents, so that all construction firms are bidding on the same scope of work.

1.3 Purpose of the Document

The purpose of this document is to provide a description of technologies and work practices that can reduce emissions associated with construction and demolition activities. Construction organizations and government authorities can evaluate these technologies and work practices in context of project-specific circumstances, which are often unique.

The intent of the document is not for organizations involved with construction and demolition activities to apply all of the technologies and practices described in the document. It is recognized that adoption of all elements of the document would not be economically feasible. Construction organizations, as well as government authorities need to consider economic, environmental, and technical circumstances in choosing the elements of the document that best suit the unique features of each project. Given the broad scope, diverse nature and unique environmental context of each construction project, it is not practical to prescribe in this document the actions and management requirements that should be undertaken for each project site.

1.4 Costs and Savings

Typically, there will be additional costs involved with reducing PM emissions (as well as emissions of other pollutants) from the construction and demolition sector. Since many of the firms within this sector are small to medium in size, operating on thin profit margins, these additional costs can represent a significant financial burden.

However, construction companies in Canada already apply quite a number of work practices to reduce emissions. A recent survey of 17 small and large Canadian construction and demolition firms, by Cheminfo Services, found all were taking actions to reduce PM emissions.

Information related to the costs of achieving emission reductions within the Canadian construction and demolition sector can be found in the following publications available from Environment Canada:

- Cheminfo Services Inc., *Socio-economic Analysis of Emission Reductions in the Canadian Construction Industry*, March, 2005.
- Senes Consultants Ltd., *Foundation Analysis Report for the Canadian Construction and Demolition Sector*, March, 2004.

Construction companies can realize numerous benefits by reducing PM/dust and other pollutant emissions. Benefits may include: improved productivity, reduction in lost-time incidents for employees, improved corporate image and differentiation from competitors, avoided unnecessary involvement with regulators, as well as development and transfer/sale of knowledge and technology.

1.5 Acknowledgements and Further Information

This Best Practices document was developed with input from the Construction and Demolition Multi-stakeholder Working Group and its subcommittees, consisting of industry representatives, government personnel, and environmental non-government organizations (see Chapter 9 for the list of working group members). The contributions of all participants who assisted in developing this Best Practices document are gratefully acknowledged.

Inquiries and comments on this Best Practices document as well as requests for additional copies of the document should be directed to:

Manager, Federal Smog Program
Transboundary Air Issues Branch
Environment Canada
Place Vincent Massey
351 St. Joseph Blvd., 11th Floor
Hull, Quebec K1A 0H3
Fax: (819) 953-8963

2. Preparation of an Environmental Management Plan

2.1 Introduction

The development of a site-specific environmental management plan is recommended before any construction or demolition activities are initiated. An environmental management plan is a way to organize and document:

- the objectives to be achieved;
- the methods to be applied in addressing potential emissions;
- the people responsible for managing and implementing the plan; and
- the records to be maintained that can demonstrate adoption of actions contained in the Best Practices document, as well as compliance with any government environmental requirements.

Environmental management plans can range in size and detail depending upon the scope of the project. Ideally, the environmental management plan should address all pollutants to all media (air, water and soil), as well as management of solid and liquid wastes. It is therefore possible that the environmental management plan for air pollutants may be a component of a broader environmental strategy or even an Environmental Impact Assessment (EIA).

2.2 Contents of the Plan

The plan should first document the size, location, timing, prevailing winds, geographical features, landscape, and nature of the construction activities and relate them to communities and ecosystems that will be sensitive to potential emissions from the site. It is important to identify/recognize the target receptors that are in need of environmental protection from the potential emissions from construction activities. The evaluation and measurement of existing (pre-construction) environmental conditions can serve as a useful baseline of the environmental quality that is to be preserved during the various phases of construction. Prevention and reduction objectives should be documented relative to the anticipated emissions from construction activities to be undertaken. These can be qualitative (e.g., visual, zero neighbour complaints) as well as quantitative (e.g., maximum concentrations in air in or around the site, dust plume height).

The plan should include site-specific design elements, operating practices, specific technologies, products, and equipment that will be applied to prevent or control emissions. Differences in linear and area surface disturbances should be taken into account when identifying dust mitigation measures. In keeping with environmental principles, pollution prevention practices are preferred to controls that contain the pollution after it has been generated. Typically, pollution prevention practices are less costly to implement.

The plan should identify the frequency and duration over which these emission reduction practices are employed (e.g., one day, one week, one month, one year). The plan should also document any measurement, monitoring, and record keeping that will be used during the course of the project. Keeping records will allow construction site owners, managers, and operators to demonstrate compliance with local by-laws, permits, and other government environmental requirements. Records can also be used to show community members the actions that are being undertaken and their effectiveness in preserving the quality of their environment.

2.3 Further Information

To assist in the preparation of an environmental management plan, those within the construction industry are encouraged to obtain and review:

- Canadian Construction Association's, "A Guide on Construction Environmental Management Planning" (http://www.cca-acc.com/documents/ccalist.html).
- Alberta Transportation's, "Environmental Construction Operations Plan (ECO PLAN) Framework (http://www.trans.gov.ab.ca/Content/doctype245/production/eco5.pdf).

3. Index of Actions to Mitigate Emissions from the Construction and Demolition Sector

3.1 Introduction

The construction and demolition sector is a very diverse industry with project sites ranging in size from single family dwelling additions to multi-billion dollar heavy engineering projects. In addition, emissions occur at many different stages during construction and demolition operations, irrespective of the size and scope of the project. These and other factors result in challenges in presenting a Best Practices document that is comprehensive and representative of all potential construction situations, while being reader-friendly and concise.

Many of the work practices and technologies that are identified and described in this Best Practices document can be applied irrespective of the size and scope of the construction and demolition project. For example, most of the actions to address dust emitted from storage piles can be applied at just about any construction site. Therefore, it is useful to identify and describe the practices/technologies contained in this document according to emission sources. This should allow readers to quickly scan the Table of Contents and identify the pages in the Best Practices document where actions to mitigate emissions from specific sources can be found. This presentation also ensures that the Best Practices document is kept concise (i.e., avoids repeating the same practices).

One of the challenges associated with grouping and describing the work practices/technologies by emissions source is that there are some differences between the PM mitigation options that can be utilized by different segments of the industry. For instance, some actions that may be applicable to road construction companies are not relevant for firms that are building residential homes.

It is difficult to identify where these distinctions are located within the Best Practices document when the practices/technologies are grouped by emission source. The Construction and Demolition Multi-stakeholder Working Group recommended that some method be applied to the Best Practices document to allow those in the industry to quickly identify which work practices/technologies are most relevant for their particular operations.

As a result, a series of cross-referenced tables have been prepared and presented in this chapter. These tables enable various construction firms to quickly identify the practices/technologies that are relevant for their operations. The utilization of this approach has allowed the various work practices to be presented in this Best Practices document both by emission source as well as by construction and demolition segment.

3.2 Presentation of Cross-Referenced Tables

The segmentation of the construction industry that has been chosen for this document is as follows:

- Residential Building Construction Operations;
- Industrial, Commercial and Institutional Construction Operations;
- Road-building and Other Heavy Construction Operations; and
- Demolition and Deconstruction.

The work practices/technologies that are relevant for firms within these segments are presented in tables on the following four pages. Note that the use of pollution prevention practices to mitigate emissions are preferred and consequently these options have been bolded in the various tables.

Table 1: Summary of Practices for Residential Building Construction Operations

Guidance On	Practices to Reduce Emissions	Page
Water Application	**Wide range of practices applied to site preparation, storage, etc.**	9-10
Dust Suppressants	**Wide range of practices applied to site preparation, storage, etc.**	9, 11
Design	**Plan for minimizing dust generation**	12
	Choose building materials to reduce dust generation	12
	Minimize distances travelled for delivery of materials	14
	Use green building materials	14
	Design and construct for maximum energy efficiency	15
Site Preparation	**Grade the construction site in phases**	16
	Utilize wind fencing	16
	Stabilize surfaces of completed earthworks with vegetation	16
	Stabilize earthworks with stone/soil/geotextiles	17
	Create ridges to prevent dust	17
	Compact disturbed soil	17
	Eliminate open burning	17
	Reduce certain activities during windy conditions	18
Storage Piles	**Storage pile activity should be conducted downwind**	18
	Utilize enclosures/coverings for storage piles	18
	Utilize wind fences/screens for storage piles	18
	Use vegetation cover as a wind break	19
	Properly shape storage piles	19
	Properly schedule the delivery of landscaping materials	19
Vehicles and Equipment	Use diesel particulate filters, fuel-borne catalysts, diesel oxidation catalysts	27-28
	Ensure catalytic converters are operating efficiently	28
	Evaluate alternative technologies to reduce emissions	28
	Properly maintain engines and exhaust systems	29
	Use low sulphur diesel	29
	Alternative fuels should be utilized where feasible	29
	Reduce or eliminate idling time	30
	Evaluate alternatives for heat and air conditioning	30
	Minimize cold starts	30
	Evaporative losses should be minimized	31
Asphalt Roofing	**Temperatures of material inside kettles should be minimized**	38
	Close fitting lids on roofing kettles should be used	38
	Kettle should be kept closed	38
	Roofing kettles should be equipped with afterburners	38

Guidance On	Practices to Reduce Emissions	Page
Material Handling & Transfer Systems	**Control mud and dirt trackout and carryout**	19
	Minimize material drop at the transfer point and enclosure	21
	Utilize foam suppression systems	21
	Secure loads on haul trucks	21
	Prevent PM emissions from spills	22
	Minimize material handling operations	22
	Capture fugitive dust emissions	22
	Utilize wind barriers	22
	Reduce certain activities during windy conditions	22
Road Surfaces	**Establish on-site vehicle restrictions**	23
	Surface improvements to unpaved road surfaces	23
	Proper maintenance of unpaved roads	23
	Work practices associated with de-icing materials	23
Fabrication	**Cutting, grinding and drilling**	24
	Avoiding cutting and grinding	24
	Sand and grit blasting and façade cleaning	24
	Concrete cutting	25
	Mixing processes	25
	Internal and external finishing and refurbishment	25
Surface Coatings	**Durable and high performance coatings with a low VOC content should be used**	32
	Minimize emissions from storage, handling & preparation	33
	Minimize coatings wastage through spillage/splashing	34
	Surface to be coated should be properly prepared	34
	Paint heaters should be used instead of paint thinners	34
	Technologically advanced spray-guns should be utilized	34
	Apply correct application techniques	35
	Proper technique should be used when cleaning spray guns	35
	Alternative coating application techniques should be used	36
	Alternative cleaners or low-VOC cleaners should be used	36
	Solvents used for cleaning should be minimized	36
	Paint colour changes should be optimized	36
	Alternative finishing practices should be used	37

Table 2: Summary of Practices for Industrial, Commercial and Institutional Operations

Guidance On	Practices to Reduce Emissions	Page
Water Application	**Wide range of practices applied to site preparation, storage, etc.**	9-10
Dust Suppressants	**Wide range of practices applied to site preparation, storage, etc.**	9, 11
Design	**Plan for minimizing dust generation**	12
	Choose building materials to reduce dust generation	12
	Minimize distances travelled for delivery of materials	14
	Use green building materials	14
	Design and construct for maximum energy efficiency	15
Site Preparation	**Grade the construction site in phases**	16
	Utilize wind fencing	16
	Stabilize surfaces of completed earthworks with vegetation	16
	Stabilize earthworks with stone/soil/geotextiles	17
	Create ridges to prevent dust	17
	Compact disturbed soil	17
	Eliminate open burning	17
	Reduce certain activities during windy conditions	18
Storage Piles	**Storage pile activity should be conducted downwind**	18
	Utilize enclosures/coverings for storage piles	18
	Utilize wind fences/screens for storage piles	18
	Use vegetation cover as a wind break	19
	Properly shape storage piles	19
	Properly schedule the delivery of landscaping materials	19
Vehicles and Equipment	Use diesel particulate filters, fuel-borne catalysts, diesel oxidation catalysts	27-28
	Ensure catalytic converters are operating efficiently	28
	Evaluate alternative technologies to reduce emissions	28
	Properly maintain engines and exhaust systems	29
	Use low sulphur diesel	29
	Alternative fuels should be utilized where feasible	29
	Reduce or eliminate idling time	30
	Evaluate alternatives for heat and air conditioning	30
	Minimize cold starts	30
	Evaporative losses should be minimized	31
Asphalt Roofing	**Temperatures of material inside kettles should be minimized**	38
	Close fitting lids on roofing kettles should be used	38
	Kettle should be kept closed	38
	Roofing kettles should be equipped with afterburners	38

Guidance On	Practices to Reduce Emissions	Page
Material Handling & Transfer Systems	**Control mud and dirt trackout and carryout**	19
	Minimize material drop at the transfer point and enclosure	21
	Utilize foam suppression systems	21
	Secure loads on haul trucks	21
	Prevent PM emissions from spills	22
	Minimize material handling operations	22
	Capture fugitive dust emissions	22
	Utilize wind barriers	22
	Reduce certain activities during windy conditions	22
Road Surfaces	**Establish on-site vehicle restrictions**	23
	Surface improvements to unpaved road surfaces	23
	Proper maintenance of unpaved roads	23
	Work practices associated with de-icing materials	23
Fabrication	**Cutting, grinding and drilling**	24
	Avoiding cutting and grinding	24
	Sand and grit blasting and façade cleaning	24
	Concrete cutting	25
	Mixing processes	25
	Internal and external finishing and refurbishment	25
Surface Coatings	**Durable and high performance coatings with a low VOC content should be used**	32
	Minimize emissions from storage, handling & preparation	33
	Minimize coatings wastage through spillage/splashing	34
	Surface to be coated should be properly prepared	34
	Paint heaters should be used instead of paint thinners	34
	Technologically advanced spray-guns should be utilized	34
	Apply correct application techniques	35
	Proper technique should be used when cleaning spray guns	35
	Alternative coating application techniques should be used	36
	Alternative cleaners or low-VOC cleaners should be used	36
	Solvents used for cleaning should be minimized	36
	Paint colour changes should be optimized	36
	Alternative finishing practices should be used	37

CHEMINFO

Table 3: Summary of Practices for Road-building and Other Heavy Construction Operations

Guidance On	Practices to Reduce Emissions	Page
Water Application	**Wide range of practices applied to site preparation, storage, etc.**	9-10
Dust Suppressants	**Wide range of practices applied to site preparation, storage, etc.**	9, 11
Design	**Plan for minimizing dust generation**	12
	Choose building materials to reduce dust generation	12
	Mitigate traffic congestion	13
	Minimize distances travelled for delivery of materials	14
	Use green building materials	14
	Design and construct for maximum energy efficiency	15
Site Preparation	**Grade the construction site in phases**	16
	Utilize wind fencing	16
	Stabilize surfaces of completed earthworks with vegetation	16
	Stabilize earthworks with stone/soil/geotextiles	17
	Create ridges to prevent dust	17
	Compact disturbed soil	17
	Eliminate open burning	17
	Reduce certain activities during windy conditions	18
Storage Piles	**Storage pile activity should be conducted downwind**	18
	Utilize enclosures/coverings for storage piles	18
	Utilize wind fences/screens for storage piles	18
	Use vegetation cover as a wind break	19
	Properly shape storage piles	19
	Properly schedule the delivery of landscaping materials	19
Vehicles and Equipment	Use diesel particulate filters, fuel-borne catalysts, diesel oxidation catalysts	27-28
	Ensure catalytic converters are operating efficiently	28
	Evaluate alternative technologies to reduce emissions	28
	Properly maintain engines and exhaust systems	29
	Use low sulphur diesel	29
	Alternative fuels should be utilized where feasible	29
	Reduce or eliminate idling time	30
	Evaluate alternatives for heat and air conditioning	30
	Minimize cold starts	30
	Evaporative losses should be minimized	31
Hot Mix Asphalt Production	**Maintenance, inspections, calibration, low-sulphur fuels**	31-32
Asphalt Concrete Paving	**Minimization of cutback and emulsified asphalts, other options**	37

Guidance On	Practices to Reduce Emissions	Page
Material Handling & Transfer Systems	**Control mud and dirt trackout and carryout**	19
	Minimize material drop at the transfer point and enclosure	21
	Utilize foam suppression systems	21
	Secure loads on haul trucks	21
	Prevent PM emissions from spills	22
	Minimize material handling operations	22
	Capture fugitive dust emissions	22
	Utilize wind barriers	22
	Reduce certain activities during windy conditions	22
Road Surfaces	**Establish on-site vehicle restrictions**	23
	Surface improvements to unpaved road surfaces	23
	Proper maintenance of unpaved roads	23
	Work practices associated with de-icing materials	23
Fabrication	**Cutting, grinding and drilling**	24
	Avoiding cutting and grinding	24
	Sand and grit blasting and façade cleaning	24
	Concrete cutting	25
	Mixing processes	25
	Internal and external finishing and refurbishment	25
Surface Coatings	**Durable and high performance coatings with a low VOC content should be used**	32
	Minimize emissions from storage, handling & preparation	33
	Minimize coatings wastage through spillage/splashing	34
	Surface to be coated should be properly prepared	34
	Paint heaters should be used instead of paint thinners	34
	Technologically advanced spray-guns should be utilized	34
	Apply correct application techniques	35
	Proper technique should be used when cleaning spray guns	35
	Alternative coating application techniques should be used	36
	Alternative cleaners or low-VOC cleaners should be used	36
	Solvents used for cleaning should be minimized	36
	Paint colour changes should be optimized	36
	Alternative finishing practices should be used	37
Traffic Markings	**Alternatives to VOC coatings, use minimization techniques**	37
Asphalt Roofing Kettles	**Minimize temperatures, close fitting lids, vents, afterburners**	38

CHEMINFO

Table 4: Summary of Practices for Demolition and Deconstruction Operations

Guidance On	Practices to Reduce Emissions	Page
Water Application	**Wide range of practices applied to site preparation, storage, etc.**	9-10
Dust Suppressants	**Wide range of practices applied to site preparation, storage, etc.**	9, 11
Storage Piles	**Storage pile activity should be conducted downwind**	18
	Utilize enclosures/coverings for storage piles	18
	Utilize wind fences/screens for storage piles	18
	Use vegetation cover as a wind break	19
	Properly shape storage piles	19
Material Handling & Transfer Systems	**Control mud and dirt trackout and carryout**	19
	Minimize material drop at the transfer point and enclosure	21
	Utilize foam suppression systems	21
	Secure loads on haul trucks	21
	Prevent PM emissions from spills	22
	Minimize material handling operations	22
	Capture fugitive dust emissions	22
	Utilize wind barriers	22
	Reduce certain activities during windy conditions	22
Road Surfaces	**Establish on-site vehicle restrictions**	23
	Surface improvements to unpaved road surfaces	23
	Proper maintenance of unpaved roads	23
	Work practices associated with de-icing materials	23

Guidance On	Practices to Reduce Emissions	Page
Demolition and Deconstruction	**Apply deconstruction techniques**	26
	Minimize drop heights for debris	26
	Enclose chutes and cover bins	26
	Use fogging systems	26
	Barriers to prevent dispersion	26
	Avoid blasting when feasible	26
	Vacuum debris	26
	Work practices for loading debris	26
	Avoid prolong storage of debris	26
Vehicles and Equipment	Use diesel particulate filters, fuel-borne catalysts, diesel oxidation catalysts	27-28
	Ensure catalytic converters are operating efficiently	28
	Evaluate alternative technologies to reduce emissions	28
	Properly maintain engines and exhaust systems	29
	Use low sulphur diesel	29
	Alternative fuels should be utilized where feasible	29
	Reduce or eliminate idling time	30
	Evaluate alternatives for heat and air conditioning	30
	Minimize cold starts	30
	Evaporative losses should be minimized	31

4. Using Water and Chemical Dust Suppressants at Construction Sites

4.1 Introduction

There are numerous PM emission sources at construction sites where water and various chemical dust suppressants can be applied in order to reduce emissions. For instance, water/dust suppressants can be applied to mitigate fugitive dust from site preparation, storage piles, materials handling and transfer, unpaved roads, etc. The discussion related to the utilization of these dust control options has been confined to this chapter. This serves to reduce the length of the Best Practices document and also makes the document more reader-friendly.

The application of water is typically the most common dust control method that is employed by construction companies across Canada. Practically all construction companies that are implementing options to reduce dust are applying water to mitigate dust generation from at least one emission source on their construction site. Water can be applied by a variety of methods, for instance trucks, water pulls, water canons, hoses, fire hydrants, sprinklers, etc.

A variety of chemical dust suppressants are available to suppress fugitive dust emissions from construction sites. While being more expensive that water, they are also more effective in suppressing dust and have to be applied much less frequently. Examples of dust suppressants include the following: (i) liquid polymer emulsions (ii) agglomerating chemicals (e.g., lignosulfonates, polyacrylamides); (iii) cementitious products (e.g., lime-based products, calcium sulphate); (iv) petroleum based products (e.g., petroleum emulsions); and (v) chloride salts (e.g., calcium chloride and magnesium chloride).

While the application of water and chemical dust suppressants are proven and effective options for mitigating dust, they have to be applied judiciously. Their usage, while mitigating dust, can trigger other (just as serious) environmental consequences. It is important to keep these environmental consequences in mind when deciding on the extent to which water and chemical dust suppressants are to be utilized.

4.2 Factors to Consider

The following potential environmental impacts of applying chemical dust suppressants must be taken into consideration before application:

- the hazardous, biodegradable and water-soluble properties of the substance;
- the effect their application could have on the surrounding environment, including water-bodies (e.g., surface water pollution from runoff, contaminated ground water, pH) and wildlife (e.g., fisheries); and
- whether the use of chemicals has been limited due to nearby watershed considerations for protection of fish and fish habitat from surface runoff.

There are potential environmental consequences resulting from the over-application of water that must be considered. These include: runoff problems; soil instability; spreading of contaminants in the environment (e.g., oil or coolant from engines), and erosion. In addition, consideration should be given to water conservation or water allocation limitations in areas where construction occurs.

The over-application of water can also lead to equipment mobility problems and reduce the ability of earth-moving equipment to efficiently move saturated soils. If the moisture contents of soils used in construction are sufficient, water may not always need to be added prior to handling, crushing, etc.

Table 5: Guidance on Applying Water at Construction Sites

Stage	Guidance on the Application of Water
Site Preparation	• Water may be applied prior to earthmoving activities to increase the moisture content of the soils thereby increasing their stability. The pre-application of water may be to the depth of the proposed cuts or equipment penetration. The area should continue to be pre-wetted if it is not moist to the depth of the cut. • After grading the construction site, water should be applied within active earth-moving areas at sufficient frequency and quantity to prevent visible emissions from extending more than 30 meters from the point of origin. Schedule thorough and consistent watering that does not run off the site throughout the duration of the construction project. At the end of each workday, water trucks may treat all exposed areas to create a stabilizing crust on the soil. Water may also be applied at the end of the day to soak the next day's work area. Water may be applied into the backfill material until the optimum moisture level is reached. • Water may be applied continuously in front of earthmoving equipment by means of water truck/water pull. If the soil is dry, the earthmoving equipment should cease further disturbance when the water truck/water pull runs out of water and should not resume until the water truck/water pull is operational again. Optimally, one water truck may work for every 1-3 pieces of heavy earthmoving equipment that are in operation, depending on soil and weather conditions (if practical). • Water may be applied on a daily basis to all inactive disturbed surface areas, where there has been no activity for seven days or more days. Water may be applied with sufficient frequency to prevent visible emissions (at least every 2 hours). Automatic sprinkler or spray bar systems are optimal in these areas. • Construction sites should employ a sufficient number of water trucks and have back-up water trucks available if the site experiences dust control problems. • Perimeter watering system or fence line misting consisting of portable irrigation equipment may be applied to mitigate dust impacting surrounding residences and businesses.
Storage Piles	• For some materials, hard crusts can be built-up on storage piles by application of water. Crusts reduce the dust blown off the storage piles. Care is required to avoid application of water to a degree that may erode or settle the fines to the bottom of the pile. • Water may be applied to at least 80% of the surface area of all open storage piles on a daily basis when there is evidence of wind driven fugitive dust. • Storage piles that are greater than 2.5 metres (8 feet) in height and not covered may have a road bladed to the top to allow water truck access or should have an operational water irrigation system that is capable of complete stockpile coverage (water truck access on large volume aggregate storage piles is unrealistic).
Material Handling and Transfer Systems	• Material to be transported may be mixed with water prior to loading and/or the entire surface area of material may be watered after loading. Water should be available while loading and unloading in order to prevent visible dust plumes. • Material may be tested to determine moisture content and silt loading. Only materials that have optimum moisture content should be crushed or screened. • Materials may be sprayed with water 15 minutes prior to handling and/or at points of transfer. • Water may be applied at the feed and/or intermediate points in the conveyor system as needed. • Washing separated or screened materials are effective in controlling fugitive dust emissions from chutes and conveyors. • Hollow cone nozzles are believed to produce the greatest control while minimizing clogging when using wet suppression systems. Optimal droplet size for surface impaction and fine particle agglomeration is about 500 μm - finer droplets are affected by drift and surface tension and appear to be less effective. • Application of water sprays to the underside of a conveyor belt improves the performance of wet suppression systems at belt-to-belt transfer points.
Road Surfaces	• Water may be applied to all unpaved roads used for vehicular traffic at least once per every two hours of active operations (i.e., 3 times per normal 8 hour working day). If the area is inaccessible to water trucks due to slope conditions or other safety factors, watering may be conducted with hoses or sprinkler systems. Runoff should be controlled so it does not saturate the surface of the unpaved haul road, therefore increasing the potential of trackout. • Control efficiency of water depends on: (i) amount (per unit road surface area) of water added during each application; (ii) period of time between applications; (iii) weight, speed and number of vehicles traveling over the watered road during the period between applications; and (iv) metrological conditions that affect evaporation.
Demolition and Deconstruction	• Water may be applied at the following times/locations in order to minimize dust generation: (i) the exterior of building surfaces prior to initiating demolition activities as well as continuously during the knock down phase. It has been suggested that all exterior surfaces of the building, up to six stories in height (where feasible), may be wetted before and during the use of the wrecking ball; (ii) debris pile immediately following blasting and as needed afterwards; (iii) debris during handling and haulage operations; (iv) the surrounding surface area following demolition; (v) unpaved road surfaces within 30 meters of the demolition site, 1 hour prior to the actual demolition; and (vi) unpaved surface areas where equipment will operate.

Table 6: Guidance on Applying Dust Suppressants/Chemical Stabilizers

Stage	Guidance on the Application of Dust Suppressants/Chemical Stabilizers
Site Preparation	• Chemical stabilizers may be applied to graded areas within 5 working days of grading completion. In addition, if an area having 0.2 hectares or more of disturbed surface area remains unused for 7 or more days, the surface area should be stabilized. Chemical stabilizers are generally only effective in areas that are not subject to daily disturbances. Vehicle traffic and disturbance of stabilized soils should be limited through the use of fencing, ditches, barriers, barricades and/or wind barriers. • Chemical stabilizers should be applied according to the manufacturers specifications. • The effectiveness and longevity of chemical stabilizers can be affected by the rate of application, soil pH, moisture levels in the air or soil, amount of sunlight, plant growth and traffic. • Construction operators may consider the addition of water-soluble surfactants to water. These surfactants increase the wetting power of water by breaking down the initial resistance of dry soils to water. Surfactants are relatively inexpensive and greatly decrease the amount of water necessary during dust control operations.
Storage Piles	• Disturbed areas of a construction site, including storage piles of fill dirt and other bulk materials, that are not being actively utilized for construction purposes for a period of 7 calendar days or more, should be stabilized with a chemical dust stabilizer or suppressant. • A much more effective technique (than applying water to the storage pile) is to apply chemical agents (such as surfactants) directly to the storage pile, which permit more extensive wetting. Surfactants allow particles to more easily penetrate the water droplet and increase the total number of droplets, thus increasing total surface area and contact potential. • Foam can be used instead of chemical surfactants to reduce fugitive dust emissions from storage piles (as well as material handling operations). Foam is generated by adding a chemical (i.e., detergent-like substance) to a relatively small quantity of water that is then vigorously mixed to produce small bubbles, high-energy foam.
Material Handling & Transfer	• Dust suppressants should be applied and maintained prior to and after to stabilize screened materials and surrounding area after screening. • Material being transported in a vehicle should be sprayed with a dust suppressant.
Road Surfaces	• The control effectiveness of chemical dust suppressants depends on: (i) the dilution rate used in the mixture; (ii) the application rate (volume of solution per unit road surfaced area); (iii) the time between applications; (iv) the size, speed and amount of traffic during the period between applications; and (v) meteorological conditions (rainfall, freeze/thaw cycles, etc.) during the period. • Chemical dust suppressants have much less frequent reapplication requirements as compared to water. • Dust suppressants are generally applied to the road surface as a water solution and should be uniformly applied to all areas disturbed by vehicles. When used to stabilize heavily trafficked areas, dust suppressants typically require ground preparation prior to application and reapplication 1-4 times a year to remain effective. • Because most chemical products need to soak into the soil, they generally require above-freezing temperatures to work (exceptions include magnesium chloride and calcium chloride). Calcium chloride and magnesium chloride are the most commonly used dust suppressants for unpaved roads. Proper road surface preparation, grading and scarification is required before applying calcium chloride or magnesium chloride. It should be noted that calcium chloride and magnesium chloride use may be restricted in certain areas by municipal or provincial authorities. Environment Canada's *Best Practices For The Use And Storage Of Chloride-Based Dust Suppressants*, (March 2004) provides guidance on the application of chloride-based dust suppressants. • For greatest effectiveness and lowest cost it is important to follow the manufacturer's instructions for mixing and applying these chemicals. • PVA polymers, acrylic copolymers, and water-emulsified petroleum resins, etc. can also be used to mitigate dust generation on unpaved roads. • Surfactants can be added to the watering operation to increase fugitive dust control. Surfactants are agents that break the surface tension of the water that allows for better penetration and saturation of the soil particles.
Demolition and Deconstruction	• Dust suppressants/chemical stabilizers may be applied during the following situations: (i) unpaved surface areas within 30 meters (100 feet) where materials from demolition will fall; (ii) debris piles immediately following blasting and periodically afterwards; (iii) the surrounding area following demolition; and (iv) unpaved surface areas where equipment will operate.

5. Design Considerations to Reduce Emissions from Construction and Buildings

5.1 Introduction

Proper planning during the design stage of construction projects can effectively reduce emissions generated during construction and lifecycle emissions. Suitable design can also minimize emissions during demolition or deconstruction. Design considerations to reduce emissions associated with construction projects include the following:

- site planning;
- building materials used;
- minimizing vehicle traffic congestion;
- minimizing distances travelled for delivery of construction materials;
- utilizing "green" building materials; and
- constructing buildings to maximize energy efficiency.

5.2 Plan for Minimizing Dust Generation

Site planning should be conducted in order to maximize construction efficiency and consequently minimize emissions. The layout of the construction site should be designed to minimize fugitive dust generation potential, including access roads, entrances and exits, storage piles, vehicle staging areas, and other potential sources of dust emissions.

One of the most critical design considerations that should be implemented is to develop a site dust management plan. The dust management plan should identify potential fugitive emission sources from the construction operation. This can be accomplished by starting with a facility site map. All paved haul roads, unpaved haul roads, stockpiles, material transfer points, material conveyances, parking lots, staging areas, and other open areas subject to wind erosion should be identified on the map. The prevailing wind direction should also be identified on the map.

Daily traffic volumes should be studied in order to determine whether roads and open areas are used frequently or occasionally. Daily routine traffic modifications should be considered that will reduce traffic in some areas or eliminate it altogether. The appropriate dust control method for each source identified on the map should be determined. For each source and each control method identified, the frequency of application should be defined. A self-inspection checklist should be prepared in order to be able to record the scheduled applications.

Other site planning considerations that can serve to reduce dust generation during the construction project, include the following:

- before construction operations are initiated, a survey should be conducted that assesses materials/tools/equipment to be used/handled. Decisions can then be make with respect to appropriate materials/tools/equipment that will serve to minimize dust generation; and
- infrastructure repair and maintenance should be co-ordinated – e.g., water, sewer and electrical underground work should be carried out in sequence rather than having to dig up and repave the road several times.

Sensitive receptors in the area (e.g., schools, hospitals, wildlife in urban areas, etc.) that require environmental protection from dust generation should be identified and taken into consideration when designing dust mitigation strategies.

5.3 Choose Building Materials to Reduce Dust Generation

The proper choice of building materials to be used at construction sites can serve to reduce the generation of fugitive dust during the construction phase as well as during the lifetime of the structure. Pre-fabricated materials and modular construction units should be used whenever possible. These units are delivered to the construction site in a finished state, which reduces the amount of cutting, grinding, etc. (and consequently on-site dust emissions) that is required at the construction site. Potential emissions at the factory where the pre-fabricated materials/modular construction units are made should be suitably addressed through effective pollution control measures. It is easier to implement emission reductions at large enclosed permanent facilities than at open construction sites.

Examples of pre-fabricated components include pre-mixed brick mortar, exterior wall systems and shot-crete. Shot-crete is a concrete product sprayed in place for footings on buildings. Shot-crete can be mixed on-site or premixed and delivered to the site ready for use. Using pre-mixed shot-crete reduces the emissions associated with its preparation on site. This can involve emissions associated with storage, handling and mixing of cement and aggregates. The use of modular components (e.g., walls that can be dismantled) minimizes waste and dust generated during retrofits of a floor or deconstruction of the building.

Improving construction quality increases the service life of buildings and other constructed structures. This reduces the need for maintenance, rehabilitation and reconstruction of structures. Often rehabilitation and reconstruction can produce more emissions than the original construction. Therefore, improving construction quality provides numerous lifecycle emissions benefits.

New developments in material science and their applications continue to provide opportunities for construction operations to reduce emissions. Continual improvements are being made to the quality and durability of construction materials. Increased material durability results in extended service life of structures, pavements, etc. and consequently reduced lifecycle emissions (as less frequent repairs and replacement of materials is required as well as the fact that the overall structure will last longer). The most advanced construction materials should be used, whenever possible, in construction projects.

Many North American jurisdictions are promoting the use of recycled materials. Currently, several existing material specifications, including asphalt, concrete, and granular, allow for partial incorporation of recycled material. Material specifications should require that the contractor use a greater percentage of recycled material for some construction operations including hot mix paving and resurfacing, concrete structures and general concrete construction, and the construction of granular base and ‘shouldering’ operations. Fly-ash (by-product of coal combustion at electric power generation stations) which is used as a replacement for Portland cement in ready-mix concrete can also result in reduced lifecycle emissions as it reduces the amount of Portland cement that has to be produced.

All of these options can result in reduced lifecycle emissions. It should be noted that care must be exercised to ensure that the increased use of recycled material does not result in reduced stability and safety of structures.

When designing walls, standard dimensions should be incorporated to match standard dimension modules. This reduces the amount of material cutting and related dust emissions. For dry wall systems, “dustless” filler compound is available to joint filling. This reduces the amount of dust generated during sanding of joints.

5.4 Mitigate Traffic Congestion

Traffic delays result from road closures, lane closures, and lane narrowing which cause vehicle speed reduction on roads and highways. Delays result in increased emissions from vehicle engines travelling slowly through the construction zone. Options to consider that increase traffic flow and thereby mitigate potential emissions are: adding a new lane on the shoulder; carrying out activities one lane at a time; and re-routing traffic.

Rapid on-site construction would reduce the duration of traffic interference and therefore reduce emissions from traffic delay. Several strategies have been investigated by the U.S. Transportation Research Board to reduce the duration of on-site road construction. In addition to ways of improving production rates, off-site fabrication of structures such as bridges also reduce on-site construction time. Off-site fabrication of structural components can also enhance the quality of work, as the production takes place in controlled settings and external factors such as weather and traffic do not interfere. Enhanced structural quality will result in extended lifecycle of structures and thus result in reduced lifecycle emissions.

5.5 Minimize Distances Travelled for Delivery of Materials

The delivery of materials such as concrete, asphalt and aggregates to construction sites can generate significant amounts of road dust and result in increased vehicle emissions, especially for sites that are relatively far from material manufacturers. Some material deliveries can be eliminated by establishing temporary, portable concrete and/or asphalt plants, located on construction sites. This practice may be feasible for large-size projects that require substantial quantities of these materials. However, in many cases these portable plants will not be feasible due to the costs involved (e.g., installation, permitting, etc.). Establishing temporary plants would reduce the number of transport trucks travelling on public and on-site roads.

5.6 Use Green Building Materials

Green building materials should be selected whenever possible in order to reduce emissions associated with the lifecycle of the building. Alternative paints, flooring, windows, insulation, walls, and other construction materials should be evaluated. There is an extensive amount of information on green building materials located on the internet. The following sites can be accessed to help identify green building materials that are most applicable and appropriate for specific construction activities:

- Canadian Green Building Council (http://www.cagbc.org/);
- Leadership in Energy and Environmental Design (LEED Canada) (http://www.cagbc.ca/building_rating_systems/leed_rating_system.php);
- Canadian Construction Association's Green Building Resource Centre (http://www.cca-acc.com);
- Athena Sustainable Materials Institute (http://www.athenasmi.ca/)
- Master Painters Institute (http://www.paintinfo.com/mpi/)
- Canadian Mortgage and Housing Corporation Healthy Housing (http://www.cmhc.ca/en/imquaf/hehosu/index.cfm)
- Green Globes Canada http://www.greenglobes.com/design/homeca.asp
- U.S. Green Building Council (http://www.usgbc.org/);
- Leadership in Energy and Environmental Design (LEED U.S.) (http://www.usgbc.org/LEED/LEED_main.asp).
- Environmental Choice Program (www.environmentalchoice.com)

5.6.1 Choosing Road Surface Type

The best road surface for reduction of emissions depends largely on the situation (the type of surface put on a road, such as gravel, chip seal, or concrete, is based on the level of traffic and amount of heavy loads carried). Different surface types require different amounts of aggregate materials as a base (concrete pavement structures have less aggregate than asphalt structures). Proximity of aggregate materials also plays a role in the cost of the pavement structure and potentially on the pavement chosen. The amount of digging and earth moving also varies according to road surface type. Less subgrade width is normally required for a concrete pavement than an asphalt pavement. In addition, less blasting is required due to the narrower subgrade.

5.7 Design and Construct for Maximum Energy Efficiency

There are many opportunities to improve the energy efficiency of buildings and consequently reduce their lifecycle emissions (e.g., selection of appliances, heating and cooling, home electronics, lighting, office equipment, etc.). The following resources should be accessed in order to identify additional information:

- The Canadian *Model National Energy Code for Buildings* is a model energy efficiency code published in September 1997 by the National Research Council of Canada (NRCC). The code sets minimum energy efficiency standards for commercial building construction in Canada. Details on how to obtain the *Model National Energy Code for Buildings* can be found at http://irc.nrc-cnrc.gc.ca/catalogue/energy2.html.
- The Model National Energy Code of Canada for Houses provides assistance in designing energy-efficient housing that minimize air-conditioning and heating bills given construction cost trade-offs. This code applies to single family houses of three story's or less, and to additions of more than $10m^2$. Details on how to obtain the Model National Energy Code of Canada for Houses can be found at: http://irc.nrc-cnrc.gc.ca/catalogue/energy1.html.
- Natural Resources Canada's R-2000 Program promotes the use of cost-effective energy-efficient building practices and technologies. (http://oee.nrcan.gc.ca/r-2000/).

6. Reducing Fugitive Dust Emissions From Construction and Demolition Sites

6.1 Introduction

This section of the Best Practices document identifies and describes various technologies and work practices that can be applied to minimize fugitive dust emissions during construction and demolition activities. The various actions have been described under the following construction activities that generate fugitive dust emissions:

- Site preparation;
- Storage piles;
- Material handling and transfer systems;
- Road surfaces;
- Fabrication processes; and
- Demolition and deconstruction.

6.2 Site Preparation

Site preparation steps such as earthworks, excavation, soil stripping, clearing and grubbing, earthmoving and landscaping, can result in significant dust emissions, especially during dry weather periods and particularly if followed by high winds. Outlined below are various work practices and technologies that may be employed prior to, during and after the site preparation process in order to minimize dust emissions.

6.2.1 Grade the Construction Site in Phases

Each area of the construction site should be graded separately (i.e., not all at once), timed to coincide with the actual construction in that area. This allows vegetation and cover to remain intact within the construction zone, until just prior to construction occurring on that segment of the construction site. Construction should be started at the location that is upwind from the prevailing wind direction. Phasing is considered to be especially critical for project sites greater than 40 hectares in size.

6.2.2 Utilize Wind Fencing

Permanent perimeter or temporary interior fencing should be installed within construction sites as early in the construction operation as possible. Detailed guidance on wind fencing includes the following:

- One to two-meter barriers with 50% or less porosity, berms or equipment should be located adjacent to roadways or urban areas.
- The bottom of wind fences should be sufficiently anchored to the ground to prevent material from blowing underneath the fence.
- Barriers placed at right angles to prevailing wind currents at intervals of 15 times the barrier height are suggested to be the most effective in controlling wind erosion.
- Windbreaks and fabric fences should be maintained in an upright and functional condition at all times until no longer needed.
- All accumulated material on the windward side of the windbreak should be periodically removed to prevent failure of the windbreak.

Examples of wind fencing include: trees or shrubs left in place during site clearing; sheets of plywood; wind-screen material such as that used around tennis courts; snow fences; hay bales; crate walls; sediment walls; burlap fences; etc. Block walls, if part of the final project, can replace wind fencing during the site construction phase.

6.2.3 Stabilize Surfaces of Completed Earthworks with Vegetation

Surfaces of completed earthworks (including landscaping) should be re-vegetated (i.e., seeded and mulched) within 10 days after active operations have ceased.

Ground cover should be of sufficient density to expose less than 30% of un-stabilized ground within 90 days of planting, and all times thereafter. Such restoration control measure(s) should be maintained and reapplied, if necessary, so that a stabilized surface is formed within 8 months of the initial application. Ground cover should be established prior to final occupancy. The area should be restored such that the vegetative ground cover and soil characteristics are similar to adjacent or nearby undisturbed native conditions (e.g., reseed using native grasses). Care must be taken to avoid introducing or promoting the spread of noxious weeds and plants. Prevent motor vehicle and/or off-road vehicle trespassing, parking, and/or access, by installing barriers, curbs, fences, gates, posts, signs, shrubs, trees or other effective control measures.

Temporary seeding and mulching may be applied to cover bare soil and to prevent wind erosion. The soil must be kept moist to establish cover. Mulch can protect the soil surface until newly seeded vegetation can take over and improves the chance of getting a good grass stand quickly. Some types of mulch require tilling to integrate them into the upper layer of soil, if they are to be effective in dust control. Light mulches such as straw should be tacked in place, either mechanically or by application of a chemical tacking agent. Areas to be reseeded should be mulched as described below:

- Hay mulch – perennial native or introduced grasses of fine-stemmed varieties should be used. At least 65% of the herbage by weight of each bale of hay should be 10 inches long in length or longer. Rotted, brittle or mouldy hay are not acceptable. Hay should be properly cured prior to use. Hay that is brittle, short fibered or improperly cured is not acceptable. Hay mulch should be crosshatched crimped to a minimum depth of two inches.
- Straw mulch – small grain plants such as wheat, barley, rye or oats should not be used. Alfalfa or the stalks of corn, maize or sorghum are not acceptable. Material which is brittle, shorter than 10 inches or which breaks or fragments during the crimping operation are not considered acceptable. Straw mulch should be crosshatched crimped to minimum depth of two inches.
- Gravel mulch –should be a maximum of three quarters to one inch in diameter and must have been crushed or screened with a minimum of one angular face.

It is recommended that existing trees and large shrubs (and other live perennial vegetation) be allowed to remain in place to the greatest extent possible during site grading processes. Perimeter vegetation should be planted early.

6.2.4 Stabilize Surfaces of Completed Earthworks with Stone/Soil/Geotextiles

The following materials may be used to stabilize surfaces, when re-vegetation is not possible (e.g., highly erodible soils):

- Stone (coarse gravel or crushed stone) can be an effective dust deterrent. The sizes of the stone can affect the amount of erosion that takes place. In areas of high wind, small stones are not as effective as large stones (e.g., 8 inches).
- Topsoil uses less erodible soil material placed on top of highly erodible soils.
- Geotextiles can be used on graded sloped surfaces to prevent wind and water erosion.

6.2.5 Create Ridges to Prevent Dust

A disk or other implement may be run on contours of slopes to disturb the soil and leave ridges as well as bring clods of soil to the surface. These ridges deflect and raise wind 5 or 6 inches above the soil surface. Plowing should begin on the windward side of the site using chisel-type plows spaced about 12 inches apart, spring tooth harrows, or similar plows.

6.2.6 Compact Disturbed Soil

Disturbed soil may be compacted with rollers or other similar equipment in order to reduce the erosion potential of the area.

6.2.7 Eliminate Open Burning

Open burning of vegetative waste or other burn materials (e.g., trash, demolition debris, etc.) should not be carried out at the construction site. Open burning is typically prohibited because it can cause air pollution that is harmful to human health and the environment, and endanger property. Waste materials disposed of via open burning typically consist of plastics, other synthetics and chemicals. The low-temperature burning of these materials leads to incomplete combustion and emissions of several toxics. In addition, emissions from open burning are highly concentrated.

Municipalities have preferred management approaches to vegetative waste depending on local circumstances. These can include mulching, firewood, resale for cost recovery, used at waste to energy facilities, etc. Operators should determine local preferences for addressing vegetative waste and ensure that this approach reduces dust generation.

During site clearing, vegetative material may be chipped and then stored for subsequent use as cover material for vehicle access lanes or storage piles.

6.2.8 Where Possible, Reduce Certain Activities During Windy Conditions

During times of windy conditions, where feasible, construction operations that generate greater levels of dust may be avoided or reduced. Instead, these activities can be conducted when more favourable weather conditions occur. Increased application of other dust suppressant techniques may also be considered in times of very windy weather.

6.3 Storage Piles

Several work practices can be employed to mitigate fugitive dust emissions resulting from storage piles. These work practices primarily reduce the exposure of storage piles to wind.

6.3.1 Storage Pile Activities Should be Conducted Downwind

Storage pile activity (i.e., loading and unloading) should be confined to the downwind side of the storage pile. This practice applies to areas around the storage pile as well as the pile itself. Storage piles should also be located away from downwind site boundaries.

6.3.2 Utilize Enclosures/Coverings for Storage Piles

Enclosures or the covering of inactive piles are effective in reducing wind erosion and controlling fugitive dust emissions from storage piles. Enclosures can either fully or partially enclose the source. Examples of enclosures used for reducing fugitive dust emissions from storage piles include:

- three-sided bunkers that are at least as high as the stockpiled materials. The sides' length must be no less than equal to the length of the pile; the sides distance from the pile must be no more than twice the height of the pile; the sides height must be equal to the pile height; and the material of which the sides are made must be no more than 50% porous;
- storage silos (in lieu of open piles). Bulk cement, bentonite and similar fine dry materials (e.g., less than 3 millimetres in particle size) should be stored in silos. Silos should be equipped with particulate matter emission control technology (e.g., fabric filters); and
- open-ended buildings or completely enclosing the pile within a building furnished with particulate matter emission control technology.

Tarpaulins, plastic, or other material can also be used as a temporary covering. When these temporary coverings are used, they should be anchored to prevent the wind from removing them. Small or short-term inactive storage piles should be enclosed or kept under sheeting while larger inactive storage piles should be shrouded, capped or grassed over. For example, turf removed early in the construction project may be re-used to grass over long-term inactive storage piles. It should be noted that enclosures/coverings may not be suitable under certain conditions.

6.3.3 Utilize Wind Fences/Screens for Storage Piles

Porous wind fences/screens provide an area of reduced wind velocity that reduces wind erosion potential and fugitive dust emissions from the exposed surface on the leeward side of the fence/screen. Wind fences/screens reduce the turbulence generated by ambient winds in an area the length of which is many times the physical height of the fence. It should be noted that wind fences/screens may not be suitable under certain conditions.

Wind fences/screens can either be man-made structures (e.g., wind fences, berms, parking construction equipment in a position to block the wind) or vegetative (see below) in nature and are considered to be very cost effective since they incur little or no operating and maintenance costs.

The level of emission reductions achieved with wind fences/screens depends upon the physical dimensions of the fence relative to the source being controlled (e.g., storage pile). The length of the wind fence/screen should be no less than the length of the pile and the height must be equal to or greater than the height of the pile.

A vertically-abrupt barrier will provide large reductions in velocity for relatively short leeward distances, whereas porous barriers provide smaller reductions in velocity but for more extended distances. If complete control is desired, then barriers must be placed at frequent intervals. In addition, the direction of wind influences the size and location of the protected areas. The area of protection is greatest for winds perpendicular to the barrier length and least for winds parallel with the barrier.

A porosity (i.e., percent open area) of 50% achieves optimum results for most applications. The porosity can be achieved by vertical or horizontal slatting or by a mesh structure, as long as the element size is no more that about a fifth of the fence height. Some research has indicated that for a small soil storage piles, a screen length of five times the pile diameter, a screen to pile distance of twice the pile height and a screen height equal to the pile height is optimal.

In addition to storage piles, wind fences/screens can be used to mitigate fugitive dust emissions from a wide variety of other fugitive dust sources (e.g., variety of exposed areas, materials handling operations, etc.). Since fences and screens can be portable, they are therefore capable of being moved around the site, as needed.

6.3.4 Use Vegetation Cover as a Wind Break

Vegetation can be grown on and around storage piles in order to mitigate fugitive dust emissions. Vegetative cover that can act as a windbreak may consist of perennial grass, trees or shrubs in 1 to 10 rows. One, two, three, and five-row barriers of trees are found to be the most effective arrangement for planting to control wind erosion. The type of tree species planted also has considerable influence on the effectiveness of a windbreak. In arid and semiarid regions where rainfall is insufficient to establish vegetative cover, mulching may be used to conserve moisture, prevent surface crusting, reduce runoff and erosion, and help establish vegetation.

Storage piles can also be situated in order to take advantage of existing landscape features and vegetation, which can act as a windbreak.

6.3.5 Properly Shape Storage Piles

Storage piles should be maintained so that they do not have steep sides or faces. In addition, sharp changes of shape in the final storage pile should be avoided. The disturbance of storage piles should also be minimized where feasible.

6.3.6 Properly Schedule the Delivery of Landscaping Materials

Material should not be ordered unless it will be used shortly after delivery. This will minimize storage time and reduce the potential for emissions.

6.4 Material Handling and Transfer Systems

There are many actions that can be employed to mitigate dust emissions resulting from material handling and transfer operations such as crushing, grinding mills, screening operations, bucket elevators, conveyor transfer points, conveyor bagging operations, storage bins, and fine product truck and railcar loading operations.

6.4.1 Control Mud and Dirt Trackout and Carryout

Mud and dirt trackout/carryout from construction sites can account for a temporary but substantial increase in paved road emissions in many areas. Elimination of trackout/carryout can thus significantly reduce paved road emissions. There are several techniques that can be employed to remove material from truck underbodies and tires prior to leaving the site as well as techniques to periodically remove mud/dirt trackout/carryout from paved streets at the access point(s).

6.4.1.1 Street Cleaning

The accumulation of mud, dirt or similar debris that is deposited on paved roads (including shoulders) adjacent to the site should be removed. This cleaning should occur at the end of each workday, or at a minimum of once every 24 hours when operations are occurring. In urban areas, this cleaning should be undertaken immediately if the trackout/carryout extends more than 10 metres (33 feet) onto the paved public road. If the trackout/carryout extends less than 10 metres, clean up should occur at the end of the workday. In addition to public roads that are located outside of the construction site, accumulated mud and dirt should also be frequently removed from the paved interior roads to prevent trackout/carryout onto the paved public roadway.

The recommended street cleaning can be conducted by: manually broom sweeping and picking up material; rotary brush or broom accompanied with or preceded by sufficient wetting; vacuum sweeping; water flushing; and water sweeper. If wet systems are used, the runoff should be controlled so it does not saturate the surface of the adjacent unpaved haul road.

Vehicle waiting areas should also be regularly inspected and kept clean by brushing or vacuum sweeping.

Street sweeping technology should be selected that is most efficient in the use of water while at the same time minimizes dust generation. Since vacuum sweepers are more effective in removing smaller, finer soil particles, they have replaced conventional broom sweepers.

Municipalities often operate street sweeping equipment. These municipalities should coordinate timing, costs and use of the equipment to ensure street clean-up occurs as soon as dust generating activity is completed or during the tracking period.

6.4.1.2 Haul Roads

Paved haul roads or gravel strips should be created early in the project. These haul roads are designed to limit mud and dirt deposits on public paved roads. The paved or gravel haul roads should be maintained at the point of the intersection of a paved public roadway and a work site entrance. Haul roads enable construction vehicles to clean their tires before movement to a more heavily travelled paved public roadway.

When paving, the surface should extend at least 30 meters into the site and be at least 7 meters wide (23 feet wide). Mud and dirt deposits accumulating on paved interior roads should be removed with sufficient frequency, but not less frequently than once per workday, to prevent carryout and trackout onto paved public roads.

When using a gravel bed, washed gravel, rock, crushed rock or other low silt (<5%) content material should be used (minimum size – one inch in diameter, preferably between 1 and 3 inches in diameter) and maintained in a clean condition to a depth of at least six inches and extending at least 7 meters wide and at least 15 meters long and a minimum of 6 inches deep. The gravel bed should cover the full width of the unpaved exit surface. When installing the gravel bed ensure that it is properly graded. The gravel should be re-screened and washed or additional gravel should be applied in order to maintain effectiveness. Any gravel deposited onto a public paved road travel lane or shoulder should be removed at the end of the workday or immediately following the last vehicle using the gravel pad, or at least once every 24 hours, whichever occurs first.

Installation/stabilization of curbing and/or paving of road shoulders can prevent tracking of dirt from construction sites.

6.4.1.3 Trackout Control Devices

There are various trackout control devices that can be installed in order to remove mud, dirt, etc. from truck tires and the undercarriage of motor vehicles and/or haul trucks prior to leaving the work site, for instance a grizzly or a wheel washing system. It should be noted that track-out control devices require environmental management plans to control surface deposition.

A grizzly is also known as a wheel shaker/wheel spreading device and consists of raised dividers (rails, pipe or grates) that are at least three inches tall, at least six inches apart, at least 8 meters long and 3 meters wide. Wheel washers may be adjusted to spray the entire vehicle including bulk-stored material in haul vehicles. Grizzlies and wheel washers should be cleaned/maintained on a regular basis to ensure their effectiveness.

These systems should be installed on all work sites with a disturbed surface area of 3 hectares or more and from all work sites where 75 cubic metres (~100 cubic yards) of bulk materials are hauled on/or off-site per day. All traffic should be routed over the installed trackout control devices.

6.4.1.4 Truck Wash

A truck wash, using hoses and ample water supply, should be installed at access points to remove mud/dirt from vehicles prior to exiting the site. The wheels and the body of each truck can then be cleaned to remove spilled materials after the truck has been loaded and prior to leaving the construction site. Vehicles may be washed prior to each trip. Construction equipment may also be washed at the end of each work day. It should be noted that truck wheel washes require environmental management plans to control surface runoff of wheel wash water.

6.4.1.5 Site Restrictions

Some site restrictions that should be considered to minimize trackout/carryout include the following:

- confine load-in/load-out procedures to leeward (downwind) side of the material;
- designate a single site entrance and exit; and
- ensure that vehicles stay on established traffic routes within the construction site.

6.4.2 Minimize Material Drop at the Transfer Point and Enclosure

When loading materials onto vehicles and conveyors, the drop heights should be kept to a minimum and enclosed whenever possible. Where feasible, transfer points and conveyor belts should be totally enclosed (or conveyor belts are to be equipped with no less than 210 degrees of enclosure) on the top and sides as needed and the collected emissions directed to particulate matter control equipment (i.e., baghouse or similar control device) at all times when the conveyors are in operation. The distance between material transfer points should also be minimized.

Conveyor belts should be equipped with belt wipers and hoppers of proper size to prevent excessive spills. Conveyor belts as well as the ground under conveyors should be periodically cleaned to remove residue material. The speed of the conveyor belt should also be restricted to minimize spills.

6.4.3 Utilize Foam Suppression Systems

Foam systems (combination of water and a chemical surfactant) may be used on material transfer systems to mitigate dust generation. The surfactant, or surface active agent, reduces the surface tension of the water. As a result, the quantity of liquid needed to achieve good control is reduced. The primary advantage of foam systems is that they provide equivalent control at lower moisture addition rates than water spray systems.

Some specific application guidelines for foam systems include the following:

- Foam can be made to contact the aggregate material by any means (high velocity impact is not required);
- Foam should be distributed throughout the product material - inject the foam into free-falling material rather than cover the product with foam; and
- Amount applied should allow all of the foam to dissipate. Presence of foam with the product indicates that either too much foam has been used or it has not been adequately dispersed within the material.

6.4.4 Secure Loads on Haul Trucks

There are several work practices that can be employed to minimize the amount of fugitive dust emissions that occur from the transportation of aggregate material within a construction site.

6.4.4.1 Partial or Total Enclosures

The entire surface area of hauled bulk materials should be covered with an anchored tarp, plastic or other material whether the cargo container is empty or full. Alternatively, completely enclosed trucks can be used. For instance, the transport of fine powdery material should be carried out in closed tankers, while dusty materials and aggregates should be transported in enclosed or sheeted vehicles.

Where feasible, the cargo compartment of haul trucks should be cleaned and/or washed at the delivery site before/after loading or unloading. This practice can be applied judiciously, for instance to specific trucks that appear to be particularly dirty (i.e., not necessary for some trucks that appear to be quite clean).

The cargo compartment of all haul trucks should be constructed and maintained so that spillage and loss of bulk material cannot occur from holes or other openings in the cargo compartment's floor, side and/or tailgate or bottom dump gate. Seals on any openings used to empty the load including, but not limited to, bottom-dump release gates and tailgates should be properly maintained to prevent the loss of bulk material from those areas. Belly-dump truck seals should be checked regularly, with any trapped rocks removed in order to prevent spillage.

6.4.4.2 Freeboard

If feasible, trucks may be loaded such that the freeboard is not less than 7 cm (~3 inches). In other words, trucks may be loaded so that no part of the load that makes contact with any sideboard, side panel or rear part of the load comes within 7 cm (~3 inches) of the top part of the enclosure for bulk materials.

6.4.4.3 Loader Bucket

Aggregate material should be emptied from the loader slowly, keeping the bucket close to the truck while dumping (to minimize drop height).

6.4.5 Prevent PM Emissions from Spills

Spillage of material caused by storage pile load-out and maintenance equipment can significantly increase fugitive dust emissions associated with vehicle traffic. If spillage cannot be prevented due to the intense use of mobile equipment in the storage pile area, then the following work practices should be adhered to:

- Methods and equipment to immediately clean-up accidental spillages of dusty or potentially dusty materials should be readily available. If necessary, use audible and visual alarm systems;
- A vacuum truck should be used to clean up spills of cement powder and similar dusty materials; and
- The material transfer site (as well as the entire construction site) should be regularly inspected for spills. There should be regular removal of spilled material in areas within 100 metres of the storage pile. Consider designating an individual to be responsible for spill response and clean-up as well as reporting requirements.

6.4.6 Minimize Material Handling Operations

The number of material handling operations should be kept to a minimum by ensuring that dusty material is not moved or handled unnecessarily. Process speeds should be minimized in order to reduce fugitive dust emissions.

6.4.7 Capture Fugitive Dust Emissions

Fugitive dust emissions escaping through building openings where material handling operations occur may be controlled by installing a removable filters over appropriate building openings, capturing emissions within the building by a proper hood system and conveying the dust through a duct to particulate collection systems.

6.4.8 Utilize Wind Barriers

Where practical, wind barriers may be installed with a porosity of no less than 50% upwind of screening operations to the height of the drop point.

6.4.9 Where Possible, Reduce Certain Activities During Windy Conditions

During very windy conditions, where feasible, specific material handling/transfer activities that generate greater levels of dust may be avoided or reduced. Instead, these activities can be conducted when more favourable weather conditions occur. Increased application of water or other dust suppression techniques may also be considered, if it is not possible to reschedule activities.

6.5 Road Surfaces

The following work actions can be employed to reduce the potential for fugitive dust emissions from the various road surfaces located within construction sites. Examples of these road surfaces include unpaved roads, haul routes, parking lots, equipment staging areas, etc. An evaluation should be made to determine which road surfaces, if treated, would mitigate the most dust (likely all unpaved surfaces cannot be treated).

6.5.1 Establish On-site Vehicle Restrictions

Vehicle restrictions limit the amount and type (e.g., restriction of roads to certain vehicle types or vehicles under a certain weight) of traffic present on unpaved roads or lowers the mean vehicle speed travelling on the road. For instance, reducing the amount of trips (e.g., by 50%) will reduce the generation of fugitive dust from unpaved road surfaces. General site traffic should also be limited to established haul routes which have been watered or treated and unnecessary vehicle movements and manoeuvring should be avoided. Barriers should be utilized to prevent motor vehicle and/or off-road vehicle trespassing, parking, and/or access, by installing barriers, curbs, fences, gates, posts, signs, shrubs, trees, or other effective control measures.

Construction sites should limit the speed of vehicles travelling on unpaved access/haul roads within construction sites to a maximum of 16-24 kilometres per hour (10-15 miles per hour) and to 10 kilometres per hour (6 miles per hour) on unmade surfaces. Speed limit signs should be posted at each construction site's uncontrolled unpaved access/haul road entrance. At a minimum, speed limit signs should also be posted at least every 150 meters (500 feet) and should be readable in both directions of travel along uncontrolled unpaved access/haul roads.

6.5.2 Surface Improvements to Unpaved Road Surfaces

Paving of the internal roadway network including roads and parking lots (using recycled asphalt, asphaltic concrete or concrete) early in a project's development phase will significantly reduce fugitive dust emissions. If an internal roadway network is paved, employees are to be instructed to park only on paved areas. It should be noted that paving internal roadways has significant costs and will only be feasible in certain situations, for instance when work is to be carried out at a site for a significant time-period. Alternatively, the unpaved road can be double chipped and sealed and subsequently maintained on an as needed basis.

If not paved, the road surface should be covered with material that has a low silt content (i.e., less than 5%) to a depth of three or more inches. Examples include gravel, slag, recrushed/recycled asphalt and road carpets. Gravel should be used in areas where paving, chemical stabilization or frequent watering is not feasible. These roads should be gravelled on a regular basis.

Vegetative cover has been suggested as a surface improvement for very low traffic volume roads.

6.5.3 Proper Maintenance of Unpaved Roads

The edges of roads and footpaths should be cleaned regularly, using brooms and damping as necessary. Weekly scraping of roads with a grader may be undertaken to clear off dirt and debris.

6.5.4 Work Practices Associated with De-icing Materials

Some work practices to reduce fugitive dust emissions associated with de-icing operations within construction sites include the following:

- Use of de-icing materials with either a lower initial silt content or greater resistance to forming silt-size particles will result in lower road surface silt loadings and subsequently lower fugitive dust emissions;
- Plow road surfaces instead of sanding;
- Sand and chips remaining from road de-icing should be swept-up and transported to a designated storage area for reuse; and
- Improvements in planning and application techniques limit the amount of de-icing material that has to be applied to roads on a construction site.

6.6 Fabrication Processes

Outlined below are work practices that may be applied to reduce fugitive dust emissions from the various fabrication processes that occur at construction sites. A common work practice to reduce fugitive dust emissions (among many of these fabrication processes) is the use of high efficiency particulate arrestors (HEPA). HEPA filters control fine particulate matter emissions from dry work on concrete such as blasting, crushing, jack-hammering, grinding, boring holes, sandblasting, polishing, and sawing. HEPA filters can capture 95% of silica dust.

Enclosures should also be used whenever possible as they are an effective way to prevent the transport of dust throughout buildings and from buildings to the environment. Wood frame and plastic film enclosures can be designed with negative pressure to ensure that dust does not flow out of the enclosed space. The potential of increased workplace exposure to dust must be considered when utilizing enclosures inside structures.

Ducting systems should be cut-off to prevent the circulation of dust during construction and renovation activities.

Material drop heights for building debris should be minimized whenever possible. When debris is being dropped from high levels, this material should be dropped over several sequential stages instead of the entire distance at once. Chutes that are used to drop materials to the ground level should be enclosed, if feasible. In addition, bins that are used to receive materials should also be covered when not in use.

6.6.1 Cutting, Grinding and Drilling

Work practices to minimize fugitive dust emissions from various cutting, grinding and drilling operations include the following:

- Use prefabricated materials whenever possible, to avoid the necessity of using these processes on the construction site;
- Apply water sprays in conjunction with cutting equipment;
- Avoid cutting out errors and re-bars;
- Always try to fill whenever possible rather than cutting back oversized work;
- Always use dust extraction/minimization systems with angle grinders and disc cutters;
- When cutting roadways, pavements, blocks, etc., a diamond bladed floor saw with water pumped through the system should be used; and
- When raking out mortar/pointing, a mortar raking kit, fitted on to a standard 5 inch (13 centimeter) angle grinder can be used on soft mortar. For hard mortar, a super-saw with oscillating blades can be used.

6.6.1.1 Design Considerations to Avoid Grinding and Cutting

If possible cutting and grinding should be avoided through the design and other techniques, such as:

- Designing tolerances for infilling rather than cutting back oversize work;
- Increasing the size of concrete pours to reduce the need for grinding;
- Use of bonding agents;
- Designing the concrete components themselves to affect interfaces; and
- Using wet grit blasting for outside work.

Should grinding be necessary, PM emissions can be mitigated by: (i) fitting tools with dust bags; (ii) pre-washing work surfaces; (iii) screening off areas to be ground; and (iv) vacuuming up, as opposed to sweeping away, residual dust.

6.6.2 Sand and Grit Blasting and Façade Cleaning

6.6.2.1 Utilize Wet or Other Processes That Minimize Dust Generation

When sand, grit or shot blasting or façade cleaning, wet processes (e.g., high pressure water blasting or water blasting supplemented by abrasives) should be used whenever possible. Wet processes introduce water into the air/grit stream, which reduces dust generation. In addition, it should be ensured that the slurries do not dry out. Spent abrasive materials should be wetted and periodically removed from the job site. Hydroblasting, vacuum blasting and centrifugal wheel blasting are also alternatives that reduce fugitive dust generation vs. dry blasting.

6.6.2.2 Utilize Enclosures

If dry grit blasting is necessary, then curtains, enclosures or shrouds should be erected to completely surround the blasting operation. This includes the area around and underneath the operation. The ground cannot be used as the bottom of the enclosure unless completely covered with plastic sheeting or a tarpaulin. The enclosure should be constructed of flexible material such as tarpaulins or containment screens which are specifically designed for this purpose or for rigid materials such as plywood. All materials should be maintained free of tears, cuts or holes.

All debris which has been collected by this operation or which has fallen to the ground should be collected and subsequently disposed of. Collection and storage should be done as often as needed, but as a minimum, at the end of each workday. Storage should be in steel dumpsters or drums. All containers should include lids that should be secured at the end of each workday.

Dry blasting should be conducted indoors, where possible, with enclosures equipped with emission controls. Negative pressure dust collectors should also be used in conjunction with enclosures and keep doors closed to reduce fugitive dust emissions.

6.6.2.3 Stabilize Particulate Matter in Surrounding Area Following Blasting

Particulate material from the surrounding area should be cleaned up during and following blasting activities. Water or a dust suppressant should be applied to the disturbed soils after blasting as well.

6.6.2.4 Alternative Abrasive Material Should be Used

More durable abrasives with lower dust generation potential should be used, such as non-friable abrasives. The reuse of abrasives containing high quantities of fines and/or toxic compounds should be avoided.

6.6.3 Concrete Cutting

Concrete cutting operations use diamond or abrasive discs for hand-cutting operations and a Vermeer grinder wheel mounted on a construction vehicle for large cutting or trenching operations. The use of water in sufficient quantities to wet the cutter, the immediate surrounding work area, and the fugitive dust immediately emanating from the cutting operation is effective (e.g., use of a wet vacuum system). This work practice also applies to asphalt cutting as well.

Enclosures, curtains or shrouds surrounding the work area that contain the emission of fugitive dust may also be utilized. In this case, the surface dust created should be promptly cleaned from the surface using a wet sweeping process. A vacuum should be used to collect dust when cutting materials.

6.6.4 Mixing Processes

Actions that can be employed to mitigate the generation of PM emissions from mixing operations include the following:

- Utilization of pre-mixed concrete, plasters and masonry compounds will serve to reduce on-site PM emissions generation;
- Use correctly-sized pre-cast sections in order to reduce the need for cutting and drilling on the construction site;
- Enclosed or protected areas should be used to mix concrete or bentonite slurries;
- Fine materials should be palletized and shrink wrapped when possible;
- Keep foundations moist; and
- Use larger pours of concrete rather than repeated small pours.

6.6.5 Internal and External Finishing and Refurbishment

Dust suppression/collection equipment should be attached when using sanding and cutting machinery. In addition, vacuum cleaning should be used whenever possible. When installing fire-proofing or insulation material, dust suppressants should be used when blowing fibres into empty spaces or encapsulated materials should be used instead.

Floor sweeping can generate dust. Inside of homes should be power vacuumed of dust and debris. When cleaning after work has been completed, damp sweeping using fine mist can also be utilized. Dry sweeping should only be utilized with vacuum extraction methods attached. Floor sweeping compounds can also be used where appropriate, or wet sawdust can be used.

6.7 Demolition and Deconstruction

Unique work practices and technologies that can be applied to reduce fugitive dust emissions from demolition and deconstruction activities are outlined below. There are many additional actions that can also be employed, but those common to demolition and construction activities are not repeated within this section. Demolition firms are encouraged to review Section 4 in order to identify additional actions that can be employed to reduce fugitive dust emissions from their operations.

6.7.1 Apply Deconstruction Techniques

Buildings that must be taken down should, to the extent possible, be deconstructed rather than demolished so that materials can be reused in other buildings. Deconstruction generally results in lower fugitive dust emissions compared to demolition.

6.7.2 Minimize Drop Heights for Debris

Material drop heights for building debris should be minimized whenever possible. When debris is being dropped from high levels, this material should be dropped over several sequential stages instead of the entire distance at once.

6.7.3 Enclose Chutes and Cover Bins

Chutes that are used to drop demolished materials to the ground level should be enclosed, if feasible. In addition, bins that are used to receive materials should also be covered when not in use.

6.7.4 Use Fogging Systems

A fogging system can be used to direct fog into the fugitive dust area. If fog droplets and airborne dust mix, dust particles stick to the water droplets thereby adding weight to the dust particles. The increased mass of the dust particles causes them to fall out of the air. Fogging systems can only be used in an area that has a pocket or cover.

6.7.5 Barriers to Prevent Dispersion

Enclosures, curtains or shrouds can be utilized during the demolition phase to confine dust generation. Negative pressure dust collectors can be used to collect the dust that has been confined by the enclosures, etc. Enclosures, curtains or shrouds may be impractical during demolition activities lasting a few days or less.

Prior to blasting, buildings should be screened with suitable debris screens and sheets.

6.7.6 Avoid Blasting When Feasible

Blasting with explosives has the potential to generate large amounts of fugitive dust emissions in a very short period of time. Blasting should be avoided and other demolition and deconstruction methods used wherever possible. It is noted that in some instances, blasting is the safest manner in which to quickly bring down a structure.

Blasting operations can significantly reduce the size of the building and its component materials. The generation of a large amount of fugitive dust in the short term through blasting may reduce the potential for prolonged periods of fugitive dust emissions that would otherwise occur in ongoing size reduction operations.

6.7.7 Vacuum Debris

Vacuums or similar cleaning devices should be used to thoroughly clean blast debris from paved and other surfaces following blasting operations. An industrial vacuum should be used to clean debris prior to the use of high pressure air to blow soil and debris.

6.7.8 Work Practices for Loading Debris

Loaders should tip debris into haulage trucks with a minimum fall distance to minimize dust emissions from tumbling debris. If possible, fine debris should be placed into the truck bin first, followed by larger debris on top. Alternatively, if possible, dry debris should be placed into the truck bin first, followed by wet debris on top. Debris loads should be balanced in truck bins. Debris loads should not be compacted using the impact of a loader bucket.

6.7.9 Avoid Prolonged Storage of Debris

Avoid prolonged storage of debris on site and its exposure to wind.

Waste and refuse bins should be covered when they are being removed from the construction site.

7. Reducing Other Emissions at Construction and Demolition Sites

7.1 Introduction

This chapter of the Best Practices document identifies actions that can reduce emissions from construction and demolition activities, beyond fugitive dust emissions. Three separate emission source categories are addressed in this section of the Best Practices document, specifically:

- Vehicle and equipment engines;
- Hot mix asphalt production at portable plants; and
- Volatile organic compounds (hydrocarbon solvents).

While the focus of this chapter is on emissions other than PM, the section on vehicle and equipment engines identifies actions that can also reduce particulate matter emissions from vehicle and equipment stacks (i.e., not fugitive PM emissions).

7.2 Vehicle and Equipment Engines

Road and heavy engineering construction activities rely on the utilization of a wide range of mobile equipment, such as bulldozers, graders, dump trucks, pavers, excavators, and bobcats. The engine exhaust from these vehicles, especially from those operating on diesel fuel, represent a source of particulate and other emissions (e.g., SO_2, NO_x, VOC, PAH, CO_2) from the construction site. Outlined below are technologies and work practices that can be employed to reduce these emissions. Construction companies are advised to ensure that their warranties on vehicles will not be voided, should they be retrofitted with emission control technologies or use of alternative fuels.

It should be noted that Environment Canada, through the Federal Agenda on Cleaner Vehicles, Engines and Fuels is establishing initiatives, including regulatory measures under the *Canadian Environmental Protection Act, 1999*, that are designed to reduce emissions from the various off-road vehicles and engines that are typically used at road and heavy engineering construction sites. The *Off-Road Compression-Ignition Engine Emission Regulations* introduce emission standards for new diesel engines such as those typically found in construction, mining, farming and forestry machines. The Regulations apply to engines of the 2006 and later model years. In addition, the *Off-Road Small Spark-Ignition Engine Emission Regulations* establish emission standards for small spark-ignition engines rated up to 19 kW (25 hp). Small spark-ignition engines are typically gasoline-fuelled engines found in lawn and garden machines, in light-duty industrial machines (e.g., generator sets, welders, pressure washers, etc.), and in light-duty logging machines. These Regulations apply to 2005 and later model-year engines. Further information can be obtained by visiting Environment Canada's CEPA Environmental Registry website at www.ec.gc.ca/CEPARegistry/regulations or calling the Inquiry Centre at 1-800-668-6767. Note that these Regulations do not set limits for GHG emissions.

7.2.1 Use Diesel Particulate Filters

The use of state-of-the-art catalyzed diesel particulate filters can significantly reduce particulate matter emissions from the exhaust of diesel-powered vehicles or equipment. Particulate traps can come equipped on newly purchased vehicles or can be installed on the existing fleet of diesel-powered vehicles operated by a construction company (i.e., retrofit existing vehicles).

All new diesel-powered vehicles should use state-of-the-art catalyzed diesel particulate filters. All existing vehicles should be evaluated, and wherever technically feasible and cost effective, retrofitted with diesel particulate filters.

Catalyst-based diesel particulate filters use catalyst materials to reduce the temperature at which collected diesel particulate matter oxidizes. The catalyst material can either be directly incorporated into the filter system, or can be added to the fuel as a fuel-borne catalyst (see below). Catalyst-based diesel particulate filters can be used with diesel fuels of varying sulphur content. However, very low sulphur fuel (i.e., no more than 15 mg/kg) should be used with vehicles equipped with these filters in order to achieve optimal emission reduction results.

7.2.2 Use Fuel-Borne Catalysts

Fuel-borne catalysts may be used to reduce the emissions of PM, NO_x, VOC and carbon monoxide from off-road diesel-fueled engines. These products typically contain an in-line solid metal oxidation/fuel modification catalyst that changes the composition of diesel fuel immediately prior to its use in an engine. Subsequent combustion of the modified fuel results in a reduction of both the elemental carbon and soluble organic fraction of diesel particulate matter, as compared to untreated fuel.

Another version of this technology is a concentrated liquid fuel-borne catalyst containing 4 to 8 parts per million of fuel-soluble platinum and cerium metal that reduces diesel particulate matter emissions from diesel-fueled engines. The fuel-borne catalyst catalyzes the rate of soot oxidation and lowers the temperature at which soot oxidation takes place.

7.2.3 Use Diesel Oxidation Catalysts

A diesel oxidation catalyst uses a catalytic substance (such as platinum or palladium) to accelerate chemical reactions. When exhaust gases contact the catalyst, the residual hydrocarbons and carbon monoxide are oxidized. The hydrocarbon oxidation also extends to such materials as polycyclic aromatic hydrocarbons (PAH) and the soluble organic fraction of diesel particulates. Diesel oxidation catalysts should be used by construction companies to reduce emissions associated with their diesel-powered vehicles.

The sulphur content of diesel fuel is critical for the performance of diesel oxidation catalysts. The catalyst used to oxidize the soluble organic fraction can also oxidize sulphur dioxide to form sulphate particulate, which is measured as part of particulate matter. Active diesel oxidation catalysts can also oxidize nitric oxide to from nitrogen dioxide. Catalysts have been developed that selectively oxidize the soluble organic fraction, carbon monoxide and PAH, while minimizing the oxidation of sulphur dioxide and nitric oxide. In general, diesel fuel with a sulphur content of 500 mg/kg by weight or less is recommended for any retrofit program.

7.2.4 Ensure Catalytic Converters are Operating Efficiently

Catalytic converters are used in gasoline-powered engines to reduce emissions (e.g., carbon monoxide, nitrogen oxides, volatile organic compounds) associated with vehicle operation. A catalytic converter changes these gases to carbon dioxide, nitrogen, oxygen, and water. Construction operations should ensure that the most advanced catalytic converters are installed on their gasoline-powered vehicles and that these converters are operating to their maximum efficiency.

Practices that serve to reduce the effectiveness of catalytic converters on gasoline-powered construction vehicles should be avoided. For instance, some engine oil additives or engine problems that cause the mixture or the temperature of the exhaust gases to change reduce the effectiveness and life of the catalytic converter. For instance, the over-use of fuel additives can shorten the life of a catalytic converter considerably. Gasket sealers and cements can also poison a converter. In addition, any time an engine is operating outside proper specifications, unnecessary wear and damage may be caused to the catalytic converter as well as the engine itself.

7.2.5 Evaluate Alternative Technologies to Reduce Emissions from Vehicle Engines

There are various emission control technologies at various stages of commercialization, a few of which are described below. These or others should be evaluated for utilization on construction vehicles.

- Selective catalytic reduction (SCR) technology was developed to mitigate NO_x emissions from stationary sources. Recently, SCR technology has been applied to selected large mobile sources. A chemical agent (ammonia or urea) is injected upstream of the SCR catalyst. It reacts with NO_x, reducing it to harmless products. SCR can also provide reductions in particulate matter and volatile organic compound emissions.

- Exhaust gas recirculation routes a portion of the exhaust to the charger inlet or intake manifold. In most systems, an intercooler lowers the temperature of the recirculated gas. The cooled recirculated gas, which has a higher heat capacity than air and contains less oxygen, lowers the combustion temperature in the engine and reduces NO_x formation.
- Lean NO_x catalysts introduce a small amount of diesel fuel into the exhaust stream. This diesel fuel acts as a reducing agent for the catalytic conversion of NO_x to nitrogen. The catalytic substrate is usually a porous material, often made up of zeolite, which provides microscopic sites for fuel (hydrocarbon rich) to react and reduce potential NO_x emissions.

7.2.6 Properly Maintain Engines and Exhaust Systems

Vehicle and equipment engines should be properly maintained to reduce exhaust emissions of CO, VOCs, and PM. Equipment that is in good condition will also reduce fuel consumption. Equipment should be inspected prior to the start of a project. While equipment is on site, a daily inspection should be conducted and parts and hoses showing signs of wear should be promptly replaced. Damaged parts should also be repaired or replaced.

Contractors should be asked to provide maintenance records for their fleet as part of the contract bid and at regular intervals throughout the life of the contract.

7.2.7 Use Low Sulphur Diesel

The sulphur content in off-road diesel is not currently regulated at the national level in Canada. However, voluntary standards set a 5,000 mg/kg specification for sulphur in off-road diesel. The U.S. Environmental Protection Agency finalized an off-road regulation that will limit the level of sulphur in off-road diesel fuel to 500 mg/kg starting in 2007, reduced to 15 mg/kg in 2010. Environment Canada has proposed the *Amendment to the Sulphur in Diesel Fuel Regulations* in October, 2004 to control the level of sulphur in off-road diesel fuel, in alignment with the proposed U.S. standards. Further information on the proposed regulations can be obtained by visiting Environment Canada's CEPA Environmental Registry website:
www.ec.gc.ca/CEPARegistry/regulations.

It should also be noted that the California Air Resources Board presently has a limit of 500 mg/kg for off-road diesel reduced to 15 mg/kg limit starting in 2006. In addition, the City of Montreal prohibits the use of diesel fuel that has sulphur content in excess of 500 mg/kg for all engines and vehicles.

Low sulphur fuels can improve air quality in two distinct ways: (i) by reducing vehicle emissions of SO_2 and PM due to lower sulphur levels; and (ii) by increasing the effectiveness of existing emission control devices and enabling the use of more advanced emission control devices.

Off-road diesel fuel currently contains a sulphur content of approximately 1,000-3,000 mg/kg in Canada. Diesel fuel with much lower sulphur levels is currently available in Canada. For instance, the current Sulphur in Diesel Fuel Regulations requires that the concentration of sulphur in diesel fuel produced or imported for use in on-road vehicles not exceed 500 mg/kg until May 31, 2006; and 15 ppm after May 31, 2006. Therefore, construction companies are encouraged to use the low sulphur diesel fuel that has been primarily produced for on-road vehicles. A Low Sulphur Fuels Procurement Guide available to aid in the purchase of low sulphur diesel fuel is available at:
www.ec.gc.ca/energ/ecology/LSF/ecological_measures_e.cfm

7.2.8 Alternative Fuels Should be Utilized Where Feasible

There are several alternative fuels that should be used to reduce the level of emissions that otherwise would have occurred with the use of diesel fuel (or gasoline). Alternative fuels that could be used include biodiesel, ethanol, propane, natural gas and various fuel additives. Electricity can also be used, primarily for equipment purposes, however also for vehicles. Biodiesel is described in greater detail below.

Biodiesel can be used in pure form or it can be mixed with diesel fuel (e.g., B20, which is a mixture of 20% biodiesel and 80% standard diesel). Biodiesel reduces the carbonaceous fraction of diesel particulate matter through improved in-cylinder combustion, which is primarily attributed to biodiesel's high oxygen content. B20 can be used without changes to diesel engines or the fuel distribution infrastructure. However, the use of pure biodiesel may require changing some engine seals and fuel lines in older engines. Biodiesel generally contains no sulphur or aromatics, however it may increase NO_x emissions by 5-10%.

7.2.9 Reduce or Eliminate Idling Time

Idling of off-road vehicles on construction sites is often practised for the following reasons:

- to provide heat or air conditioning for the vehicle;
- to keep the fuel and engine warm in cold weather to avoid cold starting;
- while being actively operated such as when waiting to load and unload commodities; and
- trucks and truck-trailer combinations may need to idle in order to operate auxiliary equipment, including power take-off (PTO) equipment.

The reduction of idling provides benefits (besides environmental) in terms of reduced fuel consumption and engine wear and consequently the saving of money to the owner/operator. The idling of off-road engines when the vehicle is not moving, or when the off-road equipment is not performing work, should be limited to less than 5 minutes at any one location. Construction companies are encouraged to institute an anti-idling campaign. Additional details can be located at http://oee.nrcan.gc.ca/idling/home.cfm.

Technologies are available which automatically shut the engine off after a preset time. These idling control technologies should be used where economical. The installation of such systems on construction vehicles avoids the reliance on the operators to comply with a time limitation. Additional details on alternatives to truck idling can be located at:
http://www.ctre.iastate.edu/pubs/truck_idling/index.htm

The City of Toronto has a by-law not allowed vehicles to idle for more than three minutes in a sixty-minute period.

7.2.10 Evaluate Alternatives for Heat and Air Conditioning for Off-Road Vehicles

There are technology-based alternatives to the provision of heat/air conditioning through idling. Examples of available technologies include auxiliary power systems or main engines and on-board electrification. The purpose of these alternative technologies is to displace the use of the higher polluting main engine for providing power and comfort to the cab. These systems are typically used by on-road tractor trailers, however there may be opportunities now or in the future for utilization within construction vehicles.

An auxiliary power system typically consists of an engine and compressor to supply electrical power and climate control to the truck cab. The unit is generally installed in place of one fuel tank and weighs approximately 140 kilograms. There are several methods to power an auxiliary power system including diesel fuel and electrical power. Several heavy-duty diesel engine manufacturers are developing integrated auxiliary power systems for their engines that will be available as an OEM option. Auxiliary power systems are designed as self-contained units that require no external power source other than fuel.

On-board electrification is an alternative to provide the power for HVAC climate control and to power ancillary devices. A simple outlet on the perimeter of the truck space typically supplies the 110-volt or 220-volt power. In order to use on-board electrification for climate control, the purchase of additional equipment may be needed. It should be noted that there are systems that can be powered alone by 110-volt power such as a space heater or small cooler but there are questions as to the practicality of such devices for this use.

7.2.11 Minimize Cold Starts

Both the combustion efficiency of the engine and the effectiveness of the emission control device are at a minimum during a cold start and therefore emissions tend to be high. In order to correct this problem, engine block heaters and pre-heated catalytic converters (using an electrical heat source) may be retrofitted onto engines for more efficient combustion and more complete oxidation of the exhaust in the catalytic converters.

Note that minimizing cold starts does not mean increasing idling times.

7.2.12 Evaporative Losses Should be Minimized

Evaporative losses from construction equipment are primarily associated with the fuel tanks. There are evaporative emission control technologies that can reduce such emissions by as much as 96%. These technologies include: (i) the closed fuel system (modified tank); (ii) tank ventilation to carbon canisters; and (iii) tank filled with expanded metal mesh. These technologies can be retrofitted to the existing fleet of construction vehicles as well as installed on new vehicles.

7.3 Hot Mix Asphalt Production at Portable Plants

The Canadian Construction Association has recently published *Environmental Best Practices Guide for Hot Mix Asphalt Plants*, which details various work practices and technologies that should be employed to minimize emissions of particulate matter, gaseous emissions, odour, and noise. This document should be consulted for additional details on practices that can be employed to minimize the environmental impact of portable hot mix asphalt plants.

The focus of this section is on work practices to reduce gaseous emissions from portable hot mix asphalt plants (work practices to reduce particulate matter emissions were discussed in Chapter 6). These gaseous emissions occur from the combustion process employed at portable hot mix asphalt plants, which is used to dry aggregate prior to it being mixed with asphalt. Gaseous emissions include sulphur oxides, nitrogen oxides, carbon monoxide and volatile organic compounds. The various work practices outlined below have been summarized from the document published by the Canadian Construction Association. For more extensive and detailed information, this document should be reviewed. It should be noted that recommendations are provided later in this Best Practices document concerning actions to mitigate emissions from hot mix asphalt operations at construction sites.

7.3.1 Maintain Proper Air to Fuel Ratio in the Combustion System

The proper air to fuel ratio in the combustion system should be maintained in order to completely and efficiently burn the fuel provided. Incomplete burning of fuel results in higher levels of carbon monoxide and volatile organic compounds.

7.3.2 Burner and Air Systems Should be Regularly Inspected and Maintained

The burner and air systems should be regularly inspected and maintained in order to ensure that fuel consumption is reduced and carbon monoxide and volatile organic compound emissions are minimized. Qualified personnel should perform tune-ups or repairs to the burner system as necessary and a tune-up should be conducted annually to ensure efficiency. The following inspections of the burner system are recommended to ensure that these parts are functioning according to manufacturer's specifications:

- all burner valves and linkages;
- fuel pressure, air-fuel ratios, and combustion air pressure;
- all moving parts are lubricated;
- all filter systems and stainers are regularly maintained;
- nozzles are clear of foreign materials; and
- blowers.

Leaking air directly affects the air to fuel ratio, thereby resulting in inefficient combustion and higher emissions. Therefore, drum and duct air seal points (i.e., the air systems) should be regularly inspected and maintained. Air leaks furthest from the burner result in the most negative impacts on the combustion process.

7.3.3 Conduct Regular Inspections of Other Equipment

Other equipment within portable hot mix asphalt plants (apart from the burner and air systems) should be regularly inspected and maintained to ensure that the combustion process operates to its maximum efficiency. Regular inspections of the following equipment should be conducted to ensure that it is operating properly and to manufacturer's specifications:

- damper - key component in controlling the fuel to air ratio;
- dryer flights - proper veiling of aggregate enables the burner system to work at optimum levels;
- primary and secondary collectors - for material build-up that may reduce the flow of air throughout the system; and
- hot oil heater systems – ensure that hot oil heater burner systems are clean and hot oil heater lines are working properly. The hot oil heater should be tested annually to ensure oxidation is not taking place.

7.3.4 Aggregate Should Not be Allowed to Pass Through Combustion Zone

Aggregate should never be allowed to veil or pass through the combustion zone of the burner's flame. If this occurs incomplete combustion will result, leading to increased carbon monoxide and volatile organic compound (VOC) emissions.

7.3.5 Thermocouples and Other Sensors Should be Regularly Calibrated

Thermocouples and other sensors are installed to monitor temperature and pressure change within the burner system. Thermocouples and other sensors should be regularly calibrated to ensure that they are functioning at their optimum levels.

7.3.6 Low Sulphur Fuels Should be Used

Low sulphur fuels should be utilized to the extent possible in portable hot mix asphalt plants in order to reduce SO_2 emissions (as well as particulate matter emissions).

7.4 Volatile Organic Compounds

Volatile organic compounds (VOCs) are primarily emitted from the construction and demolition sector through the following sources: (i) architectural surface coatings; (ii) traffic marking operations; (iii) asphalt concrete paving; and (iv) asphalt roofing kettles. Outlined below are the various work practices that should be employed in order to reduce VOC emissions from these sources.

7.4.1 Architectural Surface Coatings

Architectural surface coating operations consist of applying a thin layer of coating such as paint, paint primer, varnish or lacquer to architectural surfaces. Architectural surface coatings are applied to a variety of surfaces (e.g., metal, wood, plastic, concrete, bricks and plaster). VOCs that are used as solvents in coatings are emitted during the application of the coating as well as when the coating dries. The amount of coating used and the VOC content of the coating are the primary factors that determine emissions from this source. Solvents are also used as thinners in the coatings and for cleanup activities.

7.4.1.1 Durable and High Performance Coatings with a Low VOC Content Should be Used

Coatings having a low VOC content and meeting established performance standards should be used. Information on VOC contents of coatings purchased for use in construction operations should be requested from suppliers and if unavailable, from manufacturers. Currently, Canada has no requirement for labelling of VOC content of coatings. All manufacturers provide material safety data sheets (MSDSs) for their coatings products and some of these MSDSs provide VOC content information. Some manufacturers also provide technical data sheets for their products and some of these also provide VOC content information. The best source of this information is the website of a coatings manufacturer.

Environment Canada is currently examining potential VOC limits on Architectural and Industrial Maintenance (AIM) coatings, following recent initiatives on AIM coatings by the U.S. EPA, the California Air Resources Board (CARB) and the Ozone Transport Commission (OTC, which represents 12 northeast States). The proposed Environment Canada regulations will be developed through the regulatory process throughout 2005.

Outlined in the Table below are the VOC content limits, established in various jurisdictions in the U.S., for coatings that are commonly used in the construction sector. The environmental certification criteria included in these programs are the requirement to meet specific VOC content limits for flat paint, non-flat paint, stains and varnish. These content limits can be used as a guide to select low VOC coatings until the Environment Canada regulation limiting VOC content has been established and is in force in Canada.

Table 7: Comparison of VOC Content Limits for Coatings Used in the Construction Sector

(grams of solvent/litre of paint, excluding water)

Coatings Category	EPA	SCAQMD	CARB	OTC
Flat Coatings	250	100 (50 by Jul/08)	100	100
Non-flat Coatings	380	150 (50 by Jul/06)	150	150
Floor Coatings	400	100 (50 by Jul/06)	250	250
Industrial Maintenance Coatings	450	250 (100 by Jul/06)	250	340
Lacquers & Sealers	680	550 (275 by Jul/06)	550-680	550-680

Note: EPA – U.S. Environmental Protection Agency; SCAQMD – South Coast Air Quality Management District (California); CARB – California Air Resources Board; OTC – Ozone Transport Commission.

A national guideline for surface coatings is published by the Environmental Choice[M] Program (ECP). The ECP uses the EcoLogo[M] to label coatings products that qualify under its environmental certification criteria. Further information on the Environmental Choice Program can be found at: [http://www.environmentalchoice.com].

The Canadian Council of Ministers of the Environment has also published the following document, "Recommendations for CCME Standards and Guidelines for the Reduction of VOC Emissions from Canadian Industrial Maintenance Coatings".

In addition, the Masters Painters Institute publishes an approved products list for architectural coatings. The list is published twice a year in booklet form and can be accessed at [http://www.paintinfo.com/mpi/]. Information is currently being developed on low odour/low VOC coatings.

It should be noted that durability and performance are critical factors in selecting coatings and have an impact on the lifecycle VOC emissions. A more durable product with a higher performance will reduce the frequency of recoating, thereby reducing VOC emissions. As an example, a coating system with 20% higher VOC content than an alternative product can reduce the number of times an object has to be repainted, thereby actually lowering lifecycle VOC emissions. Also when comparing product VOC content, the total amount of product to be applied has to be taken into consideration. For example, if a coating has a low VOC content, but requires numerous applications, it can result in higher lifecycle VOC emissions than an alternative higher VOC content coating.

7.4.1.2 VOC Emissions from the Storage, Handling and Preparation of Coatings Should be Minimized

Work practices that will reduce VOC emissions from the storage, handling and preparation of coatings are primarily focused on minimizing the duration of exposure of the liquid coating surface to surrounding air, and include the following:

- all coatings containers should be tightly sealed during transportation and storage;
- a new container of paint should not be opened if one is open already;
- containers should be kept covered when not in use (to avoid excessive evaporation from convection air movement);
- a small amount of solvent should be added to empty containers (establish agreement with the supplier) prior to their return to suppliers in order to prevent the drying of paint on the inside walls. This will ensure that only a minimum quantity of cleaning solvent is used in the drum cleaning operation;
- coatings should be mixed in bulk prior to transfer rather than in smaller containers. If small containers are used, then they should be full in order to reduce the number of mixing operations that must be undertaken;
- thinners should be added to coatings just prior to application in order to avoid long dwell times;
- coatings should be thinned with water or VOC-exempt compounds, where possible;

- always mix thinner with the coating according to the manufacturer's instructions; and
- mixing operations should be undertaken to minimize the exposure of the coating to air (e.g., in sealed containers).

Some coatings manufacturers provide technical data sheets that include important information about the proper preparation and application conditions for their products. This information should be reviewed when preparing a coatings management plan and communicated to coatings applicators.

7.4.1.3 Coatings Wastage Through Spillage and Splashing Should be Minimized

Handling procedures should be designed to minimize coatings wastage through reduced spillage and splashing, for instance by adhering to the following:

- During transfers, container lids, bungs, plugs, or valves may be opened or removed, but should be replaced or closed immediately after the transfer is complete;
- If it is necessary to open coating containers for prolonged periods, the use of flexible coverings (e.g., plastic film or sheet, fabric cloth) to cover the surface of the coating should be considered to minimize VOC losses;
- During transfers of coatings from one container to another, a pump and hose system should be used where possible to minimize fugitive VOC emissions. Vent holes in the source container should be opened to prevent the creation of a vacuum that might prevent adequate drainage and potentially lead to an unexpected large spillage;
- If manual decanting from one container to another must be done, it should be performed slowly and carefully to minimize spillage and splashing; and
- Where possible, separate pumping systems should be used for different paint colours to minimize flushing requirements. If this is not possible, colour applications should be sequenced to minimize flushing.

7.4.1.4 Surface to be Coated Should be Properly Prepared

Well-prepared surfaces will not need an excessive volume of coatings. Proper surface preparation can include: (i) removal of undesirable material from the substrate; (ii) sealing of cracks and fissures; and (iii) sanding to achieve desirable roughness for proper coating adhesion. Surfaces to be coated should be prepared as per the coating manufacturers specifications. All dirt, rust, scale, splinters, loose particles, disintegrated paint, grease, oil, and other substances should be removed from all surfaces that are to be painted or otherwise finished. Surface cracks or fissures should be filled with appropriate solid materials (putty, joint compounds), sealers or primers to minimize spaces where coatings can accumulate.

7.4.1.5 Paint Heaters Should be Used Instead of Paint Thinners

Paint heaters should be used to heat coatings to reduce viscosity immediately before spraying. Paint heaters use an in-line heating element located just upstream of the spray gun. The use of paint heaters provides the necessary viscosity to the coating operation, without the use of solvent-based thinners. It should be noted that the use of paint heaters is not always applicable. For instance, the application of heated paint to cold surfaces in winter months results in poor paint surface characteristics (i.e., cracking) because of the rapid cooling of the hot paint after it is applied to the cold surface.

7.4.1.6 Technologically Advanced Spray-Guns Should be Utilized to Apply Coatings

The most technologically advanced spray-guns should be utilized in order to apply coatings. VOC emissions can be significantly reduced by utilizing the most efficient spray guns with the highest transfer efficiency. Transfer efficiency is defined as the ratio of paint that adheres to the surface of the product to the total amount of paint that leaves the gun's nozzle.

Conventional high-pressure spray guns operate between 30 and 90 psi. The transfer efficiency of these high-pressure spray guns is poor. The high pressures associated with these spray guns force paint out of the nozzle at high velocities. When paint particles leave the nozzle at high velocities, they tend to bounce off the targeted surface. If these guns have to be used, the air pressure on these systems should be lowered.

High volume/low pressure spray, low pressure/low volume and airless spray techniques are more recent developments with much higher transfer efficiency than conventional high-pressure spray guns. High-Volume/Low-Pressure (HVLP) and Low-Pressure/Low-Volume (LPLV) spray guns operate at or below 10 psi. The lower pressure ensures that paint particles leave the nozzle at slower velocities than typical spray guns, resulting in a reduction in overspray of up to 50%. Airless spray guns provide high transfer efficiency when applying thick materials. Some companies can reduce thinning of coating as well by using airless spray guns.

7.4.1.7 Spray-Gun Operators Should Apply Correct Application Techniques

Significant reductions in wasted coatings and consequently VOC emissions can result from implementing proper application techniques by operators. The following application techniques should be adhered to:

- The distance of the spray gun from the surface should be consistent. If the gun is too close to the surface, the coating will be applied to heavily and run and sag. If the gun is too far from the surface, excessive overspray, dry spray, a sandy finish and low transfer efficiency will result. HVLP spray guns should be held 15 to 20 cm (6 to 8 inches) away from the surface being coated. Air assisted spray guns should be held 20 to 25 cm (8 to 10 inches) away (20 to 30 cm or 8 to 12 inches if it is electrostatic, air-assisted airless). Airless spray guns should be held 30 to 26 cm (12 to 14 inches) away;
- The speed of the gun as it is moved across the surface should be consistent. A steady gun speed will help obtain a uniform thickness of coating. A gun speed higher than manufacturer specifications can distort the spray pattern and not permit the maximum amount of material to reach the surface;
- The proper overlap of the spray pattern should be applied. This overlap is determined by the coating being applied. Proper overlap may range from 50-80%. Greater overlap may result in wasted strokes, and less overlap may result in streaks;
- The spray gun should be held perpendicular to the surface being coated. Arcing the gun for hard to reach areas results in wasted material, since an uneven coat is applied. These areas should be coated by changing the position of the gun or the operator. Some coatings are applied to irregular surfaces (e.g., staircase banisters, decorative molding) for which the coating transfer efficiency using spray equipment is quite low. For irregular surfaces, manual application methods should be used to increase transfer efficiency;
- The manufacturers recommended system settings should be used for air and fluid pressure and coating consistency. These parameters can then be adjusted through a trial and error process; and
- VOC emissions can also be reduced by avoiding excessive application of topcoats. Primers should be applied as per manufacturers recommendations in order to minimize the quantity of topcoat that has to be applied. Application of topcoats should respect manufacturers recommended coverage rates and application thickness (wet-film thickness & dry-film thickness in mils).

7.4.1.8 Proper Technique Should be Used When Cleaning Spray Guns

For equipment that requires solvent cleaning, methods that reduce evaporation should be implemented wherever practical, for instance through the use of a gun washer to clean spray guns. A gun washer is similar to a dishwasher in that it is designed to hold a number of spray guns and related equipment and cleans by circulating solvent inside a closed chamber. Gun washers result in extended solvent cleaning life, reduced solvent waste and reduced VOC emissions from evaporation. The spent solvent from the gun washer can be reused for additional cleanings. Once the solvent has been reused to the point that it is no longer effective for cleaning the gun, it can be sent to a solvent reclaimer.

Keeping the spray gun clean maintains the gun's efficiency and reduces the risk of poor results due to clogged tips or passages or foreign matter contamination. Proper and regular maintenance of spray guns will also serve to mitigate VOC emissions. The following practices should be adhered to:

- Clean the spray gun regularly to ensure optimum atomization and spray pattern;
- Clean equipment as specified by the manufacturer; and
- Disassemble and inspect spray guns regularly.

Another cleaning practice where VOC emissions can be reduced through special equipment is line cleaning. One method that can improve line cleaning efficiency is to introduce turbulence into the solvent going through the line during cleaning. Equipment that forces alternating pulses of solvent and compressed air is one way to accomplish this.

In addition, lines should never be cleaned by spraying VOCs into the air or into filters. Clean-up solvents should always be directed using minimal pressure into containers. Solvents should be drawn from a closed supply solvent container and discharged into a closed container with an opening only large enough to accommodate the tip of a spray gun. In addition, the spray gun pressure should be lowered (decreasing air and paint pressure) to minimize atomization of the solvent during cleaning.

7.4.1.9 Alternative Coating Application Techniques Should be Used

Where feasible, rollers or brushes should be used instead of spray guns in order to reduce the quantity of solvent-based paint thinners that are required. In addition, transfer efficiency for direct application methods (i.e., rollers, brushes) can approach 100%.

7.4.1.10 Alternative Cleaners or Low-VOC Cleaners Should be Used Instead of Solvents

Where possible, non-VOC or low-VOC cleaning agents should be used instead of solvents. For surface preparation as well as clean-up operations, alternative cleaning agents to solvents (e.g., aqueous surfactant solutions) should be used.

7.4.1.11 Solvents Used for Cleaning Should be Minimized

When cleaning products containing VOCs are used, the following work practices should be applied in order to reduce the amount that has to be used:

- Solvents with a low vapour pressure (flash point greater than 60°C) should be used. The use of common mineral spirits that typically have a 40°C flash point should be avoided;
- A standard should be established to assure that used solvent is disposed of or recycled only when it loses its cleaning effectiveness, not just because it looks dirty;
- The amount of cleaning agent to be used should be minimized by blowing as much old paint as possible back through the lines with compressed air (or by scraping the paint off the surface);
- Pre-determined and measured amounts of solvent should be used (i.e., know how much is to be used beforehand);
- When soaking is required, containers with air tight lids should be used;
- Used solvents should be returned to sealed containers of a waste collection system for recycling and re-use;
- Cleaners should be contained (i.e., covered) and tightly sealed) whenever feasible in order to reduce evaporative losses.
- Solvent-soaked rags should be disposed of in a covered container;
- Segregate cleanup solvents and recover/reuse them;
- Self-closing funnels on barrels and hoses for solvent transfer should be used;
- The spray gun should be emptied of paint prior to cleaning so that the gun system is completely dry; and
- Equipment should be cleaned promptly after use in order to prevent the drying of coatings and consequently the need to use additional solvents in the cleaning operation.

7.4.1.12 Paint Colour Changes Should be Optimized to Reduce the Use of Cleaning Solvents

The amount of cleaning with solvents can be reduced through various strategic operating practices, for instance:

- specific equipment should be assigned to handle specific paint types and colours;
- paint colour changes should be scheduled from light to dark;
- no more coating than necessary should be mixed to complete the work; and
- mixing and application equipment should be dedicated to commonly used coatings.

7.4.1.13 Alternative Finishing Practices Should be Used

Non-VOC surface coverings (walls, floors, ceilings) should be used whenever economical and feasible.

7.4.2 Traffic Marking Operations

Traffic marking operations include the marking of highway centre lines, edge stripes, directional markings and parking lots. The Canadian Council of Ministers of the Environment, in its publication, *Recommendations for CCME Standards and Guidelines for the Reduction of VOC Emissions from Canadian Industrial Maintenance Coatings,* discusses traffic markings.

The following painting materials, typically used for traffic marking, emit VOCs:

- Non-aerosol traffic paint;
- Aerosol marking paint – paints used to apply stripes or markings to outdoor surfaces, such as streets, golf courses, athletic fields, etc.; and
- Preformed tapes applied with adhesive primer.

Alternatives to solvent-based traffic paints are water-based paints, thermoplastics, preformed tapes, field-reacted systems and permanent markers. Some of these alternatives (e.g., water-based traffic paints) can be used in the summer months to avoid the use of VOCs during the time of the year when ground level ozone forms. In addition, consideration should be given to refraining from traffic line painting completely when smog alerts have been issued in the area.

Many of the work practices outlined above for architectural surface coatings can also be applied to traffic marking operations.

7.4.3 Asphalt Concrete Paving

There are three categories of asphalt concrete, specifically: (i) hot-mix; (ii) cutback; and (iii) emulsified. Hot mix asphalt is a mixture of aggregate (rock) and asphalt cement (glue) that can be customized to specific paving applications. Cutback asphalt is made by adding petroleum distillates (e.g., naphtha, kerosene, etc) to asphalt cement. As a result, cutback asphalt contains the highest diluent content of the three asphalt categories and consequently emits the highest levels of VOCs per tonne used. The primary use of cutback asphalt is in tack and seal operations (related to the repair of roads) and for preparing roads for the application of hot-mix asphalt. Emulsified asphalt is made by adding water and an emulsifying agent (such as soap) to asphalt concrete. Emulsified asphalt is used in most of the same applications as cutback asphalt, but emits less VOCs.

7.4.3.1 Use of Cutback Asphalts Should be Minimized

Several jurisdictions in North America have completely or partially banned the use of cutback asphalts, since they result in high levels of VOC emissions. There are three classes of cutback asphalts: (i) rapid cure; (ii) medium cure; and (iii) slow cure. Where possible, rapid cure and medium cure cutback asphalts should not be used. Slow cure cutback asphalts containing more than 0.5% by volume organic compounds that evaporate at 260°C or lower should also not be used, where feasible.

7.4.3.2 Use of Emulsified Asphalt Should be Restricted

Emulsified asphalts that contain organic compounds in excess of 3% by volume which evaporate at 260°C or lower should not be used for paving, road construction or road maintenance.

7.4.3.3 Temperature of Asphalt Operations Should be Monitored and Controlled

VOC emissions from the storage, mixing and application of asphalt cement double for every increase of approximately 11°C (above 125°C) in operating temperature of the asphalt cement. Operating temperatures should be closely monitored and minimized to the extent possible in order to reduce the potential for VOC emissions.

7.4.4 Asphalt Roofing Kettles

VOCs are emitted from the installation and repair of asphalt roofs on commercial and industrial buildings, specifically from roofing kettles. Roofing kettles are used for melting, heating, or holding asphalt or coal tar pitch.

7.4.4.1 Temperature of Material Inside Roofing Kettle Should be Restricted

The temperature of material inside a roofing kettle should be limited to the following in order to reduce the generation of VOC emissions:

- Asphalt 260°C
- Coal tar pitch 200°C

Devices capable of correctly indicating and controlling the operating temperatures of roofing kettles should be properly installed and maintained in good working order.

7.4.4.2 Close Fitting Lids on Roofing Kettles Should be Used

During roofing kettle draining operations, the VOC vapours from the kettle should be contained by a close fitting lid. A close fitting lid is a VOC impermeable cover that fits securely over a roofing kettle or other container so that no gap greater than 1 cm (3/8 inch) exists between the kettle body and lid. The lid(s) should not be opened except for loading the kettle with solid roofing material or unless the material in the roofing kettle is less than 65°C.

Within 2 minutes after the draining operation has been completed, the vessel that received the hot roofing material should be covered with a close fitting lid or capped to prevent the release of visible smoke from the vessel.

7.4.4.3 Kettle Vent Should be Kept Closed

Any kettle vent should remain closed during a pressure release caused by flashing of the roofing material.

7.4.4.4 All Roofing Kettles Should be Equipped with Afterburners

If feasible, roofing kettles should be equipped with afterburner lids, which virtually eliminate VOC emissions from this source. Existing roofing kettles can be retrofitted with these afterburners.

These afterburner lids are different than the close fitting lids identified earlier, as these lids actually destroy VOC emissions from the roofing kettle. These lids will achieve higher levels of VOC emission reduction than the close fitting lids (however they are more expensive).

8. Measuring/Monitoring and Record-Keeping

8.1 Introduction

A critical aspect of managing fugitive dust generation at construction and demolition sites is to undertake the necessary measuring and monitoring of specified activities and parameters. The measurement and monitoring program can assist in determining the need for and extent of fugitive dust actions as well as the effectiveness of these actions in mitigating fugitive dust. Equally important is that a systematic record-keeping process be established and maintained throughout the duration of the construction/demolition project. This typically takes the form of maintaining a daily record-keeping log. Guidance and examples of measuring/monitoring and record-keeping activities are provided within this section of the Best Practices document.

It is recognized that measuring, monitoring and record-keeping is a time-consuming and costly endeavour. Regulatory authorities as well as construction companies are encouraged to consider these practices and implement where feasible and practical.

8.2 Measuring and Monitoring

The recommended procedures to measure and monitor opacity, stabilized surfaces and wind speed are provided below. Key parameters are considered to be among the most critical to measure/monitor at construction and demolition sites. There are other parameters that can also be monitored that relate to the generation of fugitive dust emissions. Construction and demolition firms are encouraged to work with their local permitting authority in order to identify which parameters should be measured and monitored in conjunction with their fugitive dust generating activities.

8.2.1 Opacity Monitoring

The opacity of dust leaving the property line where construction and demolition activities are being conducted, should not exceed 20%. The steps to follow in order to monitor opacity from fugitive dust sources are provided below.

Step 1: Stand at least 5 meters from the fugitive dust source in order to provide a clear view of the emissions with the sun oriented in the 140-degree sector to the back. Following the above requirements, make opacity observations so that the line of vision is approximately perpendicular to the dust plume and wind direction. If multiple plumes are involved, do not include more than one plume in the line of sight at one time.

Step 2: Record the fugitive dust source location, source type, method of control used if any, observer's name, certification data and affiliation, and a sketch of the observer's position relative to the fugitive dust source. Also, record the time, estimated distance to the fugitive dust source location, approximate wind direction, estimated wind speed, description of the sky condition (presence and colour of clouds), observer's position to the fugitive dust source, and colour of the plume and type of background on the visible emission observation from both when opacity readings are initiated and completed.

Step 3: Make opacity observations, to the extent possible, using a contrasting background that is perpendicular to the line of vision. Make opacity observations approximately 1 meter above the surface from which the plume is generated. Note that the observation is to be made at only one visual point upon generation of a plume, as opposed to visually tracking the entire length of a dust plume as it is created along a surface. Make two observations per source, beginning with the first reading at zero seconds and the second reading at five seconds. The zero-second observation should begin immediately after a plume has been created above the surface involved. Do not look continuously at the plume, but instead, observe the plume briefly at zero seconds and then again at five seconds.

Step 4: Record the opacity observations to the nearest 5% on an observational record sheet. Each momentary observation recorded represents the average opacity of emissions for a 5-second period.

Step 5: Repeat Step 3 and 4 until you have recorded a total of 12 consecutive opacity readings. There is no limit as to when the 12 consecutive readings must be taken. Observations immediately preceding and following interrupted observations can be considered consecutive.

Step 6: Average the 12 opacity readings. If the average opacity reading equals 20% or lower, the source is below the recommended opacity standard for construction and demolition sites.

8.2.2 Stabilized Surfaces

The purpose of this test is to check whether a property is sufficiently crusted to prevent windblown dust. The equipment that is needed for this test is as follows:

- One steel ball. Diameter - 1.6 cm (5/8 or 0.625 inches). Mass - 16-17 grams;
- A ruler or measuring tape; and
- A cardboard frame with a 30 by 30 cm (1 foot by 1 foot) opening (optional).

Step 1: Select a 30 by 30 cm (1 by 1 foot) survey area that is representative, or a typical example, of the crusted surface.

Step 2: Hold the small steel ball one (1) foot off the ground directly above your survey area. Use a ruler or measuring tape to make sure that your hand is at the correct distance above the ground. Drop the ball within the survey area.

Step 3: Pass/Fail Determination. Observe the ground around the ball closely before picking it up. Did the ball sink into the surface so that it is partially or fully surrounded by loose grains of dirt? Has it dropped out of view entirely? Then pick up the ball. Look closely where the ball fell. Are loose grains of dirt visible? If you have answered "yes" to any of the previous questions, the surface has failed the first drop test. Note that if the ball causes a slight indentation on the surface but you do not see loose grains, the surface has passed the test.

Step 4: Select two additional areas within the 1 by 1 foot survey area to drop the ball. Repeat steps 2 and 3. If the surface passes two or all three of the drop tests, the survey area is considered as passing the test.

Step 5: Select at least two other survey areas that are representative of the crusted surface. Pick the areas randomly and make sure they are spaced some distance apart. Drop the ball 3 times within each of these additional survey areas. Once again, if the surface passes the test twice or three times, count the survey area as passing the test.

Step 6: Examine Results. If all of the survey areas have passed the test, the surface is stable, or sufficiently crusted. If one or more survey areas have failed the test, the surface is insufficiently crusted.

8.2.3 Wind Speed

Site-specific wind monitoring at construction and demolition sites is encouraged due to improved accuracy when compared to regional wind monitors. Additionally, site-specific wind monitoring may document high winds that are not captured by regional wind monitors. The following guidance has been prepared to assist activities that conduct wind monitoring. Much of the guidance provided for measuring wind speed will only be practical for the largest of construction sites.

Aspects of a successful monitoring program include the selection of proper equipment, instrument siting, instrument and site maintenance, periodic audits and frequent data review. The instruments should be sited so as to characterize airflow between the source and receptor areas. In flat terrain, or where receptors are close to the source, one meteorological site may be adequate. Additional wind monitoring sites may be needed in complex terrain.

The standard sensor height for measuring surface winds in 10 meters above ground level over open, level terrain. This usually requires the installation of a tower or mast. For the instrument to be sited over open terrain, there should be minimal obstructions to the wind flow, such as from buildings, hills or trees. In general, wind sensors should be located where the distance from the sensors to any obstruction is at least 10 times the height of that obstruction. When mounted on a building, wind sensors should be mounted 1.5 times the height of the building above the rooftop. Since these siting guidelines are sometimes not possible, especially in urban areas, it is recommended that siting that deviates from these guidelines be reviewed by local permitting authorities or an experienced consultant prior to installation.

Data recorders are the preferred method of recording and archiving the data. They are more precise and require less maintenance that strip chart recorders. Data loggers also allow data to be transmitted by telephone or radio to a central computer. Data records must be kept for a period of at least three years after the need for data collection has ended. Data recovery from a self-maintained meteorological system should be at least 90% complete on an annual basis, with no large data gaps (i.e., gaps greater than two weeks). The use of data recorders will likely only be practical for the largest of construction sites.

The U.S. Environmental Protection Agency recommends a sampling frequency of once per second, which is typical for quality data loggers. Wind-averaging periods may depend on the purpose of the data collected and the need to meet specific regulatory requirements. Either 1 hour or 15-minute averaging periods are common.

For wind sensors, the starting threshold must be rated at no higher than 0.5 meters per second (m/s). If there is some suspicion that the site would have a significant number of hours of wind speeds under 0.5 m/s, sensors with a lower threshold, such as 0.2 m/s, should be used. Wind speed systems should be accurate to within 0.2 m/s ± 5% of the observed speed. Total wind direction system errors should not exceed 5 degrees. This includes an instrument accuracy of ± 3 degrees for linearity and ± 2 degrees for alignment to a known direction.

Frequent data review, preferably on a daily basis, is critical for collecting good meteorological data. In addition, visual inspections of each site should be made at least once every month. This will help to identify sensor alignment problems that may not be obvious in the data.

In order to ensure that the sensors operate within the manufacturer’s specifications, a calibration of the sensors should be performed once every six months by a trained technician or the sensor manufacturer. In corrosive, marine or dusty conditions, more frequently calibrations may be needed. Spare sensors are helpful to avoid data loss while sensors are brought down for calibration and repair. A logbook of calibrations and repairs should be kept.

Data that is critical for regulatory purposes should be independently audited by a qualified individual who is not affiliated with the organization that maintains and calibrates the instrument. The audits should be on a schedule that is appropriate for the measurements. Typically, once per year is adequate if a routine maintenance and calibration schedule is kept. An audit report should be written and problems should be corrected as soon as possible. The audit should compare the individual sensors to the sensor performance criteria and also look at the data collection system as a whole, including the data logger and siting, to ensure that the data are representative and accurate.

8.3 Record-keeping

Construction/demolition projects should maintain daily self-inspection records and this information should be retained for at least 3 years after project completion. Fuel use records should be kept. Additionally, any activity that utilizes chemical dust suppressants for dust control should maintain records indicating type of product applied, vendor name, and the method, frequency, concentration and quantity of application. All record-keeping information should be made available to the local permitting authority immediately upon request. A copy of the record-keeping should also be retained on-site.

Provided below are examples of daily record-keeping forms that can be used by construction and demolition firms, specifically related to practices to reduce PM emissions. Consideration should also be given to maintaining records of fuel usage/equipment maintenance in order to ensure proper management of fuel consumption.

CHEMINFO

Sample Daily Record-keeping Form for Fugitive Dust Abatement

Project Name:__________________ Project Location:__________________ Date:____________________

Each time you visually check an area for dust control measure implementation, write the time in the shaded box at the top of the table and write a "Y", "N" or "NA", in the boxes below your recorded time. Use the "Comments" column to record other pertinent information (e.g., describe the corrective action taken).

								Comments
1. Before Dust Generation Operations Occur								
Pre-watering to depth of cuts?								
Pre-watering storage piles?								
Work phased/disturbance minimized?								
Water trucks being operated?								
Water trucks being filled?								
Other (specify in Comments column)								
2. During Dust Generating Operations								
Is visible dust present?								
Applying water?								
Applying dust suppressant(s) other than water?								
Fences 3'-5' with 50% porosity intact?								
Shut down operations?								
Checked control measures before leaving the work site for the day?								
Other (specify in Comments column)								
3. Unpaved Haul/Access Roads								
Is visible dust present?								
Vehicles travelling less than 15 miles per hour (24 kilometers per hour)?								
Is road visibly moist?								
Is road covered with gravel, recycled asphalt or other suitable material?								
Applying dust suppressant(s) other than water?								
Other (specify in Comments column)								
4. Loading, Unloading and Storage Piles								
Is visible dust present?								
Pre-watering material?								
Water being applied during loading/unloading?								
Other (specify in Comments column)								
5. Trackout/Access Points								
Is trackout control device intact?								
Cleaned-up trackout?								
Other (specify in Comments column)								
6. Temporary Site Stabilization								
Applying water?								
Applying dust suppressant(s) other than water?								
Other (specify in Comments column)								

Total Number of Litres Applied:_________ Responsible Person's Signature and Title:________________

CHEMINFO

Sample Daily Record-keeping Form for Fugitive Dust Abatement

A daily log should be maintained that records the actual implementation of measures to mitigate fugitive dust generation. Write "yes" or "no" for each question in the Table below.

Elements Monitored	8AM	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM	5PM	Comments
Forecasted high winds											
Wind speed											
Wind direction											
# of water trucks operating											
# of water trucks available											
Roads moist/watered											
Unstabilized areas moist/watered											
Dry areas observed											
Irrigation working											
Water tanks filled											
Water pumps working											
Chemical stabilization used											
Track-out observed											
Blow sand observed on-site											
Blowing dust observed on-site											
Blowing dust observed off-site											
Wind/snow fence maintained											
# of complaints received											
Corrective action taken											

N = No or None Y=Yes N/A = Not Applicable

Name______________________ Date______________________

Additional Comments:

9. Members of the Construction and Demolition Multi-stakeholder Working Group

Name	Organization
Patrick Georges	Environment Canada
Monique Gilbert	Ville de Montréal
Dave Gylywoychuk	Manitoba Heavy Construction Association
John Jonasson	Manitoba Conservation Pollution Prevention
Dan Jutzi	Environment Canada
Jim Mahon	Ontario Environment Network
Tim Smith	Cement Association of Canada
Gerry Ternan	Environment Canada, Atlantic Region
Bruce Walker	STOP
Shelley Wearmouth	Wearmouth Demolition
Observers:	
Roch Berubé	Association de la construction du Québec
Jacques Blanchard	Ville de Montréal

Demolition/Deconstruction Sub-committee

Name	Organization
Estelle Coté	Consultant
Corinne Fulton	3R Demolition Corp.
Monique Gilbert	Ville de Montréal
Tracey Inkpen	Environment Canada
Jim Mahon	Ontario Environment Network
Olga Schwartzkopf	Soil and Water Conservation Society, BC Chapter
Jo-Anne St. Godard	Recycling Council of Ontario
Fred Topley	Greenspoon Specialty Contracting
George Venta	Cement Association of Canada
Shelley Wearmouth	Wearmouth Demolition
Observers:	
Roch Berubé	Association de la construction du Québec

Residential and Commercial Building Design Sub-committee

Name	Organization
Vince Catalli	Royal Architectural Institute of Canada
Estelle Coté	Consultant
Bruce Gillies	Environment Canada, Ontario Region
Dan Jutzi	Environment Canada
Jo-Anne St. Godard	Recycling Council of Ontario
Anna Tilman	Save the Oak Ridges Morraine
George Venta	Cement Association of Canada
Alex Zimmerman	Canada Green Building Council

Residential and Commercial Building Construction Sub-committee

Name	Organization
Estelle Coté	Consultant
Monique Gilbert	Ville de Montréal
Tracey Inkpen	Environment Canada
Christopher Morgan	City of Toronto
Olga Schwartzkopf	Soil and Water Conservation Society, BC Chapter
Anna Tilman	Save the Oak Ridges Moraine
John Volcko	PCL Construction
Observers:	
Roch Berubé	Association de la construction du Québec
Jacques Blanchard	Ville de Montréal

Architectural Surface Coatings Sub-committee

Name	Organization
Heather Atkinson	Environment Canada
Vince Catalli	Royal Architectural Institute of Canada
Estelle Coté	Consultant
Sue Fraser	Environment Canada
Barry Law	Master Painters Institute
Ian Meredith	Terra Choice Environmental Marketing
Olga Schwartzkopf	Soil and Water Conservation Society, BC Chapter
Bruce Walker	STOP

10. Bibliography

1. Antelope Valley Air Quality Management District, *Rule 1108 – Cutback Asphalt*, amended February, 1985.
2. Arizona State University, *The Dust Devel Academy – Air Quality – It's Everybody's Business*, September, 2000.
3. Associated General Contractors of America, *Federal & State Authority to Regulate Emissions from Construction Equipment Frequently Asked Questions*.
4. Baxter, Roberta., *Arrest that Fugitive Dust*!, published in Erosion Control.
5. Beardwook, Jack., *Dust – Gets in Your Eyes….Lungs, Wallet, and Other Wear Parts*, published in Grading & Excavation Contractor.
6. Bennett, Siobhan L., *Dust – Invisible, Dangerous, Avoidable*, published in Erosion Control.
7. Building Research Establishment Ltd., *Control of Dust from Construction and Demolition Activities*, February, 2003.
8. Butte County Air Quality Management District, *Rule 231 – Cutback and Emulsified Asphalt*, recodified August, 2002.
9. California Air Resources Board, *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*, October, 2000.
10. Canadian Centre for Pollution Prevention, *Survey Methods Used to Prevent and Reduce Pollutant Emissions from Construction and Demolition Activities*.
11. Chemical Manufacturers Association Solvents Council, *Solvents: Meeting Performance Needs for the 21st Century*.
12. City of Palm Desert, *Notice to Grading Permit Applicants – New Dust Control Ordinance Requirements*.
13. Clark County Department of Air Quality Management, *Construction Activities Dust Control Handbook*, March, 2003.
14. Coachella Valley County, *Coachella Valley Fugitive Dust Control Handbook*, May, 2003.
15. Coachella Valley County, *Draft Coachella Valley Model Dust Control Ordinance*, May, 2003.
16. Colusa County Air Pollution Control District, *Rule 2.33 – Cutback and Emulsified Asphalt*, amended July, 1997.
17. Dona Ana County, *Suggested Best Available Control Measures (BACM) for Reducing Windblown Dust from Manmade Sources in Dona Ana County*, December, 2000.
18. Earth Tech Canada Inc. and Millennium EMS Solutions Inc., *Pollution Prevention Manual for the Heavy Construction Industry, prepared for The Alberta Roadbuilders Heavy Construction Association*, March, 2002.
19. El Dorado County Air Quality Management District, *Rule 224 – Cutback and Emulsified Asphalt Paving Materials*, revised June, 1994.
20. Engle, David., *The War on Fugitive Dust – EPA's Crackdown is Clearing the Air in Choked Western Deserts*, published in Erosion Control.
21. Enviro-Access Inc., *First National Multi-stakeholder Workshop on Strategies to Reduce Smog-Related Air Pollution from Construction & Demolition Activities*, prepared for Environment Canada, March, 2004.
22. Feather River Air Quality Management District, *FRAQMD Best Available Mitigation Measures Construction Activity*, effective January, 2004.
23. Gluck, Robert., *A New Approach to Maintenance in the Field*, published in Grading & Excavation.
24. Idaho Department of Environmental Quality, *Air Quality in Idaho: Supplemental Fugitive Dust Control Information*.

25. Imperial County Air Pollution Control District, *Rule 426 – Cutback Asphalt and Emulsified Paving Materials*, revised September, 1999.
26. Imperial County Air Pollution Control District, *Rule 800 – Fugitive Dust Requirements for Control of Fine Particulate Matter (PM-10)*, revised November, 1996.
27. Innovative Management Solutions Inc., *NMS Guide to Environmentally Responsible Specifications for New Construction and Renovations*, February, 2000.
28. Kern County Air Pollution Control District, *Cutback, Slow Cure & Emulsified Asphalt Paving and Maintenance Operations*, amended March, 1996.
29. Kern County Air Pollution Control District, *Fugitive Dust*, amended September, 1995.
30. Manitoba Floodway Expansion Authority, *Guidelines for the Preparation of an Environmental Impact Statement for the Red River Floodway Expansion Project*, February, 2004.
31. Maricopa County Environmental Services Department, *A Guide for Reducing Air Pollution from Spray Coating Operations – Save Money and Prevent Air Pollution*.
32. Maricopa County Environmental Services Department, *Guidance for Filling-out An Application for an Earthmoving Project*.
33. Maricopa County Environmental Services Department, *Control Fugitive Dust at Construction Projects – Prepare Your Site for a Compliance Inspection*.
34. Maricopa County, Rule 310.01 – *Fugitive Dust from Open Areas, Vacant Lots, Unpaved Parking Lots, and Unpaved Roadways*, revised February, 2000.
35. Michigan Department of Environmental Quality, *Managing Fugitive Dust – A Guide for Compliance with the Air Regulatory Requirements for Particulate Matter Generation*, March, 2003.
36. Michigan Department of Environmental Quality, *Natural Resources and Environmental Protection Act*, amended July, 1998.
37. Mojave Desert Air Quality Management District, *Rule 1103 – Cutback and Emulsified Asphalt*, December, 1994.
38. Mojave Desert Air Quality Management District, *Rule 471 - Asphalt Roofing Operations*, amended January, 1994.
39. Monterey Bay Unified Air Pollution Control District, *Rule 425 – Use of Cutback Asphalt*, revised March, 1997.
40. Montreal Urban Community, *Codification Administrative Des Règlements 90, 90-1, 90-2, 90-3, 90-4, 90-5 et 90-6. Règlement 90 – Règlement Relatif à l'assainissement de l'air et remplaçant les Règlements 44 et 44-1 de la Communauté*.
41. National Paints and Coatings Association, *Issue Backgrounder – The Paint and Coatings Industry Addresses Spray Paint Issues*, June, 2000.
42. National Park Service, *Envirofacts – Waste Paint/Coatings Management*, March, 1999.
43. Nevada Division of Environmental Protection – Bureau of Air Pollution Control, *Surface Area Disturbance Permit Dust Control Plan Preparation Guidelines*, October, 2002.
44. Northcutt, Greg., *Working with Dirt When the Wind Blows*, published in Grading & Excavation Contractor.
45. Ohio Environmental Protection Agency, *Engineering Guide #57*, revised April 1996.
46. Ohio Environmental Protection Agency, *Pollution Prevention in Painting and Coating Operations*, September, 1994.
47. Pennsylvania Department of Environmental Protection, *Pollution Prevention Opportunities for Painting & Coating Operations*, May, 1997.
48. Pima County Department of Environmental Quality, *Dust Control Methods for Landscaping*.
49. Pinal County Air Quality Control District, *Article 3 – Construction Sites and Earthmoving Activities – Fugitive Dust*, December, 2002.
50. Placer County Air Pollution Control District, *Rule 217 – Cutback and Emulsified Asphalt Paving Materials*, revised September, 1990.

51. San Joaquin Valley Air Pollution Control District, *Compliance Assistance Bulletin – Fugitive Dust Control for Public Agencies*, October, 2002.
52. San Joaquin Valley Unified Air Pollution Control District, *Rule 4641 – Cutback, Slow Cure, and Emulsified Asphalt, Paving and Maintenance Operations*, amended December, 1992.
53. San Joaquin Valley Unified Air Pollution Control District, *Rule 8041 – Carryout and Trackout*, amended August, 2004.
54. San Joaquin Valley Unified Air Pollution Control District, *Rule 8021 – Construction, Demolition, Excavation, Extraction, and Other Earthmoving Activities*, amended August, 2004.
55. San Luis Obispo County Air Pollution Control District, *Rule 420 – Cutback Asphalt Paving Materials*, revised January, 1997.
56. Saunders, Marc., *Just Say "No" to Dust….Maybe*, published in Grading & Excavation Contractor.
57. Senes Consultants, *Foundation Analysis Report for the Canadian Construction and Demolition Sector*, prepared for Environment Canada, March, 2004.
58. Shasta County Air Quality Management District, *Rule 3:15 – Cutback and Emulsified Asphalt.*
59. Shearing, Jennifer., *Analysis of the Current Strategies to Reduce Fugitive Dust Emissions from the Construction and Demolition Sector in Canada*, prepared for Environment Canada, August, 2001.
60. South Coast Air Quality Management District, *Rule 403 – Fugitive Dust*, amended April, 2004.
61. Statistics Canada, *Useful Information for Construction 2002* (Catalogue No. 64F0004XIE), December, 2002.
62. Tehama County Air Pollution Control District, *Rule 4:26 – Cutback and Emulsified Asphalt*, June, 1997.
63. Thurrock Council, *Good Practice During Construction and Demolition*, September, 2004.
64. Tilton, Joseph Lynn., *Corralling Dust and Stabilizing Soil*, published in Erosion Control.
65. U. S. Environmental Protection Agency, *Particulate Emission Measurements from Controlled Construction Activities*, April, 2001.
66. U.S. Environmental Protection Agency, *AP42 – Aggregate Handling and Storage Piles* (Section 13.2.4.1), January, 1995.
67. U.S. Environmental Protection Agency, *AP42 – Heavy Construction Operations* (Section 13.2.3), January, 1995.
68. U.S. Environmental Protection Agency, *Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures*, September, 1992.
69. U.S. Environmental Protection Agency, *Storm Water Management Fact Sheet – Dust Control*, September, 1999.
70. University of Missouri, Fugitive Dust: Nonpoint Sources, October, 1999.
71. Ventura County Air Pollution Control District, *Rule 74.28 – Asphalt Roofing Operations*.
72. Ville de Montréal, *Emissions Control from Roadworks*.
73. Washington State Department of Ecology, *Clean Air Guidelines – Building and Construction Projects*, May, 1998.

11. Selected Sources to Obtain Additional Information

Topic/Area	Organization	Link
Associations	Canadian Construction Association	http://www.cca-acc.com/
	Canadian Home Builders' Association	http://www.chba.ca/
	Construction Sector Council	http://www.csc-ca.org/
Selection of Green Materials	Canadian Green Building Council	http://www.cagbc.org/
	Leadership in Energy and Environmental Design (LEED Canada)	http://www.cagbc.ca/building_rating_systems/leed_rating_system.php
	Canadian Construction Association's Green Building Resource Centre	http://www.cca-acc.com
	Green Globes Canada	http://www.greenglobes.com/design/homeca.asp
	Athena Sustainable Materials Institute	http://www.athenasmi.ca/
	U.S. Green Building Council	http://www.usgbc.org/
	LEED U.S.	http://www.usgbc.org/LEED/LEED_main.asp
	Environmental Choice Program	http://www.environmentalchoice.com
Dust Control Websites/Reports	New Mexico Environment Department	http://www.nmenv.state.nm.us/aqb/dust_control.html
	Maricopa County (Arizona) Dust Devil Academy	http://www.maricopa.gov/sbeap/dust_main.aspx
	Clark County (Nevada) Construction Activities Dust Control Handbook	http://www.co.clark.nv.us/air_quality/Permitting-Applications/Dust%20Control%20Handbook.pdf
	Coachella Valley (California) Fugitive Dust Control Handbook	http://www.cvag.org/depts/CV_DCH.pdf
	Alberta Roadbuilders and Heavy Construction Association Pollution Prevention Manual	http://www.arhca.ab.ca/order_pollutionmanual.php
Pollution Prevention	Canadian Centre for Pollution Prevention	http://www.c2p2online.com
	Pollution Prevention Information Centre – Residential Construction	http://peakstoprairies.org/topichub/toc.cfm?hub=31&subsec=7&nav=7
	Low Sulphur Fuels Procurement Guide	http://www.ec.gc.ca/energ/ecology/LSF/ecological_measures_e.cfm
Journals	Grading & Excavation Contractor	http://www.forester.net/gec.html
	Erosion Control	http://www.distributednrg.com/ec.html