

**NORTH AMERICAN ORIENTED STRAND BOARD
INDUSTRY REVIEW**

Prepared for:

Manitoba Clean Environment Commission

305-155 Carlton St.
Winnipeg, MB
R3C 3H8

Prepared by:

SENES Consultants Limited

121 Granton Drive, Unit 12
Richmond Hill, Ontario
L4B 3N4

June 2009

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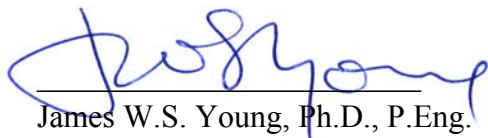


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June 2009

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EXECUTIVE SUMMARY

This report reviews the oriented strand board (OSB) industry in Canada and the United States, focusing on how emissions from OSB facilities are managed with current control technologies, and how air pollutants relevant to the OSB industry are regulated through government initiatives.

OSB is a structural panel made from thin wood strands cut from whole softwood and/or hardwood logs. The strands are dried to a low moisture content and are subsequently blended with a resin before being formed into a 3 to 5 layer mat. The mat is constructed so that each layer of strands is oriented perpendicular to an adjacent layer hence the name “oriented strand board”. The mat is hot pressed to activate the resin which binds the wood strands together to form a solid wood panel. The physical and mechanical properties of OSB make it suitable for a wide range of construction applications similar to those of softwood plywood including roof and wall sheathing, subflooring and underlayment.

There are three (3) primary sources of pollutant emissions to the atmosphere from the OSB manufacturing process: (1) combustion emissions (i.e., combustion of wood, natural gas or other fuel oil); (2) emissions driven off by drying the wood, releasing to atmosphere naturally occurring materials in the wood; and, (3) emissions associated with resins used to bind the wood strands together. Pollutant emissions can be managed using add-on control technologies, with the type of control technology used depending upon the type of pollutant as well as the type of equipment in the OSB manufacturing process. The most common control technologies used in North America’s OSB industry include wet electrostatic precipitators (WESPs) to control particulate emissions and regenerative thermal oxidizers (RTOs), regenerative catalytic oxidizers (RCOs) or biofilters to control volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions.

RTOs and RCOs are incineration type control technologies, typically generating heat through the combustion of natural gas, which results in the generation of greenhouse gases (GhGs). However, according to published emission factors, the primary source of GhG emissions from the OSB industry is through the combustion of residual wood products used to provide heat for drying and pressing operations.

The costs to operate emissions control equipment can be a large portion of the overall OSB manufacturing cost. Currently (2009), the OSB industry is experiencing the effects of the economic slow down, with government and industry contacts indicating many plants are closing due to a decrease in the North American demand for the product.

In general, Canadian provinces regulate air pollutants emitted from the OSB manufacturing sector through ground-level ambient air concentration limits. In contrast, the United States uses a control-based approach to regulate OSB HAP emissions where a level of control is specified. State authorities may also regulate HAP and non-HAP emissions in much the same way that Canadian provinces do.

1.0 INTRODUCTION

The Clean Environment Commission (CEC) is an arm's-length provincial agency established under *The Environment Act* of Manitoba. The Commission encourages and facilitates public involvement in environmental matters and offers advice and recommendations to the Minister of Conservation with respect to environmental issues, project approvals, and environmental licences. Its mandate is exercised through public hearings, investigations and mediation.

SENES Consultants Limited (SENES) was retained by the Manitoba Clean Environment Commission to provide an overview of the oriented strand board (OSB) industry in North America. This report reviews the OSB industry in Canada and the United States, focusing on how emissions from OSB facilities are managed with current control technologies, and how air pollutants relevant to the OSB industry are regulated through government initiatives. This review was completed by speaking with both industry and government representatives in Canada and the United States in addition to undertaking a review of available literature.

The report begins by outlining the study objectives and methodology used in detail. An overview of the OSB manufacturing process is then provided, highlighting the sources of emissions and which pollutants are emitted from each source. A review of current control technologies used for managing VOCs, HAPs and PM emissions is also presented, which discusses the effectiveness, control efficiencies and costs of each technology. Finally, a regulatory review is provided, which compares the standards, criteria, guidelines and objectives in place in Canada and the United States for air pollutants relevant to the OSB industry.

2.0 STUDY OBJECTIVES AND METHODOLOGY

The primary objectives of this report are (1) to conduct a review of air pollution control technologies currently used at OSB plants in Canada and the United States, and (2) to conduct a review of the regulations governing emissions to the atmosphere from the OSB industry.

2.1 POLLUTION CONTROL TECHNOLOGIES

This report reviews current air pollution control technologies at North American OSB facilities, including an evaluation of each control technology's effectiveness, efficiency, capital cost, and operation & maintenance costs. Information was gathered from two primary sources: (1) published documents, and (2) phone conversations with industry experts. Information sources are referenced within the text and summarized in Section 9.0 References.

Technical reports prepared by the United States Environmental Protection Agency (U.S. EPA) (AP-42 Section 10.6.1), Industry Canada (Wood-Based Panel Products Technology Roadmap) and other published technical documents and literature were used to develop a description of the OSB manufacturing process and common pollutant control technologies used at North American plants.

To assess the effectiveness, efficiencies and costs of each air pollution abatement technology, several manufacturer and industry representatives were contacted, including:

- Derrick Web, Biotherm;
- Jeff Kudronowicz, Anguil Environmental Systems;
- Gilles Brunette, FPInnovations, Foritek Division; and,
- Mike Hill, Applied Contaminant Control Ltd.

2.2 REGULATORY REVIEW

This report also reviews the regulations governing emissions to the atmosphere from OSB facilities in Canada and the United States. Specifically, a review of the standards, criteria, guidelines and objectives addressing emissions of volatile organic compounds (VOCs), hazardous air pollutants (HAPs), greenhouse gases (GhGs), particulate matter (PM, PM₁₀ and PM_{2.5}), oxides of nitrogen (NO_x), phenol, formaldehyde, benzene and methane diphenyl diisocyanate (MDI). Furthermore, federal, provincial and state regulations were reviewed to develop a jurisdictional comparison of air quality standards, criteria, guidelines and objectives for these pollutants.

To review the environmental regulations governing the OSB industry, government and industry representatives in Canada and the United States were contacted, including:

- James Eatkins, Environment Canada, Department of Forestry, Agriculture and Aquaculture;
- Elizabeth Palma, U.S. EPA Office of Air Quality; and,
- Roger Cook, Director of Environment, Forest Products Association of Canada (FPAC).

An effort was also made to contact government representatives in the provinces of Ontario, British Columbia and Alberta, however this was unsuccessful.

3.0 OSB PROCESS DESCRIPTION AND EMISSIONS

OSB is a structural wood panel made from long thin softwood or hardwood strands cut from whole logs. In Canada and the United States softwoods include coniferous species such as pine, fir and spruce; hardwoods are usually deciduous species such as aspen and birch.

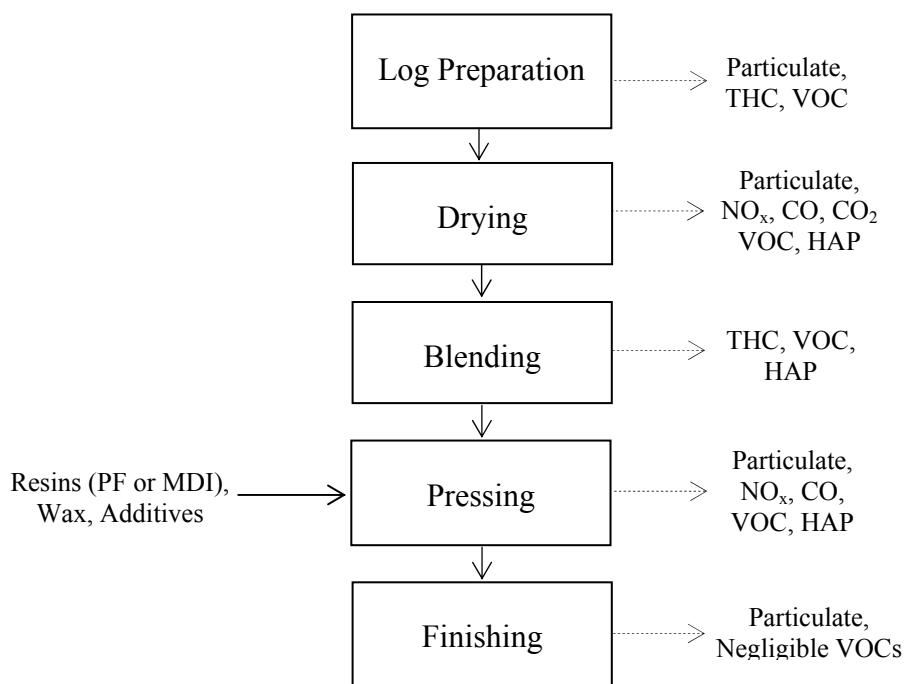
Wooden strands are blended with a resin and formed into a 3 to 5 layer mat with each layer of strands oriented perpendicular to the adjacent layer. This type of orientation makes the panel more flexible while still providing adequate strength. The mat is hot pressed to activate the resin and bind the wood strands together to form a solid board. The physical and mechanical properties of OSB make it suitable for a wide range of construction applications similar to those of softwood plywood including roof and wall sheathing, subflooring and underlayment.

The following sections describe the typical manufacturing processes at an OSB facility. Sources of atmospheric emissions are identified and the expected contaminants from each manufacturing step are outlined.

3.1 OSB PROCESS DESCRIPTION

Adapted from U.S. EPA AP-42 Section 10.6.1, Figure 3-1 shows a simplified process flow diagram of an OSB facility and highlights the sources of emissions. Each of these processes is described in some detail in the sections that follow.

Figure 3-1 Simplified Process Flow Diagram for an OSB Facility



Adapted from US EPA AP42 Section 10.6.1

3.1.1 Log Preparation

The OSB manufacturing process begins with removing the bark (i.e., debarking) from whole logs. During the debarking process logs may also be cut to lengths of approximately 2.5 m. After debarking, a piece of equipment called a flaker cuts the logs into long, thin strands roughly 3.5 cm wide, 7 to 15 cm long and 0.07 cm thick. During winter operations in northern plants, logs are put into hot ponds (18 to 43°C) to thaw prior to the flaking process. The strands are then passed through screens to remove any bits of sawdust and to sort the strands between ‘surface’ and ‘core’ material quality. Surface and core materials are the strands which will be used to construct the core and surface layers of the final OSB product.

Log debarking, flaking and screening are all sources of particulate matter (PM) emissions in the form of sawdust and wood particles. PM emissions are also broken down to smaller size fractions: particulate matter less than 10 microns in diameter (PM₁₀) and particulate matter less than 2.5 microns in diameter (PM_{2.5}). PM₁₀ is also known as inhalable particulate because it can settle in the bronchi of the lungs and PM_{2.5} is often referred to as respirable particulate because it can penetrate into the gas exchange regions of the lungs.

Fugitive emissions of particulate matter may also arise from on-site vehicle activities and wind-blown dust originating from uncovered bark or wood fines (i.e., sawdust) storage piles. Dust from the bark and fines piles can be controlled by using enclosures or by spraying piles with water, which helps to prevent wind from picking up and dispersing the particulate.

3.1.2 Drying

The drying process reduces the moisture content of the wood strands from approximately 60% down to about 5%, which allows for the addition of extra moisture from resins and other additives further on in the production process.

The most commonly used dryer in the OSB industry is the triple-pass rotary drum dryer, which circulates incoming wood strands as they dry and allows the material to pass through the dryer three times prior to exiting. Single-pass rotary dryers may also be used which only allow the incoming wood strands to pass through the dryer once. Rotary dryers are typically direct-fired using wood residue left over from plant operations. Natural gas or oil fired rotary dryers are less commonly used. The inlet temperature of a rotary dryer will range from 540°C to 870°C.

Conveyor dryers are an alternative type of dryer used in the OSB industry. Wood strands entering a conveyor dryer are simply dried as the strands are carried through on a conveyor. Conveyor dryers are usually indirectly fired and have lower inlet temperatures than rotary dryers (approximately 160°C).

Dryers are one of the primary sources of air pollutant emissions in the OSB manufacturing process. Emissions from the combustion of wood products (or natural gas or oil) are generated during the heating process, and volatile compounds naturally occurring in wood are emitted when the strands are heated in the drying process and released as volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). Combustion emissions will depend on the type of fuel used to operate the dryer, but are generally comprised of particulate matter (PM), oxides of nitrogen (NO_x), carbon dioxide (CO₂) and carbon monoxide (CO).

Condensable PM and some VOCs will leave the dryer stack as vapour, but will quickly condense at ambient air temperatures to form a visible blue haze. These compounds are primarily derived from the wood itself, and their form and abundance will therefore depend on the wood species in addition to the dryer inlet temperature, fuel used, time of year, time between logging and processing, and duration of wet strand storage.

3.1.3 Blending

After drying, fines are removed from the strands and the remaining material is separated by size and weight. The dried strands are then conveyed to the blender where they are mixed with resins, wax and other additives including catalysts to speed up the curing process. OSB facilities typically have two blenders, one for strands which will be used as the surface of the wood panel, and one for strands which will be used as the core of the wood panel. Resins used in the surface strand blender are typically liquid or powder phenol-formaldehyde (PF), and resins used in the core strand blender are either PF or diphenyl methane diisocyanate (MDI) based. There is some documentation of MDI resins used as both a surface and core resin, but this practice is not common. MDI is growing in popularity because it cures at a lower temperature and faster than PF (U.S. EPA, 2000).

Emissions from blending activities include the vapourization of VOCs and HAPs which arise directly from the resins. These emissions are much lower than from drying and pressing activities.

3.1.4 Pressing

Following blending, the strands are conveyed to a former where they are mechanically oriented as they fall onto a screen below, such that each layer of strands is perpendicular to one another. A mat consisting of 3 to 5 layers of strands is formed. The mat is trimmed prior to pressing.

Presses apply heat and pressure to the mat to activate the resin and bond the strands into a solid board. The heat required for hot pressing is typically provided by steam generated from a boiler that burns residual wood waste. Hot water or hot oil can also be used to transfer heat to the press, and natural gas or oil can be used to generate heat within the boiler. The OSB boards are usually stacked while still hot to allow the resin to cure better.

Presses are another of the primary sources of air pollutant emissions in the OSB manufacturing process, emitting combustion products during heat generation as well as VOCs and HAPs during the pressing process. Emissions from hot presses depend highly on the resin type and the amount of resin used. When the press opens vapours are released, which are comprised of resin compounds including formaldehyde and phenol from PF resins or MDI from MDI resins. Emissions are generally released into the pressing area and are expelled from the building through general ventilation exhaust; however, if emissions are controlled, the press is often enclosed and directed to a control device.

Formaldehyde emissions depend on the amount of excess formaldehyde in the resin, board thickness, press temperature, press cycle time and catalyst application rates. In general, emissions from pressing operations depend on wood species and wood moisture content, wax and catalyst application rates, and press conditions.

3.1.5 Finishing Operations

Solid boards are trimmed to the appropriate dimensions and finished as necessary prior to packing/shipping. Trimming operations result in PM emissions. OSB edges may also be painted, but because water-based coatings are typically used, little VOC emissions result from this finishing step.

Fugitive PM emissions can arise from wind-blown sawdust storage piles or from shipping vehicles driving on unpaved roads. These emissions can be controlled by watering.

3.2 FACTORS AFFECTING VOC AND HAP EMISSIONS

As discussed above, VOCs and HAPs are emitted primarily from the dryers and presses. The following sections discuss some of the factors affecting VOC and HAP emissions from drying and pressing processes.

3.2.1 Dryers

There are several factors that can affect the level of VOC and HAP emissions from dryers. Some of these factors include the inlet temperature of the dryer and the type of wood species used. Additional factors include the final moisture content of the wood strands, the amount of fines present in the incoming strand material and the type of dryer used.

As discussed in Section 3.1.2 above, VOCs and HAPs are generated from the heating of wood at high temperatures. Higher dryer inlet temperatures will result in larger emissions of VOCs and HAPs because more compounds are volatilized at higher temperatures. This effect has been demonstrated in two studies, NCASI (1999) and Otwell *et al.* (2000).

Emissions are also affected by the moisture content that wood strands are dried to. As the wood initially dries, evaporative cooling from the loss of water prevents the temperature of the wood from rising. When the moisture content becomes lower, the temperature of the wood increases and decomposition of the wood tissue begins, thereby releasing VOCs and HAPs naturally occurring in the wood. Otwell *et al.* (2000) showed that tissue decomposition is associated with specific moisture contents and that by increasing the final moisture content of the wood from 2% to 5%, total VOC emissions were reduced by 60%. Moreover, the amount of fines present in the incoming wood strands is an important factor affecting emissions as fines are easily burned off in the dryer, thereby producing VOC and HAP emissions. As a result, it is important to effectively remove the fines from the strands prior to them entering the dryer.

The most commonly used dryer type is the rotary dryer. It rotates incoming material which is tumbled as it dries. A triple-pass rotary dryer allows the material to pass through the equipment three times before exiting, whereas a single-pass dryer only allows the material to pass through once. As a result, it has been demonstrated that single-pass dryers will produce approximately two to three times less PM emissions compared to triple-pass dryers due to decreased agitation of the wood strands (O'Connor, 2006). Both triple- and single-pass rotary dryers operate at approximately the same temperatures, so VOC and HAP emission levels are comparable (Gilles Brunette, personal communication, 2 June 2009). In contrast, conveyor dryers operate at much lower temperatures and do not tumble incoming materials (see Section 3.1.2) and accordingly will produce less VOC and HAP emissions in addition to lower particulate emissions (O'Connor, 2006).

Unlike rotary dryers, conveyor dryers require a long space to be located due to the increased amount of time required for the strands to reach the desired moisture content. Furthermore, conveyors are a newer drying technology and some required refinements have been reported. For example, there is a reported tendency for fine particles to become deposited on the conveyor itself (IC, 1998), which can result in fines being burned off and therefore increasing VOC and

HAP emissions. Depending on the type of dryer, the degree to which emissions are increased is illustrated in U.S. EPA AP-42 emission factors, which are shown in Table 3-1. As stated above rotary dryers are the industry preferred type of dryer, which is likely based on lower operating costs due to increased drying efficiencies when compared to the conveyor dryer.

Table 3-1 U.S. EPA AP-42 OSB Dryer Emission Factors

POLLUTANT	ROTARY DRYER, SOFTWOOD (lb/ODT)	ROTARY DRYER, HARDWOOD (lb/ODT)	CONVEYOR DRYER, HARDWOOD (lb/ODT)
PM (Filterable)	4.1	4.2	0.72
PM ₁₀	2.5	No Data	0.062
THC (as carbon)	6.7	1.7	0.42
VOC (as propane)	8.1	2.1	0.51
Formaldehyde	0.13	0.11	0.0024
Methanol	0.10	0.33	No Data

Note: dryers have no control technologies

lb/ODT = pounds per oven dried ton of wood material

Both softwood and hardwood species are used in the OSB industry, depending upon the location of the facility. Typical wood species used in Canada and the northern United States include trembling aspen and birch (hardwoods), pine, fir and spruce (softwoods), with yellow pine (softwood) being used more in the southern United States (Gilles Brunette, personal communication, 10 June 2009).

It has been shown that the type of wood used will impact emissions from dryers. Hardwood VOCs and HAPs (primarily formaldehyde and methanol) arise from the chemical decomposition of wood tissue and are thus driven by dryer inlet temperature. In addition to VOC and HAP emissions driven by tissue decomposition, softwoods also contain VOCs called terpenes, which give these species their pine scent (Otwell *et al.*, 2000). Terpenes are affected by pressure rather than temperature. Due to additional terpenes, total VOC emissions from softwood species will be greater than VOC emissions from hardwood species (Otwell *et al.*, 2000). This was also demonstrated by the NCASI OSB study (1999), which found that total VOC emissions from hardwood and softwood species were 2.0 and 5.7 pounds per oven dried ton of wood (lb/ODT), respectively. Total HAP emissions were found to be comparable from both softwood and hardwood species because they result strictly from tissue decomposition. U.S. EPA AP-42 emission factors also support these findings (Table 3-1).

Finally, length of storage time of the wood strands prior to drying will affect VOC emissions. For example, it is well known that the decomposition of a wood tissue known as lignin generates

formaldehyde. Thus, if the wood is stored for longer periods of time, more decomposition of the wood tissue will occur, thereby releasing more formaldehyde.

3.2.2 Presses

The main factors affecting VOC and HAP emissions from presses include the type of wood species and the type and amount of resin used. Wood species will affect the emissions from a press in the same way dryer emissions are affected. For example, NCASI (1999) found that total VOC emissions from presses were greater for softwoods than hardwoods, but that HAP emissions were not significantly different between softwoods and hardwoods.

Additionally, the type and amount of resin used will greatly influence the amount of VOCs and HAPs emitted from presses. As previously mentioned, the main resin types include powder or liquid phenol-formaldehyde (PF) and dimethyl methane diisocyanate (MDI), which can be used separately or in combination with each other. Using PF resins will increase the amount of formaldehyde and phenol emitted. Also, a board made using PF requires the strands to be dried to lower moisture contents (4 to 8%) (Gilles Brunette, personal communication, 2 June 2009). As previously discussed lower moisture contents will increase dryer VOC and HAP emissions. As a result, the use of PF will indirectly increase dryer emissions due to such low, specific moisture requirements.

MDI resins will directly increase the emission of MDI, but tends to be more forgiving to varying moisture contents, therefore often resulting in fewer dryer emissions. However, MDI is more expensive than PF and also requires special handling and storage practices and is not always favoured as a result. Which resin is used will ultimately depend on the final product being manufactured. MDI based OSB is more expensive, more resistant to water and typically used in flooring applications, whereas PF based OSB is less expensive and typically used in wall sheeting applications (Gilles Brunette, personal communication, 2 June 2009).

3.3 CANADIAN NPRI DATABASE

In Canada, OSB facilities are required to report contaminant atmospheric emissions on an annual basis if certain criteria and emission thresholds are met. The means for compiling this information is through National Pollutant Release Inventory (NPRI), which is a Canadian Environmental Protection Act (CEPA) mandated program designed to track Canadian emissions, releases and transfers of hazardous / priority substances.

To gain perspective on the type and amount of air pollutants released by the Canadian OSB industry, the 2007 NPRI database was consulted. Canadian OSB facilities report their emissions

under the Canadian Standard Industrial Classification (SIC) code 2593. Using this SIC code as a search criterion, 21 OSB facilities were identified. However, based on discussions with Environment Canada there are approximately 30 OSB facilities in Canada, with some facilities currently not operating (James Eakins, personal communication, 27 May 2009). Further discussions with pollution control equipment suppliers also indicates more OSB facilities are closing due to a decrease in the North American demand for product (Mike Hill, personal communication, 12 June 2009).

According to 2007 NPRI data, a comparison of the OSB industry against all other Canadian industries combined indicates that the OSB industry contributes most significantly to the overall Canadian acrolein (71%), dimethyl methane diisocyanate (MDI) (43%), formaldehyde (37%) and acetaldehyde (21%) atmospheric emissions. Other air pollutants such as total VOCs, benzene, phenol, particulate matter, nitrogen oxides and carbon monoxide are all less than 5% of Canada's total emissions for each pollutant. Detailed emissions tables are provided in Appendix A.

To determine the amount of greenhouse gases emitted from the Canadian OSB industry, Canada's Greenhouse Gas Inventory was consulted. Only facilities which emit greater than 100,000 tonnes of CO₂ equivalents are required to report to this database. It was found that no OSB facilities in Canada were required to report to the greenhouse gas inventory in 2007.

4.0 CONTROL TECHNOLOGIES

Pollutant emissions from the OSB manufacturing process can be managed using add-on control technologies. The type of control technology used will depend on the type of pollutant as well as the type of equipment used in the OSB manufacturing process. To control particulate matter emissions, devices such as multi-cyclones (multiclones), wet scrubbers, electrified filter beds (EFBs) and wet electrostatic precipitators (WESPs) can be used. To control VOC and HAP emissions from OSB operations, incineration-based technologies such as regenerative thermal oxidizers (RTOs) and regenerative catalytic oxidizers (RCOs) may be used, or biological controls such as biofilters may be used to control some VOC and HAP emissions.

The following sections provide a general description of the most common types of control technologies currently in use in the North American OSB industry. A discussion of each technology's effectiveness, control efficiency and cost is presented. A brief discussion of pollution prevention strategies for reducing the amount of VOCs or HAPs being emitted in the first place is also provided.

4.1 WET ELECTROSTATIC PRECIPITATORS

An electrostatic precipitator (ESP) is a device which primarily controls particulate based contaminants (PM, PM_{2.5} and PM₁₀). It removes particulates from exhaust gases using the force of an electrostatic charge. An electric charge is given to incoming particles, which are then forced to collect on the walls of the ESP by a central electrode which continuously generates an electrical field (U.S. EPA, 2003a).

A wet electrostatic precipitator (WESP) is simply a dry ESP equipped with a pre-quench zone that cools and saturates incoming air. It is effective at controlling the sticky and condensable particulate emissions from OSB dryers. Particulate removal efficiencies typically range from 90 to 99% for older WESP technologies (U.S. EPA 2003a; U.S. EPA, 2000), while newer WESP technologies have efficiencies in the range of 99 to 99.9% (U.S. EPA, 2003a).

Some fractions of water soluble HAPs such as formaldehyde and methanol are also removed in the pre-quench zone of a WESP. However, the ability of a WESP to remove water soluble HAPs decreases as the water becomes saturated with these compounds. In a study by NCASI (1999), it was concluded that the average VOC removal efficiency in WESPs was only 3.3% and, therefore, was not considered effective in controlling VOCs. The ability of WESPs to remove VOCs can also be considered a disadvantage because VOC contaminated wastewater is generated and must be properly disposed. As treatment options, some facilities have opted to use this wastewater in on-site boilers, as make-up water in hot ponds or as a spray to control fugitive road dust and particulate emissions from bark and wood fines storage piles (U.S. EPA, 2002).

The typical capital and operating costs of a commonly used type of WESP are outlined in Table 4-1. Costs are expressed as 2009 Canadian dollars per standard cubic feet per minute (scfm), which have been converted from 2002 U.S. dollars based on an average exchange rate from 2002 (\$1.57 based on Canada Revenue Agency data) and a rate of inflation from 2002 to 2009 (14.5% based on Bank of Canada data).

Table 4-1 Example of WESP Capital and Operating Costs

WESP TYPE	CAPITAL COST	OPERATING & MAINTENANCE	ANNUAL COST
Wire-Pipe Type	\$72 to \$360 per scfm	\$11 to \$18 per scfm, annually	\$22 to \$83 per scfm, annually

costs are expressed as 2009 \$CAN

scfm = standard cubic feet per minute

Source: U.S. EPA, 2003. Air Pollution Control Technology Fact Sheet: Wet ESP - Wire Pipe Type

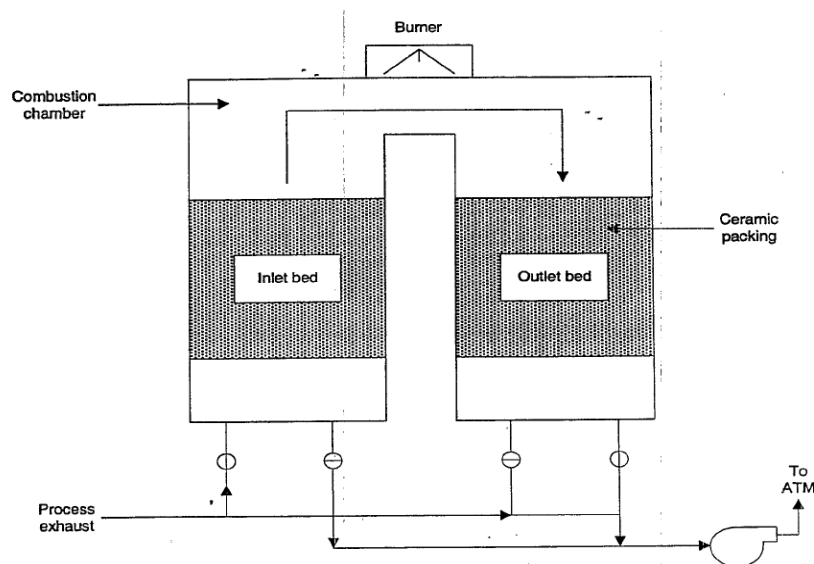
The unit scfm expresses the volumetric flow rate of gas the control equipment is processing. In OSB applications, control equipment for dryers have an average flow rate of 45,000 scfm and for presses have an average flow rate of 80,000 scfm (based on U.S. EPA background data for AP-42 Section 10.6.1). These flow rates are considered to be higher than average for RTOs in other industries (to provide perspective, a large 20ft x 20ft x 10ft living room is 4,000 ft², therefore a 45,000 scfm flow rate would change the air in this room over 11 times every minute). The required flow rate is generally based on the size of the manufacturing equipment to be controlled, where a small vacuum is established around the equipment to pull any pollutant emissions from the indoor plant environment (to which the worker would be exposure) to the pollution control equipment. Based on AP-42 background data a typical 80,000 scfm OSB press RTO corresponds to a production rate of approximately 1,500 4 ft by 8 ft sheets of OSB per hour. Although, the background data also indicates that the ratio of RTO sizing to production rate fluctuates significantly.

4.2 REGENERATIVE THERMAL OXIDIZERS

Regenerative thermal oxidizers (RTOs) are an incineration-based control technology effective at removing VOCs, HAPs and combustible particulate matter from dryer and press exhausts. This type of control is suited for dryers and presses having exhaust flow rates between 2,000 and 500,000 scfm and VOC/HAP concentrations less than 1,800 ppm (Moretti, 2002) and are therefore suitable to control OSB dryer and press emissions. RTOs destroy VOCs and HAPs by oxidizing them at very high temperatures. Emissions from RTOs include products of combustion (NO_x, CO, PM and CO₂). If a dryer is direct-fired, a RTO will also remove the large

amounts of CO present in the dryer's exhaust by oxidizing it to CO₂. A simplified diagram of a RTO is shown in Figure 4-1.

Figure 4-1 Schematic of a Regenerative Thermal Oxidizer



Source: U.S. EPA, 2000

Exhaust gases from a dryer or press enter the RTO and pass over a hot ceramic bed, which heats the exhaust gases to the required ignition temperature (typically 788°C to 871°C, but can be up to 1100°C) (U.S. EPA, 2003a; U.S. EPA, 2002). Higher temperatures allow for better destruction of the pollutants. If the desired RTO combustion chamber temperature is not attainable using only the inlet pollutants as fuel, auxiliary fuels such as natural gas are burned to achieve the required temperature. The inlet pollutants are combusted and residual heat from this reaction is absorbed by a second ceramic bed. When the first ceramic bed becomes depleted of its heat, the flow in the RTO is reversed so that heat can now be extracted from the second ceramic bed. Heat recovery is typically 95% (U.S. EPA, 2002). Efficient heat recovery makes the thermal oxidation process “regenerative” and as a result allows for less auxiliary fuel usage.

A problem often observed in RTOs is the build-up of particulate matter or salts in the ceramic media. Particulates entering the media can be heated above their melting points and will adhere to the ceramic beds, which can restrict air flow and cause pressure drops through the RTO. With dryers and presses a WESP or other particulate control device is commonly installed upstream of the RTO to remove particulate matter and salts from the incoming air stream (Jeff Kudronowicz, personal communication, 28 May 2009; U.S. EPA, 2000).

RTO performance tests on dryers and presses conducted by the U.S. EPA (2000) showed that control efficiencies averaged 90% and ranged from 51 to 99.8% for formaldehyde, 78 to 99.7%

for methanol and 90 to 99.9% for VOCs. The lower end of the ranges for formaldehyde and methanol represent conditions where contaminant inlet concentrations are less than approximately 100 ppm. A technical report by NCASI (1999) also presented an evaluation of RTO efficiencies installed on dryers and presses. The resulting control efficiencies ranged from 64 to greater than 94% for formaldehyde; 50 to greater than 93% for methanol and 80 to greater than 99% for VOCs.

RTOs can also reduce particulate emissions, with the U.S. EPA (2000) concluding that RTO PM₁₀ control efficiency was on average 80%.

In addition to destroying air pollutants, RTOs can also directly and indirectly generate air pollutants. Since RTO inlet air streams from dryers and presses are often dilute (mostly nitrogen and oxygen in the air), nitrogen is oxidized to NO_x within the hot combustion chamber of a RTO. If auxiliary fuel is required, additional NO_x will also be formed in the burner. The lower the RTO inlet VOC concentration the more auxiliary fuel is required. It should be noted that VOC emission concentrations from dryers and presses are low; therefore, for OSB manufacturing applications RTOs consume relatively large amounts of auxiliary fuel.

Engineered low NO_x burners or natural gas injection (NGI) are methods to reduce NO_x emissions. NGI is a technique which can be used to increase the hydrocarbon concentration (i.e., the injection of natural gas) in dilute air streams which will help to sustain combustion within the RTO combustion chamber without the use of the burner. As a result little to no auxiliary fuel will be required and less NO_x will be formed (U.S. EPA, 2000).

When operating a RTO, CO₂ and CO are also created in addition to NO_x. Again, these compounds are created from the destruction of VOCs and HAPs but they are also formed when auxiliary fuel (typically natural gas) is burned. For example, AP-42 emission factors suggest that approximately 20% more CO₂ is generated from using an RTO to control a direct, wood-fired rotary dryer. The primary source of GhG emissions from the OSB industry is through the combustion of residual wood products used to provide heat for drying and pressing operations.

RTOs also require substantial amounts of power to operate which will indirectly increase NO_x, CO₂ and CO as well as SO₂ emissions from power generating facilities (Sauer et al., 2002); however, these emissions will vary depending upon the source of the electricity. For example, there would be no CO₂ emitted if electricity was purchased solely from a hydroelectric generating station. In theory, an electric RTO could eliminate the use of auxiliary fuel as well as the associated secondary air impacts provided electricity is purchased from a clean energy source. However, electric RTOs cannot effectively sustain the required temperatures to

efficiently destroy VOCs and HAPs from OSB dryers and presses and are not commercially available at the required flow rates (Jeff Kudronowicz, personal communication, 28 May 2009).

The typical capital and operating costs of a RTO is outlined in Table 4-2. As with Table 4-1 above, costs are expressed as 2009 Canadian dollars per scfm, which have been converted from 2002 U.S. dollars based on an average exchange rate from 2002 (\$1.57 based on Canada Revenue Agency data) and a rate of inflation from 2002 to 2009 (14.5% based on Bank of Canada data). High installation and operating costs, particularly from auxiliary fuel use (i.e., natural gas) and purchased electricity, are one of the disadvantages of using a RTO.

Table 4-2 Typical RTO Capital and Operating Costs

	CAPITAL COST	OPERATING & MAINTENANCE COSTS	ANNUAL COST
RTO	\$63 to \$252 per scfm	\$7 to \$18 per scfm, annually	\$14 to \$59 per scfm, annually

costs are expressed as 2009 \$CAN
 scfm = standard cubic feet per minute
 Source: U.S. EPA, 2003b

According to the U.S. EPA (2003b) document, smaller RTOs controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow. In addition, based on discussions with RTO suppliers, the cost per scfm goes down as the size of the RTO increases (Mike Hill, personal communication, 22 June 2009). In OSB operations, emissions from dryers and presses have relatively low pollutant concentrations and would require RTOs with relatively high flow rates (based on U.S. EPA AP-42 background data the average RTO for a dryer has a flow rate of 45,000 scfm and the average RTO for a press has a flow rate of 80,000 scfm).

Assuming that for OSB applications RTO costs are approximately one third of the annualized costing scale provided in Table 4-2 (i.e., \$29 per scfm, annually), a typical OSB plant with RTOs on the dryer and press totalling 125,000 scfm would have annualized RTO costs of approximately \$3.6 million Canadian. Therefore, an average Canadian OSB facility with \$25 to \$50 million in annual sales (Scott's Directory 2007), annualized RTO operational costs could be 7 to 12% of overall sales.

4.3 REGENERATIVE CATALYTIC OXIDIZERS

Regenerative catalytic oxidizers (RCOs) are similar to RTOs except that the ceramic beds also contain a catalyst. A catalyst helps to speed up the destruction of VOCs and HAPs and allows

for a lower reaction temperature (approximately 316°C to 538°C) (U.S. EPA, 2002). This is the main advantage of a RCO, since lower temperatures will require less auxiliary fuel use and thus lower NO_x emissions. Typical catalyst materials include precious metals such as platinum or oxidized metallic elements such as manganese dioxide.

Catalysts have a finite lifetime in terms of activity. They can also become deactivated by compounds containing heavy metals, sulphur or phosphorous as well as particulate matter or resinous material which may accumulate on the surface of the catalyst (U.S. EPA, 2000).

RCOs are effective at controlling VOCs, HAPs and CO. Control efficiencies typically observed in RCOs are at least 90% for VOCs. Control efficiencies for methanol and formaldehyde are also typically 90% provided methanol and formaldehyde inlet concentrations are high enough (U.S. EPA, 2000). As with RTOs, formaldehyde and methanol are not as effectively destroyed at concentrations lower than 100 ppm. Platinum catalysts can also destroy CO, but efficiencies are not known (U.S. EPA, 2003b).

Catalyst media are very costly in comparison to ceramic media alone. As such, RCOs have higher maintenance and overall costs in comparison to RTOs; however, RTOs have higher operating costs due to larger amounts of auxiliary fuel usage. Typical costs associated with operating a RCO are outline in Table 4-3. As with Tables 4-1 and 4-2 above, costs are expressed as 2009 Canadian dollars per scfm, which have been converted from 2002 U.S. dollars based on an average exchange rate from 2002 (\$1.57 based on Canada Revenue Agency data) and a rate of inflation from 2002 to 2009 (14.5% based on Bank of Canada data).

Table 4-3 Typical RCO Capital and Operating Costs

	CAPITAL COST	OPERATING & MAINTENANCE COSTS	ANNUAL COST
RCO	\$63 to \$252 per scfm	\$11 to \$36 per scfm, annually	\$20 to \$76 per scfm, annually

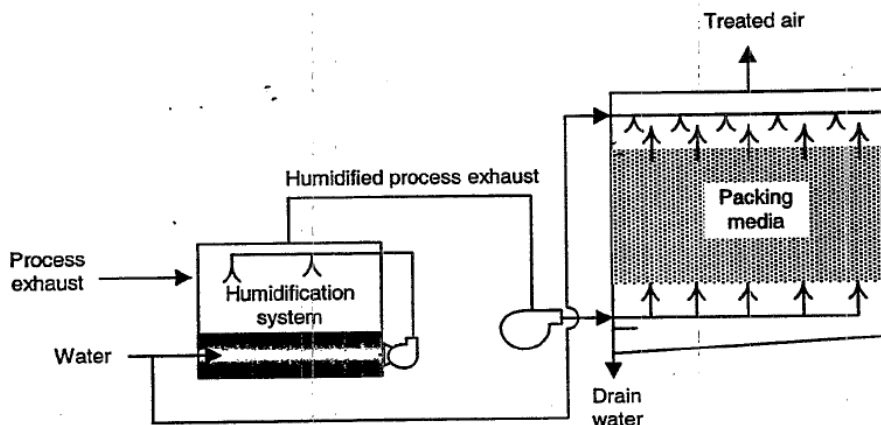
costs are expressed as 2009 \$CAN
 scfm = standard cubic feet per minute
 Source: U.S. EPA, 2003b

Following a similar approach to that outlined for RTOs above, the estimated annualized cost to control emissions from the dryer and press with RCOs would be approximately \$4.8 million Canadian, and could be greater than 12% of sales for a Canadian facility.

4.4 BIOFILTRATION

A biofilter is a control technology that uses microorganisms to decompose organic and inorganic pollutants present in the manufacturing equipment exhaust. A biofiltration system consists of a vacuum, a humidification system, and the biofilter. A simple schematic is provided in Figure 4-2.

Figure 4-2 A Simple Biofiltration System



Source: U.S. EPA, 2000

A vacuum system transports the exhaust from the manufacturing equipment through a humidification system where the air becomes cooled and saturated with moisture. Pre-humidification also helps to remove excess particulate matter. The air is then drawn into the plenum (the space below the packing media) to distribute the gases evenly before being forced upward through the moist packing media (i.e., the biofilm). Common packing media used includes bark, wood chips or synthetic materials which are inoculated with microorganisms. This media bed is usually 1 to 2 metres deep. Once in the biofilm, the microorganisms begin to decompose pollutants and convert them to CO₂, water and salts. Specific moisture content, temperature, pH, and adequate nutrients are all required to maintain the health and activity of the organisms.

Biofiltration systems are most effective at controlling VOCs and HAPs in low concentrations (less than 1,000 ppm) from manufacturing equipment with flow rates less than 100,000 scfm (Moretti, 2002; U.S. EPA, 2000). The outlet temperatures of dryers are often too hot for microorganisms to withstand therefore incoming air must be cooled prior to entering the biofilter (U.S. EPA, 2003c). Additionally, the air stream also contains large amounts of particulate matter so a control mechanism such as a WESP may also have to be installed upstream of a biofilter (Derrick Web, personal communication, 25 May 2009; U.S. EPA 2003c). For these reasons, biofilters are used primarily to control emissions from presses.

Microorganisms most effectively consume compounds which are water soluble. Therefore, biofilters are effective at removing pollutants such as acrolein, formaldehyde, methanol, and phenol. Less water soluble VOCs like terpenes from softwoods are not as effectively removed. Consequently, the typical control efficiency of a biofilter is 90 to 95% for HAPs and approximately 75% for VOCs (Derrick Web, personal communication, 25 May 2009). In comparison, the U.S. EPA (2000) reported typical control efficiencies of 97 to 98% for formaldehyde, 79 to 98% for methanol and 73 to 90% for VOCs. In a study by NCASI (1999), the efficiency of one biofilter controlling emissions from an OSB press was found to be greater than 95% for formaldehyde, 77% for methanol, and 80% for VOCs.

Unlike incineration-based controls, biofilters do not require the use of natural gas to operate, but do require some electricity to operate fans/blowers. As such, no NO_x, CO or CO₂ is produced from the combustion of natural gas and fewer secondary air pollutants from purchased power are generated when compared to RTOs and RCOs. However, a disadvantage of the biofilter is its large footprint. The larger the flow rate and concentration of the incoming exhaust to be controlled, the larger the biofilter will have to be. For example, a 220,000 scfm biofiltration system installed to control emissions from a press at an OSB facility located in Oklahoma was 150 feet (50 m) long, 75 feet (23 m) wide, and 35 feet (11 m) tall (Bio-Reaction Industries). In addition, a biofiltration system produces approximately 750 to 1500 gallons of wastewater per week which must be disposed of properly by the facility (Boswell, 2002).

An 80,000 scfm biofilter would cost approximately \$1.6 to \$2 million installed, with a 45,000 scfm biofilter costing between \$1 and \$1.2 million installed (Mike Hill, personal communication, 22 June 2009). However, operating costs are much lower since no natural gas is used and there is less power consumption. Maintenance costs are comparable to RCOs and RTOs. Due to the less frequent use of biofilters to control emissions from dryers and presses, estimating annualized costs was not possible.

4.5 OTHER CONTROL TECHNOLOGIES

In addition to the technologies discussed above, there are several other technologies which may be used to control emissions from dryers and presses, especially for particulate matter emissions. To control particulate matter emissions from OSB equipment, devices such as multi-cyclones, electrified filter beds and wet scrubbers may be used. They may be used alone, or in conjunction with a WESP, a RTO or both (U.S. EPA, 2000).

4.6 POLLUTION PREVENTION

Pollution prevention includes techniques which help to decrease the quantity of pollutants being emitted from manufacturing equipment. The factors which affect emissions as discussed in

Section 3.2 can be used to determine how emissions may be reduced from the manufacturing process.

Typically the choice of wood species is determined by what is grown in the area surrounding an OSB facility, and changing to a species with fewer emissions (i.e., hardwoods) is generally not feasible. It is also not always feasible to change the type of resin used as a means of controlling VOC and HAP emissions because the type of resin used is determined by the type of products being manufactured.

Pollutant emissions can be reduced through dryer selection. Conveyor dryers operate at lower temperatures and will reduce VOC and HAP emissions compared to rotary dryers. Also, using a single-pass rotary dryer instead of a triple-pass rotary dryer will help to reduce PM and PM₁₀ emissions. As stated in Section 3.2.1, it has been demonstrated that single-pass dryers will produce approximately two to three times less PM emissions than triple-pass dryers due to decreased agitation of the wood strands (O'Connor, 2006). Screening out fines is also important for reducing not only PM emissions, but for reducing the amount of VOCs and HAPs emitted when the fines are burned in the dryer.

Allowing a higher final moisture content in the wood strands exiting the dryer may also reduce the formation of VOCs and HAPs. However, as stated in Section 3.2.1 above, moisture content may not be possible to change since specific moisture requirements may be required for the final products.

5.0 REGULATORY REVIEW

The following sections provide an overview of the air quality standards, criteria, guidelines and objectives in place in both Canada and the United States for air pollutants relevant to the OSB industry. In general, Canadian provinces regulate air pollutants through ground-level ambient air concentration limits. In contrast, the United States uses a control-based approach to regulate OSB hazardous air pollutant emissions where a level of control is specified. State authorities may also regulate HAP and non-HAP emissions in much the same way that Canadian provinces do. Further detail about how OSB air pollutants are regulated in Canada and the U.S. is provided below.

5.1 CANADA

In Canada, air quality regulations are established primarily at the provincial level, and air quality standards, criteria, guidelines and objectives are most often based on time-averaged ground-level ambient air concentrations. Government agencies typically establish acceptable contaminant concentrations in air based on health, odour, vegetation, soiling, visibility, corrosion or other effects. Most provinces only have levels established for a group of pollutants called Criteria Air Contaminants (CACs) which include pollutants such as NO_x, CO, and PM. Ontario and Quebec currently have the most comprehensive lists of ground-level ambient air quality criteria (AAQC) which include most VOCs and HAPs of concern to the OSB industry in addition to the CACs. Alberta also has guidelines in place for most HAPs of concern. The only other provinces with HAP guidelines include British Columbia (formaldehyde) and Manitoba (formaldehyde, phenol, and MDI).

National ambient air quality objectives have been or are currently being developed by the Canadian Council of Ministers of the Environment (CCME) for contaminants such as particulate matter and benzene. For instance, the Canada Wide Standard (CWS) for PM_{2.5} is 30 µg/m³ over a 24 hour averaging period. Each jurisdiction (i.e., province), except Quebec, was required to submit an implementation plan to the CCME outlining the actions taken to achieve the standard for PM_{2.5} by the 2010 target date. Ontario and Newfoundland also have Point of Impingement (POI) guidelines which are used as limits in the permit approval process for individual manufacturing plants. Both the national and provincial ambient air quality criteria are outlined in detail in Appendix B. All jurisdictions use procedures that are slightly different from each other but have the same common elements – review of pollution effects literature, review of what other jurisdictions have set as a standard and some assessment of the economic implications of a particular level or standard. Usually a scientific panel is established which looks at all of the data and makes a recommendation to government on the level of standard and its implications to

public health, the environment and the economy. Government then passes either a law or establishes a regulation under an existing law.

In addition to concentration-based criteria, the provinces have their own permitting or approval systems in place. In general, provincial permits will contain ambient air concentration limits and/or stack emission limits, monitoring requirements, and operating and maintenance requirements. In contrast, permits in Saskatchewan limit emissions on the basis of control technology and not stack or ambient concentration limits (IC, 1998). Stack emission limits are often developed on an individual basis and will depend on the type of control technology used, whereas ambient levels are set considering the impact of concentration levels on humans and other sensitive receptors. Ambient pollutant levels resulting from a facilities operations are typically estimated using computer air dispersion models, which mathematically simulate how the atmosphere will disperse (dilute) stack or fugitive pollutant releases. The model predicted pollutant concentrations are then compared to applicable ambient criteria set on the basis of protecting health or the environment. Stack emission limits are connected to ambient levels by meteorology such that a given emission from a stack will produce a specific concentration of that pollutant at the receptor location. If control is accomplished by a stack emission limit, the maximum concentration, under the worst meteorological condition, will be achieved. Alternatively if control is accomplished by setting a concentration at the receptor, the emissions can be variable depending on the weather conditions and the limit can still be met. Using a stack limit has the advantage of fixing the total emission.

Appendix C outlines the emission limits imposed upon some OSB facilities in different provinces, and Table 5-1 provides a general outline of each provincial permitting system.

Table 5-1 Characteristics of Provincial Permitting Systems

	BC	AB	SK	MB	ON	QC	NB	NS	NF
Permit Type	Permit	Approval	Permit	License	Approval	Certificat d'autorisation	Approval	Approval	Approval
Amendment or permit required for process changes?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Expiry date	None	None	5 yr	None	None	5 yr	5 yr	10 yr	5 yr
Public comments considered (Y/N)?	Y	Y	Unknown	Y	Y	N	Y	N	Y
AAQC Considered (Y/N)?	Y	Y	N	Y	Y	Y	Y	Y	Y

	BC	AB	SK	MB	ON	QC	NB	NS	NF
Stack emission limits imposed (Y/N)?	Y	Y	N	Y	Not typically, but can be	Y	Y	Y	Y
Relevant contaminants which are regulated	NO _x , CO, PM, HCHO, opacity	NO _x , CO, PM, opacity	Permits based on control technology	NO _x , CO, PM, VOCs/HAPs	NO _x , CO, PM, VOCs/HAPs	NO _x , CO, PM, VOCs/HAPs	NO _x , CO, PM	NO _x , CO, PM	NO _x , CO, PM

Notes:

AAQC = Ambient Air Quality Criteria

Source: Adapted from NCASI (2008) with additional information obtained from IC (1998).

The province of Ontario has very recently released for stakeholder comments a proposed sector-based approach to managing air pollution in the forest products sector (EBR #010-6589 - posted June 10, 2009). The proposed approach focuses on the contaminant acrolein. Essentially the approach proposes technical standards for facilities if they will not be able to meet a new acrolein POI criterion, which is scheduled to be implemented on February 1st, 2010. For the OSB industry, the proposed technical standards are based on record keeping requirements, good engineering practices and pollution prevention, specifically setting limits on dryer inlet temperatures and exhaust moisture and recirculation requirements. The lower dryer inlet temperatures will reduce all VOC and HAP emissions, and based on the inlet temperatures for current dryer technologies it appears that conveyor type dryers will be required to meet the proposed temperature limits.

5.2 UNITED STATES

In the United States, the EPA must establish National Emissions Standards for Hazardous Air Pollutants (NESHAPs) under the *Clean Air Act*. The NESHAPs are based on the maximum achievable level of emission control, otherwise known as the Maximum Achievable Control Technology (MACT). The MACT floor is the minimum control level established for the NESHAP. In general, this type of rule imposes emissions standards which are typically met by means of add-on control devices.

Additionally, individual states have developed standards which regulate some VOCs and HAPs as well as criteria air pollutants such as particulate matter, NO_x and CO. This is achieved by enforcing stack emission limits or permitting systems similar to those in place in Canada. There are currently no federal regulations which impose standards on criteria air pollutants.

Both the federal MACT rule and examples of state regulations applicable to the OSB industry are summarized below.

5.2.1 U.S. EPA MACT Floor

In 2004, the U.S. EPA finalized the national emission standards for hazardous air pollutants (NESHAPs) under the *Clean Air Act* for the plywood and composite wood products (PCWP) industry which encompasses the OSB industry. The standards apply to any new or existing facility which is estimated to emit 25 tons of total HAPs per year or 10 tons per year of any single HAP. These amounts are for total facility-wide emissions, not just emissions from manufacturing equipment.

The final rule defines total HAPs as being the sum of six compounds including acetaldehyde, acrolein, formaldehyde, methanol, phenol and propionaldehyde. Although other organic HAPs from PCWP industry manufacturing equipment have been detected in one or more emission tests, many of these compounds occur infrequently. For example, the U.S. EPA determined that 87% of all benzene test results for uncontrolled process units were below the test method detection limit (MDL). It was also estimated that benzene only accounts for 0.2% of total HAP emissions from all PCWP facilities. The compounds included in the definition of total HAPs make up about 96% of total HAPs emitted from PCWP facilities (U.S. EPA 2004a).

Under the *Clean Air Act*, MACT floor standards are based on the level of emission reduction achieved by the best-performing 12% of existing sources in the PCWP industry. To determine the level of achievable emission reduction, control technology performance data was reviewed which focused on total hydrocarbons (THCs), methanol, and formaldehyde reduction because these pollutants are the most prevalent and most frequently tested (Hanks *et al.*, 2003). THC is not a HAP, but in general, control technologies effective at reducing THCs are effective at reducing HAPs. From their review, the U.S. EPA concluded that control levels achieved by incineration-based controls (RTOs and RCOs) and biofilters should be the basis for the MACT standards. It should be noted that the U.S. EPA does not require the installation of these control technologies, but rather will require control levels comparable to those achieved by such technologies (Hanks *et al.*, 2003).

The detailed compliance options set out by the final MACT Rule are presented in Appendix D. Each facility must choose one of the three compliance options for each piece of manufacturing equipment regulated under the final MACT Rule and must also follow the operating requirements specified under each compliance option. For OSB facilities, equipment which must comply with the MACT Rule includes rotary strand dryers, conveyor strand dryers, presses and board coolers.

If a facility chooses to follow the Production-Based Compliance Option (PBCO), they must demonstrate (without the use of any add-on control technology) that emissions from OSB process units do not exceed the HAP emission limits outlined in Appendix D.

By selecting the Add-on Control Technology Option (ACTO), a facility must then comply with one of the six additional control options for each piece of manufacturing equipment, unless for example, dryers and presses are exhausted through the same stack. The control options are:

- Reduce methanol by 90% or achieve emissions less than 1 ppm;
- Reduce formaldehyde by 90% or achieve emissions less than 1 ppm; or
- Reduce THC (i.e., VOC) by 90% or achieve emissions less than 20 ppm.

As mentioned previously, add-on control systems which are effectively able to control THC will be capable of effectively controlling HAP emissions.

The Emissions Averaging Control Option (EACO) is only available to existing facilities. This third option allows a facility to control process units not required under the final MACT Rule and in doing so, can acquire a pollution credit. Debits are acquired by not controlling required equipment. Credits must equal or exceed debits. Other specifications of this and the preceding compliance options are outlined in the final MACT Rule available at <http://www.epa.gov/ttn/atw/plypart/plywoodpg.html>.

The expected environmental and energy impacts resulting from all plywood and composite wood products facilities complying with the MACT Rule are presented in the *Background Information Document for the Proposed PCWP NESHAP* (U.S. EPA, 2000). In completing this analysis, it was assumed that all facilities would choose to install a RTO or a WESP combined with a RTO as their method of compliance. The analysis represents a worst-case scenario because RTOs result in greater energy use and greater environmental impacts than either a RCO or a biofilter would.

Tables 5-2 and 5-3 outline the expected U.S. nationwide changes in HAP, criteria air pollutants, and energy use from the installation of RTOs and WESPs at all OSB facilities. Total HAPs and THCs are reduced as they are effectively destroyed by the RTO. Primary changes in criteria air pollutants from the operation of RTOs include an increase in NO_x, a decrease in CO, and a decrease in PM₁₀.

Secondary air impacts are a result of the increased amount of energy required to operate RTOs (Table 5-2). An increase in NO_x, CO, PM₁₀ and sulphur dioxide (SO₂) will result. Although not specified in this analysis, the increase in energy requirements will result in an increase in the amount of carbon dioxide (CO₂) generated by using a RTO. This was discussed previously in Section 4.2.

Table 5-2 Estimated U.S. Nationwide Change in HAP, THC and Criteria Air Pollutants from OSB Compliance with MACT Standards

	TOTAL HAP REDUCTION	THC REDUCTION	CRITERIA AIR POLLUTANTS (tonnes/year)			SECONDARY AIR IMPACTS (tonnes/year)			
	%	%	NO _x	CO	PM ₁₀	NO _x	CO	PM ₁₀	SO ₂
OSB	79	67	+798	-3979	-2009	+415	+14	+21	+829

Source: Adapted from the U.S. EPA Background Information Document for the PCWP NESHAP (2000).

Table 5-3 Estimated U.S. Nationwide Energy Impacts from OSB Compliance with MACT Standards

	RTO NG CONSUMPTION (Billion BTU/yr)	RTO ELECTRICITY CONSUMPTION (GWh/yr)	WESP ELECTRICITY CONSUMPTION (GWh/yr)
OSB	269	129	19

Source: Adapted from the U.S. EPA Background Information Document for the PCWP NESHAP (2000).

BTU = British Thermal Units

GWh = Gigawatt Hours

Although some environmental and energy impacts were analyzed by the U.S. EPA, they did not have to be considered when developing the MACT floor. For example, the additional greenhouse gases (i.e., CO₂) produced from the operation of RTOs did not have to be considered when examining HAP control levels achievable by the plywood and composite wood products industry. Under the United States Clean Air Act, only the control of HAP is relevant to the MACT floor. Although this was met with some opposition, the Clean Air Act eliminates any consideration of the life-cycle impacts of control technologies such as the emission of greenhouse gases. However, as discussed with Beth Palma of the U.S. EPA, consideration of life-cycle impacts such as increased greenhouse gases will likely be considered in the near future upon review of the MACT control standards. A review is required 8 years following a rule's inception (i.e., 2012).

5.2.2 State Regulations

Prior to the federal MACT Rule, some states had already developed standards which regulated air pollutants common to the OSB industry. Moreover, air pollutants not regulated by the MACT Rule such as NO_x and particulate matter are only regulated at the state or local levels. Individual states impose stack emission limits or use permitting systems similar to those in place in Canada. For example, a state permit for an OSB facility in Maine limits MDI emissions to 0.01 grams per second from a press stack. Additional stack limits imposed upon the Maine OSB facility and two other state facilities are provided in Appendix C.

5.3 COMPARING GENERAL CANADIAN AND UNITED STATES APPROACHES

As stated above, in general Canadian provinces regulate air pollutants through ground-level ambient air concentration limits. In contrast, the United States uses a control-based approach to regulate air pollutant emissions where a level of control is specified based on available control technologies.

The Canadian approach is more flexible and looks at each facility individually. A facility emitting pollutants from the middle of a large property will have lower property line concentrations than the same facility with a smaller property, which is a result of more time for pollutants to travel and disperse prior to reaching the facility property line where criteria limits are typically applied. This approach can lead to a greater mass of pollutants released to the local atmosphere, but also is more science based and considers the specific environmental impacts at each site. The Canadian approach is also more labour intensive, where air quality impact assessments are prepared for each site and reviewed by Ministries of Environment.

The United States approach is less flexible and takes more of a ‘one size fits all’ approach. In general, more pollutant control equipment will be used; however, this equipment also consumes energy, which can result in greater GhG emissions through natural gas combustion at the site and/or through the generation of electricity.

5.4 CURRENT CONTROL PRACTICES AT OSB FACILITIES

5.4.1 Canada

Through discussions with government and industry representatives in Canada, it was determined that most OSB facilities control PM emissions from dryers using either WESPs or wet scrubbers. Only one facility in Canada controls VOCs and HAPs by using three RTOs to control emissions from dryers and presses. Finally, there are two facilities which use a conveyor dryer instead of a rotary dryer, which will help to minimize dryer VOC and PM emissions; however one of these facilities is currently inactive (Gilles Brunette, personal communication, 2 June 2009).

5.4.2 United States

Prior to the U.S. EPA enforcing the MACT Rule in 2004 several facilities in the U.S. already had control devices installed on manufacturing equipment as a means of complying with state or local requirements (Beth Palma, personal communication, 9 June 2009). As of the year 2000, the U.S. EPA reported that there were a total of 125 dryers used in the OSB industry and all were

controlled in some way. 60% of the dryers used RTOs to control VOC and HAP emissions and 68% of these RTOs also had a WESP installed upstream. 64% of the dryers used WESPs either alone or in combination with other control technologies to control particulate matter emissions. Out of 39 OSB presses, 20 used add-on control technologies. Of these 20 presses, 75% used a RTO. There were two presses which used a biofilter to control emissions.

It was predicted by the U.S. EPA (2000) that 23 OSB facilities would be impacted by the new MACT standards. An official survey has yet to be completed by the U.S. EPA to determine what compliance options facilities have chosen as a means to comply with the MACT Rule. It is thought that most plywood and composite wood products facilities have chosen to install RTOs, but that several facilities in the northwest have opted to install biofilters. It is suspected that biofilters are more popular in the northwest for two reasons: 1) there may have been state and local opposition to installing RTOs in the northwest because they emit large amounts of greenhouse gases and 2) it may be easier to cool hot exhaust emissions from manufacturing equipment since ambient air temperatures are lower in the northwest and would allow biofilters to better tolerate dryer and press exhaust temperatures. Further information is expected to be recovered by the U.S. EPA in the near future. (Beth Palma, personal communication, 26 May 2009).

6.0 CONCLUSIONS

There are three (3) primary sources of pollutant emissions to the atmosphere from the OSB manufacturing process: (1) combustion emissions (i.e., combustion of wood, natural gas or other fuel oil); (2) emissions driven off by drying the wood, releasing to atmosphere naturally occurring materials in the wood; and, (3) emissions associated with the resins used to bind the wood strands together. Pollutant emissions can be managed using add-on control technologies, with the type of control technology used depending on the type of pollutant as well as the type of equipment used in the OSB manufacturing process. The most common control technologies used in the North American OSB industry include wet electrostatic precipitators (WESPs) to control particulate emissions and regenerative thermal oxidizers (RTOs), regenerative catalytic oxidizers (RCOs) or biofilters to control volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions.

RTOs and RCOs are incineration type control technologies, typically generating heat through the combustion of natural gas, which results in the generation of greenhouse gases (GhGs). However, according to published emission factors, the primary source of GhG emissions from the OSB industry is through the combustion of residual wood wastes used to provide heat for drying and pressing operations.

The costs to operate emissions control equipment can be a large portion (10%) of the overall OSB manufacturing cost. Currently (2009), the OSB industry is experiencing the effects of the economic slow down, with government and industry contacts indicating many plants are closing due to a decrease in the North American demand for product.

In general, Canadian provinces regulate air pollutants emitted from the OSB manufacturing process through ground-level ambient air concentration limits. In contrast, the United States uses a control-based approach to regulate OSB HAP emissions where a level of control is specified. State authorities may also regulate HAP and non-HAP emissions in much the same way that Canadian provinces do.

7.0 REFERENCES

- Bio-Reaction Industries, Date Unknown. *Bio-oxidation Press Emissions Control for the J.M. Huber OSB Mill Broken Bow, Oklahoma*. Available online:
< <http://www.bioreaction.com/userfiles/files/papers/PanelWorld.pdf> > [28 May 2009]
- Boswell, J., 2002. Understanding the Capabilities of Bio-Oxidation. *Chemical Engineering Progress Magazine*, 100(12): 48-53.
- Hanks, K., Nicholson, B., and K. Parrish, 2003. *Determination of MACT floors and MACT for the Final Plywood and Composite Wood Products Industry NESHAP*. Memorandum to Mary Tom Kissell, U.S. EPA, December 15.
- Industry Canada (IC), 1998. *Wood Based Panel Products Technology Roadmap*. Canadian Forest Industries, Research, Technology and Innovation. Available on line at <<http://www.ic.gc.ca/eic/site/fi-if.nsf/eng/oc01501.html>> [20 May 2009].
- Moretti, E.C., 2002. Reduce VOC and HAP Emissions. *Chemical Engineering Progress Magazine*, 98(6): 30-40.
- National Council for Air and Stream Improvement (NCASI), 2008. *Wood Products Air Quality Technical Information Document*. Special Report No. 08-01, May.
- National Council for Air and Stream Improvement (NCASI), 1999. *Volatile Organic Compound Emissions from Wood Products Manufacturing Facilities, Part V – Oriented Strand Board*. Technical Bulletin No. 772, January.
- O'Connor, B., 2006. *PM₁₀ and PM_{2.5} Emissions from Oriented Strand Board Wafer Dryers Using a Dilution Tunnel Sampler*. Forest Products Society 2006 Drying Conference. Available online: <<http://www.forestprod.org/drying06oconnor.pdf>> [2 June 2009].
- Ontario EBR #010-6589 - posted June 10, 2009, *Proposed Sector-Based Approach to Managing Air Pollution in the Forest Products Sector Under O. Regulation 419/05, Chapter 2 of "Sector-Based Technical Standards to Manage Air Pollution": Proposed Forest Products Sector Technical Standard*.
- Otwell, L.P., Hittmeier, M.E., Hooda, U., Yan, H., Su, W., and S. Banjeree, 2000. HAPs Released from Wood Drying. *Environmental Science and Technology*, 34 (11): 2280–2283.
- Sauer, B., Franklin, W., Miner, R., Word, D., and B. Upton, 2002. Environmental Tradeoffs: Life Cycle Approach to Evaluate the Burdens and Benefits of Emission Control Systems in the Wood Panel Industry. *Forest Products Journal*, 52(3): 51-58.

- United States Environmental Protection Agency (U.S. EPA), 2004a. *NESHAP: Plywood and Composite Wood Products; Effluent Limitations Guidelines and Standards for the Timber Products Point Source Category; List of Hazardous Air Pollutants, Lesser Quantity Designations, Source Category List; Final Rule*. Federal Registrar 40 CFR Parts 63 and 429.
- United States Environmental Protection Agency (U.S. EPA), 2004b. *National Emission Standards for Hazardous Air Pollutants for Plywood and Composite Wood Products Background Information for Final Standards Summary of Public Comments and Responses*. Office of Air Quality, Planning and Standards, NC.
- United States Environmental Protection Agency (U.S. EPA), 2003a. *Air Pollution Control Technology Fact Sheet: Wet ESP - Wire Pipe Type*. Available online: <<http://www.epa.gov/ttn/catc/products.html#aptecfacts>> [29 May 2009].
- United States Environmental Protection Agency (U.S. EPA), 2003b. *Air Pollution Control Technology Fact Sheet: Regenerative Incinerator*. Available online: <<http://www.epa.gov/ttn/catc/products.html#aptecfacts>> [29 May 2009].
- United States Environmental Protection Agency (U.S. EPA), 2003c. *Using Bioreactors to Control Air Pollution*. The Clean Air Technology Center, NC.
- United States Environmental Protection Agency (U.S. EPA), 2000. *Background Information Document for Proposed Plywood and Composite Wood Products NESHAP*. Office of Air Quality, Planning and Standards, NC.
- United States Environmental Protection Agency (U.S. EPA), 2002. *AP-42 Section 10.6.1 Waferboard/Oriented Strandboard Manufacturing*. Technology Transfer Network Clearinghouse for Inventories & Emissions Factors.

8.0 GLOSSARY AND ABBREVIATIONS

- Acrolein:** is an organic chemical compound which is both unstable and toxic. It is used to manufacture other chemicals such as resins and polyurethane. Acrolein occurs naturally in wood.
- Acetaldehyde:** is an organic chemical compound with the chemical formula CH_3CHO . It occurs naturally in ripe fruit and other foods, and is produced by plants as a natural part of their metabolism, but it is also produced by combustion processes and by degradation of plastics.
- Benzene:** is an organic chemical compound which is carcinogenic and has the chemical formula C_6H_6 . It is commonly used as an intermediate in the manufacture of other chemicals and is also used as a gasoline additive but in very small quantities.
- Carbon Monoxide (CO):** is a product of incomplete combustion of hydrocarbon based fuels (gasoline, wood, etc.) and is commonly emitted from vehicle tailpipes. It is a colourless, odourless, tasteless, and poisonous gas which may cause severe illness or even death in people.
- CEPA:** means Canadian Environmental Protection Act, which is an “Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development”.
- CCME:** means Canadian Council of Ministers of the Environment, which is comprised of 14 environment ministers from the federal, provincial and territorial governments. The CCME serves as a forum for members to develop national environmental strategies and guidelines for areas such as air, soil, water and climate that each environment ministry across Canada can use.
- CO₂ equivalent (CO₂-e):** is a quantity that describes, for a given mixture of greenhouse gases, the amount of CO₂ that would have the same global warming potential (GWP) measured over a specified timeframe.
- Criteria air Contaminants (CACs):** is a group of air pollutants defined by Environment Canada which includes sulphur oxides (SO₂), nitrogen oxides (NO_x), particulate matter (PM), volatile organic compounds (VOCs) and carbon monoxide (CO).

Formaldehyde (HCHO): is an organic chemical compound with the chemical formula CH_2O . It is an intermediate compound in the oxidation of methane (natural gas) as well as other organic compounds. It can be used to disinfect and preserve organic tissues.

Greenhouse Gas (GhG): is an atmospheric gas which effectively traps heat in earth's lower atmosphere. GhGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and compounds known as hydrofluorocarbons (HFCs) and water vapour.

Hazardous Air Pollutants

(HAPs): are toxic pollutants defined by the U.S. Environmental Protection Agency as being carcinogenic. There are 187 pollutants currently on the list of HAPs.

Hydrocarbons: are organic compounds made entirely of hydrogen and carbon. They are a primary source of the world's electricity and heat. For example, natural gas (CH_4) is a hydrocarbon which can be combusted to form CO_2 , water and heat.

MACT: means Maximum Achievable Control Technology

MDI: means Methane Diphenyl Diisocyanate (MDI) (CAS 101-68-8) is an organic chemical compound which is primarily used for the production of polyurethane. It is also used as a resin in the manufacture of oriented strand board.

MDL: means Method Detection Limit. It is the lowest concentration at which laboratory test methods can detect the presence of a chemical compound.

Methanol: is a toxic organic chemical with the chemical formula CH_3OH . It is the simplest alcohol and can be used as an antifreeze, a solvent or a fuel. Methanol can be naturally produced by bacteria but is destroyed in the atmosphere by sunlight.

NESHAP: means National Emissions Standards for Hazardous Air Pollutants. These are standards set by the U.S. Environmental Protection Agency.

Nitrogen Oxides (NO_x): includes the gases nitrogen oxide (NO) and nitrogen dioxide (NO_2). It is formed from the combustion of fuel in a nitrogen rich atmosphere (note that ambient air is a nitrogen rich atmosphere). NO released from the combustion process quickly oxidizes to form NO_2 in the atmosphere.

Lb/ODT:	means pounds per oven dried ton of wood material. This is an emission factor unit for OSB facilities.
PCWP:	means Plywood and Composite Wood Products Industry.
PF:	is Phenol-Formaldehyde resin used in the manufacture of oriented strand board.
Phenol:	is a toxic, organic compound with the chemical formula C_6H_5OH . It can be produced naturally from the decomposition of organic matter. It may also be manufactured and is often used in synthetic resins.
Propionaldehyde:	is an organic compound with the chemical formula CH_3CH_2CHO . It may be used as an intermediate in the production of alkyd resins.
Particulate Matter (PM):	is airborne particulate in solid or liquid form. PM is subcategorized into three main size fractions: total particulate matter (TPM), PM less than 10 microns in diameter (PM_{10}) and PM less than 2.5 microns in diameter ($PM_{2.5}$). PM can restrict visibility or at the smaller size fractions can have health impacts. PM_{10} is also known as inhalable particulate because it can settle in the bronchi of the lungs and $PM_{2.5}$ is often referred to as respirable particulate because it can penetrate into the gas exchange regions of the lungs. Consequently, PM_{10} and $PM_{2.5}$ can contribute to respiratory and cardiac illness such as asthma, bronchitis, emphysema and various heart diseases.
POI:	means Point of impingement. A POI is any point on the ground or on a receptor, such as a nearby building, located outside a facility's property boundaries at which the highest concentration of a contaminant caused by the emission of that contaminant from the facility is expected to occur.
PPM:	means parts per million. A dimensionless unit used for measuring small concentrations. It denotes 1 part in 1,000,000 parts.
SCFM:	means standard cubic feet per minute. A unit used to describe volumetric flow rates corrected to a standardized set of atmospheric conditions which includes temperature, pressure, and relative humidity.
SIC:	means Standard Industrial Classification, which is a system used to classify companies and enterprises in Canada and the United States according to the activity(ies) in which they are engaged using a four-digit code.

Sulphur dioxide (SO₂): is a gas formed from sulphur contained in coal, oil and metal ores during a combustion or a refining processes.

THC: means Total hydrocarbons, which is the combined mass of measured hydrocarbons.

Volatile Organic
Compounds (VOCs): are carbon containing gases and vapours (e.g. gasoline fumes) but excluding carbon dioxide, carbon monoxide, methane and chlorofluorocarbons. VOCs are precursors to the formation of ground-level ozone and smog, as well as PM_{2.5} (Environment Canada definition).

APPENDIX A

OSB INDUSTRY 2007 NPRI DATA

Total OSB Industry Emissions Compared to Total Canadian Emissions

CAS Number	Chemical Name	OSB Industry Emissions Total (tonnes)	All Industry Emissions Total (tonnes)	% of Industry Total
107-02-8	Acrolein	94	133	71%
101-68-8	Methylenebis(phenylisocyanate) (MDI)	7.3	17	43%
50-00-0	Formaldehyde	649	1,766	37%
75-07-0	Acetaldehyde	247	1,201	21%
67-56-1	Methanol	1101	15,150	7%
71-43-2	Benzene	35	719	5%
NA - 09	Manganese (and its compounds)	4.8	154	3%
9016-87-9	Polymeric diphenylmethane diisocyanate	0.20	7.2	3%
NA - M10	PM2.5 - Particulate Matter <= 2.5 Microns	1522	60,673	3%
NA - M09	PM10 - Particulate Matter <= 10 Microns	2410	114,217	2%
NA - M08	PM - Total Particulate Matter	3643	204,400	2%
NA - M16	Volatile Organic Compounds (VOCs)	4067	264,705	2%
108-95-2	Phenol (and its salts)	9.0	878	1%
630-08-0	Carbon monoxide	8419	999,918	1%
11104-93-1	Oxides of nitrogen (expressed as NO2)	1491	830,996	0.2%
NA - 03	Cadmium (and its compounds)	4.8	27,143	0.02%
NA - D/F	Dioxins and furans - total	0.004	40	0.01%
NA - 08	Lead (and its compounds)	12	255,697	0%
NA - 02	Arsenic (and its compounds)	0	85,976	0%
118-74-1	Hexachlorobenzene	0	10,542	0%
NA - 22	Phosphorus (total)	0	173	0%

Total Provincial OSB Emissions Compared to Total Canadian Emissions

Province	CAS Number	Chemical Name	OSB Industry Emissions Total (tonnes)	All Industry Emissions Total (tonnes)	Provincial OSB % of Total
BC	101-68-8	Methylenebis(phenylisocyanate) (MDI)	6	17	36%
AB	101-68-8	Methylenebis(phenylisocyanate) (MDI)	1	17	6%
ON	101-68-8	Methylenebis(phenylisocyanate) (MDI)	0.2	17	1%
QC	101-68-8	Methylenebis(phenylisocyanate) (MDI)	0.04	17	0.21%
MB	101-68-8	Methylenebis(phenylisocyanate) (MDI)	0.006	17	0.04%
ON	107-02-8	Acrolein	60	133	45%
AB	107-02-8	Acrolein	34	133	26%
AB	108-95-2	Phenol (and its salts)	7.7	879	0.88%
ON	108-95-2	Phenol (and its salts)	1.3	879	0.15%
AB	11104-93-1	Oxides of nitrogen (expressed as NO ₂)	381	830,996	0.05%
QC	11104-93-1	Oxides of nitrogen (expressed as NO ₂)	338	830,996	0.04%
BC	11104-93-1	Oxides of nitrogen (expressed as NO ₂)	241	830,996	0.03%
ON	11104-93-1	Oxides of nitrogen (expressed as NO ₂)	223	830,996	0.03%
SK	11104-93-1	Oxides of nitrogen (expressed as NO ₂)	157	830,996	0.02%
MB	11104-93-1	Oxides of nitrogen (expressed as NO ₂)	151	830,996	0.02%
AB	118-74-1	Hexachlorobenzene	0	10,543	0%
BC	118-74-1	Hexachlorobenzene	0	10,543	0%
ON	118-74-1	Hexachlorobenzene	0	10,543	0%
SK	118-74-1	Hexachlorobenzene	0	10,543	0%
AB	50-00-0	Formaldehyde	275	1,766	16%
QC	50-00-0	Formaldehyde	150	1,766	8%
ON	50-00-0	Formaldehyde	108	1,766	6%
BC	50-00-0	Formaldehyde	64	1,766	4%
SK	50-00-0	Formaldehyde	47	1,766	3%
NB	50-00-0	Formaldehyde	6.2	1,766	0.4%
AB	630-08-0	Carbon monoxide	3140	999,918	0.31%
ON	630-08-0	Carbon monoxide	2098	999,918	0.21%
BC	630-08-0	Carbon monoxide	1378	999,918	0.14%
QC	630-08-0	Carbon monoxide	1243	999,918	0.12%
SK	630-08-0	Carbon monoxide	304	999,918	0.03%
MB	630-08-0	Carbon monoxide	187	999,918	0.02%
NB	630-08-0	Carbon monoxide	69	999,918	0.01%
QC	67-56-1	Methanol	359	15,150	2%
AB	67-56-1	Methanol	343	15,150	2%
BC	67-56-1	Methanol	175	15,150	1%
SK	67-56-1	Methanol	128	15,150	0.84%
ON	67-56-1	Methanol	73	15,150	0.48%

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MB	67-56-1	Methanol	20	15,150	0.13%
NB	67-56-1	Methanol	3.9	15,150	0.03%
AB	71-43-2	Benzene	35	719	5%
AB	75-07-0	Acetaldehyde	162	1,201	14%
BC	75-07-0	Acetaldehyde	28	1,201	2%
ON	75-07-0	Acetaldehyde	28	1,201	2%
QC	75-07-0	Acetaldehyde	25	1,201	2%
NB	75-07-0	Acetaldehyde	3.7	1,201	0.31%
AB	9016-87-9	Polymeric diphenylmethane diisocyanate	0.2	7.1	3%
SK	NA - 02	Arsenic (and its compounds)	0	85,976	0%
QC	NA - 03	Cadmium (and its compounds)	2.3	27,143	0.01%
AB	NA - 03	Cadmium (and its compounds)	1	27,143	0.004%
ON	NA - 03	Cadmium (and its compounds)	1	27,143	0.004%
SK	NA - 03	Cadmium (and its compounds)	0.24	27,143	0.001%
MB	NA - 03	Cadmium (and its compounds)	0.18	27,143	0.001%
BC	NA - 03	Cadmium (and its compounds)	0.012	27,143	0%
ON	NA - 08	Lead (and its compounds)	8	255,697	0.003%
AB	NA - 08	Lead (and its compounds)	4	255,697	0.002%
SK	NA - 08	Lead (and its compounds)	0	255,697	0%
ON	NA - 09	Manganese (and its compounds)	4.8	154	3.10%
MB	NA - 22	Phosphorus (total)	0	173	0%
QC	NA - 22	Phosphorus (total)	0	173	0%
ON	NA - D/F	Dioxins and furans - total	0.004	40	0.01%
AB	NA - D/F	Dioxins and furans - total	0	40	0%
ON	NA - M08	PM - Total Particulate Matter	1172	204,400	0.57%
AB	NA - M08	PM - Total Particulate Matter	1106	204,400	0.54%
QC	NA - M08	PM - Total Particulate Matter	710	204,400	0.35%
BC	NA - M08	PM - Total Particulate Matter	405	204,400	0.20%
SK	NA - M08	PM - Total Particulate Matter	225	204,400	0.11%
MB	NA - M08	PM - Total Particulate Matter	25	204,400	0.01%
ON	NA - M09	PM10 - Particulate Matter <= 10 Microns	1001	114,217	0.88%
AB	NA - M09	PM10 - Particulate Matter <= 10 Microns	783	114,217	0.69%
QC	NA - M09	PM10 - Particulate Matter <= 10 Microns	339	114,217	0.30%
SK	NA - M09	PM10 - Particulate Matter <= 10 Microns	160	114,217	0.14%
BC	NA - M09	PM10 - Particulate Matter <= 10 Microns	99	114,217	0.09%
MB	NA - M09	PM10 - Particulate Matter <= 10 Microns	18	114,217	0.02%
NB	NA -	PM10 - Particulate Matter <= 10	11	114,217	0.01%

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	M09	Microns			
ON	NA - M10	PM2.5 - Particulate Matter <= 2.5 Microns	775	60,673	1%
AB	NA - M10	PM2.5 - Particulate Matter <= 2.5 Microns	387	60,673	0.64%
QC	NA - M10	PM2.5 - Particulate Matter <= 2.5 Microns	142	60,673	0.23%
SK	NA - M10	PM2.5 - Particulate Matter <= 2.5 Microns	132	60,673	0.22%
BC	NA - M10	PM2.5 - Particulate Matter <= 2.5 Microns	60	60,673	0.10%
MB	NA - M10	PM2.5 - Particulate Matter <= 2.5 Microns	16	60,673	0.03%
NB	NA - M10	PM2.5 - Particulate Matter <= 2.5 Microns	9.9	60,673	0.02%
AB	NA - M16	Volatile Organic Compounds (VOCs)	1451	264,705	0.55%
ON	NA - M16	Volatile Organic Compounds (VOCs)	918	264,705	0.35%
BC	NA - M16	Volatile Organic Compounds (VOCs)	757	264,705	0.29%
QC	NA - M16	Volatile Organic Compounds (VOCs)	643	264,705	0.24%
SK	NA - M16	Volatile Organic Compounds (VOCs)	237	264,705	0.09%
MB	NA - M16	Volatile Organic Compounds (VOCs)	33	264,705	0.01%
NB	NA - M16	Volatile Organic Compounds (VOCs)	28	264,705	0.01%

APPENDIX B

AMBIENT AIR CRITERIA IN CANADA

Ambient Air Quality Criteria for Contaminants Relevant to the OSB Industry

Pollutant	Averaging Period (hr)	BC ¹	AB	SK	MB	ON	QC	NB	NS	NF	CCME
Volatile Organic Compounds											
Acetaldehyde*	1	--	50	--	--	--	--	--	--	--	--
	24	--	--	--	--	500	--	--	--	--	--
Acrolein*	24	--	--	--	--	0.08	--	--	--	--	--
Benzene*	1	--	30	--	--	--	--	--	--	--	--
Formaldehyde*	1	D:60, E: 370	65	--	60	--	28	--	--	--	--
	24	--	--	--	--	65	--	--	--	--	--
Methanol*	1	--	2600	--	--	--	28000	--	--	--	--
	24	--	--	--	--	4000	--	--	--	--	--
MDI*	1	--	0.51	--	3	--	--	--	--	--	--
	24	--	--	--	--	0.7	--	--	--	--	--
	Annual	--	--	--	--	--	0.6				
Phenol*	1	--	100	--	--	--	--	--	--	--	--
	24	--	--	--	--	30	--	--	--	--	--
Propionaldehyde*	10 min	--	--	--	--	10	--	--	--	--	--
Criteria Air Contaminants											
NO _x	1	400-1000	400	400	400	400	414	400	400	400	400-1000
	24	200-300	200	--	200	200	207	200		200	200-300
CO	1	A: 14300, B: 28000, C: 35000	15000	15000	35000	36200	34	35000	34600	35000	15-35
TPM	24	120-400	100	120	120	120	150	120	120	120	120-400
PM ₁₀	24	50		--	50	50		--	--	50	25
PM _{2.5}	24		30	--	30	30	30	--	--	25	30

All concentrations are in units of µg/m³

*Hazardous Air Pollutant

¹ A: Level A; B: Level B; C: Level C; D: Action Level; E: Episode Level

APPENDIX C

EXAMPLES OF STACK EMISSION LIMITS IN CANADA AND THE U.S.

Example Stack Emission Limits from Various Provinces in Canada

	NB		PQ	ON	MB			AB			BC
	Wood waste Stack	Press Vents			Dryer RTO	Press RTO	Thermal Oil ESP	Dryer Cyclone EFB	Press Exhaust Stack	Thermal Oil Stack	MDF Emission Guidelines
Particulate	200 mg/m ³	--	50 mg/m ³	90 mg/m ³	5.14 g/s	2.1 g/s	2.18 g/s	0.10 g/kg	--	1.1 g/kg	120 mg/m ³
Formaldehyde	20 mg/m ³	20 mg/m ³	--	--	0.085 g/s	0.08 g/s	--	100 mg/m ³	40 mg/m ³	--	300 g/t product
CO	100 mg/m ³	--	--	100 ppm	--	--	--	--	--	--	--
NO _x	20 mg/m ³	--	--	--	6.5 g/s	0.9 g/s	5.3 g/s	--	--	--	--
SO ₂	100 mg/m ³	--	--	--	--	--	--	--	--	--	--
THC	--	--	--	100 ppm	--	--	--	--	--	--	--
NMHC	--	75 mg/m ³	--	--	--	--	--	--	--	--	--
Phenol	--	--	--	--	0.05 g/s	0.7 g/s	--	--	--	--	--
VOC	--	--	--	--	1.1 g/s	0.28 g/s	--	--	--	--	--
Benzene	--	--	--	--	0.008 g/s	0.0003 g/s	0.0066 g/s	25 mg/m ³	--	--	--
MDI	--	--	--	--	--	0.0141 g/s	2.18 g/s	--	--	--	--

Notes:

- NB: An OSB Certificate of Approval
- PQ: Quality of the Atmosphere Regulation
- ON: OSB Certificate of Approval
- MB: An OSB License
- AB: An OSB Approval
- BC: Provincial MDF Guideline

Source: IC, 1998

Examples of Stack Emission Limits from 3 U.S. States

Contaminants (g/s)	Texas		Maine			Washington
	Press RTO	Heat Energy System	Press RTO	Dryer RTO and WESP	Heat Energy System	
Particulate	0.14	0.72	1.55	1.97	0.93	0.23 g/m ³
Formaldehyde	0.07	0.06	0.04	0.54		
CO	0.94	3.45	1.04	12.57		
NO _x	0.05	6.48	2.57	3.34	0.25	
SO ₂	0.001	0.50	0.06	0.09/2.6	0.06	1000 ppm
THC						
NMHC						
Phenol	0.004		0.02	0.03		
VOC	0.95	2.31	0.22	0.71	0.62	
Benzene						
MDI			0.01			

Notes:

Texas: OSB Permit

Main: OSB Permit

Washington: 173-400 General Regulations for Air Pollution Sources

Source: IC, 1998

APPENDIX D

U.S. EPA MACT STANDARDS

NESHAPs as Required by the U.S. EPA MACT Floor

COMPLIANCE OPTION	DESCRIPTION																		
Production-Based Compliance Option (PBCO)	Process units have emission limits for total HAP in units of lb/10 ³ ft ² or oven dried tons (ODT). Add-on controls cannot be used to meet this PCBO. See table below.																		
Add-On Control System Option ¹	Through the use of an add-on control system (e.g., a RTO), achieve one of the following options:																		
	<table border="1"> <thead> <tr> <th>Pollutant</th> <th>Reduce by</th> <th>OR achieve emissions ≤</th> </tr> </thead> <tbody> <tr> <td>Methanol</td> <td>90 %</td> <td>1 ppm²</td> </tr> <tr> <td colspan="3" style="text-align: center;">...OR...</td> </tr> <tr> <td>Formaldehyde</td> <td>90 %</td> <td>1 ppm²</td> </tr> <tr> <td colspan="3" style="text-align: center;">...OR...</td> </tr> <tr> <td>THC³</td> <td>90%</td> <td>20 ppm</td> </tr> </tbody> </table>	Pollutant	Reduce by	OR achieve emissions ≤	Methanol	90 %	1 ppm ²	...OR...			Formaldehyde	90 %	1 ppm ²	...OR...			THC ³	90%	20 ppm
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THC ³	90%	20 ppm																	
Emissions Averaging Option	Existing (not new) facilities have the option of complying by averaging among process units.																		

Notes:

¹ There must also be a capture device installed on presses and board coolers that meets the rule definition or a capture efficiency ≥ 95 %.

² Uncontrolled emissions entering the control device must be greater than or equal to 10 ppm.

³ THC measured as total carbon.

PCBO HAP Limits Applicable to OSB Facilities

PROCESS UNIT	PBCO TOTAL HAP LIMIT
Press pre-dryers (at new affected sources only)	0.037 lb/MSF ½"
Reconstituted wood product board coolers (at new affected sources only)	0.014 lb/MSF ¾"
Reconstituted wood product presses	0.30 lb/MSF ¾"
Rotary strand dryers	0.18 lb/ODT

Notes:

lb/MSF = pounds per 1000 square feet with a specified board thickness in inches

lb/ODT = pounds per oven dried tons