# Boilers

There are two types of boilers, internal and external combustion. External combustion occurs when the combustion air is present at or near atmospheric pressure. Internal combustion occurs in turbines (same as jet engines) where the incoming air is compressed before being mixed with the fuel. Boilers can be broken down in three categories: commercial, as in heating buildings; industrial, for manufacturing facilities; and electrical, for generation of electricity.

All boilers consist of 4 main parts: burner, firebox, heat exchanger, and a method of fuel flow. Larger boilers also include auxiliaries, which may include a flame safety device, soot blower, air preheaters, economizer, superheater, fuel heater, or automatic flue gas analyzer. (*AP-40,* 553)

There were a total of 333 boilers reported in 1995 to the Ecology database, Washington Emissions Data System. Due to lack of throughput data, the total energy produced from each of the fuel types could not be determined. However, information on the number of boilers and some reported emissions were available. Figures 1-2 show what percent of fuel types were used in these boilers and what percent fall into each of the categories listed above.

Note that the commercial category does not include all of the commercial boilers in the state because that data is not available. Also, PSAPCA reports boilers in their jurisdiction by segment, one segment for each fuel used. Because of the lack of throughput data, the main fuel for these boilers cannot be determined. Therefore, the number of boilers by fuel does not add up to the number of actual boilers present.

Natural gas powers a large number of the boilers, and also accounts for a large percentage of the power generated by boilers in Washington State. In terms of megawatts produced, lignite is in second place followed closely by wood. (*Air Toxics Emissions Estimation Methods Evaluation*, 1)

The four sub-sections of this chapter describe combustion from four fuel sources:
1. Wood-Waste
2. Oil (Distillate or Residual)
3. Coal (butiminous/subbituminous or lignite)
4. Natural gas

Other fuels used in Washington state include process gas, solid waste, liquified petroleum gas (LPG), and kerosene/naphtha (jet fuel).

**Figure 1. Number of Boilers for each Fuel Type**

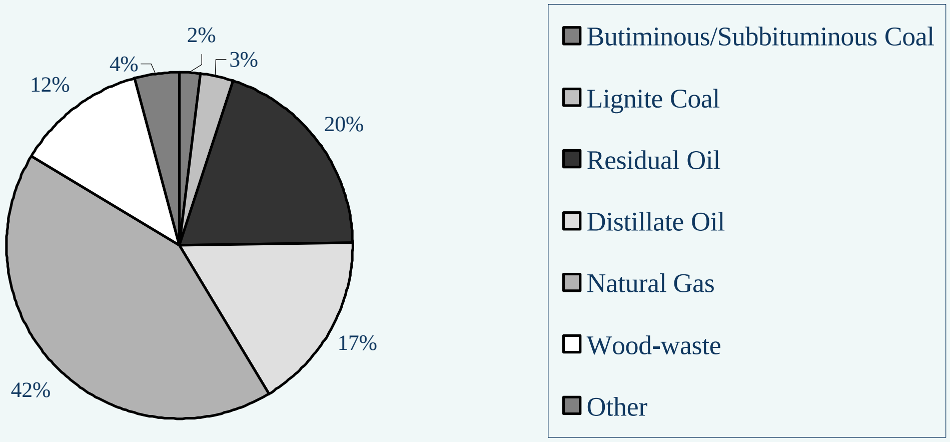



**Figure 2(a). Number of External Combustion Boilers in Each Category**

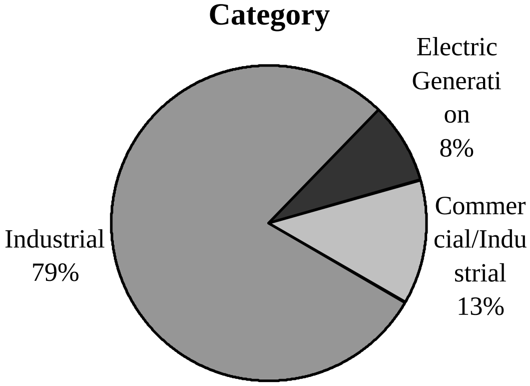
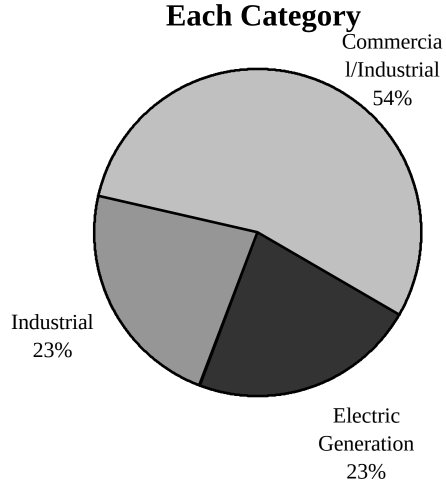



**Figure 2(b). Number of Internal Combustion Boilers in Each Category**



EPA updated all the boiler sections in *AP-42*[1] in October 1996. Information on boilers which combust specific types of fuel can be found in that report in the following sections:
Section 1.1 Bituminous and Subituminous Coal
Section 1.3 Fuel Oil Combustion
Section 1.4 Natural Gas Combustion
Section 1.6 Wood Waste Combustion in Boilers
Section 1.7 Lignite Combustion

This update includes emission factors for toxics such as polychlorinated, polynuclear aromatics, organics, acid gases, trace metals, and controlled toxics.

The Clean Air Act requires development of regulations for toxic air emissions from several categories of industrial combustion sources, including boilers, process heaters, waste incinerators, combustion turbines, and internal combustion engines. The EPA has started Industrial Combustion Coordinated Rulemaking (ICCR) to develop recommendations for MACT regulations that address the various combustion source categories and pollutants. The ICCR is expected to provide its recommendations to the EPA by the year 2000. Regulations will be developed under sections 111, 112 and 129 of the Clean Air Act.

[1] U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emissions Factors Volume 1: Stationary Point and Area Sources*, Fifth Edition with Supplements, October 1997, Document No. AP-42.

## References

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Washington State Department of Ecology, *Air Quality Program database*, 1995. Contact: Sally Otterson, 360-407-6806.

# Wood Waste Boilers

According to a recent Ecology survey there are currently 85 wood-waste boilers in Washington State. These boilers combust about 3.3 million tons of wood annually, which accounts for 64% of all the fuel combusted in wood-waste boilers. The other fuels burned include refuse-derived fuel, old corrugated cardboard, tire-derived fuel, pulp mill sludges, natural gas, coal, and oil. Of those that combust fuels other than wood (therefore, excluding those that are burn wood-waste only) about one-half of the fuel combusted are other fuels. (DeMay, p. 2-7)

## Description of Process

Waste wood in the form of chips, sawdust, shavings, sander dust, hogged wood or bark is fired in a boiler to obtain heat. Depending on the boiler type, the fuel may also include other waste materials that get entrained in the fuel conveyor system such as soil, rocks, rags, and metal parts and pieces. The operator may also burn oil along with the wood waste, especially when the wood is wet, to supplement the heat content of the fuel.

The predominant species of wood burned in the western part of the state are Douglas fir, spruce, western red cedar, cottonwood and hemlock. In eastern Washington the mix of species is markedly different: ponderosa pine, Douglas fir, white fir and a small (1-5%) quantity of western red cedar.

The moisture content of the fuel is typically between 40-50% by weight. Facilities which store the fuel outside have a problem with fuel moisture in the winter, in which moisture content may be up to 60-70%.

Wood that has been transported or stored in salty or brackish water creates salt-laden wood. Combustion of salt-laden wood increases fine particulate loading and plume opacity as well as air toxics such as dioxin. About 24% of the wood waste boilers in Washington combust some salt-laden wood. (DeMay, p. 7)

In Washington, wood-waste boiler types include pile burners (dutch and fuel cell oven), spreader-stokers (mechanical and pneumatic), suspension burners, and fluidized bed. Figure 3 below shows the number of each type in Washington. The most common use of the wood-fired boilers in the state is in industry for the production of steam for process use. Wood-fired boilers are also used for cogeneration (production of steam for both process use and for electric generation).

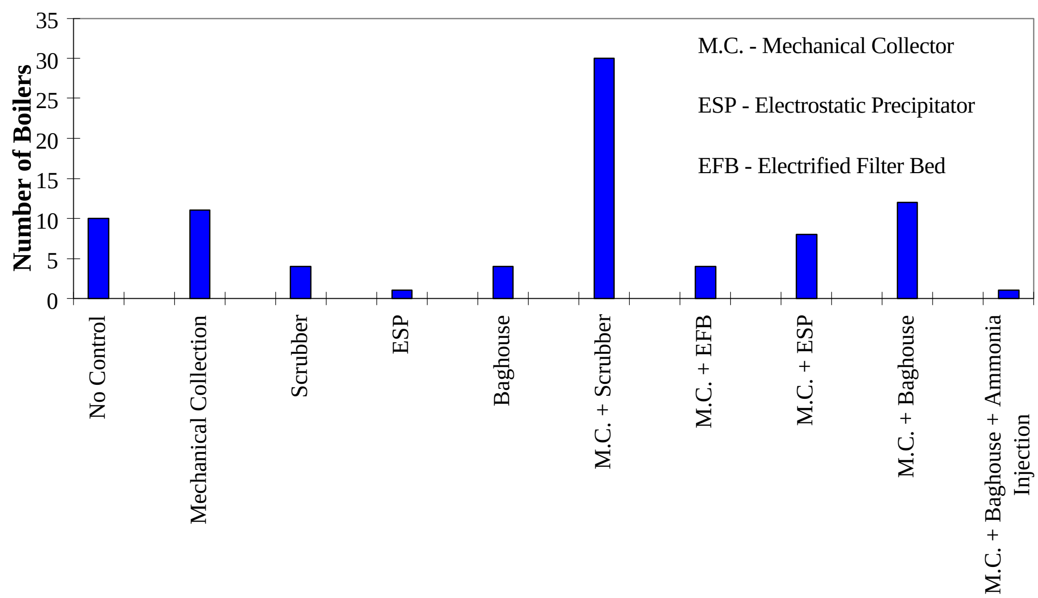
**Figure 3. Wood-Waste Boiler Design Distribution in Washington State**[2]
(DeMay, Table 7, pg. 18)

| Types of Boiler Design | No. of Boilers | % |
|---|---|---|
| Spreader Stoker | 24 | 38 |
| Dutch Oven | 22 | 34 |
| Fuel Cell | 13 | 20 |
| Fluidized Bed | 2 | 3 |
| Other | 3 | 5 |

## Method of Determining Emissions

The existing emission control equipment for wood-fired boilers in Washington is exclusively for particulate control. In pulp mills and larger facilities, electrostatic precipitators may be used. Most of the wood waste boiler population is controlled with either cyclones or wet scrubbers, and less commonly with fabric filters (baghouses). Figure 4 shows the control equipment present in Washington State.

**Figure 4. Air Pollution Control Equipment**[3] (DeMay, Graph 4, pg. 14)




[2] Note: 64 out of 85 boilers reported.
[3] Note: 64 out of 85 boilers reported.

Typically, flyash reinjection is also practiced in some of the 1970 generation boilers and newer. The main purpose of flyash reinjection is to improve fuel efficiency, though it does increases particulate emissions. Of Washington wood-waste boilers, 32% use flyash reinjection (only 86% of boilers reported).

Only a few of the boilers in the state are equipped with automatic controls. Proper combustion and low air emissions, even in those that are equipped with automatic controls, is largely dependent on the skill and experience of the boiler operator. Conversations with facility personnel indicate that there is currently no recognized training program for boiler operators. Training, for most facilities, occurs on the job.

Fuel storage is also an important parameter. Facilities that have covered storage areas for their fuel may have fewer moisture problems in the winter.

The Washington State Department of Ecology is currently undergoing a Reasonably Available Control Technology (RACT) analysis for the source category of Wood-fired Boilers. The likely outcome of this analysis could include new air emission limitations for both toxic and criteria pollutants.

If no mill-specific source tests are available, toxic emission factors are available from *AP-42* or *NCASI* (1995) for these sources.

## References

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# Appendix
# Alternate Methodology[4]

Wood waste boiler emissions are subject to more local variables such as fuel type, mix and moisture content than the other categories. Emphasis was placed on characterizing emissions from wood waste boilers. A database was created which contains 76 wood waste boiler source test runs conducted either in Washington or on the West Coast.

To characterize the population and operation of boilers in Washington, Ecology staff surveyed and visited nine facilities including sawmills, plywood manufacturers, an electric generating facility and a pulp and paper mill. These facilities are located throughout the state and account for thirteen boilers. A literature search was conducted in addition to site visits, and conversations with boiler operators, local air personnel, and other state and federal agency staff. This information is included in the bibliography. Source tests from in and out of state were obtained and are also reflected in the bibliography.

The FIRE database contains the latest EPA emission factors based on section 1.6, supplement F of AP-42, released in April 1993.

One of the greatest misgivings of the current FIRE/AP-42 database is the wide numerical range of calculated emission factors per species. For example, benzene emission factors range from 8.6 E-5 to 1.4 E-2 lb/ton. For a 'typical' 100 MMBTU/hr wood waste boiler in Washington this range translates to 13.9 lbs. versus 1.14 tons per year. This range places the user in a predicament of picking a number "out of the air". Typically, regulatory agencies use the high end of the range to base decisions on. The following proposed estimation methods result in narrowing the range for each emission type.
AP-42 and FIRE utilize a variety of units:

- pounds per ton of fuel burned (lb/ton)
- pounds per million BTU input (lb/MMBTU)
- milligrams per metric ton (mg/tonne)
- milligrams per kilogram (mg/kg)

The energy input emission factor is based on the following assumptions:

* Heating value: 4500 Btu/lb of wood.
* Moisture content: 50%
* F Factors[5] of 9240 dscf/MM Btu for wood and 9600 dscf/MM Btu for bark

[4] This analysis was presented in the first edition of this report. Since then, new toxic emission factors are not available. However, the analysis is still relevant and is included here in it's original form. Explanatory footnotes have been added where needed.
[5] A F-factor is "a factor representing a ratio of the volume of dry flue gases generated to the caloric value of the fuel combusted." (40 CFR Part 75 Appendix F 3.3.5)

In fact, heating value for the fuel used in our state deviates widely (4000-10000 BTU/lb). The systematic error interval produced from just the heating value is 136% of the calculated value. In other words, for an emission factor of 0.014 lb X[6]/MM Btu, the uncertainty interval is equal to 0.019 lb X/MM Btu. Note that this uncertainty interval was calculated only taking into account the heating value variation.

There are other factors that vary dramatically such as moisture, boiler efficiency, F-factors (due to the heterogenous nature of wood waste), and fuel mix. Probably the greatest error is introduced in the estimation of the mass of wood burned. None of the facilities weigh the wood waste before burning it. Only in one of the facilities visited is the mass of wood bought actually measured because they pay the suppliers based on the weight delivered to the storage area where it is piled up. However, even that facility does not weigh the wood waste before burning it.

Due to degree of error propagation described above, units of pounds per million BTU output are recommended for a facility-specific emission factor. The pounds of steam produced is an operating boiler datum readily available; therefore, factors with units of lb/MMBTU can more accurately reflect emissions.

## Gaseous Emissions

The many compounds in the gas phase emitted from boilers have not been consistently characterized. Much attention has been focused on benzene and formaldehyde since both are known carcinogens. Although the bulk of the gaseous emissions exhibit low toxicity, Kleindienst et.al. have demonstrated that the mutagenic activities of the gas-phase (and the particulate phase) species such as propylene and toluene increase significantly upon irradiation in the presence of nitrogen oxides (NOx). Note that these compounds are ubiquitous in an urban environment mainly due to mobile source contributions. Since hydrocarbons are products of incomplete combustion, theoretically, carbon monoxide could be used as a surrogate.

Indeed, three studies (Hubbard, Sassenrath, and Atkins, et.al.) have found a linear, but not absolute correlation. The variability in gaseous emissions can not be explained solely by carbon monoxide variability. The preponderance of the data does follow theory especially for benzene and formaldehyde. For other compounds such as acetaldehyde, benzaldehyde, salicylaldehyde, acrolein, and certain individual polycyclic aromatic hydrocarbons (PAHs) the correlation does not hold. In most cases this is probably due to very small data sets, high blank values, and below detection limit calculations based on half of the detection limit.

Since the available data on other compounds of gaseous organic emission data is so sketchy, it is not possible to develop emission factors for any of them for the category as a whole. AP-42/FIRE do contain emission factors for more gaseous emissions compounds; however, as explained above their use is not recommended, especially in the case of factors developed from data sets smaller than four runs.

[6] X is used to refer to any toxic, and is just used as an example.

The tables presented below were developed based on data collected in Atkins, et. al. which contains a comprehensive summary of the wood-fired boiler data collected to date. The 95 percentile confidence intervals were calculated from the standard deviation of the sample data. Propagation of random error was accomplished through propagation of variance equations (Shoemaker,et.al.).

**Table 1. Recommended Benzene Emission Factors for Wood/Bark Fired Boilers and Associated 95% Confidence Interval**

| Units Benzene | CO Range corrected to 12% $CO_2$ 0-200 ppm | CO Range corrected to 12% $CO_2$ 200-500 ppm | CO Range corrected to 12% $CO_2$ 500-1500 ppm |
|---|---|---|---|
| lbs/MMBTU (in) | 6.9 E-5 +/- 3.5 E-5 | 6.9 E-4 +/- 4.0 E-4 | 2.0 E-3 +/- 1.1 E-3 |
| lbs/MMBTU(out)[a] | 1.2 E-4 +/- 1.0 E-4 | 1.2 E-3 +/- 1.0 E-3 | 3.4 E-3 +/- 2.9 E-3 |

[a] Based on a boiler efficiency of 60%, the 95% confidence interval includes propagation of error for boiler efficiency ranging from 40-80%

**Table 2. Recommended Formaldehyde Emission Factors for Wood/Bark Fired Boilers and Associated 95% Confidence Interval**

| Units Formaldehyde | CO Range corrected to 12% $CO_2$ 0-200 ppm | CO Range corrected to 12% $CO_2$ 200-500 ppm | CO Range corrected to 12% $CO_2$ 500-1500 ppm |
|---|---|---|---|
| lbs/MMBTU (in) | 6.3 E-4 +/- 3.5 E-5 | 1.0 E-3 +/- 4.0 E-4 | 2.1 E-3 +/- 1.1 E-3 |
| lbs/MMBTU(out)[a] | 1.1 E-3 +/- 8.6 E-4 | 1.7 E-3 +/- 1.3 E-3 | 3.4 E-3 +/- 3.2 E-3 |

[a] Based on a boiler efficiency of 60%, the 95% confidence interval includes propagation of error for boiler efficiency ranging from 40-80%

Particulates and Semi-volatiles
More emission source tests are available from well controlled rather than uncontrolled sources. Most of the source tests conducted to date on wood waste boilers are to determine total particulate emissions.

Trace metals are part of wood tissues. During combustion the metals become partitioned between the bottom ash and the fly ash. The metals fly ash emissions from wood combustion are generally insignificant. For example, emission factors for cadmium, chromium, manganese and nickel range from 1 E-7 to 1 E-5 lb/MMBTU for multiclone-controlled boilers with no flyash reinjection. For a 'typical' 100 MMBTU/hr wood waste boiler in Washington this range translates to 0.53 lbs. versus 48 lbs. per year.

Flue gas emissions of most trace metals (except for mercury) have been correlated to the particulate emissions (Atkins, et.al.). Metal emissions in the stack gas are directly related to the efficiency of the particulate control device. Electrostatic precipitators achieve the highest removal efficiency, followed by wet scrubbers and multiclones. The FIRE/AP-42 emission factors do not account for this correlation diminishing their utility. A comprehensive summary of the metals flue gas emissions data is available (Atkins, et.al.). Table 3 emission factors were calculated using that data. Uncertainty intervals were not calculated.

**Table 3. Recommended Metal Emission Factors**

| Element | TSP 0-0.005 gr/dscf corrected to 12 % $CO_2$ | TSP 0.005-0.01 gr/dscf corrected to 12 % $CO_2$ | TSP 0.01-0.005 gr/dscf corrected to 12 % $CO_2$ |
|---|---|---|---|
| Arsenic | 1.8 E-7 | 7.1 E-7 | 1.1 E-5 |
| Beryllium | 1.7 E-7 | 1.9 E-7 | 2.1 E-7 |
| Cadmium | 4.4 E-7 | 3.5 E-7 | 1.3 E-7 |
| Chromium | 1.3 E-6 | 9.4 E-6 | 8.0 E-6 |
| Hexavalent Chromium | 2.6 E-5 | N/A | 4.0 E-6 |
| Copper | 3.0 E-6 | N/A | 2.4 E-5 |
| Lead | 3.2 E-6 | 2.2 E-5 | 3.7 E-5 |
| Manganese | 4.2 E-5 | 9.9 E-5 | 1.3 E-4 |
| Mercury | 2.7 E-7 | 2.6 E-7 | 7.0 E-7 |
| Nickel | 3.0 E-6 | 3.8 E-6 | 1.1 E-5 |
| Selenium | 2.0 E-6 | N/A | 2.5 E-6 |
| Zinc | 6.0 E-5 | N/A | 3.8 E-4 |

The semi-volatile emission species studied include PAHs, dioxins and furans. The review of emission factors for these species has not been completed, and is pending analysis of the Ecology database.

## Proposed Estimation Method

Two approaches are proposed. The most accurate approach is for each individual facility to source test each unit for the individual compounds of interest. The operating parameters that must be recorded at the time of testing are: pounds of steam generated per hour, pressure and temperature of the steam, inlet make-up water temperature and pressure. This data will be used to calculate the energy generated in the boiler with the aid of steam tables. The ratio of underfire and overfire air must also be recorded as well as the percent excess air, percent CO2, CO and O2. In addition, fuel moisture and type are necessary pieces of information. An ultimate analysis of the fuel would be useful. Another hint is to record the name of the boiler operator. If questions arise later about operating parameters, it is useful to have the operator's name.

An example calculation is shown below:

Source test information: 1 lb. of X/hour
Boiler information: 100,000 lbs./hour of steam produced at 200 psia and 400 F
Boiler Operator: Ms. Jane Smith

Temperature of water coming in: 70 F at atmospheric pressure

From steam tables: Enthalpy of steam (out)= 1240.6 Btu/lb
Enthalpy of water (in) = 38.05 Btu/lb

Total energy out in Btu = 100,000 lbs./hr (1240.6-38.05 Btu/lb.) = 1.2 E8 Btu = 120 MMBTU (out)/hr

Facility-specific emission factor: 1 lb. of X/ 120 MMBTU = 8.3 E-3/MMBTU (out) when burning fuel of Y moisture and Z type, at R ratio of underfire and overfire air, A% $CO_2$, B% excess air, C% $O_2$, and D% CO.

The second approach is to use tables 1-3 to estimate benzene, formaldehyde, and metals emissions. Note that to use these tables it is necessary to know the carbon monoxide and particulates concentration typically emitted from the facility. An average of the source tests performed recently is appropriate. A CO continuous emission monitor is advisable. If the boiler efficiency is known, divide the emission factor based on inlet Btu's (lbs/MMBTU (in)) by the efficiency, and then multiply the total Btu's produced from the boiler to obtain the estimated pounds of pollutant X emitted. If boiler efficiency is not known, use the factor based on total BTU output.

Speciation of gaseous emissions requires the use of a variety of different analytical techniques. The measurement methodology is still evolving for some compounds.

Contribution of HAP Emissions from Wood-Fired Boilers in Washington

Statewide benzene and formaldehyde emissions were estimated. The estimate was based on 43% of the boilers operating at CO levels between 0-200 ppm, 26% between 200-500 ppm, and 31% greater than 1500. These percentages were calculated from the Ecology database[7]. In reality, it is expected that the percentage operating between 200-500 ppm CO is higher because the database contains some runs which purposely intended to reflect poor combustion conditions (such as when grate cleaning or soot blowing). The estimated pounds per year from all the wood-fired boilers in Washington of benzene and formaldehyde were 1950 and 2710, respectively.

[7] Refers to Ecology's Washington Emissions Data System (WEDS).

# Distillate and Residual Oil Boilers or Oil Backup

## Description of Process

There are two main types of oil used in boilers in Washington state: residual oil and distillate oil. Distillate oil (includes kerosene and diesel) is more volatile than residual and is usually used in domestic or small commercial boilers. Residual oil is more viscous than distillate and is usually used in electric generation, industrial and large commercial boilers.

Combustion of the various oil grades (light distillate to residual) requires different burner technology due to the large specific gravity range (from below zero to more than 90 degrees API). Heats of combustion also vary widely (17,000-20,500 Btu/lb). Sulfur, inert and impurity content depends on the place of origin of the oil. The main boiler configurations include water tube, fire tube, cast iron, and tubeless.

## Method of Determining Emissions

The boiler configuration and size, fuel type and composition, and combustion practices affect emissions. Organic toxic emissions are mostly dependent on combustion efficiency.

If no mill-specific source tests are available, toxic emission factors are available from *AP-42* for these sources.

## References

U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emissions Factors Volume 1: Stationary Point and Area Sources*, Fifth Edition with Supplements, January 1995, Document No. AP-42. (Section 1.3, Fuel Oil Combustion, October 1996) (available by section on Internet at http://www.epa.gov/ttn/chief/ap42.html)

Washington State Department of Ecology, *Facility/Site site on the Web*, accessed 1/20/98. (http://www.wa.gov/ecology/iss/fsweb/fshome.html)

# Coal-Fired Boilers

## Description of Process

There are many different ranks of coal including the most common: lignite, anthracite, bituminous, and subbituminous. The coal's volatile matter, fixed carbon, inherent moisture, and oxygen determine the rank. Generally, increasing in rank increases the fixed carbon and decreases the volatile matter and moisture.

In Washington state, coal-fired boilers use three types of coal: bituminous, subbituminous and lignite. Figure 5 shows the heating values for these coal-types.

**Figure 5. Heating Values In British Thermal Units (Btu) /Pound**
(*AP-42*, Sections 1.1 and 1.7)

| Basis | Lignite | Bituminous | Subbituminous |
|---|---|---|---|
| **Wet, mineral-matter free** | | 10,500-14,000 | 8,300-11,500 |
| Wet | 5,000-7,500 | | |
| As-mined | | 10,720-14,730 | 9,420-10,130 |

Boilers can be classified by their heat transfer method type and arrangement and their firing configuration. Heat transfer methods include water tube (most common), fire tube, and cast iron, which can be arranged in horizontal, vertical, straight or bent tube position. The firing configuration can be either suspension, stoker, or fluidized bed.

The Pacific Power and Light Company, Centralia Steam Electric Generating Plant is the largest source in this category in the state.

## Method of Determining Emissions

Emissions are affected by rank and composition of coal, type and size of boiler, combustion conditions, load, and equipment maintenance.

Organic toxic air emissions depend on what chemicals are present in the coal and are products of incomplete combustion (PIC). Organic toxics can take the form of dioxins and furans, and polycyclic organic matter (POM).

Metals, such as manganese, beryllium, cobalt, chromium, arsenic, cadmium, lead, antimony, mercury, and selenium, are also products of coal combustion and are controlled by particulate controls such as electrostatic precipitators (ESP), fabric filters, wet scrubbers, cyclones, and side stream separators.

Other common toxic emissions from coal combustion are hydrogen fluoride, fluorine, hydrogen chloride, and chlorine. The hydrogen chloride and fluoride can be controlled using an acid gas scrubbing system.

*AP-42* classifies trace metal emissions into the following three classes (*AP-42*, 1.1-5):

> "Class 1: Elements that are approximately equally concentrated in the fly ash and bottom ash, or show little or no small particle enrichment. Examples include manganese, beryllium, cobalt, and chromium.
> Class 2: Elements that are enriched in fly ash relative to bottom ash, or show increasing enrichment with decreasing particle size. Examples include arsenic, cadmium, lead and antimony.
> Class 3: Elements which are emitted in the gas phase (primarily mercury, and in some cases, selenium).

Control of Class 1 metals is directly related to control of total particulate matter emissions, while control of Class 2 metals depends on the collection of fine particulate. Because of variability in particulate control device efficiencies, emission rates of these metals can vary substantially. Because of the volatility of Class 3 metals, particulate controls have only a limited impact on emissions of these metals." (*AP-42*)

Other controls techniques that can be used to reduce criteria emissions are fuel treatment or substitution (generally controls $SO_2$), combustion modification (generally NOx and some PM), and post combustion control.

If no mill-specific source tests are available, emission factors are available from *AP-42* for dioxins and furans, speciated PAHs, aldehydes and other organic compounds, hydrogen chloride, hydrogen fluoride, and metals.

## Reference

Mrazek, S. Southwest Air Pollution Control Agency, facsimile 3/15/94.

U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emissions Factors Volume 1: Stationary Point and Area Sources,* Fifth Edition with Supplements, January 1995, Document No. AP-42. (Section 1.1, Bituminous and Subituminous Coal, Section 1.7, Lignite Combustion, October 1996)
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Washington State Department of Ecology, *Facility/Site on the Web,* accessed 1/20/98.
(http://www.wa.gov/ecology/iss/fsweb/fshome.html)

# Natural Gas Boilers and Turbines

## Description of Process

Natural gas is the main fuel used to generate power in the state.  Gas turbines are used extensively in Washington for natural gas pipeline compression and power generation.

If no mill-specific source tests are available, toxic emission factors are available from *AP-42* for these sources.

## References

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