Approaches to Permitting Wood-Fired Boilers in Vermont and New Hampshire

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ABSTRACT

Significant increases in fossil fuel prices have stimulated demand for biomass fuel in northern New England. Many institutions, including secondary schools, colleges, universities and hospitals have replaced, or plan to replace, older oil-fired boilers with new wood-fired boilers. Consultants and state air pollution control agencies are experiencing a significant increase in air pollution permit projects in response to the demand for wood-fired energy.

While federal air pollution control standards are equally applicable among all states, state air pollution control regulations vary. This paper will describe approaches to permitting wood-fired boilers in Vermont and New Hampshire according to the following categories: (1) permit applicability thresholds, (2) emission limits, (3) emission controls, (4) air toxics evaluation thresholds, (5) ambient air quality impact evaluation thresholds and (6) record keeping requirements.

This paper will focus on wood-fired boilers ranging in size from two to less than 30 Million British Thermal Units of heat input per hour (MMBtu/hr). It will also summarize findings relative to measured wood-fired boiler operating and emissions characteristics. Lastly, it will summarize newly developed permit conditions addressing Best Available Control Technology (BACT), fuel specifications, monitoring requirements and operation and maintenance requirements.

INTRODUCTION

Rising fuel oil prices combined with growing concern for national security and global climate change have sparked interest in using local, renewable energy to produce heat and electricity. Institutions, such as schools, colleges/universities and hospitals are switching from fuel oil to biomass, specifically wood chips. A growing number of facility managers, air quality consultants and state permitting agencies are now engaged in evaluating and permitting wood-fired steam generating units, frequently referred to as wood-fired boilers.

The wood-fired boiler landscape is changing in many ways. The following key changes have been observed. First, wood combustion and pollution control technologies are significantly

improving. Second, new permit requirements are being developed by state air pollution control agencies, which vary on a state-by-state basis. Third, the U.S. Environmental Protection Agency (U.S. EPA) recently made the National Ambient Air Quality Standards (NAAQS) for fine particulate matter (PM2.5) more stringent.

While federal air pollution control standards are equally applicable among all states, state air pollution control regulations vary. To illustrate these differences, this paper will describe approaches to permitting 2.1 to 27.5 MMBtu/hr wood-fired boilers in Vermont and New Hampshire. The differences will be summarized according to the following categories:

1) permit applicability thresholds,
2) emission limits,
3) emission controls,
4) hazardous air pollutant evaluation thresholds,
5) ambient air quality impact evaluation thresholds,
6) record keeping requirements and
7) permit conditions.

PERMIT APPLICABILITY THRESHOLDS

The permit applicability limit is a threshold value above which an air pollution permit is required. This value is based on heating surface area in Vermont and heat input capacity in New Hampshire.

A permit is required in Vermont if the wood-fired boiler has 900 square feet or more of heating surface area. Vermont regulations are based on the assumption of one horse power equating to 10 square feet of heating surface area. This would put the permit applicability limit at 90 hp for 900 square feet of heating area. Current wood-fired boiler technology can achieve more than one horsepower per 10 square feet; therefore, there are a number of un-permitted wood-fired boilers in Vermont having a capacity exceeding 90 horsepower.

A permit is required in New Hampshire for wood-fired boilers having a design heat input equal to or greater than 2.0 MMBtu/hr. This equated to approximately 46 horsepower for a wood-fired boiler recently permitted which had a heat input capacity of 2.1 MMBtu/hr. Note the design heat input is a function of the heat content of the fuel burned and the fuel consumption rate. Furthermore, wood heat content is also a function of moisture content.

EMISSION LIMITS

PM and CO Emission Limits

The primary pollutant of concern with wood-fired boilers is particulate matter (PM). Recently, much attention has been given to fine particulate matter emissions, also referred to as PM fine or PM2.5 (particles with an aerodynamic diameter less than or equal to 2.5 microns). Both states have emission limits for PM.[1]

Emissions of hazardous air pollutants (HAPs) are also a concern with wood-fired boilers (see Section 5, below). Consequently, Vermont has begun limiting carbon monoxide (CO) emissions in addition to PM emissions. CO is widely considered an indicator of gaseous HAPs, such as benzene or formaldehyde. Therefore, HAP emissions are indirectly controlled by controlling CO emissions.

The precedents for Vermont's PM and CO emission limits were derived from the state's air toxics regulation (5-261). This regulation requires air pollution sources to minimize emissions of HAPs if eight hour emission thresholds are exceeded.[2] Recent interpretation of this rule resulted in a PM emission limit of 0.25 pounds emitted per MMBtu and CO emission limit of 150 parts per million (ppm). Note both emission limits apply to normal operating conditions and do not reflect transitional periods or soot blowing.

New Hampshire has a regulation (Env-A 2000) directly specifying a PM limit of 0.30 lb/MMBtu for PM. Therefore, this limit is not interpreted on a case by case basis. New Hampshire also has an air toxics regulation (Env-A 1400). However, this regulation has not applied to wood-fired boiler permit applications.

While a new rule for PM2.5 exists, emission limits for PM2.5 have not yet been established. State air pollution control agencies are currently determining which emission factors should be used for PM2.5, especially since the fraction of PM2.5 varies significantly by type of wood-fired boiler (stoker versus gasifier).

Emission Limits instead of Fuel Restrictions

There are two types of fuel burned. Wood with bark (bole tree and whole tree chips) and wood without bark (mill end or sawmill chips). According to chapter 1.6 of AP 42,[3] the latter produces more PM emissions. Hence, the consensus among state permitting agencies is wood without bark is preferable for minimizing PM emissions. However, there is also consensus

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[1] PM is also referred to as Total suspended particulate matter (TSP).

[2] The lowest possible emission rate for a given HAP is called the hazardous most stringent emission rate (HMSER).

that the supply of debarked wood may not always be continuously available; therefore, state permitting agencies do not prohibit combustion of wood with bark. To this end, the precedent in Vermont is to burn the "cleanest available fuel." In addition, New Hampshire allows combustion of wood with bark provided the wood burning facility demonstrates the New Hampshire PM emission limit will be met on a continuous basis. For example, New Hampshire recently accepted stack test results from a comparable wood-fired boiler in Vermont burning wood with bark, as a means for demonstrating compliance with the New Hampshire PM emission limit.

EMISSION CONTROLS

Emission controls have evolved in response to the emission limits just described.

Add-on controls are typically required for PM. Inherently lower emitting processes and practices are required to control emissions of PM and other pollutants. Mechanical collectors (single cyclones and multicyclones) are required to control PM emissions from small wood-fired boilers.[4] Large wood-fired boilers install baghouses for PM control.

Single cyclones have typically been used to control larger particles, such as fly ash. In recent years, the multicyclone has emerged as the minimum requirement for controlling PM. However, in New Hampshire facilities, such as sawmills, have recently been allowed to use single cyclones when they formally restrict fuel use to debarked wood.

In light of the more stringent PM2.5 NAAQS, high efficiency multicyclones are being considered by the author for controlling PM2.5. High efficiency multicyclones have higher pressure drops and different geometric designs than conventional cyclones/multicyclones to achieve higher PM2.5 collection efficiencies. The author of this paper is not aware of any demonstrated applications of high efficiency multicyclones in New Hampshire or Vermont.

HAZARDOUS AIR POLLUTANT EVALUATION THRESHOLDS

HAPs, also referred to as "air toxics" are produced in both gaseous and particulate form from wood-fired boilers. Vermont has 8-hour emission thresholds called "Action Levels" for a number of the 188 federal HAPs. Facilities whose emissions exceed any action levels must achieve the hazardous most stringent emission rate (HMSER). HMSER is determined in a process similar to the "top-down" process used for BACT studies. Vermont can also require and ambient air quality impact evaluation if an Action Level is exceeded.

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[4] Wood-fired boilers having a design heat input capacity less than10 MMbtu/hr have been classified as "small wood-fired boilers in recent Best Available Control Technology (BACT) studies in New England.

New Hampshire's air toxics rule does not apply to wood-fired boilers. However, it has been applied to other fuel burning devices, such as wood-fired dryers used for wood pellet formation.

AMBIENT AIR QUALITY IMPACT EVALUATION THRESHOLDS

Air quality modeling, also referred to as air dispersion modeling, is used to estimate air quality impacts from wood-fired boiler emissions. Vermont and New Hampshire typically require wood-fired boiler modeling for criteria pollutants (particulate matter less than ten microns in size (PM10), nitrogen oxides (NOx), sulfur dioxide (SO_2) and carbon monoxide (CO)).

Modeling is required in Vermont when annual emissions of any criteria pollutant equal or exceed 10 tons per year and may be required when Action Levels are exceeded. Modeling is always done in New Hampshire if the permit applicability threshold is exceeded.

RECORD KEEPING REQUIREMENTS

Consistent and thorough record keeping is considered prerequisite for ensuring optimal operating conditions on a continuous basis. This is because optimal operating conditions promote thorough combustion which minimizes pollutant emissions. Therefore, well kept records are considered a means for demonstrating ongoing compliance with pollutant emission limits.

Record keeping is required in the areas of fuel use, maintenance and monitoring. Selected record keeping requirements are summarized below. These requirements listed are directly quoted or derived from recent permits issued in Vermont and New Hampshire.

Selected Vermont Record Keeping Requirements

Records are kept to describe the following in Vermont:

- Track fuel use on an annual basis.
- Track fuel use on a daily basis if heat input equal to or greater than 10 MMBtu/hr.
- Measure and record oxygen in percent volume, in the exhaust gas and permanently record the output in a log book. Measurements shall be observed and recorded in accordance with an approved schedule in the operation and maintenance plan at a minimum of three times per day with a minimum of three hours between each reading.
- Maintain records of the results of the combustion efficiency testing conducted on the Facility's boiler. These records shall at least include the test date, identification of boiler tested, a measurement of the load on the boiler (such as fuel feed rate or steam production rate), the concentrations of oxygen, carbon monoxide and carbon dioxide in the exhaust gas as well as the calculated combustion efficiency.

- Install and maintain a temperature sensor to measure the wood-fired boiler's exhaust exit temperature and permanently record the output in the log book. Measurements shall be observed and recorded in accordance with the approved schedule in the operation and maintenance plan at a minimum of three times per day with a minimum of three hours between each reading.

Selected New Hampshire Record Keeping Requirements

Records are kept to describe the following in New Hampshire:

- Track fuel use on an annual basis.
- Track fuel use on a daily basis if heat input equal to or greater than 10 MMBtu/hr.
- Observe visible emissions (via EPA Method 22) once a day on normal business days. Record the date, time, duration of excursion, and corrective actions taken if visible emissions are not typical of good operation.
- Inspect the differential pressure across the cyclone (once per shift).
- Visually inspect the cyclone shell, piping, and ducts for leaks; inspect the ash collection equipment and check for abnormal noise or hot spots (once per shift).
- Clean the boiler grates once a day on normal business days.
- Inspect the cyclone/multicyclone at least once per year or if conditions indicate it may need maintenance. Clean the boot and vanes if possible on the annual inspection.
- Empty the cyclone/multicyclone ash collection vessel as necessary, but not less than once per week, in accordance with the manufacturer's recommendations.

SELECTED NEW PERMIT CONDITIONS

A number of new permit conditions were developed recently to regulate wood-fired boiler emissions and provide operational flexibility for wood-fired boiler operators.

Selected Vermont Permit Conditions

- Cleanest available fuel: As mentioned, it is unclear if a continuous supply of de-barked wood will be available in Vermont and New Hampshire. This is largely due to potential variability in economic conditions in the forest products industry.[5] Consequently, this condition was developed to encourage use of de-barked wood as frequently as possible.

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[5] Most de-barked wood is supplied by sawmills; therefore, the closure of a given sawmill results in the loss of supply of de-barked wood for numerous wood-fired boilers.

- Carbon Monoxide concentration: CO concentration in the exhaust gas is considered a good indicator of the degree of combustion completeness, especially combustion of gaseous HAPs. Therefore, Vermont has implemented a permit condition requiring that CO emission not exceed 150 parts per million by volume normal operations.
- Boiler combustion efficiency: The relationship between CO and carbon dioxide (CO_2) concentrations is thought to provide an indication of combustion completeness. Vermont has begun implementing a permit condition requiring measurement of both CO and CO_2 in the exhaust gas to determine combustion efficiency. Combustion efficiency is determined using this equation:

$$CE\ (\%) = \frac{CO_2}{CO_2 + CO} \times 100 \qquad \text{Equation 1}$$

Where:

CE = Combustion efficiency,
CO_2 = % by volume of carbon dioxide in the flue gas, and
CO = % by volume of carbon monoxide in the flue gas.

Compliance is demonstrated when the combustion efficiency is calculated to be equal to or greater than 99%.

- Operation and maintenance plans: Having an operation and maintenance plan in place increases confidence that good combustion conditions will occur and opacity and emission limits will be met. An operation and maintenance plan was recently required, via permit condition, to meet the following minimum criteria within 180 days of permit issuance:
  - Descriptions of routine maintenance and inspection procedures.
  - Description of procedure for and frequency of ash removal from the boiler and the particulate matter emission control device.
  - Provisions for maintaining records of maintenance and inspection procedures, including both routine activities and actions taken in response to observations of low combustion efficiency.
  - Provisions for calibration and maintenance of any testing instruments and/or equipment used to measure the concentrations of CO_2 and CO in the boiler exhaust gases.

Selected New Hampshire Permit Conditions

- Cyclone/multicyclone pressure drop: The collection efficiency of a mechanical collector is largely a function of the decline in pressure from the exhaust gas's point of entry to the point of exit from the mechanical collector. Consequently, New Hampshire has begun

requiring facilities to establish the operating parameter range for the pressure across the cyclone/multicyclone within six months of permit issuance.

- Observe plume opacity: The degree of plume opacity is an indicator of wood-fired boiler operating conditions and emissions. Consequently, "EPA Method 22", a qualitative method for assessing exhaust plume opacity, has been required once a day on normal business days. Furthermore, visible emissions appear not typical of good boiler operation, corrective actions are taken.

SUMMARY

The demand for wood-fired boilers has spawned much consideration of existing applicable regulatory requirements. It has also spawned new precedents for fuel use restrictions, emission limits, emission controls and recordkeeping requirements. These precedents will both protect air quality and encourage ongoing innovation among wood-fired boiler operators and manufacturers.

While somewhat different, the air pollution control regulations in Vermont and New Hampshire provide a comprehensive framework control in each respective state. In addition, the regulatory framework can and will continue to change to ensure ongoing improvements are achieved in wood-fired boiler technology and air quality.

The wood-fired boiler field will change given the new NAAQS for PM2.5. State air pollution control agencies are currently implementing the new PM2.5 rule. Ultimately, new procedures for evaluating compliance with the new rule will be developed. This will result in additional resources devoted to analysis and control of PM2.5 emissions.

REFERENCES

3. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*. AP 42, Fifth Edition. U.S. Environmental Protection Agency, September, 2001.

KEY WORDS

Wood-fired boiler, multicyclone, action level, boiler combustion efficiency, PM2.5