EMISSION TESTING THE MISSOURI TYPE CHARCOAL KILN

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NOTE TO EDITORS

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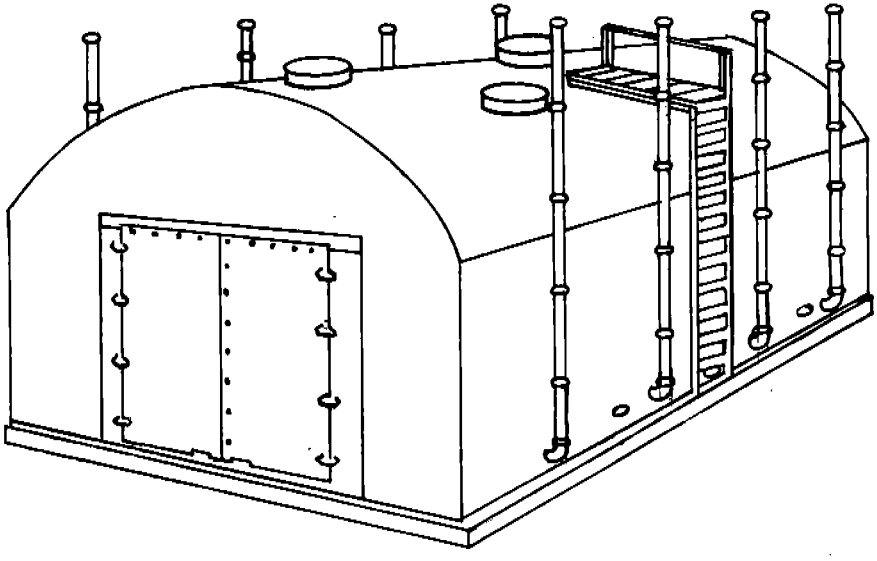
Missouri is the nation's leading producer of charcoal. The hardwood charcoal is primarily used in charcoal briquet manufacturing but in recent years the industrial uses have greatly increased. Nearly all the charcoal produced in Missouri is by the kiln method. These kilns are generally made of concrete and have eight stacks per kiln, Figure A, and process 45-55 cords of hardwood per burn and one burn consists of a 7-8 day carbonizing period and then the kiln is sealed off completely from air and allowed 12-14 days to finish pyrolisis and cool producing about 18 tons of charcoal per burn. There are over 500 such kilns in Missouri which produce nearly 150,000 tons of charcoal annually. These kilns are typically located in rural areas of the state.

The original Missouri Air Conservation Commission exempted the charcoal kilns from the odor and visible emission regulations but failed to exempt them from the process weight regulation feeling it was not applicable to charcoal kilns at that time. These charcoal kiln operations have been largely ignored by the state air pollution agency because of the remote location and the depressed economic condition of the charcoal industry in Missouri.

In mid-1975 the Missouri Air Conservation Commission was asked by the United States Environmental Protection Agency to control the emissions of these charcoal kilns with the process weight regulation. Therefore, it became necessary to determine whether the kiln operations complied with Regulation S-V, Restriction of Emission of Particulate Matter from Industrial Processes, for the Outstate Missouri Area. The Air Quality Program decided to attempt a stack test of a Missouri type charcoal kiln. Also, an independent consultant was hired by the EPA to do testing concurrently with the State Air Quality Program staff. The consultant was primarily looking for total mass emissions and polynuclear organic matter, POM, to see if the Missouri charcoal kilns emit substantial quantities of carcinogenic materials. No substantial POM was found in the seven day burn cycle.

We found many problems involved in testing such an operation. The process is a batch operation in which approximately 45 cords (128 cubic feet) of hardwood weighing 85 tons is carbonized over a seven day burn period. The process emissions continually change throughout the burn cycle. One charcoal kiln



THE MISSOURI CHARCOAL KILN

Figure A

has eight separate stacks each being approximately six inches in diameter. The kilns are natural draft and have a stack flow rate of about six feet per second; a pitot tube can not measure flow rates this low. The emissions are substantial wood tars and other organic materials approximately 70% by weight which may or may not be considered particulate matter with respect to the process weight regulation. Also, the moisture content runs from 35-65 percent by volume and the moisture being saturated in state readily condenses on anything it touches, causing blinding of sampling filters, and combined with the wood tars it is just plain messy.

TEST METHOD

The first decision was the selection of a sampling train to use for the sample collection. Because of the high moisture content we decided to use a modified EPA method 5 train, Figure B. Hoping the filter heater would help prevent moisture blinding of the filter, we designed and had a special glass probe prepared by the University of Missouri glass shop. This all glass probe allowed the samples to be taken six inches down from the center of the exit of the six inch stacks. The glass probe also cleaned up very nicely with acetone.

Next we had to determine what portion of the train would be used for compliance comparison. The EPA method 5 specifies that that portion of the sample collected on or before the filter, front half, be used to determine compliance with particulate process weight limitations. Therefore, we decided that we would use the front half for our results. EPA's contractor was to collect and weigh the entire mass emission.

With the low flow rate from the natural draft kiln and the inability to use pitot tubes for isokinetic sampling, we used the isokinetic relationship (Eq. 1) to sample isokinetic volumes.

(Eq. 1) $I = Vs\ (An/As)/Vm$

Where:

I = Isokinetic
Vs = Volume stack gas
As = Area stack
An = Area nozzle
Vm = Volume meter

Setting I, equal to 1 for 100 percent isokinetic sampling, we solve for the volume for the meter, Vm, (Eq. 2).

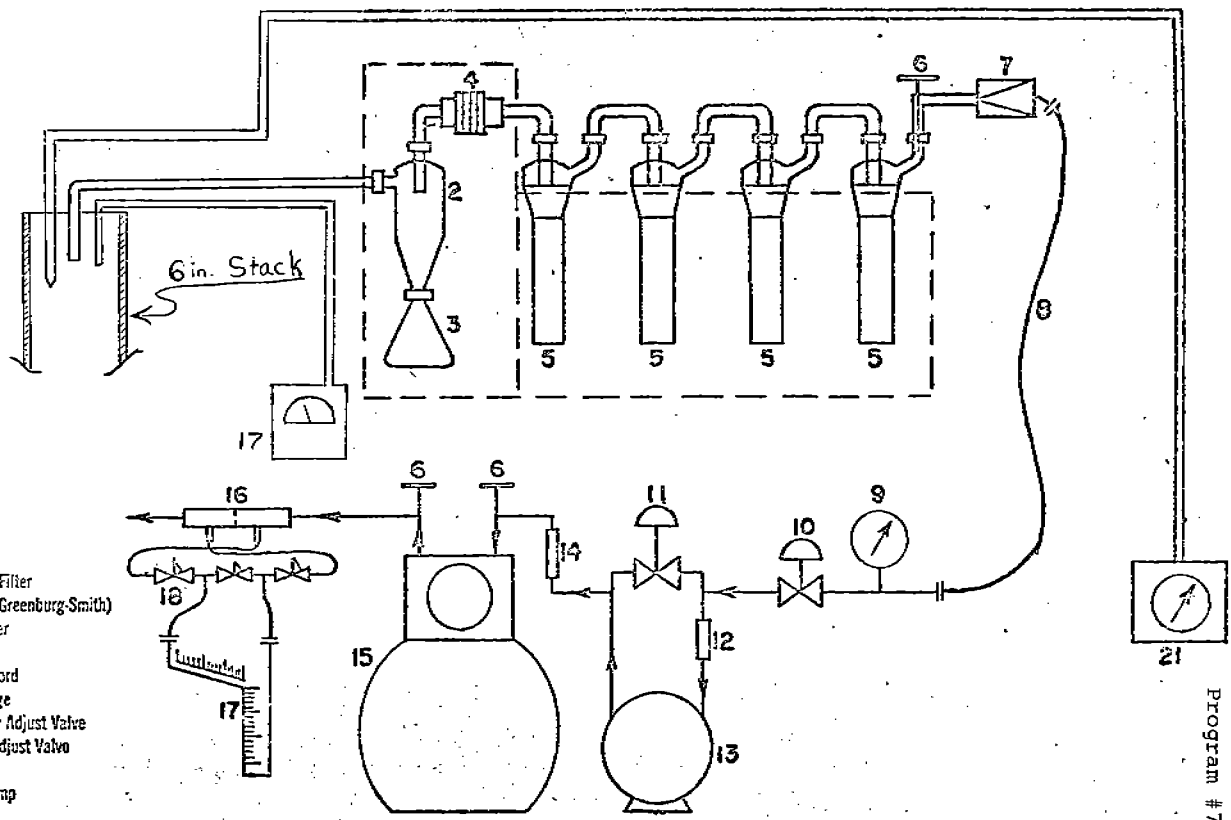


Figure B

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(Eq. 2) $Vm = Vs(An/As)$

Adding those measurable parameters we get the isokinetic sampling equation, (Eq. 3).

(Eq. 3) $Vm = [Us\ t\ dn^2\ Tm\ (1-Bw)]/Ts$

Where:

Vm = Volume of the meter, (cu. ft.)
Us = Velocity of the stack, (ft./min.)
t = Time of the run, (min.)
dn = Diameter of the nozzle, (ft.)
Tm = Temperature at the meter, (°R)
Ts = Temperature of the stack, (°R)
Bw = Moisture content

By solving equation 3 for the volume to be metered we conducted isokinetic sampling for five minute runs of each of the eight kiln stacks. A volumeter was used to measure the stack gas velocities in feet per minute.

TEST PROCEDURE

The length of the charcoal burn cycle varies from burn to burn depending on the charge wood characteristics, climatic conditions and the charcoal properties desired. This particular burn cycle was seven days and the emissions changed from day to day. Therefore, it would be best to make several test runs throughout the burn and average all the runs for a representative sample of the entire burn cycle.

The time and money allotted to this project allowed for only one test run per day. Every test run consisted of a five minute sample from the center of each of the eight stacks for a 40 minute total run time. Using the meter volume equation, (Eq. 3), for a time of five minutes yields the total isokinetic volume to be sampled for each stack. Dividing Vm (Eq. 3) by 20 gives the volume through the meter per every 15 seconds. By observing the 15 second flow rate adjustments were made to the sampling train flow to maintain isokinetic sampling.

TEST RESULTS

The charcoal kiln was tested every day and each day's results given a weighted average to get the representative emissions in pounds per hour. Averaging the emissions for the seven days we found 4.69 pounds per hour emission during the burn period. Spreading the front half emissions over the entire cycle of 21 days results in a 1.56 pounds per hour average

emissions . The material collected when analyzed was found to be approximately 70 percent organic matter. Also, the tests ran from one third to two thirds water vapor by volume. The high moisture content and organics would indicate that most of the emissions are aerosols. When the entire train catch was considered the total mass emissions calculated by weighted average of the daily runs was 2136 pounds. Nearly two times more mass was collected in the impingers section of the train rather than by the filter.

CONCLUSION

The emissions allowed from the Missouri process weight regulation are based on the average emissions for the entire batch cycle. In the case of the charcoal kiln, the burn cycle of seven days aggregates only one third of the total cycle which lasts approximately 21 days.

Therefore, in determining compliance with Regulation S-V, Restriction of Emission of Particulate Matter from an Industrial Process, a weighted average of the emissions are spread over the entire production cycle of 21 days. This yields an average emission of 4.23 pounds total mass per hour. Based on a wood weight of 85 tons per cycle, the process weight would be 337 pounds per hour. Regulation S-V for process weight limitations gives the allowable emissions for processes of 1,000 pounds per hour or less to be 4.1 pounds particulate per hour. It should also be noted that the Missouri process weight regulation defines particulate matter as "any material, except uncombined water vapor, that exsists in finely divided form as a liquid or solid at standard conditions", (standard conditions - 60 degrees Fahrenheit and 14.7 pounds per square inch absolute).

Therefore, compliance of the kiln should be based on the total mass emissions as collected in the entire testing train. This test would indicate that the kiln's emissions were marginal. Considering the accuracy of the test, the kiln should be considered in compliance.