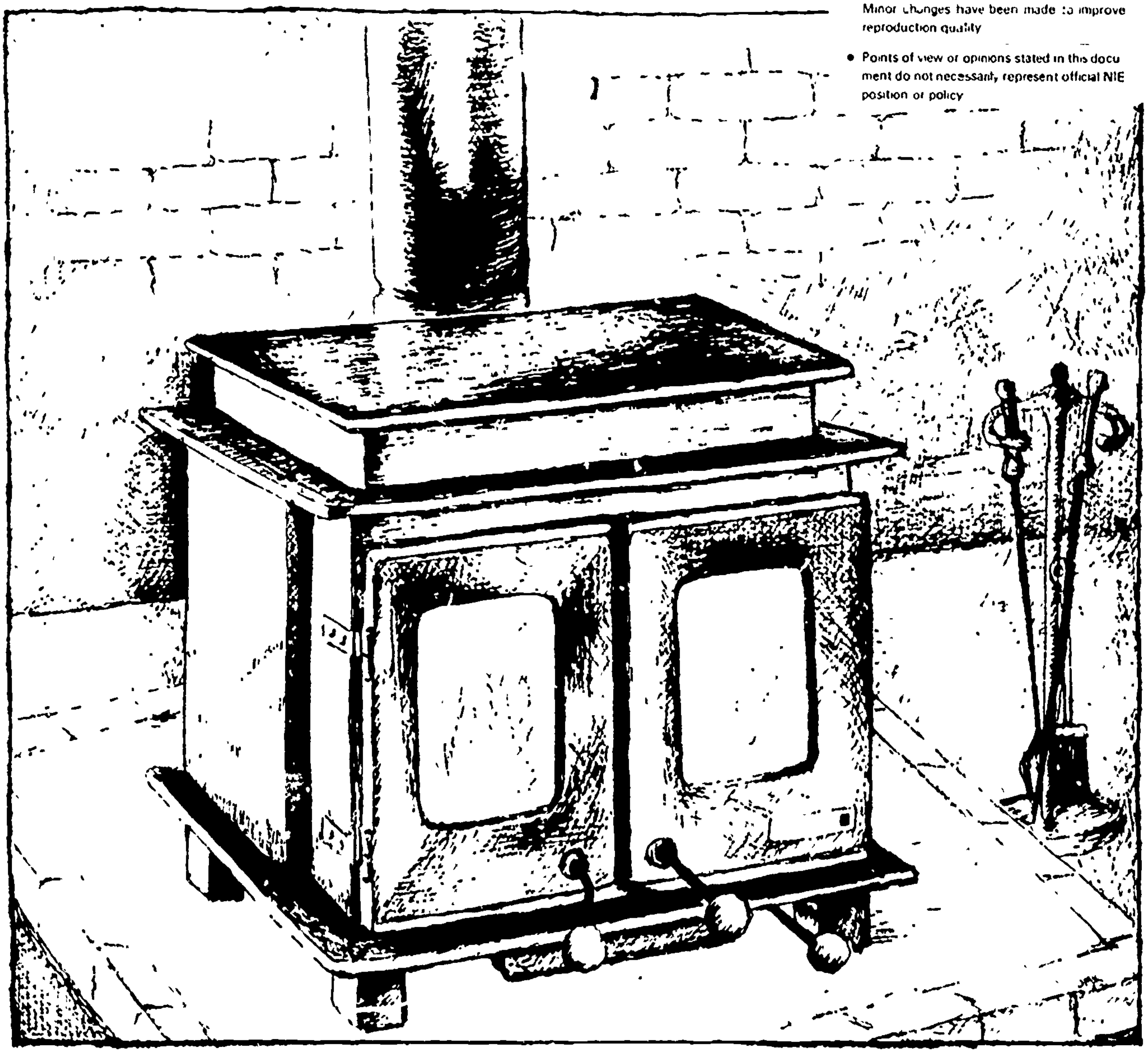
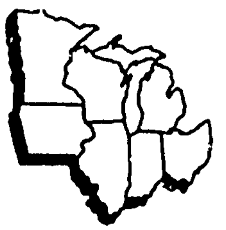
Residential Wood Combustion Emissions and Safety Guidebook





Great Lakes Regional
Biomass Energy Program

January 1985

heat the living area and the kitchen. Becuase they were easily available and burned extremely well, scraps of CCA-treated (outdoor grade) wood and plywood had been burned over any other type of wood. (The wood treating industry has warned against the use of treated woods as fuel as they are well aware of the hazards of burning CCA-treated wood.) Drs. Peters, Croft, Woolson and Darcey "cannot be certain to what extent each of the three elements was responsible for the broad spectrum of signs and symptoms in this family, since all three elements are known to be toxic and synergistic effects are probable."(47)

This incident appears to be an isolated one at this time; however, the popularity of woodburning is increasing, and this type of problem would not be unlikely to develop if scrap lumber were burned in homes.

E. MEASURING EMISSIONS: MONITORING AND TESTING

1. Ambient Air Monitoring of Residential Wood Combustion Emissions

Emissions from residential wood combustion substantially increases ambient air pollution under certain conditions. In particular, they contribute to existing levels of carbon monoxide, particulates, and carcinogenic compounds such as benzo(a)pyrene, causing public health risks and/or exceeding air quality standards. Maintenance of acceptable air quality may require monitoring of residential wood combustion emissions. There are two general types of source apportionment modeling that provide the basis for such monitoring currently in use. These are **source-dispersion modeling** and **receptor modeling**. A brief description of these two types is provided as background for ambient air quality monitoring of residential wood combustion emissions. This might be done if an area determines to modify a **State Implementation Plan** to include residential emissions or if a local jurisdiction wishes to develop a strategy to determine alternatives for developing residential-industrial trade-offs of specific pollutant loadings, so new development can occur. If a problem with residential wood combustion emissions must be quantified, ambient air emissions modeling might also be beneficial.(48)

Source-dispersion modeling involves direct sampling of stack emission rates or may only involve a telephone survey of woodburning residences to estimate the amount of residential wood combustion emissions. This information is then used in combination with meteorological dispersion parameters (wind speed and direction, mixing height, etc.) to predict the impact of wood combustion on ambient air quality within that region. Dispersion modeling is subject to a great deal of approximation though because of such factors as low stack heights, the impact of low inversion heights, the great number of variables random in nature which vary with time and space, and the non-linear manner in which the variables interact.

In **receptor modeling**, on the other hand, the characteristics of residential wood combustion particulates have been previously determined. From analysis of ambient air particulate samples that are collected on a filter, the contribution of residential wood combustion emissions to total ambient air pollution can then be determined by **either microscopic or chemical** methods. The **microscopic** approach utilizes optical and electron microscopes to both qualitatively and quantitatively analyze particulate emissions. Density and number of particulates may be estimated, while examination of morphology, color, and elemental contents allows for specific particulate identification. An inventory of "microscopic fingerprints" based on morphology, color, and elemental content is currently maintained as a source for comparison to aide in identification. The major limitations of the microscopic approach include poor precision, small size of organic residential wood combustion emissions, and high cost of analyzing a sufficient quantity of particles.

The **chemical approach** to receptor modeling involves the comparison of ambient chemical patterns with source chemical patterns to pinpoint sources of aerosols. A least squares multiple regression analysis is used to quantify the source contributions as obtained as a total mass on different collecting filters or as a mass of individual chemical species on a single collecting filter. The two categories of chemical analysis of emissions include: 1) **chemical mass balance** methods which "attempt to define the most probable linear combination of sources to explain chemical patterns on a single filter"(49) and 2) **multivariate methods** which "attempt to define the most probable linear combination of sources to explain either time or spatial variability in ambient chemical patterns."(50) Chemical mass balance methods provide a high degree of confidence in impact projections. Both mass balance and multivariate methods should be included in data interpretation.

Each specific analytical method has its advantages and disadvantages. The cost effectiveness and appropriateness of the analytical tools depend on airshed characteristics, potential sources, relative contribution of residential wood combustion sources, the desire to characterize most of the mass, the need to measure key indicating features, and compatibility with the sampling substrate. Information obtained from a single analytical approach many not be sufficient to quantitatively relate emissions source to ambient air impact, therefore, it may be valuable to utilize a combination of methodologies to compare and evaluate estimates. Table 4.10 on the following pages summarizes the advantages and disadvantages of the analytical methods described above.

TABLE 4.10. ANALYTICAL METHODS FOR EVALUATING THE AMBIENT AIR QUALITY IMPACTS OF RESIDENTIAL WOOD BURNING.

X-RAY FLOURESCENCE

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ low cost	- possible destruction of more volatile compounds prevalent in residential wood combustion (RWC) compounds	* maximum information obtained when membrane-type filters used
+ precise and accurate if appropriately validated	- provides less competitive sensitivities for higher atomic numbers than monochromatic photon excitation	* quartz fiber hi-vol filters used for quantitative determination of elements above atomic number 20
+ capable of measuring most abundant inorganic species and common key indicating elements		
+ 30 to 40 elements usually analyzed		

NEUTRON ACTIVATION ANALYSIS

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ 40 to 50 elements can be analyzed	- high cost	* can be applied to high purity quartz fiber filters
+ may be essential in some airsheds to measure key indicating elements		
+ independent of filter absorption effects		

ION CHROMATOGRAPHY

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ when used with X-ray flourescence uniquely identifies: SO_4^{-2}, NO_3^-, NH_4^+, and Na^+.	- NH_4^+ accurately quantified once in solution but difficult to interpret in terms of ambient concentration due to artifacts and potential losses	****
	- cation analysis for only Na^+ is not cost effective	
	- NO_3^- and SO_4^{-2} difficult to interpret when samples collected on glass fiber filter because of chemical artifacts	
	- SO_4^{-2} analysis of limited value in RWC studies	

ATOMIC ABSORPTION SPECTROPHOTOMETRY AND INDUCTIVELY COUPLED ARGON PLASMA

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ excellent technique for analysis of solutions	- limitations when applied to aerosol samples	****
+ valid results for V, Mn, and Pb with normal glass fiber hi-vol filters	- inadequate detection limits for some key elements	
	- difficulties in solubizing the sample	
	- high costs relative to X-ray flourescence	
	- destructive nature	

ORGANIC, ELEMENTAL, AND CARBONATE CARBON ANALYSIS BY COMBUSTION METHODS WITH PYROLYSIS CORRECTION

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ accurate separation of these three major carbon components	- limited applicability to amorphous carbonaceous material such as in RWC	****
+ useful in apportioning contributions of RWC and resolving this source of carbonaceous material from others such as diesel exhaust		

BEST COPY AVAILABLE

(Table 4.10 continued.)

OPTICAL MICROSCOPY

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
distinguishes between organic particles such as coal, oil soot, starch, tire fragments, pollens, spores, paper fibers, etc. when greater than 2 um	- difficult to quantify - most RWC particles are less than 2 um	****

SCANNING ELECTRON MICROSCOPY

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ provides morphological and elemental information about individual particles + range of a few hundreths of a micron thus applicable to fine RWC emissions	- expensive - limited applicability to RWC studies because emissions highly carbonaceous	

LIQUID CHROMATOGRAPHY

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ less expensive + applicable to higher molecular weight compounds likely to be more stable in transport from source to reactor	****	* has not been used extensively for RWC studies

GAS CHROMATOGRAPHY-MASS SPECTROMETRY

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ capable of characterizing large number of the more volatile compounds	- costly - interpretation of results difficult due to likelihood of deviations from conservation of mass as a result of compound reactivity and portioning between gaseous and particulate phases - usually addresses only small portion of total organic aerosol - many of compounds produced in combustion of other organic material; depends strongly on temperature of combustion and available oxygen	****

X-RAY DIFFRACTION

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
+ applicable to a variety of relatively stable compounds + selectivity and sensitivity for determination of geological or crustal compounds	****	* quantitative analysis requires summation of mass for specific particle classes and this depends on an estimate of particle volume and density for between 1,000 to 10,000 particles * applicable to hi-vol filters but particles must be removed by vacuum or ultrasonic methods

(Table 4.10 continued.)

RADIOCARBON ANALYSIS

ADVANTAGES	DISADVANTAGES	GENERAL INFORMATION
* excellent for distinguishing between fossil carbon sources such as diesel and distillate oil emissions and modern carbon sources such as RWC emisssions	* large samples required to be a precise indicator of modern carbon (although Currie, et al. have obtained accurate results with as little as 5 mg of carbon)	* "modern" carbon sources are younger than C-14 half life (5730 years) and "fossil" carbon sources are older than C-14 half life
* concentration of C-14 in atmosphere is approximately constant with time		* fraction of modern carbon = $\frac{\text{observed aerosol radiocarbon activity}}{\text{activity in pure source of modern carbon}}$
		* ir ite of the large number o potential modern carbon sources, they can be separated from PVC aerosols by: size--collect only fine particulates time--collect during winter when natural carbon sources are minimal or when other combustion events are not permitted
		* samples must be collected with a size selective hi-vol sampler to eliminate large particle carbon (pollen, spores, wood fibers, etc.) although normal hi-vol samplers are adequate if microscopic analyses confirm minimal large size modern carbon impact
		* method expensive when applied to small carbon samples with 24-hour hi-vol samplers but cost minimized by compositing filters for a seasonal average

(Data obtained from: John A. Cooper, "Chemical and Physical Methods of Apportioning the Contributions of Emissions from Residential Solid Fuels to Reductions in Air Quality," and Frederick W. Lipfert, "An Assessment Methodology for the Air Quality Impact of Residential Wood Burning." Both articles found in: Proceedings of the 1981 International Conference on Residential Solid Fuels: Environmental Impacts and Solutions (Beaverton, Oregon: Oregon Graduate Center, 1981).

2. Measuring Emissions

a. Woodstove Testing Protocol for Measuring Emissions

There are two major components of testing protocol that must be considered when developing a wood stove certification or emissions labeling program. One component involves the technique by which emissions are sampled, measured and evaluated. The other is the burn operating procedures that will be used during emissions sampling. In practice, any operating procedure can be used with a given sampling technique and vice versa. The possible variations are numerous, each variation potentially yielding different results for a given stove. The fact that there are innumerable variations on the theme, which may yield different results, underscores the need for standardization of both emissions sampling techniques and burn operating procedures. By way of example (this is an actual situation), State A will in all probability adopt a standard emissions sampling technique that has already been accepted by State B. However State A is thinking about changing the burn operating procedures used by State B. If that happens, stove manufacturers who have been certified in State B could be required to retest in State A - a prohibitively costly requirement for many manufacturers. This situation poses a serious obstacle to maximizing the availability of clean burning stoves that homeowners can buy. If an overall testing protocol is not standardized among states, an emissions cleanup program is unlikely to reach the high level of success that is possible.

What kinds of issues do states face in developing a stove testing protocol? There has been some heated controversy over what an appropriate testing protocol should involve. Many of the emissions sampling techniques and burn operating procedures that are being proposed or challenged by various proponents are presented and discussed in the following sections.

b. **Objectives for Woodstove Emissions Sampling Techniques**

There are a number of primary objectives that must be met before a woodstove emissions sampling technique can be successfully implemented on a widespread basis. These are:

(1). Research Techniques

Adequate woodstove emissions evaluation research techniques must be established to evaluate all pertinent aspects, e.g. priority pollutants, of woodstove emissions.

(2). **Laboratory Certification**

Routine laboratory certification procedure or procedures must be established to evaluate and certify appliances. A successful certification technique must:

* Be **adequately precise** (produce repeatable and accurate results) so that stoves can be separated into pass-fail categories on a scientifically equitable basis.

* Be of **simple** construction, composed entirely of rugged, standardized components which do not require frequent, difficult calibrations.

* Be **user friendly**, having well documented, clearly written instructions so that any competent technician can produce consistent and valid results.

* Be able to be used by **manufacturers** as well as test laboratories. Next to adequate precision and accuracy this is the most significant criterion. This requires low procurement costs, high reliability and extreme userfriendliness. These attributes will encourage rapid development of clean stoves because:

  - The manufacturer will have an effective, quick feedback evaluation tool available to him during stove development.

  - The manufacturer can have confidence that results he obtains in his lab will also be produced in the certification test lab. He needs a reliable tool to evaluate his progress in stove development so he can avoid costly retesting. Otherwise he will be unlikely to pursue or be successful at clean stove design.

* Entail **reasonable (low) costs** to certify a stove. This is particularly sensitive in the stove industry because many stove models will have to be tested and the industry is not cash rich. (The industry is in a shake-out period since total annual national stove sales are decreasing).

* Be a technique that has a high likelihood of being either a **nationally used technique** or an acceptable alternative (officially called an **"equivalent procedure"**). This does not necessitate that an official "national EPA standard" be established, but only that a technique be adopted that enjoys widespread use among states. Consistency is important to stove manufacturers. They will not be able to endure multiple testing if different states have different standards - either a difference in testing technique or test operating procedures.

The current situation relative to the above objectives will be assessed by first describing the historical development of testing procedures and then discussing how well the objectives have been met. Then recommendations for further work will be made.

c. **History of Certification Testing of Woodstove Emissions**

Woodstove emissions (especially particulates) have been actively investigated for only about 6 years. The locations where research has taken place, which has led to standardized techniques, are: Battelle (on EPA contract) and later TVA, Oregon's DEQ, and Condar Company. Several other methods have been investigated but there is insufficient data to verify their accuracy, reliablility or economic feasibility at this time.

(1). **Federal Government**

EPA-Battelle Protocol. About five years ago Battelle, under EPA contract, modified EPA's standard source evaluation technique for measuring particulates(EPA Method 5) especially for woodstove testing. Basically, a Method 5 passes flue gases through a fiberglass filter and then dries the cleaned flue gases in chilled glass impingers before passing them through a sampling flow meter and sampling pump. Particulates are measured as the amount collected on the filter. When sampling woodstove smoke, the overwhelming presence of liquid droplet hydrocarbons in the smoke causes the glass impinger part of the collection train to condense hydrocarbons in addition to the water of combustion which normally was trapped there. It was discovered that the condensable hydrocarbons were so abundant that additional means beyond the impingers had to be added to the system to trap hydrocarbons effectively. An X-ad resin trap was added just in front of the impingers, and a backup fiberglass filter was added at the back of the sampling train. The condensable hydrocarbons are the sum of what is collected on the front filter, X-ad resin trap, impingers, and backup filter.

This sampling system is expensive to operate and has only been used in recent years by the TVA in its extensive woodstove research program. It is however, a system that can consistently measure essentially all hydrocarbons (TVA Phase II Project results indicate an average of 97% recovery). It is unquestionably the best measure of total hydrocarbon emissions available. It also is probably the best emissions measuring technique with which to collect and study specific hydrocarbon species (POMs etc.).

In spite of the extensive development and research data obtained from this technique, the EPA has yet to designate it as an EPA reference standard. There is no EPA standard at this time.

(2). <u>Oregon DEQ</u>

About four years ago Oregon's DEQ, in response to serious woodsmoke problems in certain Oregon valleys, began a woodstove source testing program which eventually led to establishing a state-approved testing method as well as emissions standards for new woodstove appliances.

For its technique, Oregon chose a modification of EPA's original Method 5 which is called Oregon Method 7. Method 7 has been used in Oregon for measuring industrial stack emissions (often timber industry emissions) for a number of years. This system is basically identical to the EPA-Battelle Protocol except Method 7 lacks the X-ad trap between the front filter and impingers. As such, it is less expensive to operate Method 7 but, some (as yet undetermined amount of) hydrocarbons probably escapes the sampling system. Method 7 might be the better method for measuring condensable particulates and EPA-Battelle the better measure of total hydrocarbons.

The precision of Method 7 has been determined by Oregon's DEQ using dual simultaneous sampling trains to be definitely adequate. The standard deviation is approximately plus or minus 8% and is more precise than EPA Method 5.

In spite of its well established validity as a research tool, Method 7 does not lend itself as well as one would like to widespread routine lab certification of woodstoves. Method 7 utilizes a complicated glassware collection impinger system with many hose connections that must be tightly sealed. Even under the best of lab conditions, connections come loose and unnoticed holes develop in hoses. Retrieval of the hydrocarbons involves cleaning a multitude of items from the sampling train, carefully weighing and reweighing many beakers and properly removing hydrocarbons from the collected impinger water. All these procedures must be done with extreme care. For example, with clean stoves only 50 - 300 mg. of hydrocarbons must be accurately determined using this complicated technique. In short, Method 7 is a highly complicated procedure; a lab situation that allows for introduction of error, even with experienced technicians. Observation of the technique in action indicates that only technicians with extensive experience with Method 7 can operate it reliably. Method 7 has been used successfully for stove certification at one experienced lab, but it is very impractical for use by manufacturers in stove development and interlab consistency is likely to suffer.

(a). Oregon Emissions Test Operating Procedures

Historically emissions test operating procedures have been as varied as emissions sampling techniques. With the advent of the Oregon Woodstove Regulations, a strong movement towards standardization of procedures has developed. These procedures reflect homeowner woodburning patterns more closely than earlier procudures. In capsule form, Oregon's stove test starts when the stove is stabilized at the temperature at which the test will be conducted. Then precisely one complete charge of wood is burned. The fuel is dimensional lumber Douglas fir with all pieces nailed together into a specified geometric pattern. Wood moisture content is restricted to 16 to 20 percent (wet basis). Four stove tests are conducted at varying heat outputs. They are designed to span the range of heat outputs encountered in homes. The final average emissions calculation (in grams per hour of particulates) is actually a weighted value, obtained by weighing the individual test results according to the percentage of time a home owner burns at that particular heat output in Oregon's climate (4000 degree days). Heat outputs of about 13,000 Btu/hour net are weighted the most, with declining weights on either side. High burn rates (less than 20,000 Btu/hour) are given the least weight.

(3). Condar Company

At Condar Co. work by S. G. Barnett on woodstove emissions, has been underway since 1979. The primary early objective was to develop an easy to use, rugged, reliable and precise emissions measuring technique which provides quick feedback evaluation information for developing cleaner burning stoves. The system, now called the Condar Emissions Sampling System, uses the air dilution tunnel principle which condenses hydrocarbons into particulates in a manner almost identical to the auto exhaust dilution tunnels the EPA mobile source branch uses. However, the Condar System adapted the dilution tunnel concept to woodstove sampling rather than simply using the more costly and cumbersome dilution tunnel itself.

The Condar System was used over a 12-month period to develop Condar's clean burning stove technology. This technology is considered by Oregon's DEQ to be the Best Available Technology. Oregon set its emission standards based on the Condar stove design's performance(Hansen, DEQ memo to EQC June 8, 1984). More recently using over 100 developmental emissions tests, one of the stove manufacturers in Condar's stove technology program was able to produce a production stove that far exceeded Oregon's strictest standard in standardized certification testing.

Following a stringent evaluation, the Oregon Department of Environmental Quality has accepted the Condar Emissions Sampling System as an equivalent of their Method 7, meaning that it can be used for stove certification in lieu of Method 7. This is the only system to date which has this standing. Use of the Condar Sampler in testing labs should decrease testing costs and increase testing volume. Since many manufacturers already use the system, the development rate of clean burning stoves should sharply increase. The WHA is proposing that a second dilution tunnel type test method be considered by the American Society for Testing and Materials.

(4). Issues to Consider in Adopting Emissions Test Operating Procedures

Emissions test operating procedures can be designed to be scientifically complex in order to obtain detailed data under laboratory conditions. Procedures must be repeatable and results, under controlled burning conditions, consistent. Some of the criticisms of the Oregon method are listed below. These concerns should be addressed in evaluation of any similar testing system.

(a). Wood Species

"The test wood species is not representative of **wood burned in most** of the country." This issue is not resolved yet. Research is needed to study a wide range of stoves - for instance, Oregon's study stoves - varying only wood type in the test. The preliminary work that has been done using hardwood suggests that the same ranking and even very similar emissions numbers are produced.

(b). Type of Wood

"The use of dimensional lumber instead of cordwood distorts the results." This needs to be answered in the same manner as section (a) above.

(c). Wood Spacing

The use of 1-1/2" spacing between wood pieces distorts results." The situation is the same here as with (a) and (b), except that wood spacing must be varied in tests. No results are yet available.

(d). Wood Size

"The size of the wood charge is too small to simulate real world conditions." All available data on actual homeowner wood loading patterns indicates Oregon's value (7 pounds per cubic foot of firebox) is correct. Also if larger wood loads are used in lab testing, the tests would be longer and cost more. Conflicting data is based on laboratory tests.

(e). Draft Level

"The draft level used to test in the lab is too low." This is true. Draft levels are generally .02 to .04 inches of water and home levels start at .04 inches and go up from there (no overlap). The excessively low draft levels do markedly distort stove performance in some lab tests.

(f). Weighting Emissions Values

"The scheme of weighting emissions values emphasizes low burn rates too much." To the contrary, data obtained by Oregon's Department of Energy, the DOE's annual energy survey and direct measurement of home energy use by S. Barnett, all indicate that about 9,000-10,000 Btu/hour, not 13,000 Btu/hour, is the average heat demand for Oregon. The Oregon weighting scheme is actually the most appropriate one to use for climates up to about 6,000 degree days.

(g). Efficiency Measuring Technique

"The woodstove efficiency measuring technique used in conjunction with emissions measurements is neither a recognized technique nor has it been verified by independent evidence. Additionally, it adds unnecessary expense." These objections are valid and other more appropriate methods are available, some, like the Condar System, are far less expensive. Fortunately, since variations in efficiency measurements have only a minor effect on the final emissions value for a test series, changes can be made through time, and emissions data obtained now will not be outdated and retesting will not be necessary.

(h). Cost

"Oregon testing methods involve some overcomplicated and costly aspects." This may well be true for the efficiency testing procedures including the requirement that bomb calorimeter tests be made on sawdust from cutting the test wood. Research is needed to verify that 1) such a procedure is valid. (Less than 1% of the wood is sampled. Bomb calorimetry of wood is sensitive since the boiling points both of water and some of the wood's volatiles are very close.) 2) It has not been determined by homogenizing cuttings from entire wood loads that a significant variation in heat content/pound actually exists from load to load. The cost of the required stove tests per stove is about $6800.

(5). Discussion

(a). Assessment of Status Quo

The situation today can best be assessed by evaluating how well the earlier stated testing procedure objectives have been met.

- Adequate research techniques have been developed. The EPA Battelle protocol can investigate total hydrocarbons and chemical species effectively. Oregon's Method 7 and the Condar System can investigate particulates. The EPA-Battelle protocol probably has adequate credentials to qualify it as a national reference standard because it has the broadest based capabilities and it measures total hydrocarbon emissions and individual chemical species.

- The EPA-Battelle Protocol is not appropriate for routine laboratory certification due to its complexity, requirement of highly trained technicians and high operating cost. Therefore equivalent techniques are needed for routine field certification.

Oregon Method 7 has been used effectively as a research and certification technique. It appears to possess adequate credentials to become a national particulate standard. However, the disadvantages discussed in the previous section have become apparent - complexity leads to potential reliability problems and highly trained technicians are required.

The operating cost of Method 7 is lower than EPA-Battelle Protocol, but apparently too high for the stove industry to bear in the long term. Importantly, stove manufacturers cannot afford to buy or operate this system for stove development, or pre-testing.

(b). <u>Need for Standardized Emissions Test</u>

As of today, no decision has been made on a national certification technique. Historically, it has taken many years for EPA to adopt standards and no reason exists to expect this situation to be different now. In the meantime a defacto standard (or equivalent standards) should emerge if broad usage of any system emerges. The groundwork that Oregon has laid is adequate to make this happen. The Method 7-Condar equivalent standards satisfy all criteria necessary to encourage clean stove development and certification.

Oregon's regulations have produced a standardized set of emissions testing procedures that are in our opinion, generally acceptable. Modifications will probably take place but generally research is needed to justify such modifications. It is both in the interest of the stove manufacturers and the public that standardization of procedures (especially to the degree that the integrity of today's test results be maintained) be a high priority. Requirements to force manufacturers to retest due to procedural changes will short-circuit development and sale of clean burning stoves.

F. HOW CAN THE EFFECTS OF WOOD COMBUSTION EMISSIONS BE EVALUATED?

Enough monitoring and research has been done, to date, to indicate the nature of emissions from residential woodburning activities and the conditions under which these emissions are a problem. Sampling of emissions has been done in at least twelve major studies.(52) With the exception of one study done in 1968 by Clayton, all have been initiated since 1975 during the period of time that residential wood heating activities have increased. Some studies have measured ambient air in regions of high woodburning activity. Most have been source analysis studies of stack gases. Most of the early studies (see footnote 1) that are often quoted were conducted at burn rates and/or using fuel unrepresentative of home burning conditions. Studies conducted by DeAngeles et al.,(53) most of the Battelle studies,(54) early Tennessee Valley Authority (55) studies and some others were conducted at too high burn rates so emission factors are too low. Barnett and Shea documented in 1981 actual home burning rates and demonstrated the sensitivity of results to deviations under actual home burning conditions.(56 More recent work by the State of Oregon's Department of Environmental Quality and others has focused on burn rates appropriate to actual in-home stove use, including attention to fuel type and moisture content.(57)

Information does exist to assist in the evaluation of the importance of residential wood combustion emissions contributions in an area and to provide information about potential health or human welfare impacts. The paragraphs below provide a brief summary of these considerations.

To date no quantitative assessment of health effects directly attributable to residential woodburning has been completed. However, it has been determined that residential wood combustion may result in emissions containing substantial quantities of air pollutants of known concern due to their impacts on public health. These include: **particulates, carbon monoxide, hydrocarbons and polycyclic organic matter.**

The **US EPA Emission Source Assessment Program** established a series of