Foreword

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In order to respond to urgent market requirements, ISO has also introduced the possibility of preparing documents through a workshop mechanism, outside of ISO committee structures. These documents are published by ISO as International Workshop Agreements. Proposals to hold such workshops may come from any source and are subject to approval by the ISO Technical Management Board which also designates an ISO member body to assist the proposer in the organization of the workshop. International Workshop Agreements are approved by consensus amongst the individual participants in such workshops. Although it is permissible that competing International Workshop Agreements exist on the same subject, an International Workshop Agreement shall not conflict with an existing ISO or IEC standard.

An International Workshop Agreement is reviewed after three years, under the responsibility of the member body designated by the ISO Technical Management Board, in order to decide whether it will be confirmed for a further three years, transferred to an ISO technical body for revision, or withdrawn. If the International Workshop Agreement is confirmed, it is reviewed again after a further three years, at which time it must be either revised by the relevant ISO technical body or withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO should not be held responsible for identifying any or all such patent rights.

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Workshop Resolutions

Resolution 1

The International Workshop on Cookstoves recognizes that the VITA WBT 4.1.2 protocol referenced in this document is not the only valid protocol for rating cookstove performance in the laboratory.

As such, the International Workshop on Cookstoves recommends that:

a. New protocols be developed and/or current protocols be updated to more adequately address all stove and fuel types (e.g. cooking stoves used for heating, plancha/griddle stoves, batch-fed stoves, charcoal stoves, double pot stoves, and solar cookers);
b. Tier level equivalence to those used in the IWA for the VITA WBT 4.1.2 protocol be developed for any protocols created or adapted (such as the *Beijing City Local Standard DB11/T 540-2008 – General technical specification of domestic biomass stove/boiler* and associated protocols, and the Indian *"Solid Bio-Mass Chulha - Specification"* (IS 13152));
c. Research be conducted for high priority initiatives such as coupling lab and field testing; improving indoor emissions protocols; climate change impacts; and developing a pool of resources for testing stoves.
d. All protocols be rigorously evaluated by an independent, technically qualified group; and
e. The acceptability of a protocol for a particular stove and tier designation be determined by the ability of the test procedure to repeat the performance metric within one-third of the distance between tiers, under conditions that are consistent with the test specification.

Resolution 2

The International Workshop on Cookstoves recognizes that laboratory testing may not fully reflect performance as seen in the field as performance is dependent on many factors (such as user behavior, cultural acceptance and operating conditions); and it is critical that these factors be incorporated in future standards and protocols.

Resolution 3

The full range of exposure to household air pollution is currently being compiled by the World Health Organization (WHO) in new indoor air quality guidelines for household fuel combustion (due to be published in 2013). The International Workshop on Cookstoves recommends that the evidence of health risks across these guidelines be reviewed to ensure consistency with future standards or IWAs.

Resolution 4

The International Workshop on Cookstoves recommends that a performance indicator (and corresponding protocols) for durability be developed and included in a future standard or IWA. In addition, the International Workshop on Cookstoves recommends further research be conducted and protocols be developed as needed to adequately evaluate the safety of all stove types and fuels (e.g. solar, kerosene, propane, solid fuel).

Resolution 5

The International Workshop on Cookstoves recommends that emissions relevant to health, environment (ambient air quality and climate) and performance, in addition to those currently addressed in the IWA, be addressed in a future standard or IWA as data becomes available.

Resolution 6

The International Workshop on Cookstoves recognizes that the quality and type of fuel used by a testing center may impact the emissions of a cookstove. Because of that, the International Workshop on Cookstoves recommends that testing centers document the key physical and operational characteristics (e.g. fuel, moisture content, pot size and shape) of the system.

Introduction

Nearly half of the world population – three billion people in the developing world – cooks their food by burning coal and biomass, including wood, dung, and crop residues over open fires or on rudimentary, often unvented stoves. Indoor burning of these solid and liquid fuels releases dangerous particulate matter, carbon monoxide, and other toxic pollutants. This practice can lead to indoor air pollution levels that are 20 to 100 times greater than the World Health Organization's (WHO) air quality guidelines and release greenhouse gases and black carbon into the environment. WHO estimates that nearly 2 million people, primarily women and children, die prematurely each year from exposure to indoor smoke from these cooking practices. Open fires and rudimentary cookstoves may also increase pressures on local environmental resources (e.g. forests, habitat) and contribute to climate change at regional and global levels.

PCIA and the Alliance are working with more than 550 partners in 117 countries[1] to achieve the adoption of 100 million clean and efficient stoves and fuels by 2020. Developing globally recognized standards that are widely accepted by the stove community and adopted by country governments could spur wider deployment of clean cookstoves in a number of ways, including: defining what an "improved cookstove" is for users, stove makers, and policy makers; and enabling the rating of stoves by efficiency, safety, and cleanliness (particulate matter and carbon monoxide emissions), while allowing for differences in local conditions and user behavior.

National performance-based standards have been developed and implemented in a few countries, but no international standard has been found to contain commonly agreed upon and accepted criteria by which to define "clean" in regards to cookstoves. Such an international standard would significantly enhance efforts to see clean cookstoves adopted at scale.

This International Workshop Agreement (IWA) serves as a guideline for policy-makers, investors, manufacturers and others in the cookstoves community and it will inform the future work required in developing new or revised internationally agreed upon cookstove standards and protocols.

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[1] A full list of PCIA's partner organizations is available at: http://www.pciaonline.org/partners/search. A full list of the Alliance's partner organizations is available at: http://cleancookstoves.org/the-alliance/partners/.

Guidelines for evaluating cookstove performance

1 Scope

This International Workshop Agreement (IWA) provides a framework for rating cook stoves against tiers of performance for a series of Performance Indicators including: Fuel Use (Efficiency), Emissions (Carbon Monoxide and Particulate Matter 2.5), Indoor Emissions (Carbon Monoxide and Particulate Matter 2.5), and Safety. Rather than select a single laboratory protocol to determine cookstove performance, this International Workshop Agreement will enable stove testers to utilize laboratory protocols most appropriate for the stove and performance indicator being tested. Tiers of performance for each protocol will chart all stove test results on the same page in order to ensure equivalent results regardless of protocol used.

2 Normative references

The following referenced documents are indispensable for the application of this document.

- Biomass Stove Safety Protocol developed at Iowa State University -- http://www.pciaonline.org/files/Stove-Testing-Safety-Guidelines.pdf

- VITA Water Boiling Test, version 4.1.2 -- http://www.pciaonline.org/files/WBT4.1.2_0_0.pdf

- U.S. EPA 40 CFR Part 60 -- http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title40/40cfr60_main_02.tpl

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the following apply.

Air exchange rate: The rate at which the air within a defined space (normally a room or house) is replaced, usually expressed as air changes per hour.

Batch-loaded stove: A stove in which fuel is loaded one time per burn cycle.

Biomass stove: An apparatus which is used to cook food and/or provide warmth and/or boil water through the conversion of biomass, typically through combustion.

Biomass Stove Safety Protocol developed at Iowa State University: A specific methodology for evaluating the safety of a stove.

Constant volume pump:. A device which repeatably moves a standard volume of fluid (liquid or gas).

Dilution tunnel: A device in which air is mixed with an emissions stream in a known ratio. Dilution air is sometimes cleaned with filtration for particles and/or activated carbon for gases.

Electrochemical cell: A device in which chemical energy is converted to electrical energy when in the presence of a specific compound.

Flow grid (or self-averaging pitot tube array): A method of evaluating volumetric flow through the measurement of velocity at a series of locations across a path of known cross-sectional area. Temperature and pressure must also be measured to determine volumetric flow.

Gravimetric measurement: Quantification of a sample through the direct measurement of mass.

Heating stove: An apparatus which is used to increase the temperature in a space.

High-power: Operation of a stove at maximum (or nearly maximum) rate of energy use.

Light scattering: A physical process used to quantify particulate matter concentrations. Scattering is caused by the reflection and refraction of light by particles. The amount of light scattered is based on the concentration of particles and the properties of the particles in the light's path (e.g., the size, shape, and color of the particles).

Low-power: Operation of a stove at minimum (or nearly minimum) rate of energy use.

Non-dispersive infrared: A method of determining the concentration of a substance by measuring the absorption of a light wave at a specific frequency.

Plancha (or griddle) stove: A stove design in which the majority of cooking occurs on a heated surface, usually a metal plate.

Site-built stove: A stove design in which the majority of assembly and/or construction occurs at the location of final use.

Tiers of performance: A method of rating stoves by categorizing them in relation to a set of specified ranges.

Type K thermocouple: A device used to quantify temperature, comprised of two metals (90% nickel and 10% chromium). It is the most common general purpose thermocouple.

Water boiling test: A test in which the performance of a stove is evaluated through the heating of a known quantity of water across a specified range of temperature following a defined protocol.

4 Framework for evaluating cook stove performance

1. The rating system will define tiers of performance in the areas of fuel efficiency, emissions of fine particulate matter (PM 2.5) and carbon monoxide (CO), indoor emissions (particulate matter 2.5 and carbon monoxide), and safety. Each area will be ranked separately.

2. Tiered ratings for multiple performance indicators communicate both current performance and the expectation of future performance improvements. The tiers for each performance indicator are developed by choosing values of performance for the upper and lower tier boundaries, and then selecting intermediate values. One end of the spectrum is the performance of a defined laboratory three stone fire. The other end of the spectrum is an aspirational goal specific to each performance indicator. Five tier levels are currently used (with 0 being lowest performing and 4 being the highest performing). The number of tiers (5) reflects a balance between measurement uncertainty, and the ability to provide meaningful differentiation between stove performance.

3. Emission and efficiency ratings shown here are based on data from the VITA Water Boiling Tests.

4. Safety ratings shown here are based on the Biomass Stove Safety Protocol developed at Iowa State University for solid fuels only.

5. The following methodology is allowable for certified rating of indoor emissions:

Method 1

Indoor emissions are captured in a chamber (or "test kitchen") with controlled and measured air exchange rate, measured air volume, and well mixed air. Indoor emission rates of $PM_{2.5}$ and CO are calculated from measurements of pollutant concentrations in the chamber, air exchange rate, and air volume.

Method 2

Indoor emissions are captured with a hood and are mixed with air in a dilution tunnel. Indoor emission rates of $PM_{2.5}$ and CO are calculated from measurements of pollutant concentrations in the dilution tunnel and air flow rate.

Note: Concentrations of indoor emissions can be approximated from indoor emission rates (obtained by Method 1 or 2) by using an accessible, open source model with the assumption of perfect mixing and with specification of room size and air exchange rate.

6. The following minimum equipment or methodology is required for certified testing of emissions, performance, and indoor emissions:

a. For carbon monoxide emissions or room measurement: non-dispersive infrared (with calibration consistent with U.S. EPA 40 CFR Part 60, Appendix A, Method 10) or electrochemical cell (with pre/post calibration method)

b. For particulate matter emission or indoor air quality measurement:

   (i) real-time measurement of a particulate matter proxy via light scattering, and

   (ii) PM 2.5 gravimetric measurement such as U.S. EPA 40 CFR Part 60, Appendix A, Method 5.

c. For emissions exhaust gas flow: constant volume pump or flow grid both with real time temperature and pressure correction consistent with U.S. EPA 40 CFR Part 60, Appendix A, Method 1 or 2d, or equivalent.

d. For temperature measurement: Type K thermocouple or equivalent.

e. Computer data logging of all measurements with a minimum time resolution of one measurement per ten seconds.

f. For measuring fuel and water masses, a calibrated digital scale with 1-gram resolution or better.

4.2 TIERS ASSOCIATED WITH THE VITA WATER BOILING TEST 4.1.2*

EMISSIONS

	High Power CO (g/MJ_d)**	Low Power CO (g/min/L)
Tier 0	>16	>0.20
Tier 1	≤16	≤0.20
Tier 2	≤11	≤0.13
Tier 3	≤9	≤0.10
Tier 4	≤8	≤0.09

	High Power PM (mg/MJ_d)***	Low Power PM (mg/min/L)
Tier 0	>979	>8
Tier 1	≤979	≤8
Tier 2	≤386	≤4
Tier 3	≤168	≤2
Tier 4	≤41	≤1

EFFICIENCY / FUEL USE

	High Power	Low Power
	Thermal Efficiency (%)	Specific Consumption (MJ/min/L)
Tier 0	<15	>0.050
Tier 1	≥15	≤0.050
Tier 2	≥25	≤0.039
Tier 3	≥35	≤0.028
Tier 4	≥45	≤0.017

INDOOR EMISSIONS

	Indoor Emissions CO (g/min)	Indoor Emissions PM (mg/min)
Tier 0	>0.97	>40
Tier 1	≤0.97	≤40
Tier 2	≤0.62	≤17
Tier 3	≤0.49	≤8
Tier 4	≤0.42	≤2

* Similar tiers will be developed for other laboratory tests.
** g/MJ_d is grams per megajoule delivered to the pot
*** mg/MJ_d is milligrams per megajoule delivered to the pot

TIERS ASSOCIATED WITH THE BIOMASS STOVE SAFETY PROTOCOL DEVELOPED AT IOWA STATE UNIVERSITY

	SAFETY
Tier 0	<45
Tier 1	≥45
Tier 2	≥75
Tier 3	≥88
Tier 4	≥95

Bibliography

(1) Beijing City Local Standard DB11/T 540-2008 – *General technical specification of domestic biomass stove/boiler*

(2) Heterogeneous Stove Testing Protocols for Emissions and Thermal Performance, Sustainable energy Technology and Research Centre (SeTAR).

(3) Indian Standard 13152 – *Solid Bio-mass Chula Specification*, Bureau of Indian Standards

(4) The Proceedings from the ISO International Workshop on Clean and Efficient Cookstoves – which may provide context for the IWA – can be found on the Partnership for Clean Indoor Air website at www.pciaonline.org/proceedings