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Clean cookstoves and clean cooking solutions — Field testing methods for cookstoves

Fourneaux et foyers de cuisson propres — Méthodes d'essai sur site des fourneaux

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 285, *Clean cookstoves and clean cooking solutions*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Field measurements of cooking systems are essential for providing metrics for impact evaluation and performance evaluation. Elements of the cooking system include cooking practice, fuel type, fuel quality, cooking device (cookstove) characteristics, and environmental conditions. Each can affect performance. Field tests provide measurements that capture elements of the system that are not able to be reproduced in a laboratory setting. The performance metrics in this document are considered more representative of cooking system performance than those described in ISO 19867-1. However, field testing results are generally only applicable to the study region. Guidelines for determining social impacts on individuals and communities from the cooking system are the subject of ISO/TR 19915[1].

Clean cookstoves and clean cooking solutions — Field testing methods for cookstoves

1 Scope

This document provides field testing methods to evaluate cooking system performance in real-world conditions.

This document is intended to:

a) Provide quantitative and qualitative measurements of cooking system performance. Requirements and guidance are provided for evaluation of usage, usability, fuel consumption, energy consumption, power, emissions, safety, and durability. These measurements include uncontrolled and controlled cooking tests.

b) Provide guidance for measurements of household air pollution and personal exposure to $PM_{2,5}$ and CO.

c) Provide guidance for field assessments that compare cooking system performance metrics either to defined performance levels or to a counterfactual scenario that enables assessment of whether the new cooking system is improved compared to what would have been observed without the implementation of a new cooking system.

d) Provide guidance for prioritizing measurements that balance comprehensiveness and feasibility.

The parts of the cooking system include the cookstove, cooking vessel, fuel, user practice, and additional cooking devices (such as pot skirts and retained heat cookers). Several measurements in this document are presented as measurements of "cookstoves" or "cooking devices" for simplicity, but are intended to be interpreted as measurements of cooking systems. Some measurements (usage, kitchen energy consumption, and pollutant exposure) pertain to household-level cooking systems that include all cookstoves, cooking devices, fuels, and user practices in a household. Cooking systems can also include other aspects of the cooking environment (such as ventilation when measuring exposure).

This document is applicable to cookstoves used primarily for cooking or water heating in domestic, small-scale enterprise and in institutional applications, typically with firepower less than 20 kW and cooking vessel volume less than 150 l. The provisions of this document are applicable to solar cookers. This document does not cover electric stoves or cookstoves used primarily for space heating. Although some parts of this document can be applicable to electric stoves (usage, usability, safety, durability, cooking power, and household energy consumption), specific considerations required for testing electric stoves are not provided.

This document is intended for manufacturers, implementing organizations, researchers, governments, or other entities that need to evaluate cooking system performance in the field.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19867-1:2018, *Clean cookstoves and clean cooking solutions — Harmonized laboratory test protocols — Part 1: Standard test sequence for emissions and performance, safety and durability*

ASAE S580.1, *Testing and reporting solar cooker performance*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Cooking system

3.1.1
cooking device
apparatus used for cooking (by heating)

Note 1 to entry: Cooking devices include such items as *cookstoves* (3.1.4), pot skirts, *cooking vessels* (3.1.3), and retained heat cookers.

3.1.2
cooking system
combination of *cookstove* (3.1.4), fuel, cooking equipment, cooking environment (including ventilation) and cooking practice

3.1.3
cooking vessel
pot or container in which food or water is heated and prepared

3.1.4
cookstove
device primarily employed for the cooking of food, but which can also be employed for space or water heating, or other purposes

3.1.5
improved cookstove
cookstove (3.1.4) proposed for a geographic region or *target community* (3.2.7), which has been shown to outperform a *baseline* (3.2.2) with respect to primary criteria that can include *emission factors* (3.4.5), *fuel consumption* (3.3.3), *thermal efficiency* (3.3.12), *durability* (3.5.2) and/or *safety* (3.5.7)

3.1.6
solar cookstove
solar cooker
device that delivers useful cooking heat from thermal energy received from the sun

3.1.7
traditional cookstove
type of *cookstove* (3.1.4) or three-stone open fire that has been in long existence in a region and has been established from generation to generation

3.2 Adoption

3.2.1
adoption
condition in which a user employs an *improved cookstove* (3.1.5) regularly and maintains it

3.2.2
baseline
status of a market, community, or *cooking system* (3.1.2) prior to intervention, determined by measurements and metadata

3.2.3
displacement
replacement of a *cookstove* (3.1.4) for major tasks with a different technology that is more efficient, safer, and/or produces fewer harmful emissions

3.2.4
initial acceptance
regular use of *improved cookstove* (3.1.5) by household when it is acquired

3.2.5
cookstove stacking
continued household use of one or more traditional biomass-burning *cookstoves* (3.1.4) in addition to *adoption* (3.2.1) of an *improved cookstove* (3.1.5) for some cooking tasks

3.2.6
sustained adoption
state in which there has been *adoption* (3.2.1) for an extended period of time

Note 1 to entry: The length of time for an *improved cookstove* (3.1.5) to be considered adopted is location and stove specific, but should be defined by the users' reliance on the stove, integration into regular cooking behaviour, and frequent use of the improved cookstove, as well as repair and/or replacement of the improved cookstove when it breaks or wears out.

3.2.7
target community
social group that regularly employs *cookstoves* (3.1.4) and has expressed a willingness to consider the use of *improved cookstoves* (3.1.5)

3.2.8
usability
extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

[SOURCE: ISO 9241-210:2010, 2.13]

3.2.9
usage
action, amount, or mode of using a cooking device; often a quantitative measure of time that a *cookstove* (3.1.4) is used

3.3 Fuel consumption

3.3.1
as fired
condition of a fuel immediately before testing in a *cookstove* (3.1.4)

3.3.2
burn sequence
combustion of fuel in a *cookstove* (3.1.4) from ignition to an end point defined in a specified protocol

3.3.3
fuel consumed
mass of *raw fuel* (3.3.9) fed, see *fuel fed* (3.3.5), minus mass of *residual fuel* (3.3.10), if applicable, during a defined *burn sequence* (3.3.2)

Note 1 to entry: It is expressed in kilogrammes (kg).

Note 2 to entry: For applicability of *residual fuel* (3.3.10), see details in testing protocol.

3.3.4
fuel energy used
product of the *heating value* (3.3.6) of the *raw fuel* (3.3.9) and its mass as fired, less the product of the heating value of the *residual fuel* (3.3.10), if applicable, and its mass

3.3.5
fuel fed
fuel supplied to a *cookstove* (3.1.4) during the course of the *burn sequence* (3.3.2)

3.3.6
heating value
energy per unit mass released in the complete combustion of a sample of fuel

Note 1 to entry: The heating value shall be stated as either *higher heating value* (3.3.7) or *lower heating value* (3.3.8).

3.3.7
higher heating value
measured value of the energy of combustion of a fuel burned in oxygen in a bomb calorimeter under such conditions that all the water of the reaction products is in the form of liquid water at 15 °C, MJ.kg^{-1}

3.3.8
lower heating value
calculated value of the energy of combustion of a fuel burned in oxygen in a combustion bomb under such conditions that all the water of the reaction products remain as water vapour at 150 °C, MJ.kg^{-1}

Note 1 to entry: The *heating value* (3.3.6) at constant pressure is generally used when calculating lower heating value.

3.3.9
raw fuel
mass of the unburned fuel supplied to a *cookstove* (3.1.4) during the course of the *burn sequence* (3.3.2)

3.3.10
residual fuel
material that has a usable energy content that remains after a *burn sequence* (3.3.2) is completed

3.3.11
specific fuel consumption
amount of *fuel consumed* (3.3.3), on a mass or energy basis, per mass of food cooked

3.3.12
thermal efficiency
ratio of *useful energy delivered* (3.3.13) to *fuel energy used* (3.3.4)

3.3.13
useful energy delivered
energy transferred to the contents of a *cooking vessel* (3.1.3), including the sensible heat that raises the temperature of the contents of the cooking vessel and the latent heat of evaporation of water from the cooking vessel

3.4 Emissions

3.4.1
black carbon
particulate carbonaceous material containing mostly carbon by mass and measured by its high absorption of visible light

3.4.2
carbon emission ratio
ratio of a pollutant concentration to total carbon concentration

Note 1 to entry: Total carbon includes the CO_2, CO, CH_4, non-methane hydrocarbons, and PM.

3.4.3
carbon monoxide
toxic gas formed during the incomplete combustion of carbonaceous material

3.4.4
elemental carbon
particulate carbonaceous material emitted during combustion that demonstrates a refractory nature according to a defined thermal-optical protocol

3.4.5
emission factor
ratio of the mass of a pollutant emitted to a defined measure that quantifies the activity emitting the pollutant

3.4.6
emission rate
ER
mass of an air pollutant emitted per unit time, reported in units such as mg/h or g/s

3.4.7
fuel-based emission factor
EF_{mass}
mass of pollutant per mass of *fuel consumed* (3.3.3)

3.4.8
fuel energy-based emission factor
EF_{energy}
mass of pollutant per MJ of heat from the fuel

3.4.9
household air pollution
presence of air pollutants including solid particles or gases in air in both indoor and outdoor environments of living spaces

3.4.10
modified combustion efficiency
MCE
proxy for true combustion efficiency calculated as molar CO_2 over the sum of molar CO_2 and CO

3.4.11
organic carbon
carbonaceous material emitted during combustion in which the carbon is chemically bonded to hydrogen and possibly also oxygen, nitrogen, sulphur, or other elements

3.4.12
partial capture method
emission sampling method in which part of the exhaust plume is captured and a continuous sample is collected

3.4.13
particulate matter
PM
solids and liquids of a sufficiently small size to be suspended in air

3.4.14
$PM_{2,5}$
fine *particulate matter* (3.4.13) such that the aerodynamic equivalent diameter of the particles is less than or equal to 2,5 µm

3.4.15
pyranometer
instrument used for measuring global (all-sky) solar radiation

3.4.16
total capture method
emission sampling method in which all of the exhaust plume is captured and a continuous sample is collected

3.5 Safety and durability

3.5.1
acute hazard
hazard (3.5.3) that has immediate or short-term negative consequences

3.5.2
durability
ability of a *cookstove* (3.1.4) to continue to be operated for an extended period safely and with minimal loss of performance under conditions typical of those found in the *target community* (3.2.7)

3.5.3
hazard
potential source of harm

[SOURCE: ISO 7176-14:2008, 3.13]

3.5.4
kitchen
location where food is prepared and cooked

Note 1 to entry: The kitchen may be located indoors or outdoors.

3.5.5
likelihood of hazard
probability of occurrence of a *hazard* (3.5.3)

3.5.6
risk
product of the severity of the consequences of a *hazard* (3.5.3) and the likelihood that the hazard will occur

3.5.7
safety
ability of a *cookstove* (3.1.4) to be operated at an acceptable level of risk of harm

3.5.8
serious hazard
hazard (3.5.3) associated with outcomes that, if present, would lead to severe consequences, such as death or severe injury

4 Symbols, abbreviated terms, and units

NOTE Following ISO convention, decimal comma and thousand spacer in strings of numbers are used in this document.

Symbol/ Abbreviated term	Definition/ Meaning
BC	black carbon
C	carbon
C_C	total carbon concentration, g/m^3
C_{CO}	average CO concentration (background subtracted), g/m^3
$C_{CO,ppm}$	average CO concentration (background subtracted), ppm
$C_{CO,ppm,bkg}$	average background CO concentration, ppm
$C_{CO,ppm,bkg,realtime}$	real-time CO background data series, ppm
$C_{CO,ppm,postbkg}$	post-test background period average CO concentration, ppm
$C_{CO,ppm,prebkg}$	pre-test background period average CO concentration, ppm
$C_{CO,ppm,realtime}$	real-time CO data series, ppm
$C_{CO,ppm,realtime,n}$	measured CO concentration at time point index n, ppm
$C_{CO,ppm,test}$	test period average CO concentration, ppm
C_{CO2}	average CO_2 concentration (background subtracted), g/m^3
$C_{CO2,ppm}$	average CO_2 concentration (background subtracted), ppm
$C_{CO2,ppm,bkg}$	background CO_2 concentration, ppm
$C_{CO2,ppm,postbkg}$	post-test background period average CO_2 concentration, ppm
$C_{CO2,ppm,prebkg}$	pre-test background period average CO_2 concentration, ppm
$C_{CO2,ppm,realtime,n}$	measured CO_2 concentration at time point *n*, ppm
$C_{CO2,ppm,test}$	test period average CO_2 concentration, ppm
CCT	controlled cooking test
$C_{EC(or\ OC)}$	EC or OC concentration (background subtracted), mg/m^3
$C_{EC(or\ OC),back}$	EC or OC concentration measured by backup quartz filter, mg/m^3
$C_{EC(or\ OC),bkg}$	EC or OC background concentration, mg/m^3
$C_{EC(or\ OC),prim}$	EC or OC concentration measured by primary quartz filter, mg/m^3
$C_{EC(or\ OC),sample}$	EC or OC sample concentration, mg/m^3
$CFrac_{eff}$	effective fuel carbon fraction, g/g
$CFrac_{fuel,af}$	as-fired fuel carbon fraction, g/g
CO	carbon monoxide
CO_2	carbon dioxide
CoV	coefficient of variation; standard deviation/mean
$c_{p,p}$	specific heat of cooking vessel material, J/gK
$c_{p,w}$	specific heat of water, 4,186 J/g/K
C_{PM}	average PM concentration (background subtracted), mg/m^3
$C_{PM,bkg}$	average background PM concentration, mg/m^3
$C_{PM,sample}$	average PM concentration, mg/m^3
CSM	continuous stove monitor
D_{back}	backup quartz filter spot diameter, cm
D_{prim}	primary quartz filter spot diameter, cm
DTT	dithiothreitol
EC	elemental carbon
E_{cons}	energy consumed in past 24 h, MJ
$EF_{CO,energy}$	fuel energy based CO emission factor, g/MJ
$EF_{CO,mass}$	fuel mass based CO emission factor, g/kg
NOTE ppm = parts per million.	