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Clean cookstoves and clean cooking solutions — Test protocols for institutional cookstoves

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Foreword

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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

This document is applicable for evaluating institutional cookstoves. Institutional cookstoves often have characteristics requiring specific considerations not already covered under ISO 19867-1 and ISO 19869. These considerations include, but are not limited to, the following.

— The cooking vessels and contents used with some institutional cookstoves may be too heavy to be practically removed for weighing, as specified in ISO 19867-1.

— Institutional cookstoves tend to operate at high firepower with substantial release of emissions requiring specific measurement considerations.

— Built-in-place institutional cookstoves can be difficult or impossible to transport to a laboratory for testing, and this may require them to be tested in place (in situ).

— For some institutional cookstoves that produce char, the hot char remaining at the end of test phases can be difficult or unsafe to remove for weighing, as specified in ISO 19867-1 and ISO 19869.

— Institutional cookstoves often have longer operating durations and more specialized cooking tasks than household cookstoves. Test phases specified in ISO 19867-1:2018, 6.2 are not applicable for most institutional cookstoves.

— Heat radiation from chimneys is a safety concern because of the higher firepower of institutional cookstoves compared with household cookstoves.

Because of these reasons, additional guidance is needed for testing institutional cookstoves.

Institutional cookstoves may be tested for either energy performance only (such as efficiency, power and/or specific energy consumption), or energy performance and air pollutant emissions together. Institutional cookstoves may be tested separately for safety (see Clause 7) and/or durability (see Clause 8).

An institutional cookstove may be tested in a laboratory if the cookstove is either portable (can be transported to the laboratory) or can be built-in-place in the laboratory, as specified in Clause 5. An institutional cookstove may be tested in situ (rather than, or in addition to, in a laboratory), as specified in Clause 6.

In Table 1, options are listed for testing institutional cookstoves for energy performance and air pollutant emissions either in the laboratory or in situ, along with primary energy performance and emissions metrics. Primary and other metrics are described in Clauses 5 and 6.

The performance of two or more different institutional cookstoves may be compared with the same appropriate protocol options and test conditions, as specified in this document.

It is common for an institutional cookstove to be one element of larger, multi-component systems. These systems may include multiple fuel/energy sources or modes of operation. Therefore, multiple tests or protocols may be required to evaluate the range of potential use scenarios for a given cooking system.

Table 1 — Testing options

Testing options	Primary energy performance metrics (units)		Primary emissions metrics (units)[a]
Water-heating test With test sequence defined by either field data in 5.2.6 or protocol, in 5.2.7 — Laboratory testing, Clause 5 — In situ testing, Clause 6	Thermal efficiency (%) Specific energy consumption, fuel energy / product mass (MJ/kg)	Cooking power (kW) Firepower (kW)	Emission factors, pollutant mass / delivered energy (mg/MJ) Pollutant mass/ fuel energy(mg/MJ) Emission rates (mg/min)
Controlled cooking test — Laboratory testing, Clause 5 — In situ testing, Clause 6	Specific energy consumption, fuel energy / product mass (MJ/kg)	Firepower (kW)	Emission factors pollutant mass/ fuel energy (mg/MJ) Emission rates (mg/min)
Uncontrolled cooking test — In situ testing, Clause 6	Usage (min/day)		

[a] NOTE Emissions testing is optional, as described in the Introduction.

Clean cookstoves and clean cooking solutions — Test protocols for institutional cookstoves

1 Scope

This document provides testing methods to evaluate the energy performance, emissions, safety and durability of institutional cookstoves. For general guidance (not a requirement), institutional cookstoves typically have firepower greater than 10 kW and/or cooking vessel volume greater than 25 l. The evaluation of household cookstoves is covered in ISO19867-1 and ISO19869 and is not addressed in this document.

This document provides the following:

— quantitative and qualitative measurements of performance and safety of institutional cookstoves – methods include uncontrolled and controlled cooking tests;

— guidance for the measurement of air pollution, and;

— guidance for prioritizing measurements that balance comprehensiveness and feasibility.

This document includes testing methods for energy performance, emissions and durability that are applicable to institutional cookstoves that burn solid, liquid, and gaseous fuels and for energy performance, safety and durability that are applicable to institutional cookstoves powered by solar thermal energy.

Safety testing methods are applicable to institutional solar cookstoves and cookstoves that burn solid fuels and are not applicable to cookstoves that burn liquid or gaseous fuels, such as LPG (liquefied petroleum gas), alcohol, plant oil or kerosene. Safety evaluation of gas-fuelled cookstoves can be found in ISO 23550 and the ISO 23551 series. Safety evaluation of liquid-fuelled cookstoves is not found in existing ISO standards. This document is not applicable to electric cookstoves.

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*

ISO 19869:2019, *Clean cookstoves and clean cooking solutions — Field testing methods for cookstoves*

3 Terms and definitions

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

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

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

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

3.1
built-in-place cookstove
cookstove (3.5) in which the majority of assembly and/or construction takes place where it will be used

3.2
char
carbonaceous residue resulting from pyrolysis or incomplete combustion of solid biofuels

3.3
cooking power
average rate of energy delivered to the contents of a *cooking vessel* (3.4) over any chosen period during the course of a cooking sequence or other task

Note 1 to entry: The cooking power is expressed in kilowatts.

3.4
cooking vessel
pot or container in which food or water is heated and prepared

3.5
cookstove
appliance primarily employed for the cooking of food, but which may also be employed for space or water heating or other purposes

3.6
dilution tunnel
device in which ambient or cleaned air is mixed with an emission stream in a controlled and measured volumetric flow rate

3.7
durability
ability of a *cookstove* (3.5) to continue to be operated for an extended period in a safe manner and with minimal loss of performance

3.8
emission factor
ratio of the mass of a pollutant emitted to a defined measure that quantifies the activity emitting the pollutant

EXAMPLE Potential defined measures for emission factors include the *useful energy delivered* (3.23), mass of the fuel consumed, the dry mass of the fuel consumed, or the energy of the fuel consumed.

3.9
emission rate
mass of an air pollutant emitted per unit time

Note 1 to entry: The emission rate is expressed in mg/h or g/s.

3.10
field
locations where cooking is normally performed in real-world situations, such as homes and target communities

3.11
firepower
over a specified period in the burn sequence, rate of energy release from the combustion of the fuel assuming complete combustion

Note 1 to entry: The firepower is expressed in kilowatts.

3.12
ignition
initiation of a period of a self-sustained combustion reaction

3.13
institutional cookstove
appliance primarily employed for the cooking of food, but which may also be employed for space or water heating or other purposes, in settings that require more *cooking power* (3.3) than provided by household appliances

EXAMPLE Settings may include, but are not limited to, schools, hospitals, restaurants, displaced-persons camps, etc.

3.14
laboratory
facility that provides controlled conditions for conducting research and evaluating performance

3.15
laboratory testing
measurement of product performance quantified under controlled and documented conditions, where performance can be replicated by duplicating those conditions

3.16
$PM_{2,5}$
fine particulate matter such that the aerodynamic diameter of the particles is less than or equal to 2,5 µm

3.17
risk
product of the severity of the consequences of a hazard and the likelihood that the hazard will occur

3.18
safety
ability of a *cookstove* (3.5) to be operated at an acceptable level of *risk* (3.17) of harm

3.19
solar cookstove
device that delivers useful cooking heat from thermal energy received from the sun

3.20
thermal efficiency
ratio of *useful energy delivered* (3.23) to fuel energy used

3.21
thermocouple
temperature sensor consisting of two dissimilar metals forming an electrical junction

3.22
usage
action, amount, or mode of using a cooking device; often a quantitative measure of time that a *cookstove* (3.5) is used

3.23
useful energy delivered
energy transferred to the contents of a *cooking vessel* (3.4), including sensible heat energy that raises the temperature of the contents of the cooking vessel and the latent heat of evaporation of water from the cooking vessel

Note 1 to entry: For *cookstoves* (3.5) that are used for both cooking and space heating, useful energy delivered may also include heat delivered to a living space.

Note 2 to entry: For cookstoves that are used for both cooking and baking, or for baking only, useful energy delivered may also include the heat delivered to the baking process.

3.24
water-heating test
test of a *cookstove* (3.5) that uses one or more *cooking vessels* (3.4) or heat exchangers containing water that are heated to a specified temperature less than the local boiling point during a defined set of burn sequences

4 Abbreviated terms

C	carbon
CCT	controlled cooking test
CI	confidence interval
CO	carbon monoxide
CO_2	carbon dioxide
EF	emission factor
LPG	liquefied petroleum gas
$PM_{2,5}$	particulate matter with an aerodynamic diameter ≤ 2,5 µm
SD	standard deviation
UCT	uncontrolled cooking test
~	approximately

5 Emissions and energy performance of institutional cookstoves tested in the laboratory

5.1 General

The laboratory testing systems to be used shall be designed to handle the high firepowers often seen with institutional cookstoves. The laboratory emissions testing system shall provide sufficient dilution to ensure that gaseous pollutant concentrations are within the range of instruments, and that $PM_{2,5}$ concentrations are low enough to avoid overloading filter samples. If a total-capture dilution-tunnel system is used, then the system shall provide sufficient airflow to ensure total capture of air pollutant emissions, and adequate heat removal exists so air/gas temperature in the dilution tunnel does not exceed 60 °C. A total-capture dilution-tunnel system shall meet the requirements specified in ISO 19867-1:2018, 5.3.8.

If a partial-capture emissions measurement system is used, then the system shall meet the requirements specified in ISO 19869:2019, 8.4 and 8.5.

If a typically built-in-place cookstove is to be tested in the laboratory, then the cookstove may be either:

— constructed on a platform, pallet, or wheeled cart for moveability; or

— constructed in the laboratory for testing and then deconstructed and removed after testing.

The following testing protocols may be used for testing institutional cookstoves in the laboratory, depending on the objectives and constraints of the testing.

— ISO 19867-1:2018, Clauses 5 and 6, laboratory test methods with exceptions for institutional cookstoves

  This protocol can be used for testing institutional cookstoves under controlled conditions with a water-heating test. Test conditions may be defined with or without data from field use on fuels, cooking vessels, operating procedures, test phase duration(s) and test phase power level(s). Exceptions to ISO 19867-1:2018 for testing institutional cookstoves are specified in 5.2.

— ISO 19869:2019, 7.6, controlled cooking test with exceptions for institutional cookstoves

  This protocol can be used for testing institutional cookstoves under controlled conditions with an appropriate standard cooking task that is typical of the region for the cooking technologies being tested. Exceptions to ISO 19869:2019 for testing institutional cookstoves are specified below in 5.3.

5.2 ISO 19867-1:2018, Clauses 5 and 6, laboratory test methods with exceptions for institutional cookstoves

In ISO 19867-1:2018, Clauses 5 and 6, laboratory test methods for emissions and efficiency, may be used with the following exceptions for institutional cookstoves.

If the cooking vessel with contents (water) cannot be safely and practically removed from the institutional cookstove for weighing as specified in ISO 19867-1:2018, 6.7, then the cookstove may be tested using either the platform scale method in 5.2.3 or the pre-evaporation method in 5.2.4.

Institutional cookstoves often have longer operating durations and more specialized cooking tasks than household cookstoves. The test phases specified in ISO 19867-1:2018, 6.2 are not applicable for most institutional cookstoves. The test phase duration(s) and power level(s) for testing shall be defined by the methods specified in 5.2.6.

In addition to the energy performance metrics specified in ISO 19867-1:2018, specific energy consumption, as defined in ISO 19869:2019, Clause 7, shall be calculated and reported to enable comparison of results with controlled cooking tests conducted in the laboratory or in situ.

5.2.1 Volume of water

The volume of water in the cooking vessel specified in ISO 19867-1:2018, 6.5.2 may not be applicable to institutional cookstoves. For testing institutional cookstoves, the volume of water for testing shall be determined by either (a) field data or (b) cookstove manufacturer's written instructions or (c) agreement between the interested parties, such as the testing laboratory, sponsors (entities paying for testing), authorities, etc. Conflicts of interest shall be avoided, see ISO 19867-1:2018, 9.2.4.3.

If field data are available regarding typical volume of water or liquid observed during actual use, then that volume of water may be used for testing. A detailed description of the methodology and statistical indicators of the representativeness of the field data shall be provided along with the laboratory test results, as specified in Clause 9, if field data are used to determine the water volume.

The method used to determine the water volume (a, b, or c in this subclause) shall be included in the final report of results, as specified in Clause 9.

The volume of water used for testing may significantly affect the results. A sensitivity analysis to evaluate the impact of using different volumes of water is recommended.

Note that for institutional cookstoves with pot skirts or with sunken pots, filling the pot with water up to the level at which the pot is exposed to hot combustion gases typically maximizes thermal efficiency and minimizes emission factors based on useful energy delivered.