
**Clean cookstoves and clean cooking
solutions — Harmonized laboratory
test protocols —**

Part 3:

**Voluntary performance targets for
cookstoves based on laboratory testing**

iTeh STANDARD PREVIEW

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*Fourneaux et foyers de cuisson propres — Protocoles d'essai en
laboratoire harmonisés —*

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Foreword

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Introduction

It is recognized that performance assessed through laboratory testing does not always accurately represent performance when the device/fuel combination is in actual use. Although field performance is often worse than laboratory-based performance, it is still valuable to assess the performance and progress of improved cookstoves through laboratory testing, because laboratory tests can provide guidance for best practices in design that can be translated into better cookstove performance in the field.

Differences between performance as measured in the laboratory and in the field arise for a number of reasons, including the test protocols and actual conditions, variations in the type and characteristics of the fuel (e.g., moisture of wood), deterioration of the cookstove over time, user behaviour, etc., which can impact multiple aspects of cookstove performance.

These benchmarks are based on laboratory test results, thus their validity for real performance estimation of cookstoves and cooking solutions in the field is limited. Guidance on how the targets may be implemented is provided in this document.

Countries and organizations can use these voluntary performance targets as examples and might prefer to develop performance targets based on their own priorities, needs, and markets. Readers are reminded that these voluntary performance targets are only provided as examples.

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Clean cookstoves and clean cooking solutions — Harmonized laboratory test protocols —

Part 3: Voluntary performance targets for cookstoves based on laboratory testing

1 Scope

This document provides voluntary performance targets for cookstoves and is intended to supplement ISO 19867-1. These voluntary performance targets are intended for use with the results of the laboratory testing specified in ISO 19867-1.

These voluntary performance targets are provided as informative guidance, and are not intended as normative requirements for the testing of cookstoves. Performance targets can be considered as an approach to benchmarking potential performance of cookstoves and clean cooking solutions, and provide guidance to help organizations and countries with international collaboration and trade in household energy technologies, fuels, and related products.

This document is therefore not intended to serve as the sole basis for decisions about which technologies/fuels to promote for a given setting, since the performance of a given technology will likely differ under real-use conditions. The best way to assess real-world impacts of a stove intervention or program is through field studies, see ISO 19869¹⁾, as well as other existing methods^{[2][3]}.

In addition to the limitations arising from differences from real-world performance, laboratory test metrics (efficiency, emissions, safety, and durability) do not inform other factors that are critical to the impacts a product, program, or intervention may achieve. These factors include, but are not limited to geographic/cultural suitability, price-affordability, acceptability to the target user group, and other socio-economic factors.

These voluntary performance targets for emissions are intended to evaluate cookstoves used for small-scale household applications, with maximum firepower of up to 10 kW. Cookstoves that have firepower above 10 kW could emit substantially more overall pollutants into the household environment than those under 10 kW, while still meeting targets based on grams emitted per megajoule of useful energy delivered.

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, *Clean cookstoves and clean cooking solutions — Harmonized laboratory test protocols — Part 1: Standardized test sequence for emissions and performance, safety and durability*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19867-1 apply.

1) Under preparation. Stage at the time of publication ISO/DIS 19869:2018.

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/>

4 Symbols and abbreviated terms

ACH air changes per hour

ALRI acute lower respiratory infection

CI confidence interval

CO carbon monoxide

g gramme

h hour

HAP household air pollution

IER integrated exposure-response function

J joule

m metre

min minute

mg milligramme

MJ megajoule

MJ_d megajoules delivered

PM_{2,5} particulate matter with an aerodynamic diameter ≤2,5 μm

ppm parts per million

RR relative risk

SD standard deviation

WHO World Health Organization

μg microgramme

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5 Default target values

5.1 General

Tiered performance targets provide a set of reference values against which to monitor and assess progress on five criteria: efficiency, emissions of fine particulate matter (PM_{2,5}), emissions of carbon monoxide, safety, and durability. The tiers range from the lowest level, Tier 0, representing the performance typical of open fires and the simplest types of solid-fuel cookstoves, to the highest level, Tier 5, which represents high levels of performance sought for each of these five characteristics. Distributed between these lower and upper levels are tiers representing intermediate goals that can be used to assess progress along a continuum of performance.

5.2 Default performance tiers

Voluntary performance targets and associated tiers are shown in [Table 1](#). For unvented devices (no chimney or flue), emissions listed represent total emissions. For vented devices (with flue or chimney), emissions represent ‘fugitive’ emissions that are not captured by the device-venting system.

For emissions of PM_{2,5} and CO, default tier levels are shown in [Table 1](#); two alternative sets of tier levels for these same emissions are provided in [6.3](#) for conditions with ventilation rates assumed at higher and lower values.

NOTE Ventilation rate refers to air changes per hour (ACH) and can include natural and mechanical ventilation. The term “ventilation rate” is synonymous with the terms “air change rate” and “air exchange rate.”

These alternative scenarios demonstrate how the targets may change based on conditions that can vary between regions and settings.

[Clause 6](#) provides more information on sources of tiered targets, the basis for selection of tiers, interpretation of tiers, further detail on default and alternative scenarios, and how users of these standards can customize performance targets.

Table 1 — Voluntary performance targets – default values^a

	Tier ^b	Thermal efficiency %	Emissions		Safety (score) ^c	Durability (score) ^d
			CO g/MJ _d	PM _{2,5} mg/MJ _d		
Better performance ↑	5	≥50	≤3,0	≤5	≥95	<10
	4	≥40	≤4,4	≤62	≥86	<15
	3	≥30	≤7,2	≤218	≥77	<20
	2	≥20	≤11,5	≤481	≥68	<25
	1	≥10	≤18,3	≤1030	≥60	<35
	0	<10	>18,3	>1030	<60	>35

^a For non-default values, see [Clause 6](#).

^b The tier level for each performance metric should be reported separately. See example in [Table 2](#).

^c Safety protocols (see ISO 19867-1:2018, Clause 7) cover solid-fuel stoves and solar cookers only.

^d Durability protocols (see ISO 19867-1:2018, Clause 8) evaluate common material failures in biomass cookstoves. The protocol is not comprehensive of all failures that might be found in the field, nor are the tests found in the durability protocol applicable for all cookstoves. Instead the durability protocol seeks to cover the most prevalent durability concerns found across a range of cookstove technologies and construction materials.

For PM_{2,5} and CO, equivalent kitchen concentrations at each level of emissions performance (tier) under the assumptions of the model used to derive these values are provided in [6.3](#), along with further description of the model and references.

5.3 Reporting the tiers

Test conditions (e.g., fuel burning rate, fuel moisture, cookstove operating procedure) should be reported when reporting results against targets (tiers). A simple average of the values obtained from testing at different power levels should be used when reporting results against targets, unless there are demonstrable data from the field, in which case a weighted average can be used. See ISO 19867-1.

The tier ratings for thermal efficiency should be determined by the lower bounds of the 90 % confidence intervals for the combined results. See example in [Table 2](#).

The tier ratings for PM_{2,5} and CO emissions should be determined by the upper bounds of the 90 % confidence intervals for the combined results. See example in [Table 2](#).

Cookstove performance should be reported separately for all tier categories including CO, PM_{2,5}, thermal efficiency, safety, and durability, further described in [Clause 6](#). See example in [Table 2](#).

EXAMPLE A cookstove with emissions of PM_{2,5} of 336 mg/MJ_d on the upper bound of the 90 % confidence interval for the combined result would be Tier 2 for PM_{2,5}, and emissions of CO of 0,9 g/MJ_d on the upper bound of the 90 % confidence interval for the combined result would be Tier 5 for CO. See example in [Table 2](#).

For CO, PM_{2,5}, and thermal efficiency, performance should be reported based on individual test-phase-wise reporting and averaging (see example results table, [Table 2](#)).

Table 2 — Example table of reported results

Metric		Test Sequence Phase				Performance against target (e.g., tier rating)
		High	Medium	Low	Combined ^b	
Thermal efficiency without char ^a (%)	Mean	31,4	34,7	35,1	33,7	3
	SD	1,9	1,7	2,1	1,9	
	90 % CI	29,6-33,2	33,1-36,3	33,1-37,1	31,9-35,5	
Thermal efficiency with char ^a (%)	Mean	33,6	37,0	39,8	36,8	3
	SD	2,2	1,6	2,0	1,9	
	90 % CI	31,5-35,7	35,5-38,5	37,9-41,7	35,0-38,6	
Char energy productivity (%)	Mean	4,1	3,3	2,7	3,4	n.a.
	SD	0,9	0,7	0,5	0,7	
Char mass productivity (%)	Mean	2,2	1,3	0,7	1,4	n.a.
	SD	0,6	0,3	0,1	0,3	
Cooking power (kW)	Mean	1,6	1,2	0,7	n.a.	
	SD	0,2	0,1	0,1		
Fuel burning rate (g/min)	Mean	16,5	12,8	8,9	n.a.	
	SD	1,9	1,1	0,7		
PM _{2,5} per useful energy (mg/MJ _d)	Mean	497	203	216	305	2
	SD	55	19	22	32	
	90 % CI	445-549	185-221	195-237	274-336	
CO per useful energy (g/MJ _d)	Mean	0,6	0,8	1,1	0,8	5
	SD	0,1	0,2	0,1	0,1	
	90 % CI	0,5-0,7	0,6-1,0	1,0-1,2	0,7-0,9	
Safety	Score	88				4
Durability	Score	18				3

^a For solid-fuel stoves that produce char, thermal efficiency should be reported both 1) without energy credit and 2) with energy credit for remaining char. Thermal efficiency without char is applicable when users do not use the char remaining after cooking as fuel. Thermal efficiency with char is applicable when users use the char remaining after cooking as fuel.

^b Values in bold are the conservative bounds of the 90 % confidence intervals for determining the tier level, as described in [5.3](#).

Some of the fuels/technologies that fall within the general scope of ISO 19867-1, including gas/liquid-fuelled cookstoves, are not covered by the safety testing protocol (see ISO 19867-1:2018, Clause 7) that serves as the basis for the tiered targets in [Table 1](#). Accordingly, test results obtained from other safety testing protocols should be reported separately.

6 Technical basis and guidance for implementation

6.1 General

This clause provides information on the technical basis for the tiered performance targets, and guidance on how these targets may be implemented, covering the following:

- a) definitions of the tier levels for thermal efficiency and emissions (PM_{2,5} and CO);
- b) the empirical basis for selection of the tiers, including:
 - the emissions model used for PM_{2,5} and CO,
 - description of the integrated exposure-response function (IER) providing the basis for PM_{2,5} tiers,
 - application of evidence of both chronic and acute toxic effects for CO, and
 - laboratory test data used as the basis for safety and durability tiers;
- c) default and alternative sets of targets for PM_{2,5} and CO, with equivalent kitchen pollutant concentrations as predicted by the emissions model, and percentages of homes meeting key criteria at each tier level; and
- d) guidance on selecting relevant tiers for different settings.

6.2 Thermal efficiency

6.2.1 Definition of tier categories for thermal efficiency

Based on the ratio of useful energy delivered to fuel energy used during controlled laboratory testing, tier categories are defined as follows in Table 3 for each tier:

Table 3 — Definitions of thermal efficiency tier categories

Tier category	Tier	Definition
Highest	5	The thermal efficiency that is at a level representative of the best existing technology for fuel-combustion cookstoves
Intermediate	1-4	Mathematical division of range based on even spacing with five levels, with Tier 1 set to reflect performance observed with simple cookstove technology improvements
Lowest	0	The thermal efficiency observed with open fires and other simple solid fuel cookstove technologies

6.2.2 Empirical basis for tiers

Tiers for thermal efficiency are multiples of 10 % from 10 % to 50 %. These tiers were chosen because published test results show that the most advanced cookstoves approach or exceed a thermal efficiency of 50 %, while open fires and rudimentary cookstoves achieve an efficiency around 10 % or less^[4].