UlAANBAATAR CLEAN AIR PROJECT

Project Number CWHB-01-A

FINAL REPORT

on

UPDATING AND DEVELOPING EMISSION STANDARD FOR MINIMUM PERFORMANCE OF INDIVIDUAL HEATING STOVES FOR GER AND SMALL DETACHED HOMES

Prepared for

Ulaanbaatar Clean Air Project, Project Management Unit

Prepared by

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CONTENT OF REPORT

ABBREVIATIONS

ADB	Asian Development Bank
AQDCC	Air Quality Department of the Capital City
ASM	Agency for Standardization and Metrology
CT	Consulting Team
DEM	Department of Environment Monitoring
ETCASM	Energy Technical Committee of ASM
ETCASM	Environment Technical Committee of ASM
IACC	Inspection Agency of the Capital City
IDI	Inspection Department of Infrastructure
IDNEGM	Inspection Department of Nature, Environment, Geology and Mining
IDNEGM	Inspection Division of Nature, Environment, Geology and Mining
IPH	Institute of Public Health
ITEIE	Institute of Thermal Engineering and Industrial Ecology
MHS	Ministry of Health and Sports
ME	Ministry of Energy
MNEGDT	Ministry of Nature, Environment, Green Development and Tourism
MOCC	Mayor's Office of Capital City
MUST	Mongolian University of Science and Technology
NAMHEM	National Agency for Meteorology, Hydrology and Environment Monitoring
NAPRC	National Air Pollution Reduction Committee of Mongolia
NIA	National Inspection Agency
PMU	Project Management Unit
RECB	Research and Experiment Center for Boilers
SHWB	Small hot water boiler
SPE	School of Power Engineering
UB	Ulaanbaatar
UBCAP	Ulaanbaatar Clean Air Project

I. Introduction

By mutual agreement between the Research and Experiment Center for Boilers of MUST and Project Management Unit of Ulaanbaatar Clean Air Project on April 28, 2016 to perform project "Updating and developing emission standard for minimum performance of individual heating stoves for ger and small detached homes" within the Ulaanbaatar clean air project implementing under the soft loan from the World Bank/International Development Association.

According to this agreement consulting team of RECB MUST performed research work according to term of reference and had handed finished inception report and progress report-1 and 2 to the clients.

After the progress report-2, formal proposals, reviews and recommendations of key stakeholders, other relevant professional organizations, experts and producers were incorporated to standard draft and developed final version of the standard "MNS 5216:2016 General technical requirements and maximum acceptable level and measuring method of pollutants in the exhaust gases of the stoves for heating and cooking" and sent to the Agency for Standardization and Metrology for assessment and approval by Energy Standardization Technical Committee and national Council of ASM.

In according with chapter 2, article 4.1 and 6.2 of the Mongolian Standardization and Conformity Assessment Act, updating the existing applicable or associated standards of the household stoves, rising the requirement for air polluting substances releasing from the ger district households heating appliances and that will important documents for reduction air pollution.

This report includes project work summary, minutes of meeting of Energy Standardization Technical Committee of ASM, and the resolution of National Council of ASM approved this standard and standard in English language.

II. Project performance summary:

2.1 In accordance with the mutual agreement between the Research and Experiment Center for Boilers of MUST and Project Management Unit of Ulaanbaatar Clean Air Project Consulting team identified stakeholders, handed inception report including work chart, human resource allocation, and standard processing techniques.

2.2 In accordance with the terms of reference within the 2nd phase the Consulting team met with the key stakeholders and introduced necessary information, data, stove replacement program documents, relevant standards, studied the comparative analyzes of stove test protocols and determined the standard processing order.

2.3 Including the relevant parties and the representative researchers discussed standard draft and research results 2 times, proposals from the discussion were included in standard draft and sent to the key stakeholders, other relevant professional organizations, experts and producers, and the final proposals, reviews and recommendations were received, finalized and sent to the Agency for Standardization and Metrology's Energy and the Environment Standardization Committee, National Council of Agency for Standardization and Metrology for discussion.

2.4 The final version of the draft standard "MNS 5216: 2016, General technical requirements and maximum acceptable level and measuring method of pollutants in the exhaust gases of the stoves for heating and cooking" was received by Agency for Standardization and Metrology and in relation with changing the structure, Standardization Technical Committee and the National Council sent official letter on 6th of September, that the council will not hold a meeting in September, 2016 and the meeting is scheduled in October and November.

2.5 Therefore, based on official documents of Agency for Standardization and Metrology the contract was extended until March 31, 2016.

III. Consultant's activities after the progress report-2.

3.1 Final version of standard draft "MNS 5216: 2016, General technical requirements and maximum acceptable level and measuring method of pollutants in the exhaust gases of the stoves for heating and cooking" was reviewed and translated into English language.

3.2 The final version of standard draft "MNS 5216: 2016, General technical requirements and maximum acceptable level and measuring method of pollutants in the exhaust gases of the stoves for heating and cooking" was discussed by Energy Standardization Technical Committee of ASM on 18th of November, 2016 and some correction were made, and the title of the standard was changed to MNS 5216: 2016, "Household stoves. General technical requirements". The approval was supported by ASM's National council.

3.3 In accordance with the proposals and recommendations of members of the Energy Standardization Technical Committee the standard title was changed to MNS 5216: 2016 "Household stoves. General technical requirements" and edited, and the draft standard was included in the official form with the Secretary of Energy Standardization technical committee and was finalized and prepared for National Council of ASM.

3.4 The final draft of standard MNS 5216: 2016 "Household stoves. General technical requirements" discussed by Energy Standardization Technical Committee of ASM was approved on 24th of November, 2016 by National Council of ASM.

3.5 The approved standard by National Council of ASM "Household stoves. General technical requirements" is attached in English.

3.6 The minutes of meeting of the Energy Standardization Technical Committee of ASM, and the resolution of National Council of ASM is attached.

ANNEX 1

Contents

Foreword

Mongolian Agency for Standardization and Metrology is a member of the International Standardization Organization and fulfill the National standardization policy in a scope of its work with state and non government organizations.

This Agency is in charge of the national standard treatment by technical committee. The considered standard draft is effective when it is supported by more than 75 votes under the discussion of the Technical Committee and Subcommittee, then was approved by a resolution of National Council of Standardization and Metrology.

Consulting team developed this standard within Project "Updating and developing emission standard for minimum performance of individual heating stoves for ger and small detached homes" of Project Management Unit and Ulaanbaatar clean air project in 2016.

The considered standard draft is approved by resolution of National Council of Standardization and Metrology after discussion and consultation with the Energy and the Environmental Technical Committee.

STANDARD OF MONGOLIA
Classification code:

Household stoves. General technical requirements.	**MNS 5216: 2016** Instead of MNS 5216:2002 and MNS 5216-1:2011

The considered standard draft is approved by a 50 number of resolution of the National Council of Standardization and Metrology on 24th November, 2016.

The standard is in valid from 1st April, 2016.

Normative requirements of the standard shall be guided from the date of state registration,

1. Scope

This standard is applicable to production and import of household stoves with capacity 3-15 kW. This standard established general technical requirements, test method and the maximum acceptable level of air pollutants in the flue gas of solid fuel burning stove used Mongol ger and other similar accommodation or dwellings.

2. Normative references.

In this standard used the following cited standard and documents. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publications referred to applies (including amendments).

2.1 Mongolian State national standardization system. Part 1: Procedures for the technical work. MNS 1-1 : 2006

2.2 Mongolian State national standardization system. Part 2: Rules for the structure and drafting of standards. MNS 1-2 : 2006

2.3 ISO/IEC Directives Part 1. 2016. Contians the Final version and The Redline Version. Procedures for the technical work.

2.4 ISO/IEC Directives Part 2. 2016. Principles and rules for the structure and drafting of ISO and IEC documents.

2.5 www.estandard.mn site. How to write standards? Recommendation.

2.6 MNS4585:2016 Air quality. General requirements.

2.7 MNS 5216:2002 MNS 5216:2002. Domestic burners using the solid fuel. Technical general requirements.

2.8 MNS 5216-1:2011 Householder stove. General technical requirements.

2.9 MNS 5458:2005, Maximum acceptable level and measuring method of toxic elements (CO, SO_2, NO_x, ash) in the exhaust gases contents of heating boilers and home stoves.

2.10 MNS 5568:2005, Household apparatus used the liquid fuel. General technical requirements.

2.11 MNS BS EN 13240:2011. Roomheaters fired by solid fuel- Requirements and test methods.

3. Terms and definitions

The following terms and definitions apply to this standard.

3.1

household stove

equipment is used for heating and cooking of Mongol ger and other similar dwellings by combustion heat of solid fuel

3.2

emission of Pollutants per unit useful heat

The levels of air pollutants for unit useful heat or output heat from stove are indicated by units of mg/kCal or mg/MJ.

3.3

efficiency

ratio of total heat output to total heat input during the test expressed as a percentage during the test period;

3.4

Natural fuel

Natural fuel is type of the fuel used for heat generation of stove

3.5

the mass concentration of pollutants

the mass of pollutant concentrations per cubic meter of smoke, is commonly expressed in unit mg/m^3 (milligram per cubic meter)

3.6

the volume concentration of pollutants

the volume of pollutant concentrations per cubic *meter* of smoke, is commonly expressed as $1cm^3/m^3$=1 ppm

Note: 1 ppm is gaseous volume level of parts-per-billion ($1ppm=10^{-6}$)

3.7

Maximum allowable level of air pollutants

Maximum acceptable level of air pollutants in the exhaust gases from the household stove or maximum acceptable level of toxic emissions from other pollution sources

Note: This is expressed by units "mg/m^3" or "mg/kg.e.f" and "mg/mJ" and when uniting with the air pollutants, discharged from other sources, pollution concentration should not be higher than the levels, stated in the standard of "Ambient air quality "

3.8

furnace

that part of the stove in which the fuel is burned.

3.9

indoor air temperature

The average air temperature measured at distance of 40 cm from the floor in the circle with 1.5 m radius of the stove center.

3.10

Heat output

quantity of useful heat released by the stove

3.11

Heat input

Quantity of energy which the fuel provides to the stove;

3.12

nominal heat output

total heat output of the stove quoted by the manufacturer and achieved under defined test condition when burning the specified test fuel;

3.13

equivalent fuel

Lower calorific value of 1 kilogram fuel is Q_j^r= 7000 kCal/kg or 29.33 MJ/kg.

Note: In the nature, there are different calorific value or combustion heat of all types natural fuel. Therefore, it is a international concept used for comparison between them. Natural fuel is transferred to equivalent fuel is as follows.

$$B_{ж.т} = Bxk = Bx(Q_i^r/7000) = Bx(Q_i^r/29.3) \quad (1)$$

Here, B, Q_i^r- fuel rate and lower calorific value or net calorific value of natural fuel.

3.14

excess air coefficient α

The comparative ratio of the amounts of air needed for per unit of coal combustion and calculated (theoretical) air requirement.

Note: This coefficient (α) is varies considerably depending on the fuel combustion condition of each stove design.

3.15

carbon monoxide emissions

Carbon monoxide is contained in the flue gas existing by stove chimney;

3.16

Emission of Pollutants released from combustion of 1 kg fuel

The levels of air pollutants released during the combustion of 1 kg natural or equivalent fuel, are indicated by units of mg/kg.f or mg/kg.ef.

3.17

Fire door

door through which the fire may be viewed and which may be opened to allow refueling of the fire bed;

3.18

ash content of the fuel

solid matter remaining after the complete combustion of solid fuel;

3.19

Lower Heating value (**or net calorific value**), **Q_j^r**

The heating value is determined by subtracting the heat of vaporization of the moisture (water) in the fuel and H_2O vapor from the amount of heat released during the complete combustion of 1kg fuel.

Exp: The calorific value is a characteristic for each substance.

3.20

emission of total suspended particles

fly ash and dust is contained in the flue gas existing by stove chimney;

3.21

bottom grate

part of the stove at the base of the furnace which supports the fire bed through which the residue falls into the ash pan and through which combustion air may be drawn

3.22

bottom grate bars

bars supporting the fuelbed, separate or integral with a surrounding frame;

3.23

flue gas temperature

temperature of the flue gas at the specified point in the measurement section of chimney;

3.24

ashpit

enclosed chamber designed to receive the residue or the ashpan;

3.25

Ashpit loss

Part of the residue which is combustible;

3.26

ashpan

removable drawer shaped with handle to receive the residue falling from the fire bed;

3.27

heating surface

outside surface for transfer fuel combustion heat to indoor air;

note: All external surface of a stove including the flue gas connector in accordance with this standard are classified as heating surfaces because they are designed to transmit heat into the ger in which they are installed.

3.28

wall stove

Heating appliances with three and more horizontal and vertical, mixed wells by brick for prolong flue gas path which used flue gas heat for heating of house.

note: Size and the internal organization of the house depend on the number and size of well walls

3.29

Solid fuel

Naturally occurring or manufactured solid mineral fuels or manufactured wood logs and peat briquettes;

3.30

Solid mineral fuel

Coal, lignite, coke and fuels derived from these;

3.31

normal condition

The condition, determined as: internal pressure *of* boiler flue gas is 101325 Pascal (760 mm Hg) and temperature of 273.15 K (0 °C)

3.32

Basic fire bed

quantity of glowing embers which ensures ignition of the test fuel to be charged;

Note: the basic fire bed may be specified by the manufacturer.

3.33

Combustion air

Air supplied to the furnace which is entirely or partially used to burn the fuel;

3.34

Combustion gases (smoke)

Compounds in gaseous form produced inside an stove when fuel is burned;

3.35

flue draught

differential between the static pressure in the place of installation and the static pressure at the flue gas measurement point;

4. Technical requirements

4.1 General technical requirements of stove are shown in The table 1.

Table 1. General technical requirements of stove

No	Specification	Measuring unit	Allowable level	Note
1	Heat capacity	kW	3-7	
2	Efficiency	%-иар, багагүй	70	
3	flue draught / Negative pressure in the furnace/	Па	6-12	
4	Flue gas temperature (average temperature)	^{o}C	150	Normal operation condition

4.2 Furnace linings of stove will do quality by refractory clay.

4.3 Stoves should be designed available easy cleaning from ash and soot of the furnace and heat exchanger.

4.4 Will be equipped explosion protection valve and flue gas cleaning devices in the furnace and flue gas duct of stove.

4.5 7-15 kW stove can be mounted in the wall based on industrial drawings, scheme and the manual.

4.6 The stove must have technological drawing and scheme and guaranteed not less (at least) than 4 years.

4.7 Requirements of stove design

4.7.1 boiler steel structure

4.7.1.1 Welding and welding materials

The materials used shall be suitable for welding.

4.7.2 Inside cleaning of the stove

All heating surfaces shall be accessible from the flue gas side for inspection and cleaning with brushes, scrapers or chemical agents by means of sufficient cleaning openings.

4.7.3 Top cast iron of stove

Top cast iron of stove is shaped ring and plays an important role in the cooking and heating. Outside diameter of the large ring is no less than 300 mm.

4.7.4 Flue spigot or socket

Connector length is at least 80 mm for horizontal flue connection and more than 25 mm for vertical flue connection.

4.7.5 Requirements for chimney of stove

Chimney diameter is 100 mm and with high should exceed more than 700 mm above ger top or the roof of house.

4.7.6 Requirements for the wall stove

4.7.6.1 Design is simple, set and masonry lining no difficulties and strength and durability and long-term (typically life time of brick stoves is 20-30 years). To ensure the conditions as free flow of flue gas and connecting part is not affect to the flue draught and with a few turnover, corner and twist.

4.7.6.2 To be heated well and uniform all the surface, especially the bottom part and the last wells. Must be heated regular and uniform for dwelling in the day period, or until the next firing.

4.7.6.3 Inner section of connector is from 110 mm x 110 mm to 140 mm x 140 mm and its length from 100 mm to 250 mm for straight connection, and at least 140 mm x 140 mm, length 250 mm, and are more inclined than 120 degrees for in the angular connection of wall stoves.

4.7.7 ashpan

4.7.7.1 The ashpan can be shovel shaped. When an ashpan is provided, it shall be capable of containing the combustion residue from two full charges of fuel whilst retaining sufficient space above to allow adequate primary air flow through the bottomgrate or firebed. If the ashpan resides in the appliance it shall locate in the ashpit in such a way that it allows the free passage of primary air and in such a position that it does not obstruct any primary air inlet control.

4.7.7.2 It effectively collects the residue from beneath the bottomgrate and should not interfere to primary air flow.

4.7.7.3 Ashpan can be easily and safely withdrawn, carried and emptied when hot, using the tool(s) provided, without unduespillage of residue material.

4.7.8 Bottomgrate

Bottom grate can be removable or fixed.

Note: The preferred design with the firedoor(s) and ashpit door(s) closed should allow de-ashing to be carried out. The de-ashing should be possible without undue effort.

4.7.9 Primary and secondary **air inlet control**

Primary air inlet setting is available by opening ash systems and secondary air inlet by opening or closing of fire door and their holes in the upper part.

4.7.10 Control of flue gas

The damper shall be easy to operate or move freely, which does not block the flue totally or a continuous area occupies not more than 75 % of the cross-sectional area.

4.7.11 Flue bypass device

Any flue bypass device shall be easily operable. The extreme positions corresponding to full opening and closing shall be stable and easily identifiable.

4.8. Requirements for materials

4.8.1 Thickness of stove structural steel is no less than 2 mm.

4.8.2 Requirements of the cast iron parts of stove are shown in Table 2.

Table 2. Minimum mechanical requirements for cast irons

Grey cast iron (in accordance with EN 1561:1997)	
Tensile strength Rm	> 150 N/mm²
Brinell hardness R_m	160 HB-220 HB
Spheroidal graphite iron (In accordance with EN 1563:1997)	
Tensile strength Rm	> 400 N/mm²
Elongation	18% A_3

4.8.3 Furnace linings of stove is refractory and the ability to heat storage and will be less than its wall thickness of 30 mm. Clay is suitable glutinous dirt for ceramic products.

4.8.4 Specific weight, density, fluff quality, refractory and corrosion resistance of wallstove brick meet requirements of MNS 392-99 standard. And this brick should be complete combustion, heat quickly self-absorbed and high conductivity.

5. Environmental requirements or the maximum acceptable level of pollutants.

5.1 The acceptable maximum level of pollutants in the flue gas shown in the table 3.

Note: There are different emission pollutants depend from low combustion heat if use various solid fuels. Therefore, used the understanding of equivalent fuel for comparing between.

Table 3. Acceptable level of pollutants

No	Pollutants	Measuring unit	Acceptable level	Note
1	Total dust or TSP	mg/Nm^3	130	
		mg/MJ	90	
		mg/kg.n.f	1850	
2	Fine-grained particles- PM2.5	mg/Nm^3	100	
		mg/MJ	70	
		mg/kg.n.f	1430	
3	Carbon monoxide (CO)	mg/Nm^3	9800	
		mg/MJ	6800	
		mg/kg.n.f	140000	
4	Sulfur dioxide (SO_2) and sulfur compounds	mg/Nm^3	1200	
		mg/MJ	850	
		mg/kg.n.f	17400	
5	Nitrogen oxides (NO_x)	mg/Nm^3	700	
		mg/MJ	480	
		mg/kg.n.f	9800	

5.2 Measuring units of pollutants shown above in the table shall be transferred by the following. Include:

a. If measured by mg /m^3 of air pollutants concentration converted to the normal condition (mg /Nm^3) by calculation method in the paragraph 8. After that mg/Nm^3 to be converted to other units.

b. Unit mg/Nm^3 will multiplied by dry flue gas volume of the combustion 1 kg fuel (Nm3 / kg) and divided by low heating value of fuel and stove efficiency for converting to unit mg/MJ. Here, a stove efficiency is received 70 percent, according to the standard.

c. Unit mg/Nm^3 will multiplied by dry flue gas volume of the combustion 1 kg fuel (Nm^3/kg) for converting to unit mg/kg.

d. Unit mg/MJ will multiplied by low heating value of fuel and stove efficiency for converting to unit mg/kg.

e. Unit mg/kg will divided by dry flue gas volume of the combustion 1 kg fuel (Nm^3/kg) for converting to unit mg/ Nm^3.

6. Safety requirements

6.1 Producers of stoves produced and designed at a highly professional level and must be issued conclusion and tested by accredited laboratory and the authorized professional organizations. Must be certified by Mongolian national certificate of the conformity on the basis of conclusions of National Inspection Agency, Disaster Research Laboratory, accredited laboratory and the authorized professional organizations. And must be handed each sold stoves accompanied safety and operating instructions to customers.

6.2 Outside surface temperature of stove should be at least 140 ^{0}C and not exceed than 400 ^{0}C during the operation. But the surface temperatures on the areas to be touched, shall not exceed the ambient room temperature by more than the following specified amount. Include:

a. 35 ^{o}C for metal;

b. 45 ^{o}C for porcelain, vitreous enamel or similar materials;

c. 60 ^{o}C for plastics, rubber or wood.

NOTE: If these temperatures are exceeded, the manufacturer shall indicate in the safety instructions the need to use an operating tool.

6.3 Must be reflected guidelines and recommendations about not burn and hurt, contact the hot surface during the operation of stove in the operation and safety instructions .

6.4 Fire door of stove tightly closed and ash pn is well sealed from each side. The stove is designed to fully protect of falling out of the red-hot fuel ash by fire door and a hole for entry air.

6.5 Outside surface of wallstove is without crack and breakage and meet maximum temperature (90-95 ^{0}C) on the surface, does not exceed the fire safety and sanitary norms. And must have not a negative effect on residents health, the housing interiors and the appearance.

6.6 Will not causing threat, risks of residents life because of disintegration due to a high pressure and accumulating hydrocarbon oxide from combustion fuel in the wallstove during the operation.

6.7 Any costumer or purchaser has the right to evaluate and accurate information, referral and required quality assurance for testing and checking of the stove from producers.

7 Test method

7.1 Stove tested in the laboratories or Mongol ger and used dedicated and certified measuring instruments with high accuracy. In the stack made hole for placing sensor of gas analyzer for determining flue gas composition before stove test. Fuel consumption, stove capacity, its efficiency and flue gas flow rate, temperature and emissions of pollutants will be determine by test.

7.2 Any stove is met general technical and safety requirements of this standards before stove test.

7.3 Measurement sequence

7.3.1 Weigh stove;

7.3.2 Preparation weigh the fuels for ignition and using to test.

7.3.3 All the measuring instruments will place in the measuring points and check and set up;

7.3.4 Prepared fuels input to the stove and weighing;

7.3.5 Ignition stove;

7.3.6 Start measurement;

7.3.7 Keeping notes of measurement progress;

7.3.8 Measurement control and completion test.

7.4 All measuring equipment are used for testing was validated by an accredited laboratory, that shall meet the following requirements.

Table 4. Technical requirements for emission measuring equipments

No	Purpose of measurement	Measuring items	Technical requirement
1	Weighing	Weight of stove and fuel	± 2
2	Or measuring temperature	Temperature of flame, flue gas and stove surface	1°C
3	Measuring air pollutants in the flue	Carbon dioxide, CO_2	Measuring Range 0...20 % Accuracy 0.1 %
		Oxygen, O_2	Measuring Range 0...21 % Accuracy 0.1 %
		Carbon dioxide, CO_2	Measuring Range 0...3000 мг/м^3 Accuracy ±12 мг/м^3
		Nitrogen oxide, NO	Measuring Range 0...5000 мг/м^3 Accuracy ±15 мг/м^3
		Nitrogen dioxide, NO_2	Measuring Range 0...2000 мг/м^3 Accuracy ±10 мг/м^3
		Nitrogen oxides, NO_x(NO+ NO_2)	Measuring Range 0...5000 мг/м^3 Accuracy ±15 мг/м^3
		Sulphur dioxide, SO_2	Measuring Range 0...5000 мг/м^3 Accuracy ±15 мг/м^3
		Fly ash or PM	Measuring Range 0...3000 мг/м^3 Accuracy ±12 мг/м^3
		Flue gas temperature, ^{0}C	Measuring Range 0...800 ^{0}C Accuracy 0.1 ^{0}C
		Excess air, α	Measuring Range 0...10 Accuracy 0.1

7.5 To take samples from used fuel for test and ash and shall be analyze in the laboratories for determining the following characteristics.

a. Combustion heat of low calorific value of fuel $\left(Q_i^r\right)$, volatile matter (V^{daf}), moisture (W^r), and ash (A^r);

b. The elements composition (C^r, H^r, O^r, N^r, S^r);

c. The amount of flammable substances in the ash and slag ($G_ш$, $G_{пр}$, $G_{ун}$).

8. Calculation methods

Measurement results during the test will developed in accordance with the following methodology for determining the necessary characteristics.

8.1 Heat losses in the flue gas.

$$Q_2=(t_a-t_{ут})\cdot[[(C_{c.yx}\cdot(C-C_Y))/(0.536\cdot(CO+CO_2))]+[C_{c.H2O}\cdot 1.224\cdot(9H+W)/100]]$$

$$q_2=100\cdot Q_2/\left(Q_i^r\right) \quad (2)$$

Here: $t_{ут}$- flue gas temperature, ^oC;

t_a- indoor air temperature , ^oC;

$C_{c.yx}$- the specific heat of the dry flue gases in standard conditions, kJ/(K·m^3);

C, C_Y- carbon content of the test fuel and the residue, referred to the quantity of test fuel fired., %;

CO, CO_2- carbon monoxide and carbon dioxide content of the dry flue gases, %;

$C_{c.H2O}$- specific heat of water vapour in flue gases in standard conditions, depending on temperature, kJ/(K·m^3);

H, W- hydrogen and moisture content of the test fuel (as fired basis), %;

Q_i^r - lower calorific value of the test fuel (as fired basis), kJ/kg.

8.2 The specific heat of the dry flue gases in standard condition ($C_{c,yx}$) is calculated using the formula:

$$C_{c.yx}=3.6\left(0.361+0.008\cdot\left(\frac{t_{ут}}{1000}\right)+0.034\cdot\left(\frac{t_{ут}}{1000}\right)^2+\left(0.085+0.19\left(\frac{t_{ут}}{1000}\right)-0.14\cdot\left(\frac{t_{ут}}{1000}\right)^2\right)\cdot\left(\frac{CO_2}{100}\right)+\left(0.03+\left(\frac{t_{ут}}{1000}\right)-0.2\cdot\left(\frac{t_{ут}}{1000}\right)^2\right)\cdot\left(\frac{CO_2}{100}\right)\right) \quad (3)$$

8.3 The specific heat of the water vapour ($C_{c.H20}$) in the combustion products is calculated using the formula.

$$C_{c.H20}=3.6\cdot\left(0.414+0.038\cdot\left(\frac{t_{ут}}{1000}\right)+0.034\cdot\left(\frac{t_{ут}}{1000}\right)^2\right) \quad (4)$$

8.4 Chemical heat losses in the flue gas

$$Q_3=12644\cdot CO\cdot(C-C_Y)/[0.536\cdot(CO_2+CO)\cdot 100]$$

$$q_3=100\cdot Q_3/Q_i^r \quad (5)$$

8.5 Combustible matter contained in the slag and ash from coal combustion (fallen coal through the holes of bottom grate) during the test shall be determine in the laboratory. After that heat loss from mechanical incomplete combustion is determined by the following formula.

$$q_4=\frac{m_н}{B\cdot\tau}\cdot 100\ \% \quad (6)$$

Энд: $m_н$ –Combustible constituents in residues referred to mass of residues, kg;

B-mass of the test fuel (as fired basis,kg;

τ - total time of the test, h.

$$m_н = m_Y \frac{100-A}{100} \quad (7)$$

Энд: m_Y- Residue passing through the grate, referred to the mass of the fired test fuel, kg;
A-ash in the residue, %.

8.6 The efficiency will determine by the reverse balance method on the basis of stove heat losses.

$$\eta = 100 - q_2 - q_3 - q_4 \quad (8)$$

8.7 Heating capacity of stove, kW.

$$N = (B \cdot Q_i^r \cdot \eta)/(100 \cdot 3600) \quad (9)$$

8.8 Fuel consumption of stove

$$B = ((m + m_г \cdot \left(\frac{Q_i^{rг}}{Q_i^r}\right) - m_Y)/\tau \quad (10)$$

Энд: m, $m_г$-the mass of ignition and test fuel, kg;

Q_i^r , Q_i^{rr} - low heating value of test and ignition fuel, MJ/kg;

9. Permissible error of the test results.

Tests done at least 3 times and the results will be weight and arithmetic average.

9.1. The test should be repeated if results of determination for stove capacity (N), fuel consumption (B) and efficiency (η) difference such more than 2 % and 10 percent identify pollutants. Results of repeated test results are final.

9.2. Should be meet results processing method to MNS 2659: 1991 and the results of evaluation error to MNS2660: 1993 standards.

10. Methodology for converting m**easuring results of air pollutants to the normal conditions**

10.1 Determine the concentrations of NOx, SO_2, CO and fly ash in the flue gases from the stove on the based test results of measuring gas analyzer for gas composition and excess air.

10.2 Concentration of air pollutants shall be measure by "ppm" or mg/m^3 in the composition of flue gas depending of the measurement provisions.

10.3 The measurement values of air pollutant concentration in flue gas composition shall calculated at the excess air coefficient α = 1.9 (oxygen 10 %) in the flue gas for converting to the normal condition.

10.4 If concentration of pollutants expressed by the volume content or ppm

$$C_v^{xн} = C_v \cdot [(V_{xx}^o + (\alpha - 1) \cdot V_a^o)/(V_{xx}^o + (1.9 - 1) \cdot V_a^o)] \quad (11)$$

10.5 If concentration of pollutants expressed by mass concentration or mg/m^3

$$C^{xн} = C_д \cdot \left[\left((273 + □)/273\right) \cdot \left(\frac{□}{□}\right) \cdot (V_{xx}^o + (\alpha - 1) \cdot V_a^o)/(V_{xx}^o + (1.9 - 1) \cdot V_a^o)\right] \quad (12)$$

Here:C_v- The average volume concentration of air pollutants in flue gas determined by measurement, ppm;

$C_д$- The average mass concentration of air pollutants in flue gas determined by measurement, мг/$м^3$;

V^o_{xx}- Theoretical volume of the dry flue gases of fuel combustion , Nm^3/kg;

α- excess air coefficient;

V_a^o- theoretical volume of required air for combustion 1 kg fuel, Nm^3/kg;

B=101325 Па – air pressure in normal conditions, Па;

t- - temperature of flue gas, ^{0}C;

p- pressure of ambient air or flue gas, Pa.

10.6 Emissions of Pollutants is determined as follows.

10.6.1 Amount of air pollutants in the flue gas from the 1kg fuel combustion, mg/(kg.f) or mg/(kg.e.f)

$$m = C_д x V_{x.x} x 10^{-3} \quad \text{or} \quad m = C_д x V_{x.x} x \left(Q_{ж.т}/Q_i^r\right) x 10^{-3} \tag{13}$$

Here: $V_{x.x}=V^o_{xx} + (\alpha - 1)\cdot V_a^o$ - the average volume of dry gas from the 1kg fuel combustion, Nm^3/kg;

$Q_{ж.т}$- lower calorific value of the equivalent fuel, kJ/kg;

Q_i^r- lower calorific value of the test fuel (as fired basis), kJ/kg.

10.6.2 The amount of pollutant corresponding to heat 1 MJ, that to the ger or the air in the house, mg/MJ

$$K = C_д \cdot V_{x.x} \cdot 10^{-3}/(Q_i^r/\eta) \tag{14}$$

10.6.3 Air pollutants formation of fuel in the unit of time,g/s

$$M = C_д \cdot B \cdot V_{x.x} \cdot 10^{-3} \tag{15}$$

Here b - the natural fuel consumption, kg/s.

11. Test report

11.1. Receiving-handover, regular and models test results shall be as official after commiting the protocol contains following informations.

a. the name and address of the appliance manufacturer;

b. the name, serial number and description of the appliance;

c. related documents of stove;

d. Used fuel type for testing;

e. Test conditions and methods;

f. This standard notation and normalized performance;

g. Test results;

h. Conclusion;

i.Test date;

j. name, signature.

12. Labeling

12.1. Each stoves used by label and write to the following things. Include:

a. The manufacturer's name and the name of the place of residence;

b. Date of manufacture;

c. Stove mark;

d. Operation instructions (of using fuel and the safety conditions);

e. The symbol of this document and national conformity mark (images) used on the label;

f. Warranty;

Annex A

Table A1. Notations and units used in calculations

No	Notation	Definition	Unit
1	A	Ash content in the residue ,	%.
2	A^r	Ash content of the test fuel (as fired basis)	%
3	B	Air pressure in the normal condition	Pa
4	Bт	Mass of the test fuel hourly (as fired basis)	Kg
5	b	Mass of the test fuel seconds (as fired basis)	kg/s
6	C^r	Carbon content of test fuel (as fired basis)	%
7	$C_{c.y.x}$	Specific heat of dry flue gases in standard conditions, depending on temperature and composition of the gases	kJ/(K·m^3)
8	$C_ч$	Carbon content of the residue, referred to the quantity of test fuel fired.	%
9	$C_{c.H2O}$	Specific heat of water vapor in flue gases in standard conditions, depending on temperature.	kJ/(K·m^3)
10	Cн	Concentration of pollutants in the normal condition	mg/nm^3
11	Cv	The average value volume concentration of air pollutants in flue gas composition determined by measurement	Ppm
12	Cд	The average value mass concentration of air pollutants in flue gas composition determined by measurement	mg/m^3
13	CO	Carbon monoxide content of the dry flue gases	%
14	CO_2	Carbon dioxide content of the dry flue gases	%
15	$G_ш$	Combustible constituents in slag referred to mass of residues	%
16	$G_{ун}$	Combustible constituents in the fly ash referred to mass of residues	%
17	H^r	Concentration of hydrogen in the fuel mass (as fired basis)	%
18	K	The amount of pollutant corresponding to heat 1 MJ, that to the ger or the air in the house	mg/MJ
19	$m_н$	Mass of fuel in the residues after test	kg
20	$m_ч$	Mass of he residues during the test	kg
21	m_a	Mass of fuel for test	kg
22	m_r	Mass of ignition fuel	kg
23	m	Amount of air pollutants in the flue gas from the 1kg fuel combustion	mg/(kg.e.f)
24	M	Air pollutants formation of fuel in the unit of time	g/s
25	N	Heating capacity of stove	kW
26	N^r	Nitrogen content in the the fuel mass (as fired basis)	%
27	NO_x	Nitrogen oxide	-
28	O^r	Oxygen content in the the fuel mass (as fired basis)	%
29	P	Ambient air pressure	Pa
30	Q_i^r	lower calorific value of the test fuel (as fired basis)	MJ/kg
31	Q_i^{rr}	lower calorific value of the ignition fuel	MJ/kg
32	$Q_{ж.т}$	lower calorific value of the equivalent fuel	MJ/kg
33	Q_2	Heat losses in the flue gas	MJ/kg
34	q_2	percent of Heat losses in the flue gas	%
35	q_3	Chemical heat losses in the flue gas	%
36	q_4	heat loss from mechanical incomplete combustion	%
37	RO_2	Three atoms gas volume in the combustion products	%
38	S^r	Sulfur content in the the fuel mass (as fired basis)	%
39	SO2	Sulfur oxide	-
40	$t_{yт}$	Flue gas temperature	^{o}C
41	t_a	Indoor air temperature	^{o}C
42	V^{daf}	Volatile matter	%
43	V_a^o	Theoretical volume of air for combust ion of 1 kg fuel	nm^3/kg
44	Vx.x	Actual volume of dry combustion product	nm^3/kg
45	V_{xx}^o	Theoretical volume of dry gas from the combustion of fuel	nm^3/kg
46	W^r	Water content of the test fuel (as fired basis)	%
47	α	Excess air coefficient	-
48	τ	Total time of test	Hour
49	η	Efficiency of stove	%

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The end**.**

ANNEX 2

Meeting minutes of Energy Standardization Technical Committee
02/2016

Energy Standardization Technical Committee meeting has been held in the conference room of "National dispatch center" in 18 of November 2016.

Agenda of Meeting:
Updated Standards:

1. MNS 5216: 2016. "General technical requirements and maximum acceptable level and measuring method of pollutants in the exhaust gases of the stoves for heating and cooking".

2. MNS 5043 : 2016 4,2 MBt small water heating boiler. Technical specification.

Energy Standardization Technical Committee was conducted by the technical committee director J,Gerel.

Attendees: J.Gerel, B.Itgel, P.Byabajav, B.Turbat, D.Gyalgar, B.Amarbaysgalan, G.Erdenebileg.
Following people voted electronically: S.Bazarragcha, M.Batbold, S.Bat-Erdene, Y.Gantogoo.
Absent but supporting: G.Purevdorj, D.Jargal
Absent: T.Altangerel, D.Oyun.
Attendees were 75%.

Representatives of consulting team for developing standards:
J.Tseyen-Oidov- Professor, Doctor (Ph.D) of Power engineering school MUST
Ts.Amarjargal- Engineer of Power engineering school MUST.

Meeting Discussion:
Consulting team of Power engineering school MUST developed draft standard under the contract with " Ulaanbaatar clean air project".

Newly updated standards (MNS 5216: 2016. "General technical requirements and maximum acceptable level and measuring method of pollutants in the exhaust gases of the stoves for heating and cooking" and MNS 5041:2016 "Small hot-water boilers with capacity to 20 kW. General technical requirements, test method and maximum acceptable level of pollutants in the exhaust gases of the chimney") present by Professor J.Tseyen-Oidov.

Presentation of draft standards MNS 5216: 2016 and MNS 5043:2016 are attached.
The members of the technical committee asked about the justification for the draft standards, language and record and after received answer, issued the following proposals:

The standard improving project implementation process was based on the emission testing results of ger stove and SHWB and analyzing the current stove standards against the test results.
One of the main air pollution sources is the emissions from the traditional stoves in ger area, therefore it is necessary to eliminate these high emission traditional stoves and improve the current standards.
As of today there aren't any specific SHWB standards in Mongolia, however there are only "MNS 5041:2001 General technical requirement, SHWB with capacity of up to 100 kW" in Mongolia. Technical specifications of this standard is for SHWB with water temperature of up to 95^{o}C and pressure of 0.4 MPa, and another MNS 5457:2005 standard is for boilers with capacities from 0.8 MW to 3.15 MW. Therefore Air Quality Department of Municipality of Ulaanbaatar, SEET laboratory and other organizations have concluded that there is a need of improvement for the current stove standard and it should be suitable for the stoves with capacities of up to 20 kW.

Specifications of the current SHWB standards are different than each other, therefore the improved standards specifications are based on the stove emission and efficiency testing results and other characteristics.

Members have reviewed the draft standards and commented the following:

1. Misspelling or grammars of the standards are need to be verified
2. Some definitions and compositions need to be modified.
3. Title of the standard draft "MNS 5216: 2016, General technical requirements and maximum acceptable level and measuring method of pollutants in the exhaust gases of the stoves for heating and cooking" will change to MNS 5216: 2016, "Household stoves. General technical requirements". And standard draft MNS 5041:2016 "Small hot-water boilers with capacity to 20 kW. General technical requirements, test method and maximum acceptable level of pollutants in the exhaust gases of the chimney." will integrated with hot water boilers standard, the title of the new standard will change to MNS 5043: 2016 "Hot water boilers with capacity up to 4.2 MW. General technical requirements."

Comments from the participating organizations are annexed to the file.

Decisions:

1. Improved standards MNS 5216:2016 for household stoves, its technical requirements; MNS 5043:2016 for HWB with a capacity of up to 4.2 MW and its technical requirements are need to be discussed and approved by the National Council of standardization.
2. Effective date of the new standards will be declared and approved by the National Council of standardization meeting.
3. Many definitions and terminology of energy sectors are in need of standardization, and it needs to be presented to the Mongolian Agency for Standardization and Meteorology in order to be solved.

Minutes by: G. Erdenebileg

Reviewed by: J. Gerel