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UGANDA STANDARD

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Domestic biogas lamp — Specification

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Contents

Page

Foreword

Uganda National Bureau of Standards (UNBS) is a parastatal under the Ministry of Trade, Industry and Cooperatives established under Cap 327, of the Laws of Uganda. UNBS is mandated to co-ordinate the elaboration of standards and is

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Committee membership

Domestic Biogas Lamp — Specification

1 Scope

This Uganda Standard covers construction, operation, safety requirements, sampling and methods of test for lamps intended for use with biogas.

2 Normative references

The following referenced documents are indispensable for the application 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.

CD-ENG-12: 2012, Biogas — Glossary, and fundamental principle

3 Terms and definitions

For the purposes of this Uganda Standard the following terms and definitions, including the terms given in DUS 1641, shall apply.

3.1
Air sleeve
a sleeve with a number of air holes, which can be rotated to adjust and vary the gas and air ratio in the mantle holder

3.2
Lamp
a device used to generate light by combustion of the gas

3.3
Mantle holder
a part of the lamp, which is fitted with the carborundum venturi where a mantle can be fitted. The holder consists of gas nozzle for the flow of the gas for combustion and air holes for proper mixing of gas and air.

3.4
Reflectors
Pieces of glass, metal, or other material fitted on top of the lamp for reflecting heat and light in a required direction so that heat and light produced at the mantle is reflected below and the flow of heat through the lamp top is retarded

4 Technical requirements

4.1 Performance requirements

4.1.1 Rated pressure

The rated pressure shall be 2400 N/m^2, 1600 N/m^2 and 800 N/m^2 respectively.

4.1.2 Specified heat load

The specified heat load will not be over 525 W (450 kcal/h) while the minimum is 410W (350 kcal/h).

4.1.3 Burning stability

Under the specific pressure at the heat value being 19 MJ/m^3 (4500 kcal/m^3) and 25MJ/m^3 (6000 kcal/m^3) the lamp should be flaming in a stable condition.

Under the 50 % specific pressure the biogas lamp should not be flaming back, while under the 150% specific pressure flaming should not be seen. While burning under the specific pressure the range of luminance fluctuating should not be over ±10 %.

4.1.4 Luminance

Under the three different specific pressures the luminance should not be less than the figures in Table 1 as below.

Table 1 — Luminance

Pre-lamp pressure, N/m^2	2400	1600	800
Luminance, lx	60	45	35

4.1.4 Lighting efficiency

Lighting efficiency is one of the parameters for indicating the economic effect of light sources. The lighting efficiency of the biogas lamp is the ratio of luminance to heat load with the unit being lx/W.

Under the rated pressure of pre-lamp the shining efficiency should not be less than the figure in Table 2.

Table 2 — Lighting efficiency

Pre- lamp	**2400**	**1600**	**800**
Shining Efficiency, Lx/W	**0.13**	**0.10**	**0.08**

4.1.5 Content of CO in disposal of smoke

When the lamp is working under the rated heat load, the CO (α= 1) content in the disposal of smoke is not more than 0.05%.

4.1.6 Time of igniting

The time from the mantle is burning at the rated pressure (except the mantle for the first igniting) to giving light should not be over 20 sec.

4.1.7 Noise of burning

When the lamp is working under the 150 % rated pressure the burning noise should not be more than 55dB.

4.1.8 Surface temperature

When the lamp is working at the 150 % rated pressure the surface temperature at the jet connecting to the pipe should not be over the room temperature plus 50 °C.

4.1.9 Glass mantle

The dropping rate of luminance through the glass mantle should not be over 20 %.

Resistance to sudden change of temperature: at the temperature T = 80 °C, no cracks appear for two times of sudden temperature drop.

4.2 Requirements of structure

4.2.1 The leaning rate of the central hole for the jet should not be more than 0.2mm, and the mantle jet should be protected with necessary measures.

4.2.2 The burner of the lamp should be strong and durable with air-tightness. The inner wall of the jet should be smooth without burrs.

4.2.3 The muddy head (i.e. head of burner) should not be with cracks if pottery products are used.

4.2.4 After the assembling of the lamp the leaning difference between the jet mouth and the axes of the mixing tube for the jet should not be more than 0.2 mm.

4.2.5 The switch and air adjustment board or the air-intake hole should be flexible and easy to operate. Once it is fixed on position it should not be movable.

4.2.6 For the biogas lamp with rated pressure of 2400 N/m^2 and 1600 N/m^2 , No150 yarn mantle is selected; while for that of 800 N/m^2, No.200 yarn mantle is used.

4.2.7 The requirements of the size and look for the glass mantle:

a) The geometric dimension of the glass mantle is met according to the general structure of the lamp;

b) The height difference between the upper and lower mouths of the glass mantle should not be more than ±0.5 mm;

c) The out-off roundness of the upper and lower mouths of the glass mantle should not be more than ±0.5 mm;

d) Both the upper and lower mouths for the mantle should be smooth without cuts;

e) The thickness of the mantle should be even with the difference not more than 0.5 mm.

f) The shortcoming for the glass mantle should meet the following requirements:

i. Gas bobble of over 1.0 mm is not allowed, that of less than 1.0 mm should not be too dense. Within the space of 20 mm x 20 mm no more than three bobbles are allowed.

ii. It is not allowed to be existing for calculi and sand of over 1.0 mm, and to be dense for those less than 0.5 mm. Within the space of 20 mm x 20 mm no more than three are allowed.

iii. Obvious stripes are not allowed.

4.2.8 The reflecting cover of the lamp should be smooth on the surface with smoke exhaust hole. The cover and the burner should be installed hardly.

4.3 Requirements of the materials

4.3.1 The jet mouth should be made of metal material with melting point being over 500°C.

4.3.2 The burner should be made of metal material with melting point being over 700°C.

4.3.4 The sealing materials contacting biogas and the lubrication agent for the switch should be suitable for the features of biogas.

4.3.5 The reflecting cover of the lamp should be made of materials of heat resistance at least 500^{o}C, higher coefficient of surface reflection of at least 40%.

4.3.6 The materials used shall comply with the relevant Uganda or International Standards.

5 Test methods

5.1 Test conditions.

5.1.1 The temperature at the lab should be kept between 15 – 25°C. During the test process the fluctuation of the room temperature should be less than ±3 °C. And the content for the CO in the room should be less than 0.002 %. The air flow rate should be not more than 0.5m/s while the humidity in the air should be controlled under 80 %.

5.1.2 In the test system it should be installed with high-pressure biogas storage cylinder and pressure adjustment equipment. During the test process the fluctuation of the pressure should not be more than ±20 Pa.

5.1.3 In the test system it should be installed with high-pressure biogas storage cylinder and pressure adjustment equipment. During the test process the fluctuation of the pressure should not be more than ±20 Pa.

5.1.4 The luminance of the biogas lamp should be tested in a special dark room or box, while the inner wall of which should be white. The base luminance value should be zero.

5.2 Test of gas use.

The low heat value of man-made biogas is fixed as 21 MJ/m^3 ±1 MJ/m3 (standard volume) (5250 Kcal/m^3 ±240 Kcal/m3).

5.3 Apparatus and system for testing

5.3.1 The apparatus for testing should be stipulated as in Table 3 and checking and adjustment should be done before testing.

Table 3 — Accuracy of measuring equipment

	Testing item	Name of apparatus	Specification	Precision
1.	Temperature of biogas and indoor	Glass, alcohol and thermometer	$0 - 50^0$ C	0.5^0C
2.	Biogas pressure	U-type pressure meter	±5000Pa	10Pa
3.	Biogas flow	Wet-type gas-flow meter	0.5m3/h	0.2L
4.	Atmosphere pressure	Box-type gas pressure meter	81-107kPa	0.1kPa
5.	Time	Watch of second	15 min	0.2sec.
6.	Luminance	Luminance meter	0.1-199 900lx	0.1lx
7.	Smoke content	Gas chromatograph & Infrared-CO analyzer		
8.	Heat value of biogas	Water-flow type, thermo flow-meter		
9.	Surface temperature	Surface thermometer	0—200 °C	2 °C
10.	Noise	Sound meter	40-140dB- human audible range	0.5dB
11.	Glass-cover with sudden temperature change	Constant temperature oven	0-150 °C	2 °C
12.	Wind speed	Hot-ball breezing instrument	0-5m/s	0.2m/s
13.	NOTE Testing gas: 21± 1 MJ/m3 (60 % CH_4 + 40 % CO_2)			

5.3.2 The test system is seen in Figure 1.

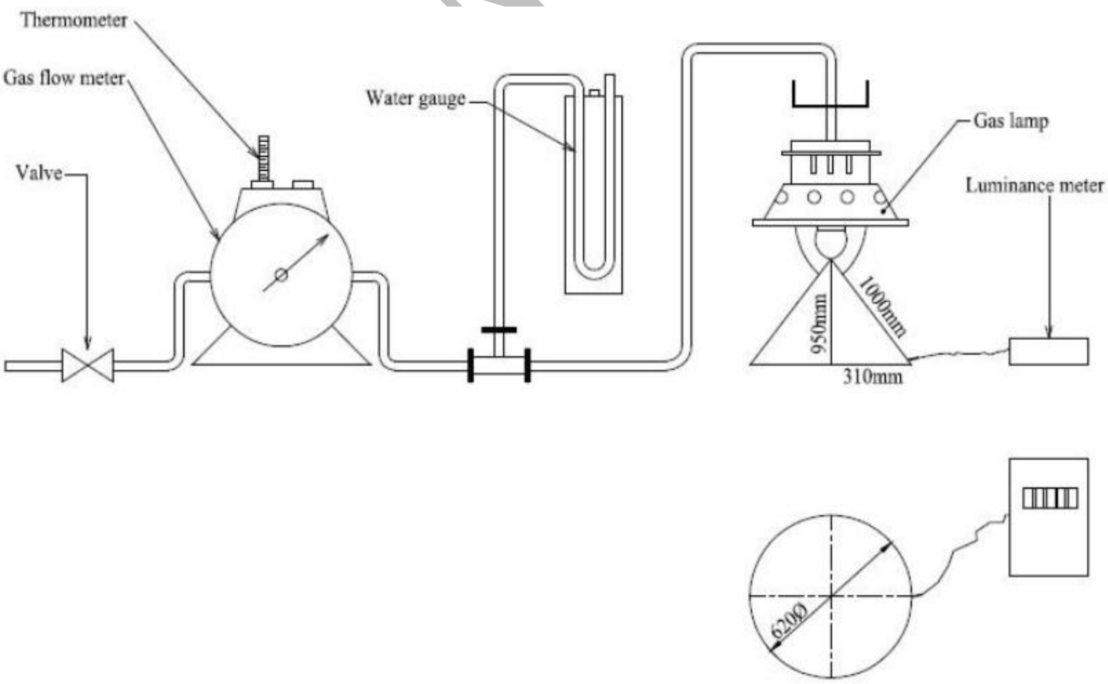


Figure 1 —Biogas lamp testing set up

5.4 The test content and method

5.4.1 Check the structure, dimensions, materials and processing preciseness and installation to see if they meet the requirements of drawings and technology.

5.4.2 Check of air-tightness from the intake of gas to jet mouth when the valve is at the position of open (shut the jet mouth) and close, and under the pressure of 10,000 Pa (1000mmH_2O) for 1min, the reading of the U-type pressure meter should not drop.

5.4.3 Heat load Switch on the lamp at the rated pressure and adjust the lamp to the optimum condition and let it burn for 10 minutes, then record the initial reading on the gas flow-meter. At the same time timing starts until 6 minutes to record the final reading to seek out the difference value.

The rated heat load at the standard pressure is calculated by conversion of the following formula (1):

$$I_0 = V.Q\left(\frac{T_0}{T_0+t}\right)\left(\frac{P_a+P_g-P_v}{P_0}\right)\left(f_1.f_2\right) \qquad (1)$$

Where:

I_0 Heat load of the lamp, W;

V Wet biogas flow detected by the flow meter, m^3/h;

Q Low heat value under the standard state, KJ/m^3;

T_0 Temperature of thermostatic of biogas under the standard state, 273K;

I Temperature of biogas at the outlet of the gas flow-meter, °C;

P_a Atmosphere pressure at the lab, Pa;

P_v Steam branch pressure from biogas at the outlet of the gas flow-meter, Pa;

P_o Standard atmosphere, 101325Pa;

f_1 Revised coefficient of the flow-meter;

f_2 Conversion coefficient of heat unit, 0.277 78

5.4.4 Stability of burning

Under the rated pressure of 0.5 times switch on the lamp and observe if there is fire back within 10 minutes.

Under the rated pressure of 1.5 times and observe if there is flame appearing.

Under the rated pressure and at the 0.95 m from the yarn mantle to test the maximum and minimum. luminance of the biogas lamp. Compare with the average luminance the value should not be over ±10%.

5.4.5 Luminance and lighting efficiency

The biogas lamp should be installed with a glass mantle and adjusted with proper amount of air intake. After 10 minutes of ignition until the luminance get to the optimum value test the luminance in a normal way.

At the four selected points on the circle of 0.95 m vertical from the hanging lamp and 0.31 m in radius put the photo-sensitive elements of the luminance meter pointing to the lamp, the mean luminance at the four points should not be lower than the stipulated value in Table 1.

Put the photo-sensitive elements as at the horizontal distance of 0.95 m from the desk biogas lamp on the random four points of the circle with 0.31 m in radius, the average luminance on the four points should not be less than the stipulated value in Table 1.

Make the comparison between the luminance of the lamp and the heat load of the light source, the lighting efficiency should not be lower than the stipulated value in Table 2.

The lighting efficiency is figured out by the following formula (2):

$$N = E\frac{E_v}{I_O} \qquad (2)$$

Where:

N Lighting efficiency, lx/W;

E_v Luminance

I_0 Heat load of the lamp, W.

The test should be done at least for two times. The final result is from the average value detected and the relative error for each time value $\Delta = \frac{Max - Min}{MeanValue}$ should not be over 5 %. Otherwise do it again.

5.4.6 CO content in exhausted smoke

While detecting the luminance of the lamp, use a ring-type sample collector to put it above 3-5 mm of the yarn mantle. It is forbidden to touch flame. The speed for take the smoke is 0.5 - 1 L/min, and the oxygen content in the sample should not be over 12 %.

The ring-type sample collector is made of copper or stainless steel tube with inner diameter of 3 mm and inner-wall of 1 mm. In the inner side of the ring-type tube it is evenly distributed with 12 gas intake holes, each of 0.5mm in diameter.

While exhausting smoke the content of CO is calculated as follows:

$$CO(\alpha = 1) = \frac{CO^b - CO^c\left(O_2/20.9\right)}{1-\left(O_2/20.9\right)} \qquad (3)$$

Where:

$CO(\alpha=1)$ As surplus air coefficient being 1, the Carbonmonoxide content of dry smoke, %;

CO^b Carbonmonoxide content in the sample of smoke, %;

CO^c Carbonmonoxide content in the indoor air, %;

O_2 Oxygen content in the sample of smoke, %

5.4.7 Noise

In the environment of base noise less than 45 dB switching on the lamp at the rated pressure of 1.5 times test the burning noise at 0.5 m in front of the lamp with Grade A of a sound meter.

5.4.8 Surface temperature

Igniting the lamp at the rated pressure of 1.5 times for 30 min, then detect the joint temperature between the jet mouse and plastic pipe.

5.4.9 Glass mantle

5.4.9.1 The detecting of luminance dropping rate

a) Under the rated pressure detect respectively the luminance with the glass mantle and without it, record the reading.

b) Calculate the average value for three times according to the formula (4):

$$L_{DR} = \frac{L_0 - Lg}{L0} \times 100 \qquad (4)$$

Where:

L_{DR} Luminance dropping rate (%)

L_0 Luminance without glass mantle

L_g Luminance with Glass mantle

5.4.9.2 Detecting of resistance to sudden temperature change

The temperature change of the oven with constant temperature is ±2 °C. At temperature $\Delta t = 80$ °C, put the glass mantle into the oven within 5 sec. After 5 minutes at stable temperature of 15 s ±1 s and cool it in the air to see if there is crack or not. Do the test for two times for the same sample.

5.4.9.3 Check of geometric dimension and outlook

Check gas bubble, calculi, all geometric dimensions by eyes and ruler. Take 30 samples randomly each time. When 8 % is not qualified take samples doubly. If it is still over 8 % not qualified, it means the whole batch is not qualified.

6 Regulations of test

6.1 Ex-factory check

The products should be checked by the authorized quality test department before being taken out the factory. For items of 4.1.2, 4.1.3, 4.1.4, 4.1.6, 4.1.7, 4.1.10, the products shall be tested at the delivery.

6.2 Model test

In case of any one of the following conditions it should take model test.

a) After normal production if there is a big change of structure, materials and production process, which may affect the character of the products;

b) At the time of new products being appraised;

c) When the production to be restarted after a long time stop;

d) In case the test result is of big difference at the ex-factory with that of the last model test;

e) At the request of the monitoring authority to make the model test;

f) For the continuous production such test should be done once a year;

6.3 Classification of items and identification

The classification of items and identification is seen in Table 4.

Table 4 — Disqualification item classification and determination methods

Clasification	Series	Item	Mode of Identification
A	1	Luminance	All items should be qualified
	2	Burning stability	
B	3	Igniting time	One unqualified item is allowed
	4	CO content in smoke exhausted	
	5	Dropping rate of luminance for the glass mantle	
	6	Character of the glass mantle on resisting sudden change of temperature	
C		Others	Five unqualified item is allowed

6.4 Sample size

The number of samples for quality test should not be less than three. If the results do not meet the requirements, do the test repeatedly with double sample quantity. If there is still one lamp which cannot meet the requirements in the result of the repeat test, it means the whole batch of the products is not qualified.

7 Process quality control

7.1 Quality checking during manufacturing

The manufacturer shall consistently check the quality of the product during various stages of its manufacturing. Quality control at following points are recommended, however depending upon the procedure followed the manufacturer may include other suitable points also:

a) Raw material shall be checked to ensure that they conform to the requirements of Clause 4.2.

b) Mantle holder shall be checked as follows:

i. Diameter and concentricity of jet hole.

ii. Quality and measurement of inside and outside thread

iii. Length and diameter of sleeve

iv. Position and diameter of air holes

v. Quality of the machining.

c) Air sleeve shall be checked as follows

i. Inside diameter of the sleeve

ii. Position and diameter of air holes.

iii. Position and quality of handle. Quality of brazing

d) Reflectors shall be checked as follows

i. Position and diameter of central hole of upper reflector.

ii. Position and diameter of holes for turning lock and hinges in upper reflector.

iii. Position and diameter of holes for spoke, hinges for lower reflector

iv. Centre distance between holes of lock holes and hinge holes.

v. Dimensional measurements of lock set.

vi. Quality of powder coat on the lower reflectors.

e) Spokes and glass holder shall be checked as follows

i. Dimensional requirements of spokes.

ii. Position and diameter of holes on spokes.

iii. Profile (V- shape) of spokes.

iv. Dimensional requirements of glass holder.

v. Quality of Powder coat on the spokes and glass holder

f) The lamps shall be assembled completely to check the quality of fitting.

7.2 Quality plan

The supplier shall prepare a quality plan describing exactly how the specification and other quality requirements specified in this standard will be met. The plan shall clearly specify different inspection/ control points. The supplier shall maintain records of dimensional checks, visual inspection and other tests carried as a proof of conformance of the product to the requirements of this standard. The supplier shall preserve and present these records whenever required.

8 Workmanship and finish

The finish and workman ship of the lamp parts shall be of high quality. The surface of the lamp shall be smooth, without any blur, projections or protrusion. Any sharp edge shall be suitably removed. There shall be no leakage of gas from threaded joints of the lamp assembly.

9 Sampling

This sampling plan shall be followed for any lot wise inspection of the products for the purpose of lot acceptance.

9.1 Batch — all of the products cast from one melt shall constitute a batch.

9.2 Lot — a number of products offered for inspection at one time and manufactured from the raw material from same source shall constitute a lot. Maximum and recommended lot size shall be 500 sets of biogas lamp.

9.3 Defective sample, any sample not conforming to any one or more of the specified requirements.

9.4 Random sampling

A random sampling method ensuring that every piece of products offered for inspection shall have equal probability for being selected as a sample shall be followed. Either of the two random sampling methods shall be followed:

(a) Systematic sampling

(b) Use of random sampling table

9.5 Sampling plan for visual inspection and dimensional check

9.5.1 Sampling plan

Table 2 — Sampling plan

Lot size	Sample size	Acceptance number	Rejection number
(a)	(b)	(c)	(d)
1 – 15	2	0	1
16 – 90	13	1	2
91 – 150	20	2	3
151 – 280	32	3	4
281 – 500	50	5	6

9.5.2 Criteria for conformity

For the lot size specified in column (a) of the above table sample size specified in column (b) shall be inspected for visual and dimensional requirements. If the number of defected samples is less or equal to the number mentioned in column (c) then the lot shall be considered conforming to the requirements of this standard in visual and dimensional requirements, if the total number of defective samples is equal to or more than the number mentioned in column d then the lot shall be considered not conforming to the requirements of this standard.

10 Marking

Each biogas lamp shall be legibly and indelibly marked as following;

10.1 Lower reflector of every lamp shall permanently be marked with the following information

a) Manufacturers name/ or logo/ or any other identification

b) Batch No

c) Colour code.

10.2 On the label of every individual packing:

a) Model of the biogas lamp

b) Rated pressure (Pa)

c) Heat load (W)

d) Specification of the yarn mantle matched for the lamp

e) The label shall be prepared in English.

11 Packing

11.1 Different parts of the biogas lamp shall be suitably packed. All parts except the glass shall then be packed inside a cardboard box. On the outside of the box it should be marked with names of the manufacture, names of products, model, quantity, dimensions of the outlook, weight and ex-factory date. Further, it is also necessary to be marked with damp-proof, quakeproof and handle with care, glass products easy to break etc. The box shall be securely sealed with the label in place.

11.2 Glass shall be separately packed in appropriate protective packing.

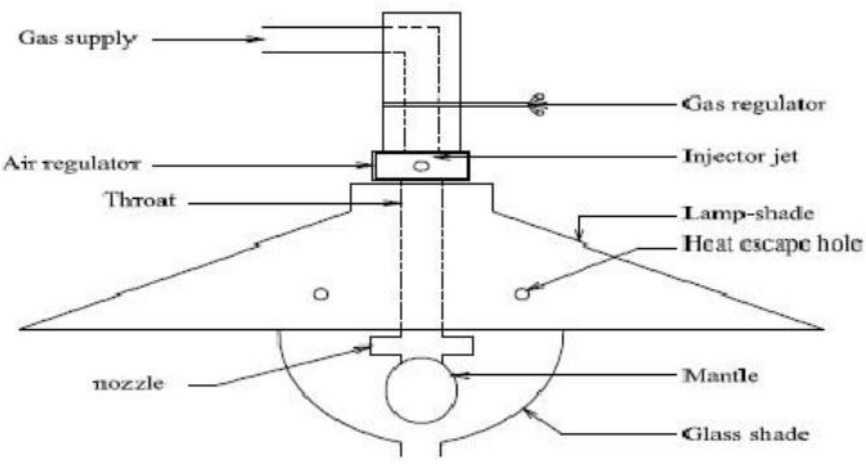
11.3 Each product should be packed with quality certificate and manual book.

Annex A
(normative)

Illustration of General Biogas Lamp Parts

A.1 General Features

Biogas can be burnt in lighting mantles. A biogas lamp consists of gas supply tube, a gas regulator, gas injector jet, primary air hole (s) or air regulator, a nozzle, a silk mantle, a lamp shade and a glass shade (reflector). Schematic diagram of a biogas lamp is shown in Figure A.1.



Mantles are normally made by saturating a ramie-based artificial silk or rayon fabric with rare earth oxides (cerium and thorium). It resembles a small net bag. A binding thread made of ceramic fiber thread is provided for tying it onto the head. When heated at a temperature of more than 1000ºC, the mantle glows brightly in the visible spectrum while emitting little infrared radiation. Fabric of the mantle, when flamed for the first time, burns away, leaving a residue of metal oxide. Therefore the mantle shrinks and becomes very fragile after its first use.

In a lamp, the burning gas heats a mantle until it glows brightly. The key factors which determine the luminous efficiency are the type and size of mantle, the inlet gas pressure and the fuel-air mixture. The hottest inner core of the flame, should match exactly with the form of the mantle. If the mantle body is too large, it will show dark spots. If the flame is too large, then gas consumption will be too high for the light flux yield. If the inlet gas pressure is below 75 mm water column, the lighting is poor. The lighting is satisfactory if the gas pressure is above 100 mm water column and excellent at 150 mm water column. If the flame is too large, then gas consumption will be too high for the light flux yield. The maximum light flux values that can be obtained with biogas are 400-500 lumens, corresponding to luminous efficiency in the range of 1.2 to 2.0 lm/W and equivalent to those of a normal 25-75 W incandescent light bulb.

Annex B
(informative)

Biogas Combustion

B.1 Combustion

Biogas burns in oxygen to give carbon dioxide and water and energy content in methane is released.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Energy}$$

Each m3 of biogas releases about 20-24 MJ of energy. The oxygen required for combustion is taken from air, which contains approximately 21 per cent oxygen and 79 per cent nitrogen by volume. The chemical reaction is depicted below:

$$CH_4 + 2O_2 + 7.5N_2 \longrightarrow CO_2 + 2H_2O + 7.5N_2 + \text{Energy}$$

Thus, about 9.5 volumes of air per volume of combustion of methane are required to achieve complete oxidation. This is the stoichiometric methane-air mixture and is the optimum concentration of methane in air at which complete combustion occurs without unused air or fuel. The combustion of biogas involves mixing of air with fuel gas, adding heat in the form of a pilot and burning the resultant air-gas mixture. The chemical reaction of combustion of biogas (containing 60 % methane and 40 % carbon dioxide) and air mixture is shown below:

$$0.6CH_4 + 0.4CO_2 + 1.2O_2 + 4.5N_2 \longrightarrow CO_2 + 1.2H_2O + 4.5N_2 + \text{Energy}$$

Thus, one volume of biogas requires 5.7 volumes of air or the stoichiometric requirement is 1/ (1+5.7) = 0.149, i.e., 14.9 per cent biogas in air.

The biogas burns over a narrow range of mixtures from approximately 9 per cent to 17 percent of biogas in air. If the flame is 'too rich', i.e., has too much fuel, then it will burn badly and incompletely, giving carbon monoxide, which is poisonous and soot particles. Therefore, the designs of appliances should aim at to maximize the conversion of methane into carbon dioxide in order to minimize the release of unburned methane and products of incomplete combustion.

The large quantity of carbon dioxide present in biogas poses a threat to stable combustion of biogas. CO2 traps not only heat but it also interacts with the flame which could potentially cool the flame down enough that it becomes unstable and blows out. Similarly, the water vapours present in biogas have a small but noticeable impact on flame temperature, inflammability limits, lower heating value and air-fuel ratio of biogas.

B.2 Flame

Biogas flame is cone shaped and consists of an inner cone and an outer mantle as shown in Figure B.1. When biogas and air mixture reaches the burner ports and burnt with a pilot heat, it forms a cone shaped blue flame. The cone shape of the flame is a result of laminar flow in a cylindrical mixing tube. The unburned gas is heated up in an inner cone and starts burning at the flame front. The mixture at the centre of the tube moves at a higher velocity than at the outside. In the main combustion zone, gas burns in the primary air and generates heat in the flame and combustion is completed at the outer mantle of the flame with the aid of secondary air or the flame from the sides. With the vertical rise of combustion products, i.e., carbon dioxide and water vapours, heat is transferred to the air close to the top of the flame. The hot air, which moves vertically away, draws in cooler secondary air to the base of the flame. The size of the inner cone depends on the primary aeration. A high proportion of primary air makes the flame much smaller and concentrated, giving higher flame temperature. If combustion is complete, which requires a temperature of less than 850°C and residence time of less than 0.3 second, the flame is dark blue and almost invisible in daylight. If too little air is available, then the gas does not burn fully and part of the gas escapes unused. With too much supply of air, the flame cools off and as a result the consumption of biogas is increased and the cooking time is prolonged. Further there is a risk of flame lifting which can result in undesirable high CO concentration.

Bibliography

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