

PUTTING INTO OPERATION



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1. Preparatory works

1.1. Initial putting into operation

Only trained GILLES staff may put the equipment into operation. The training of the future user's staff is an integrated part of work within the facility initial putting into operation. Please, assure the presence of the future personnel on these works!

1.2. Preparatory works

- Examination of all the electrical devices.
- Check up, whether the heating system is duly vented, and whether the facility pressure is sufficient.
- Control the presence of all the safety equipment and their functionality.
- Control the sufficient ventilation of the heating room.
- Adjust the required parameters and options.
- Prepare the fuel (is the fuel storage room filled up?)
- See the instruction for starting the heating.

2. How to put the facility into operation

2.1. Putting into operation

The GILLES representative or an authorised GILLES contractual partner shall adjust the program data for SPS to every one type of heating system according the individual requirements.

These data shall be stored for the case of some system failure or breakdown. Nevertheless, the user may change these data at any time, if necessary. More detailed information may be found in the chapter **Adjustment of the control parameters**. Following any changes, the parameters are automatically stored, so it is assured that no data disappear even in case, when master switch is off. The equipment continues all its functions fully automatically, preserving all the programmed data and functions



NOTICE

The equipment shall be handed over upon its initial putting into operation and upon the training of the user's staff.

The warranty period starts from this date!

2.2. Heating




WARNING

Before switching on the facility, it is unconditionally necessary to assure that no person can be endangered by the heating system!


Lock-off the master switch before repeated switching on.

Then select the operating mode on the control panel – **Manual**.


08:10:11 Boiler 72 C
Control is off

 continue continue


Inc. - Quantity 0050 %
02- Rate 12,9 %

 continue

Program selection 0
Control is off

 continue

Program selection 1
Manual operation

 confirm

Fuel feeding

For the transportation of fuel from the fuel storage room to the heating facility burner use only the manual-operating mode.



Fuel feeding in manual operation mode shall start with continue



Manual operation
F1 onw. F2 backw.

Worm screw direction of rotation (forwards/ reversed)
Wait 2 seconds at each key pressing
F2 backw. may be pressed only once, then pressing **F1 onw.** (often) is possible, after **F1 onw. the backw. F2** is allowed again (once)



F1-Onwards 5 sec. at least.



F2 The reversed worm screw revolution is limited for 2 seconds.

Ignition

Then select operating mode on the control panel **Automatic operation**

08:10:11 BOILER 72 C
Manual operation



continue

Incl. -Quantity 0050 %
02-Rate 12,9 %



continue

Program selection 0
Control is off



continue, press more times... till

Program selection 4
Automatic operation



confirm

08:10:11 BOILER 62 C
Automatic operation



press more times – back to main display

The automatic ignition is initiated and the heating system starts to work.

3. Exhaust gases measurement

3.1 Brief information about the flue gases values

Specification	Abbreviation	Correct value	Remarks
Carbon dioxide	CO ₂	> 10... 12 Vol-%	Participant on the greenhouse effect. CO ₂ as a combustion product is retained by wood (nutrition substance for plants) that is why the wood is „CO ₂ neutral“:
Oxygen	O ₂	< 7... 10 VW»	Residual oxygen from the burning air.
Carbon monoxide	CO	< 500... 1.000 mg/m _N ³ 13 Vol-% O ₂	Dangerous blood toxicant, hampering the blood ventilation. In the air degrades very quickly.
Nitrogen oxide	NO _x	< 200... 500 mg/m _N ³ 13 Vol-% O ₂	Resp. toxicant, strongly depending on the nitrogen concentration in the fuel. The permissible values are to be kept : < 0,15 % of weight.
Hydrocarbons	HC	-	Various harmful compounds of combustion process; effects similar to those of CO; difficult to measure.
Dust	-	< 50 mg/m _N ³ 13 Vol-% O ₂	Fine particles; their quantity depends on the dust portion contained in the fuel.
Combustion efficiency	Eta, ii	> 88... 95 %	Depending on the CO ₂ - content and on the waste gases temperature (ca. boiler efficiency + 2 %).

Table. The most important flue gases values and their significations

3.1.1. Exhaust gases values – units

Sorry to state that standards or regulations do not contain any uniformly specified unit for exhaust gases measurements. The conversion calculations are very difficult and demanding, as a large number of influencing factors must be taken into consideration. The specifications in the following tables enable at least the approximate calculations.

Abbreviation	Description	Remarks
% CO ₂ and O ₂	Volume percentage (m ³ /m ³)	measured in dry flue gas flue gas (without water vapour)
ppm	Parts per million (cm ³ /m ³)	= 0,0001 Vol. %, measurement of CO and NO. Without data on CO ₂ content, the value has no significance because there is no indication about the concentration of the air and flue gas.
mg/m _N ³ 10 Vol-% O ₂	Milligram per standard cubic meter at 10% of residual oxygen in flue gas	Reference value: 1 m ³ flue gas at = 0°C and 1,013 bar and residual oxygen of the flue gas of 10 Vol-%. It indicates (in mg) the quantity of harmful substances per mN ³ of flue gas .
mg/MJ	Milligram per MJ	Reference: The lower value of the fuel caloric capacity in MJ (= 0,277 kWh). It indicates (in mg) the quantity of harmful per unit of heat.
mg/kWh	Milligram per kWh	Reference: lower value of the fuel caloric capacity in kWh (= 3,6 MJ). It indicates (in mg) the quantity of harmful per unit of heat.

Table: the most important flue gases units.

3.1.2. Conversion factors for exhaust gases valid for wood heating

CO	[ppm] at 13% O ₂	[ppm] at 10% O ₂	[mg/Nm ³] at 13% O ₂	[mg/Nm ³] at 10% O ₂	[mg/MJ]	[mg/kWh]
1 [ppm] at 13% O ₂ =	1	1,38	1,25	1,72	0,85	3,07
1 [ppm] at 10% O ₂ =	0,73	1	0,91	1,25	0,62	2,23
1 [mg/m ³] at 13% O ₂ =	0,8	1,1	1	1,38	0,68	2,45
1 [mg/ m ³] at 10% O ₂ =	0,58	0,8	0,73	1	0,5	1,78
1 [mg/MJ] =	1,17	1,61	1,47	2,02	1	3,6
1 [mg/kWh] =	0,33	0,45	0,41	0,56	0,28	1

NO_x	[ppm] at 13% O ₂	[ppm] at 10% O ₂	[mg/Nm ³] at 13% O ₂	[mg/Nm ³] at 10% O ₂	[mg/MJ]	[mg/kWh]
1 [ppm] at 13% O ₂ =	1	1,38	2,05	2,82	1,4	5,03
1 [ppm] at 10% O ₂ =	0,73	1	1,49	2,05	1,02	3,66
1 [mg/ m ³] at 13% O ₂ =	0,49	0,67	1	1,38	0,68	2,45
1 [mg/ m ³] at 10% O ₂ =	0,35	0,49	0,73	1	0,5	1,78
1 [mg/MJ] =	0,72	0,98	1,47	2,02	1	3,6
1 [mg/kWh] =	0,2	0,27	0,41	0,56	0,28	1

HC	[ppm] at 13% O ₂	[ppm] at 10% O ₂	[mg/Nm ³] at 13% O ₂	[mg/Nm ³] at 10% O ₂	[mg/MJ]	[mg/kWh]
1 [ppm] at 13% O ₂ =						
1 [ppm] at 10% O ₂ =						
1 [mg/ m ³] at 13% O ₂ =			1	1,38	0,68	2,45
1 [mg/ m ³] at 10% O ₂ =			0,73	1	0,5	1,78
1 [mg/MJ] =			1,47	2,02	1	3,6
1 [mg/kWh] =			0,41	0,56	0,28	1

DUST	[ppm] at 13% O ₂	[ppm] at 10% O ₂	[mg/Nm ³] at 13% O ₂	[mg/Nm ³] at 10% O ₂	[mg/MJ]	[mg/kWh]
1 [ppm] at 13% O ₂ =						
1 [ppm] at 10% O ₂ =						
1 [mg/ m ³] at 13% O ₂ =			1	1,38	0,68	2,45
1 [mg/ m ³] at 10% O ₂ =			0,73	1	0,5	1,78
1 [mg/MJ] =			1,47	2,02	1	3,6
1 [mg/kWh] =			0,41	0,56	0,28	1

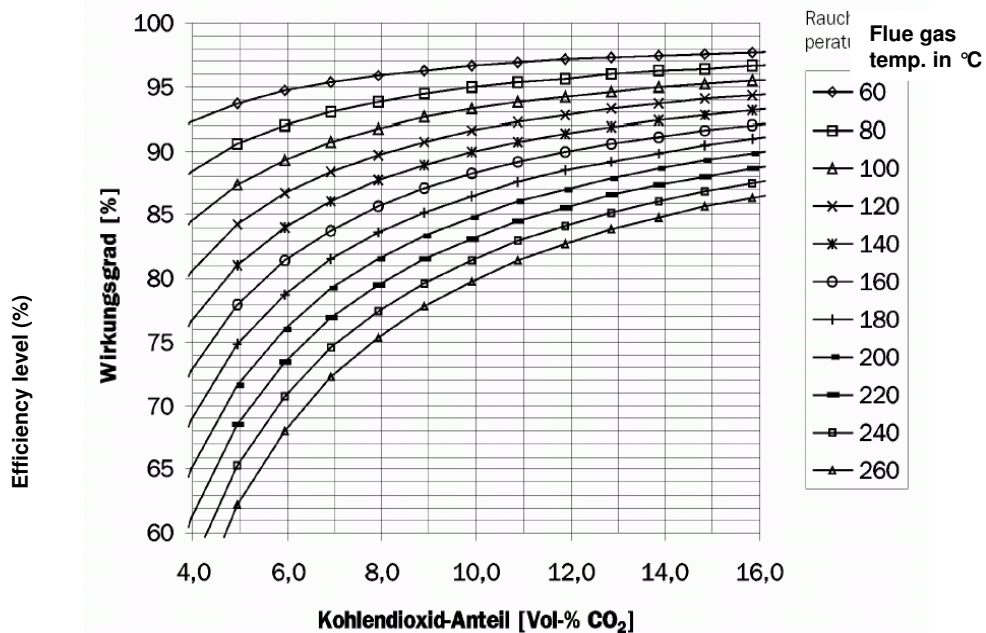
Table: Conversion factors for exhaust gases valid for wood heating (coniferous wood, 30 % of water, Resource: BLT Wieselburg

3.1.3. Conversion of the heating efficiency level

The following table and scheme represent the mathematical relation among the contents of oxygen, carbon monoxide and heating efficiency level.

Energy efficiency level in %													
Suction temperature 20 °C			Flue gas temperature °C										
O2 Vol-%	CO2 Vol-%	Lambda	60	80	100	120	140	160	180	200	220	240	260
1	19,8	1,05	98,1	97,1	96,2	95,2	94,3	93,3	92,4	91,4	90,5	89,5	88,6
2	18,8	1,10	98,	97,0	96,0	95,0	94,1	93,1	92,1	91,1	90,1	89,1	88,1
3	17,8	1,17	97,9	96,9	95,9	94,8	93,8	92,8	91,7	90,7	89,7	88,6	87,6
4	16,8	1,23	97,	96,8	95,7	94,6	93,5	92,4	91,3	90,3	89,2	88,1	87,0
5	15,8	1,31	97,	96,6	95,5	94,3	93,2	92,0	90,9	89,8	88,6	87,5	86,4
6	14,8	1,40	97,	96,4	95,2	94,0	92,8	91,6	90,4	89,2	88,0	86,8	85,6
7	13,9	1,50	97,5	96,2	94,9	93,7	92,4	91,1	89,9	88,6	87,3	86,1	84,8
8	12,9	1,61	97,3	96,0	94,6	93,3	91,9	90,6	89,2	87,9	86,5	85,2	83,8
9	11,9	1,75	97,1	95,7	94,2	92,8	91,4	89,9	88,5	87,0	85,6	84,1	82,7
10	10,9	1,90	96,9	95,3	93,8	92,2	90,7	89,1	87,6	86,0	84,5	82,9	81,4
11	9,9	2,09	96,	94,9	93,3	91,6	89,9	88,2	86,5	84,8	83,1	81,5	79,8
12	8,9	2,33	96,	94,5	92,6	90,8	88,9	87,1	85,2	83,4	81,5	79,7	77,8
13	7,9	2,62	95,9	93,8	91,8	89,7	87,7	85,6	83,6	81,5	79,5	77,4	75,4
14	6,9	2,99	95,4	93,1	90,7	88,4	86,1	83,8	81,5	79,2	76,9	74,5	72,2
15	5,9	3,49	94,7	92,0	89,3	86,7	84,0	81,4	78,7	76,0	73,4	70,7	68,0
16	4,9	4,18	93,	90,5	87,4	84,2	81,1	77,9	74,8	71,6	68,5	65,3	62,2
17	4,0	5,23	92,2	88,3	84,5	80,6	76,7	72,8	68,9	65,0	61,1	57,3	53,4
18	3,0	6,97	89,	84,7	79,6	74,5	69,4	64,2	59,1	54,0	48,9	43,8	38,7
19	2,0	10,45	84,	77,3	69,8	62,2	54,7	47,1	39,6	32,0	24,5	16,9	9,4

Table: Mathematical expression of the heating efficiency as a function of the combustion air at various flue gases temperatures valid for wood burning.



Heating efficiency level for burning of wood (water content – 20 %)

Carbon dioxide ratio (volume % of CO₂)

3.1.4. General information on carbon dioxide

- Measured in %, more precisely: volume percentage in relation to the dry flue gas.
- Carbon dioxide is produced during combustion of coal, it originates also during respiration – ca. 3 %, it consists a part of plants nutrition; known as a gas causing the greenhouse effect.
- Not smelling, colourless gas, not poisonous but irritant.
- Natural generation of CO₂ also during wood combustions. Thanks to the new grown trees consummating the CO₂, the greenhouse effect should not increase.
- Maximum value during wood combustion (CO₂max): » 20%.
- The CO₂ content should be within the range from 10 to 12%.
- Values over 14% (air shortage) cause the boiler sooting.
- Values fewer than 9% result in low combustion efficiency and in case of a wet fuel, in too low combustion temperatures.

3.1.5. General information on O₂

- Residual oxygen: remains after the fuel combustion.
- Unit: measured in %: volume percentage in relation to the dry flue gas.
- Necessary for combustion processes and for life functions: (breathing, mouldering).
- Not smelling, colourless gas, in pure state burns up completely.
- The content of O₂ in air: 21 % .
- The content of O₂ may be calculated from the CO₂ content directly:

$$\%O_2 = 21 - \%CO_2$$

3.1.6. General information on air proportion number λ

- Proportion of the combustion air quantity and the minimum air needed.
- The minimum air needed is the air quantity theoretically necessary for the fuel combustion (CO₂ = 21%, l=1) .
- This proportion should be between 1,9 and 2,3.
- The air proportion may be calculated directly form the contents of O or CO₂:

$$\lambda = 21/\%CO_2 = 21/(21-O_2)$$

3.1.7. General information on carbon monoxide CO

- Units: ppm, mg/mn³ at 13% O₂, mg/MJ
- CO is generated during an incomplete combustion of coal, caused by the air shortage or due to the too low combustion temperatures.
- Not smelling, colourless gas, it disables the oxygen transportation in blood (death, exhaust gas poisoning).

Concentration values and their impact on human beings:

>2.500 ppm death after few minutes

1000 ppm headache after 30 minutes
 vertigo after 1,5 hour,
 headache, sense malfunctions,
 vomiting after 2 hours or death after
 6 hours

400 ppm headache and sickness after 1 – 2 hours

100 ppm nominal values, influencing the health only long-continuing inspiring

Limit value

30 ppm maximum concentration on the workplace

3.1.8. General information on nitrogen oxides NO_x

- Nitrogen oxide NO (ca.95 %) and NO₂
- Units: ppm, mg/mn³ at 13 % O₂, mg/MJ
- NO_x is generated during the wood combustion, from the nitrogen contained in wood. The boiler adjusting cannot influence its content.
- The measured gas is NO. Nox can be calculated thereof.
- NO₂ is a russet gas, rasping lungs, is involved in the ozone and acid rains generation.
- The maximum permissible concentrations of nitrogen oxide in natural wood (< 0,15 of weight %) do not use to be exceeded. The content of NO₂ is rising in materials containing nitrogen (glues, grains). Thence, the substantially increased measured values represent a signal to pay attention to such pollution.

3.1.9. General information on hydrocarbons HC, C_xH_y, Corg

- Hydrocarbons, various substances (gases, tar, smoke, acids).
- Units: ppm, mg/mn³ at 13 % O₂, mg/MJ
- Hydrocarbons are generated during the wood gasifying before it burns up. They may be found in the flue gases only due to an incomplete combustion caused by to low combustion temperatures.
- Hydrocarbons are difficult to be measured because of their various bindings. The behaviour of these emissions during combustion is the same like the behaviour of CO emissions.
- Smoke, fume, smog.

3.1.10. General information on dust contents

- Any solid parts found in flue gas: soot, carbon blacks and small parts of fuel.
- Unit: mg/mn³ at 13 % O₂, mg/MJ
- The dust content is higher in case of very fine fuels combustion, or at a substantial air shortage (sooting). In the first case, these values may be lowered by decreasing the inlet of primary air; in the second case, the more amount of air should be delivered.
- There are more possibilities of measurement:
 - Ringelmann scale: The soot portion is determined either upon the black colour intensity on the filter, or
 - by a gravimetric method: the flue gas is filtered through fibreglass. This filter is weighted before and after flue gas infiltration. The difference in weights specified the impurity level. (1.BIMSCH V Germany, type approval testing).

3.1.11. General information on energy efficiency level η

The **combustion energy efficiency level** indicates the portion of the fuel energy preserved after deduction of flue gas losses (10 - 20%) and losses caused by uncompleted combustion (very low value).

The **boiler efficiency level** indicates the portion of the fuel energy preserved after deduction of flue gas losses, losses due to incomplete combustions and losses caused by boiler surface heat radiation (ca. 2 - 4%).

The flue gas losses depend on the combustion temperature and on the CO₂ content in the flue gas. The year efficiency level (75 - 90%) means a ratio of an energy used for one year and fuel amount consumed. Downtimes, starting and heat system distribution losses should be taken into consideration as well.

Flue gases temperature is increasing at
higher combustion temperature,
presence of too much air,
thick soot layer in heat exchanger.

Combustion temperature is increasing at
lower water content in fuel or
lower air excess.

3.1.12 General information on air draft

- The draft means the under pressure in the fire tube in relation to the ambient pressure.
- Units:: 1 hPa (Hektopascal) = 100 Pa = 1 mbar
- Optimum value: 0,1 - 0,2 mbar
- The chimney draft may be adjusted by means of a draught control valve. The suction ventilator increases the feeding pressure and the demand on a draft is lower, but the chimney draught is not increased!
- **The draught is worse:** at lower flue gas temperature (insulate the fire tube), narrow fire tube/chimney (caused by fly ash), horizontal or bowed fire tube/chimney, katabatic wind or fire tube leakage (draught control valve).
- **Too strong draught** causes higher air excess, a lot of cinder, increased downtimes losses.
- **Too weak draught** causes air shortage if a boiler is large, penetration of the fume into the heating room, heat accumulation in the boiler base, back fuming in the containers and ventilators.

3.2. Measurements carried out on the wood heating facilities

Measurements carried out on the wood heating systems are more exacting than measurements of gas or oil heating systems. The wood flame responds on the adjustment slowly therefore it requires longer time for stabilisation after changes of parameters.

3.2.1. Preparation for boiler measurement

In order to achieve correct results of measurements, pay attention to the following notices:

1. The boiler must be in operation already for a certain period of time. Otherwise, the measured values of exhaust gases (CO and HC) will be too high due to evaporation of the boiler surface varnish and oil layer. Nevertheless, the CO₂ content in flue gases may be set up already during the initial putting of the boiler into operation.
2. The measuring instrument must be precise (all the measuring part must be OK, no leakage or clogging of hose tubes, regular examination of all the parts is necessary).
3. Fuel: dry wood.
4. Measuring instrument is calibrated in a pure air.
5. Measurements are performed in the core of the flue gas stream (especially at lower outputs, since there the flue gas temperature is the highest).
6. The boiler must be sealed as well as possible. The false air lowers the efficiency level.
7. The measured values must be stable, otherwise, in case of substantial deviations, it is necessary to check up the heating level.
8.) The chimney and exhaust gases measurements are carried out during the closed door of combustion chamber.
9. The measurements should be carried out at the nominal loading, the control measurements may be performed also at the other loading levels.

3.2.2. Combustion adjustment (CO₂ value)

1. Let the boiler work at nominal loading for ca. 10-20 minutes.
2. Check up the draught.
3. Examine the flame shape.
4. Adjust again the parameter.

3.3. Sources of incorrect measurement values

3.3.1 Measurement procedure

The suction probe is out of flame core: If the flue gas is taken from a draught „dead“ corner, the measured value changes very slowly and the flue gas temperature is biased.

The value cannot be taken as true one: If there are deviations in measured values, the mean value must be expressed. The measurement values must be observed for at least 5 minutes.

The burner is not stabilised: The measurement may be performed only when the firing is stabilised (not raising or falling down). At lower output, it may take about one half of hour.

3.3.2. Measuring instrument

Measuring element:

Observe the indication during calibration of instrument.

Leakage of measuring instrument:

All the hose connections and condensation containers must be well sealed. Check up by a short closing of suction opening. The pump must fall down evidently.

Measuring gas stream is insufficient (clogged intake path, or damaged pump):

Occurs when there is no draught on the intake opening and the measured value is changing only very slowly. It may be caused by a drop of water in the pump valve (the instrument must be disconnected from the hoses and let dry for one day). The hoses must not be blown through when connected to the instrument – disabled pump and draught measurement!).

Calibration was not carried out in the pure air:

On the floor level the CO and CO₂ values are a little bit higher. Also, the sooted measuring instrument filter and hoses release CO and CO₂ when they are hot.

3.3.3 Boiler

Penetration of the false air into the combustion space:

The door of the combustion chamber must be tightly closed. It may be adjusted by handle and door locking.

Penetration of the false air between flue gas probe and measurement gap:

The measurement orifice should be placed 0,5 m beyond the inlet ventilator. The flue gas path (cover, Briden, connection fittings) must be perfectly sealed. When chimney draught is too strong, the inlet ventilator wave may enable the air penetration. In case of any doubt, it is recommended to drill another orifice into the fire tube shield and compare the CO₂ value.

Undesirable materials make the values of CO₂ and CO higher:

In case of new boilers, the varnish, greases and glues of insulating materials used for boiler door are releasing gases. In the old boilers, the soot layer or bad burned particles in ash may be burned again.

3.3.4 Sources of measurement incertitudes

The following errors may occur even if the measurement was performed absolutely correctly. However, these errors are negligible for the boiler installation.

Measuring instrument tolerances: (MRU Nova H8):

- Temperature: ± 2 °C
- CO₂ content: $\pm 0,2$ Vol %
- CO content: ± 25 ppm
- Draught: $\pm 0,03$ mbar

Standard values for the conversion provided by measuring instrument:

In addition to the above mentioned values and upon their basis, the measuring instrument may calculate and display also additional ones. In relation thereto, the standard values are taken into consideration for the fuel parameters (as calorific capacity, water content, chemical analyses), that do not correspond with the fuel's attributes - emission values in mg/Mg, efficiency level).

3.4. Analyses

3.4.1. Analyses: Fuel

In every case, it is strongly recommended to do some smaller tests on the delivered wood chips. These tests are simple and even the user of the facility will be able to perform them.

Visual examination of the fuel condition and size:

The fuel may contain only an insignificant portion of dust and bark. The dark colour of the wood chips may signify the presence of too high portion of bark.

- Humidity: max. 35 % of water content in fuel
- Size of pieces: max. 50 mm
- End pieces: max. 1% to 120 mm
- Fine particles: max. 5% of $\varnothing < 3$ mm
- Bark portion: max. 10%

Visual examination of the humidity level

Testing the water content in material: Take a handful of wood chips and compress it. The wood chips / filings must not form a compact matter in any case (snow ball effect).

The fuel humidity must not exceed the specified values, as the combustion would not run in a prescribed way. The achieved combustion temperatures are too low and the flue gases emission too high. In addition, there is a danger of overfilling the furnace and the flame may go out.

Generally valid rule: Always let your distributor to guarantee the quality. The quality is more important than price.

Visual examination of contamination

Foreign particles, as pieces of stone, metal, soil, too big pieces of wood, etc. may jam and damage the feeder, or they may result in creation of clinkers or pollution of the furnace.

Any other fuel – free forest wood, wood from wood processing plants – waste wood, waste pieces of hardboard, doubtful wood cuttings, etc. cannot be considered as compatible with corresponding regulation and may damage the equipment (rust, mechanical damages). They may influence also the environment adversely (heavy metal emissions). Do not use, please, such non standard fuel material in any case!

3.4.2. Analysis: malodour – smelling

„**Smoke**“: Eyes irritating when opening the furnace door: high values of hydrocarbons and CO, signalise a wet, resin fuel.

„**Coal-like smoke**“: Air shortage, high CO values, soot.

3.4.3. Analysis: Ash

Cement-like, heavy, snow -white, even dark grey, not black colorizing	Wood ash, its colour depend on the ash composition and on the combustion temperature	OK
Very fine, light, floury	Paper ash!	Unacceptable
Thick, sharp edges	Soil, sand, glass particles in fuel.	Unacceptable
Thick, rounded, smelted edges	Metal, cereal particles sintering the ash, melting due to high temperatures (very rarely)	Unacceptable
Fine pieces of charcoal	Fein fuel part are blown by heat	Should never occur, adjustment necessary
Thick pieces of charcoal	Larger pieces of fuel	Should never occur, adjustment necessary
Ash quantity	A lot of ash (more than 2 % of fuel amount) always means the presence of admixtures and non standard ah reactions. (E.g. the bark contains even up to 10 % of ash – tenfold quantity in comparison against standard	Unacceptable

3.4.4. Analyse: Combustion coating

Shiny soot (black, solid): bad or any burning out, the unburned fuel gases are condensed on the boiler wall.

Black „icicles“ hanging on the burner chamber ceiling: the boiler is not well sealed, a shiny soot originates during time down of the boiler and it catches fire at the full loading – there is a danger of chimney fire!

Soot (a dull black, mealy, „beard“): Air shortage or low burning temperature, carbon falls away, when the flue gases are cooling down.

Light, even white, mealy: High burning temperature, the lightweight ash particles are condensed on the boiler wall.

Light, even white „beard“: High content of lightweight ashes, cereal or grass admixtures.