Method of Determinig the Calorific Value

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The German standard DIN 51 900 deals with determining the calorific value with a bomb calorimeter and calculating the heating value. Furthermore this standard defines the following terms:

1. The higher heating value HHV (also known as gross calorific value) of a substance is defined as the amount of heat released by a specified quantity (initially at 25°C) once it is combusted (incinerated) and the products have returned to a temperature of 25°C. The higher heating value takes into account the latent heat of vaporization of water in the combustion products, and is useful in calculating heating values for fuels where condensation of the reaction products is practical.
2. The lower heating value LHV (also known as net calorific value) of a substance is defined as the amount of heat released by combusting (incineration) a specified quantity (initially at 25 °C or another reference state) and returning the temperature of the combustion products to 150 °C, so that the contained water remains gaseous. The lower heating value assumes the latent heat of vaporization of water in the reaction products is not recovered.

Furthermore it has to be considered whether a fuel/material has been dried or contains water. The determination of a anhydrous heating value has the advantage that the maxímum energy content of a fuel/material can be determined and the influence of water content is eliminated.

To distinguish a specific waste in terms of its treatment or thermal utilisation, respectively, the *lower heating value LHV* is relevant, because it represents the amount of heat that can be released by incineration.

Calculation of Heating Value

$$C = DM * H * 9$$

C = condensate [kg H2O]
DM = dry matter [kg TS]
H = hydrogen content of a matter [% TS]

$$LHV = DM * HHV - (m_{water} + C) * h_e$$

LHV = lower heating value of a matter [kJ]
DM = dry matter [kg DM]
HHV = higher heating value, anhydrous [kJ/kg TS]
m_{water} = water amount [kg]
C = condensate [kg H_2O]
h_e = enthalpy of evaporation [2442 kJ/kg water at 25 °C]

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Calculation of Heating Value

$$LHV^* = LHV / WM$$

LHV* = lower heating value [kJ/kg]
LHV = lower heating value of a matter [kJ]
WM = wet mass [kg FS]

$$LHV_{total} = \sum_{i=1}^{n} x_i * LHV_i$$

LHV_{total} = total LHV of a matter calculated fromdetermining the LHVs of multiple sorting fractions
x_i = portion (wet mass) of a sorting fraction of the total mass [kg/kg]
LHV_i = LHV of a sorting fraction [kJ/kg]

Even if dry material is incinerated one output of this process is water, depending on the composition of the basic material. This water is exhausting via the fumes in the gas phase. For evaporation of this water content a part of the released energy is taken.

The heat quantity, which is released as usable heat quantity (100% released heat energy less energy consumed by evaporating water generated by incineration process) is called lower heating value.

The total amount of generated heat energy is equivalent to the higher heating value HHV. Examples for lower heating value LHV (net calorific value) for dry matter:

Fuels (fossil)	**Caloric Value**
• mineral coal	27.000 – 34.000 kJ/kg
• light fuel oil	42.900 kJ/kg
• brown coal	8.400 – 11.300 kJ/kg
• wood (air-dried)	14.600 – 16.800 kJ/kg
• methane (natural gas)	50.000 kJ/kg 35.900 kJ/m³
Types of waste	
• residual waste (moist)	8.000 – 11.000 kJ/kg
• light fraction (refuse derived fuels)	16.000 – 18.000 kJ/kg
• used tyres	29.500 kJ/kg
• fermented sewage sludge (dry matter)	11.000 kJ/kg
• unfermented sewage sludge (dry matter)	17.000 kJ/kg