IEA CLEAN COAL CENTRE profiles

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Coal sampling and analysis standards

Coal is used for power generation, steel making, cement production and many other purposes. Each year, billions of tonnes of coal are traded in regional and international markets. In commercial operations, the price of coal not only reflects the quantity but also the properties. The properties of coal often form the basis of sale contracts, and include calorific value, volatile matter, moisture, sulphur, chlorine and ash (elemental composition) content. These properties are all measured at samples taken during loading of the coal. Payment for the coal is based on the analytical results.

Coal sampling and preparation

Coal sampling is performed whenever there is a need to analyse the coal. Coal is highly heterogeneous in nature consisting of particles of various shapes and sizes each having different physical characteristics, chemical properties and residual ash content. Sampling is further complicated by the sampling equipment available, the quantity to be represented by the sample mass, and the degree of precision required. In addition, the coal to be sampled may be a blend of different coal types and how the coal is blended has a profound effect on the way a representative sample is obtained. Coal sampling protocols must satisfy the general principles of sampling so as to provide material which when analysed will provide results that are representative of the lot sampled. National and international standards have been developed to provide guidelines for coal sampling procedures under different conditions, sample preparation and bias test procedures for the purpose of obtaining unbiased samples.

The selection of a sampling method depends on factors such as the sampling purpose, accuracy desired, accessibility of the site and technical, economic and time constraints. Mechanical sampling from moving streams is the preferred method for sampling fuels whilst manual sampling should always be avoided whenever possible. The best location for sampling from a moving stream is at the discharge point of a conveyor belt or chute where the complete stream can be intersected at regular intervals. Coal samples can also be taken from a moving conveyor belt. Sampling from stationary coal such as a coal storage pile or railcars is, sometimes, necessary but this is problematic. Automated mechanical sampling systems have now gained widespread applications. Modern mechanical sampling systems include some degree of preparation of the coal sample and are designed to accommodate the installation of an online coal analyser within its subsystem. To ensure a sample is representative, correct sampling and preparation procedures should be followed and certain rules adhered to. Modifications to the standard procedures may have significant effects on the precision of the final results, which can lead to disputes between the seller and the customer.

Standard laboratory tests of coal

The type of analysis normally requested by the coal mining and coal-consuming industries may be a proximate analysis and/or an ultimate analysis, together with one or more of the miscellaneous analyses or tests. Due to the heterogeneous nature of coal, several analytical techniques are needed for its characterisation in order to accurately predict its behaviour during applications such as coal combustion. The analyses need to be sufficiently accurate so as to preclude negative scientific or economic consequences. Coal has the tendency to gain or lose moisture and to undergo oxidation when exposed to the atmosphere. Also, many of the test methods applied to coal analysis are empirical in nature and therefore it is necessary that all coal analyses follow some kind of procedural guidelines in order to obtain repeatable and reproducible results. In other words, there is a requirement that reliable standard test methods be applied to coal analysis. Furthermore, the significant volume of coal traded among coal-producing and coal-consuming countries means that cross-referencing of standards for coal sampling and coal analysis accepted by both seller and buyer is a necessity. As a result, international and various national standards for coal sampling and evaluation have been well established. A detailed

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Each issue of **Profiles** is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of Profiles is based on the report:

Coal sampling and analysis standards

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description of the standard test methods that are commonly employed for analysis of coal that is used for power generation/combustion is given in this report. Strict adherence to the standard procedures is necessary to obtain repeatable and reproducible results.

Sampling and analyses normally required for coal evaluation (Speight, 2005)	
Test/property	Results/comments
Sample information	
Sample history	Sampling date, sample type, sample origin (mine, location)
	Assurance that sample represents gross consignment
Chemical properties	
Proximate analysis	Determination of the 'proximate' overall composition such as moisture, volatile matter, ash, and fixed carbon content
Ultimate analysis	Absolute measurement of the elemental composition such as carbon, hydrogen, Sulphur, nitrogen, and oxygen content
Sulphur forms	Chemically-bonded sulphur: organic, sulphide, or sulphate
Ash properties	
Elemental analysis	Major and minor elements
Mineralogical analysis Trace element analysis	Analysis of the mineral content Analysis of trace elements; some enrichment in ash
Ash fusibility	Qualitative observation of temperature at which ash passes through defined stages of fusing and flow

Instrumental analytical techniques

Conventional coal test methods are well established and are widely used in laboratories worldwide. However, these methods often involve the use of wet analysis or the use of typical laboratory bench-scale apparatus and can be time consuming. There are many relatively new approaches, usually based on modern sophisticated instrumentation, that have been shown to have wide applicability to coal analysis. Several such instruments are fast and can simultaneously determine carbon, hydrogen, and nitrogen and/or other elements in various samples. The use of instrumental analytical techniques has grown rapidly in recent years and instrumental analysis is now widely applied for analysis of coal and coal products, in particular, in online analysis of coal. The commonly used instrumental techniques for routine coal analysis mostly involve spectroscopic methods such as x-ray spectroscopy, electron microscopy, atomic spectroscopy, mass spectrometry, and neutron activation analysis. Instrumental analytical techniques enable tests of coal be carried out in situ where the coal is mined, processed, transported or utilised. Online analysers provide an automatic, fast, relatively accurate, and instantaneous method of coal analysis for pricing, quality or process control, and SO_2 emissions control. These analysers apply a wide range of technologies including nuclear, microwave, ultrasonic and optical to deliver an appropriate online solution.

Coal is an extremely complex, heterogeneous material that exhibits a wide range of physical and chemical properties. The rapid increase in coal utilisation in the twentieth century led to the development of a number of test methods for coal analysis so as to correlate coal composition and properties with its performance and behaviour during applications such as coal combustion and gasification. Over the years, new methods are continually being developed and the accepted methods are modified/optimised to increase the accuracy of the technique as well as the precision of the results. However, it is only by assiduously careful analyses of coal that the various aspects of coal usage can be achieved in an effective and environmentally acceptable manner.