Appendix-I
Proximate analysis procedure (IS 1350-Part I-1984)

Moisture content (M_o):

Two methods namely indirect and direct methods are used for determination of moisture in the coal and coke. Indirect method is divided into one stage and two stage drying of sample. In the present study, one stage (drying in air) indirect method was adopted for determination of moisture in the lignite. The first step was to heat the empty vessel at 108 ± 2°C and weighed after cooling for 20 min. in a desiccator. A lignite sample was prepared and ground to pass through the 212-micron IS sieve. The sample was uniformly spread in the vessel so that there was not more than 0.15 g of the material per cm² area, and weighed again. The vessel was uncovered in the drying oven and heated at a temperature of 108 ± 2°C for approximately 1.5 hrs. The vessel was cooled in a desiccator for 20 min. and weighed. The moisture percentage in the sample was expressed as the loss in the mass due to drying as a percentage of the total mass of the sample.

Figure I.1. Hot air oven
**Volatile matter (V):**

The volatile matter of fuel is the actual carbon present in the fuel, which when heated convert in to volatile. Initially the crucible was heated at 900 ± 10°C for 7 min. Then it was removed from the furnace and cooled first on metal plate for 5 min. and then in a desiccator for 10 min. The weight of the empty crucible was measured and lignite sample was also measured in crucible. This sample was then placed in a muffle furnace at 900 ± 10°C for about 7 min. Subsequently, crucible was removed from the furnace and cooled first on metal plate for 5 min. and then in a desiccator for 10 min. The weight of the crucible was measured. The residue left in the crucible was fixed carbon and ash. The percentage of volatile matter in the sample was calculated by following formula.

\[ \text{Volatile matter, } V = 100 \times \left( \frac{M_2-M_3}{M_2-M_1} \right) - M_o \]

Where, \( M_o \) = percentage of moisture in the sample on air dried basis  
\( M_1 \) = mass in gram of empty crucible  
\( M_2 \) = mass in gram of crucible and sample before heating  
\( M_3 \) = mass in gram of crucible and sample after heating

Figure I.2. Muffle furnace
**Ash content (A):**

Lignite sample was dried (air dried) and ground to pass through 212-micron IS sieve. The weight of empty disc or crucible was measured. A small quantity of lignite sample was placed in the crucible or dish and distributed so that spread did not exceed 0.15 g/cm². The dish or crucible was inserted in the muffle furnace at room temperature. The temperature was raised to 500 °C in 30 min. and to 815 ± 10 °C in a further 30 to 60 min. The temperature was maintained for 60 min. Then dish or crucible was removed from the furnace and allowed to cool, first on a cold metal slab for 10 min. and finally in a desiccators for 15 min. Weight of the crucible was measured. Re-ignite at the same temperature until the change in mass of the ash was less than 0.001 g. Afterward color of the ash was observed and brush out. The disc or crucible was reweighted and ash percentages obtained by using following formula:

\[
\text{Ash percentages, } A = 100 \times \left( \frac{M_3 - M_4}{M_2 - M_1} \right)
\]

Where, \(M_1\) = mass in gram of dish  
\(M_2\) = mass in gram of dish and sample  
\(M_3\) = mass in gram of dish and ash  
\(M_4\) = mass in gram of dish after brushing out the ash and on reweighing

**Fixed carbon (F):**

Fixed carbon in the lignite sample was calculated by difference. It was obtained by deducting from 100 the sum of moisture, volatile matter and ash contents and expressed as percentage, that is,  

Fixed carbon, \(F = 100 - (M_0 - V - A)\)