CONE CALORIMETRY

The Cone Calorimeter has become a standard bench scale model of early flaming. In particular, it replicates the penetrative burning seen as fire burns into a specimen. It is used as a standard test and as a research tool to understand the burning characteristics and decomposition/combustion of polymers under a range of conditions. In addition to normal, standard test measurements, a range of special research tools are available including techniques to probe into the flame and decomposition zones and extract samples for analysis under both normal and restricted burning conditions.

IMO Lateral Ignition and Flame Spread Test/Spread of Flame Apparatus (IMO-LIFT). This uses a large (1.0 x 0.3 m) area of sample which is exposed to a radiant panel, giving data on both time to ignition and rate of surface flame spread. It provides the data in a robust and repeatable way, and in addition to classifying the fire safety of products for the shipping, it has found wide use as a research tool in fire science and modelling.

Combustion Mass Loss and effluent analysis. In addition to thermogravimetric and differential thermal analysis the laboratory has a special furnace for controlled decomposition and burning of small samples of polymeric materials under a range of fire conditions to study their burning behaviour fom mass loss and residue analysis.

Other Standard Tests. In addition to our specialised research equipment, UCLan also have a number of ISO, EN, BS and ASTM standard tests for ignitability, flammability, and heat release determination. These can be modified for use in research programmes but are also available as standard tests so that materials and product behaviour can be determined in a standard manner and results directly related to the requirements of industry and regulators.

Cone calorimetry (ISO 5660)

A very well-established tool, providing data on surface ignition and penetrative burning.

This has become the established small-scale standard for measuring the rate of heat release and the effective heat of combustion from a burning polymer under a controlled radiant heat source (ISO 5660 part 1). Heat release rate is the major cause of fire spread and growth, and the timing and magnitude of the peak rate of heat release (PRHR) and the short term (e.g. 3 minute) average rates of heat release are the single most important factor in predicting fire growth rate. The cone is established as the principal technique for the measurement of a number of fire and flammability hazard parameters for early or well-ventilated fires. The cone calorimeter can also be used to determine smoke generation (ISO 5660 part 2).

The apparatus consists essentially of a conical electric heater (preset to 10 - 100 kW m-2) delivering uniform radiance to the sample (100 mm x 100 mm x up to 50 mm thick). The sample is mounted on a load cell recording its mass during the experiment. A spark is used to ignite flammable vapours. Air passes through the apparatus and tests are typically carried out under very well ventilated conditions (a modified cone calorimeter is available for studies in oxygen depleted environments, see below). The fire effluent gases travel upward into an instrumented hood system from where gas samples are collected.

The cone calorimeter measures heat release on the basis of oxygen consumption calorimetry. This is based on the fact that the heat output from many combustible materials including most natural and synthetic plastics, rubbers and textiles is almost always a constant 13.6 kJ per gram of oxygen consumed. Other gas measurements, such as carbon monoxide and carbon dioxide concentrations are made, together with measurement of smoke density. The cone calorimeter experimental conditions are usually characterised by the following parameters:

Parameter	Typical Operating Conditions	Range of Operating Conditions
Radiant Flux	15 - 75 kW m-2	10 – 100 kW m-2
Ventilation	Very well-ventilated	Controlled Atmosphere version available
Sample dimensions	10cm x 10cm x ~0.5cm	10cm x 10cm x 5cm
Orientation	Horizontal	Horizontal or Vertical

Output data are recorded for mass loss, for oxygen, carbon monoxide and carbon dioxide concentrations, for smoke density and fire effluent flow as a function of time. The raw data is manipulated and heat release rates and effective heats of combustion are calculated together with averaged data calculated by oxygen consumption calorimetry. Fire gas and smoke yields per gram of sample burnt are also calculated. Typical output summaries may include:

Cone test parameter	Typical material values
Time to ignition	3 – 600 s
Flameout time	Up to 1200 s
Time to Peak Rate of Heat Release	Often shortly after ignition for non-FR materials but some may show two peaks
Peak Rate of Heat Release	~ 250 kW m-2 but up to 650 kW m-2
Ave (3 min) rate of heat release	~100 kW m-2
Effective heat of combustion	30 MJ / kg
Total Heat Release	~ 100 MJ m-2