How Cigarettes Are Tested For Chemical Content

Recently, the British Columbia government released the amount of some 40 chemicals found in Canadian cigarettes. Below is a summary of the main chemical analysis of cigarettes.

The chemical analysis of cigarettes generally involves a three-step process: collection, extraction & processing, and quantification.

Collection

Cigarette smoke is collected by a "smoking machine". The filtered end of the cigarette is placed into a port, and "puffed" by the suction of a pump. Figure 1 shows a rotary 20-port smoking machine with a yellow cigarette in each port.

There are two types of smoking machine: rotary and linear. Rotary smoking machines collect a cumulative sample from several cigarettes per run, with each cigarette being puffed in turn by the one pump. This method is best for the collection of chemicals that are present in tobacco in very small quantities, such as the aromatic amines.

Figure 1: Rotary Smoking Machine - Analysis of Mainstream Smoke
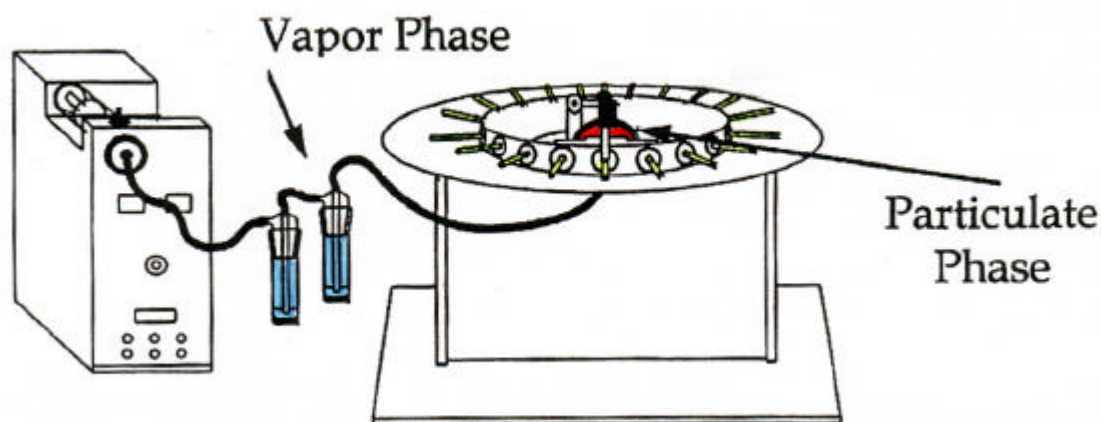
Linear smoking machines operate with one cigarette port per pump, thus each cigarette is puffed with each intake of the pumps, and samples are collected individually per port. This method is used for collection of larger quantities of chemicals, such as tar and nicotine samples.

Samples are collected for both "mainstream" and "sidestream" smoke chemicals. "Mainstream" smoke is the smoke inhaled at the filter end of the cigarette; "sidestream" smoke is that which is emitted at the lit end.

Smoke from cigarettes is comprised of approximately 12% particulate matter (solid and liquid) and about 88% gases. The particulate matter is collected mainly onto filter pads. Mainstream smoke particulates are collected on filter pads located behind the cigarette port (figures 1 & 2,

red). Sidestream smoke is collected with the use of BAT "fishtail" devices (figure 2, purple), which allow smoke to travel up the glass enclosure to a filter pad located at the top (figure 2, red).
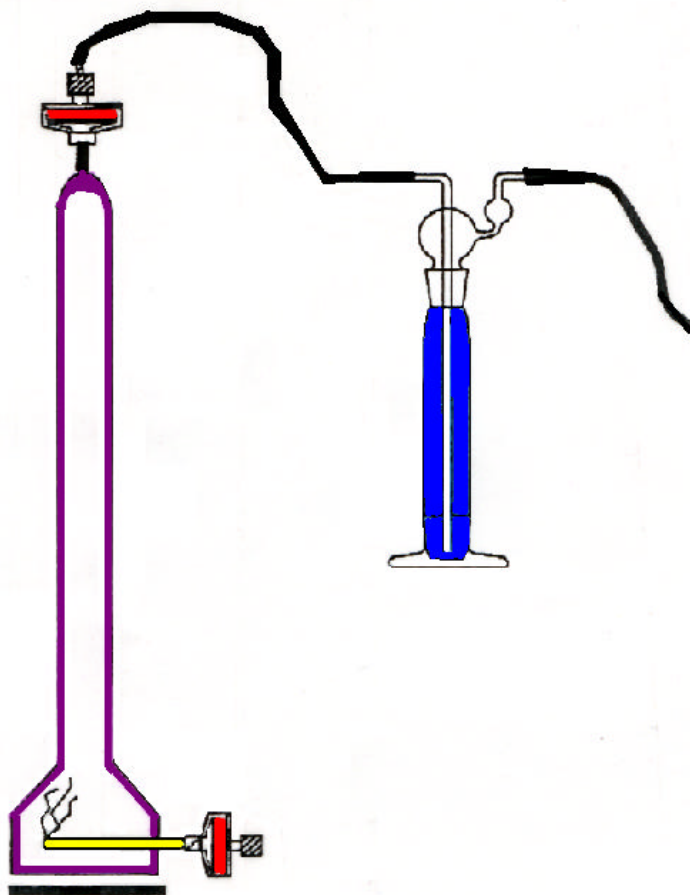
Any of the desired chemicals that travel through the filter are later trapped by "impingers" (figures 1 and 2, blue). The smoke is drawn to the impinger by a pump, and bubbled through a liquid designed to trap the chemical component by either a cooling process or a chemical reaction.

Carbon monoxide (and other gases) pass through the filter pads into collection bags, which are individually tested by a Non-Dispersive Infra-Red analyzer to determine the carbon monoxide yield per cigarette.

In order to ensure accuracy, the fishtails and tubing are rinsed into the impinger solution, and the filter pad holders wiped with the filter pad.

Figure 2: Analysis of Sidestream Smoke

Extraction & Processing

Filter pads are weighed before and after a "smoking" run to determine the Total Particulate Matter (the amount of particulates accumulated on the filter pad).

The filter pads are then placed either into the impinger solution or another solvent and the mixture is shaken to release the chemicals from the filter pads into the solution.

Once the extraction is completed, various chemical and physical separation techniques are used to isolate the desired component(s). The next step is to quantify, or find the amount of, the chemical component.

Quantification

Once the desired chemical has been isolated, various analytical methods are used to determine the amount of chemical collected (GC/MS, ion chromatography, HPLC etc).

A set of standards, containing known amounts of the desired chemicals, are set up and tested first. A "calibration curve", which is a graph showing the amount of chemical versus its analyzed value, is then constructed. Finally, the "smoked" samples are analyzed and their quantity determined by comparison with the calibration curve. Since each "smoked" sample is duplicated, precision for each run is determined by how closely the two values overlap.

During collection, a "Kentucky Reference Cigarette" is also smoked and the accuracy of the run may be determined by comparing the final quantified value of the chemical from the "Kentucky Reference Cigarette" with the known, previously determined quantity for that chemical.

Finally, the value obtained undergoes mathematical manipulation, such as accounting for dilution factors or dividing by the number of cigarettes used during collection, in order to obtain the amount per cigarette.