The physical basis and associated mathematical model for estimating the firegenerated environment and the response of sprinkler links in well- ventilated, curtained compartment fires with fusible link-actuated ceiling vents is developed.

Complete equations and assumptions are presented. Phenomena taken into account include:

- the flow dynamics of the upward-driven, buoyant fire plume;
- growth of the elevated-temperature smoke layer in the curtained compartment;
- the flow of smoke from the layer to the outside though openceiling vents; the flow of smoke below curtain partitions to building spaces adjacent to the curtained space of fire origin;
- continuation of the fire plume in the upper layer;
- heat transfer to the ceiling surface and the thermal response of the ceiling as a function of radial distance form the point of plume-ceiling impingement;
- the velocity and temperature distribution of plume-driven near-ceiling flows and the response of near-ceiling-deployed fusible links as functions of distance below the ceiling and distance from plume-ceiling impingement.

The theory presented here is the basis of a computer model now under development which will be used to study parametrically a wide range of relevant fire scenarios.

The results of the parametric study will be presented in the Part II: Application portion of this paper.