# Electronically Produced Equidensities from Time Exposures and Instantaneous Photographs in the Investigation of Pool Flames

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Information contained in the negatives of time exposures and instantaneous photographs of pool flames can be quantitatively evaluated by the use of electronical equidensitometry. In this method, up to 15 colored lines of constant optical density (equidensities) are produced. *N*-hexane, methanol, *n*-butane and liquefied natural gas, in pools of varying diameter, as well as a natural gas jet flame, are investigated without influencing the combustion processes. Equidensities obtained from time exposures, instantaneous photographs, and a series of high-speed frames are evaluated. The mathematical relationship between the optical density of the emulsion and the spectral radiance $L_\lambda$ emitted by the flame in the visible region is then derived. Thus the quantitative significance of the equidensities as lines of $L_\lambda$ = const. becomes apparent. The equidensities obtained from time exposures (long-time equidensities) can be related to the time-averaged values of flame properties such as radiance, temperature, flame shape, flame height, and soot concentration. A characteristic dependence on fuel type exists. Furthermore, the minimum sampling time for statistical combustion processes taking place in the flames is easily measured. The equidensities obtained from instantaneous photographs (short-time equidensities) afford a detailed insight into the complicated turbulent flame field. It appears that the eddies are generally elliptical. In hexane and methanol pool flames, the lengths and widths of the largest eddies increase with increasing pool diameter. The dimensions of the smallest eddies, which are almost spherical and in which the transfer of kinetic energy into heat occurs, remain constant. Using equidensities obtained from a series of high-speed frames the dissipation of a single eddy can be visualized in detail. Presently, we are using a high-speed camera to make a film of the equidensities obtained from the pool flames. In this way, the migration velocity, the dynamics of the geometrical dimensions, and the lifetime of the eddies, including their fluctuation quantities, can be determined.

## 1. INTRODUCTION

Photographic methods have often been used to investigate flames without causing inertia or influencing the process examined. We determined the shape of an *n*-hexane pool flame photographically, and computed the thus visible shape using a statistical Gaussian dispersion model [1]. We then superimposed the visible flame synchronously upon the corresponding interferogram, producing an interferometric synchron image which can be used for detailed investigation of the turbulent flame field [2-4]. Furthermore, by taking additional time exposures, we have shown [5, 6] that a Fickian diffusion with an effective diffusion coefficient of the initial fuel is present in the so-called flame neck and that soot is formed through pyrolysis. In the expanded region (flame plume) above the flame neck, a turbulent mass transport of all gaseous components, as well as of the soot, occurs [5, 6].

In the above mentioned investigations, additional quantitative information, such as optical density of the negatives, was not evaluated. Therefore, a description of the use of equidensitometry in pool flames follows in this article. Equidensitometry involves flame photographs in which lines of constant optical density (equidensities) become visible.

### 1.1 Experimental Methods of Producing Equidensities

The earliest methods of equidensitometry, negative–positive combinations, the Sabattier and


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