FLAME CHARACTERISTICS CAUSING AIR POLLUTION I. EMISSION OF OXIDES OF NITROGEN AND CARBON MONOXIDE

Joseph M. Singer
Edwin B. Cook
Joseph Grumer

U.S. Bureau of Mines, 4800 Forbes Avenue,
Pittsburgh, Pennsylvania

ABSTRACT

This investigation is part of a program by the Bureau of Mines, sponsored by the Public Health Service, to determine the factors that govern emission of air pollutants by domestic and industrial gas combustors. Methods based on kinetic and thermodynamic theory are proposed for predicting concentrations of nitrogen oxides and carbon monoxide in the combustion gases of flames, specifically of lean, stoichiometric, and rich propane-air flames. These theoretical data are compared with concentrations observed experimentally downstream of flat grid-type burner flames (approximately 25,000 Btu/hr) that were used to simulate gas appliances such as water and space heaters. Air pollutant concentrations were computed for (1) flames chemically perturbed by recycling flue gases into the primary fuel-air mixtures; (2) flames thermally perturbed by cooling the burned gases at different rates; and (3) flames perturbed by combinations of these two effects. In general, experimental and computed concentrations agreed to within a factor of 2 to 4 with the experimental values always being higher than the theoretical. Cooling the burned gases and recycling cold flue gases (with and without excess air) reduced the relative amount of nitric oxides. Carbon monoxide concentrations were substantially reduced by recycling flue gases only when the cooling rates were less than about 5000-10000°R per second.