



# Project Summary

## Comparison of Pilot Plant Data with Predictions from the U.S. EPA SPRAYMOD Computer Program

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This report compares SO<sub>2</sub> removal predictions of the EPA-developed SPRAYMOD computer program with 12 different data sets collected at the University of Tennessee with a 1000 cfm (28.3 m<sup>3</sup>/min) lime spray dryer operating without recycling of the baghouse collected solids. The experimental results were obtained with spray dryer operating conditions of: SO<sub>2</sub> concentration, 633-3178 ppm; inlet gas temperature, 123-171°C (254-339°F); and approach to saturation, 8-20°C (14-36°F).

The predicted SO<sub>2</sub> removal efficiency depended on SO<sub>2</sub> concentration and/or slurry concentration as well as the user's choice of the model reaction rate coefficient (KR). For large KR (>10<sup>5</sup> cm<sup>3</sup>/mole-s), both the backmix and plug flow models were insensitive to most operating conditions and overpredicted the observed efficiency. With KR=0, the plug flow model predicted lower efficiency, and its sensitivity to operating conditions more closely approached that seen in the pilot spray dryer. Detailed analyses of predicted versus measured efficiencies indicated the model (KR=0) to be less sensitive to lime slurry concentration and SO<sub>2</sub> concentration than the observed performance. The model underpredicted efficiency at low slurry concentrations and overpredicted efficiency at high slurry concentrations. Recommendations for improving the model are suggested.

*This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research*

*Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).*

### Introduction

The use of computer models for sulfur dioxide (SO<sub>2</sub>) removal processes allows the user to predict conditions which may not have been tested in spray dryer/fabric filter applications. This report compares the U.S. EPA-developed SPRAYMOD computer program with 12 different data bases collected at the University of Tennessee on a 1000 cfm (28.3 m<sup>3</sup>/min) spray dryer with a calcium hydroxide [Ca(OH)<sub>2</sub>] slurry. Results are presented from a variety of operating conditions for the spray dryer without recycle, including:

SO <sub>2</sub> concentration:	633-3178 ppm
Inlet temperature:	123-171°C (254-339°F)
Approach to saturation (AT):	8-20°C (14-36°F)

The SPRAYMOD computer program is a simulation program that mathematically models the removal of SO<sub>2</sub> in a spray dryer. The model developed by Research Triangle Institute under contract to EPA, is a simultaneous heat and mass transfer model that predicts the simultaneous evaporation of a droplet and the absorption/reaction of SO<sub>2</sub> with Ca(OH)<sub>2</sub> in the evaporating droplet. The SO<sub>2</sub> removal is modeled by two mecha-

nisms corresponding to wet and dry particle stages. A bulk volume reaction rate coefficient (KR) for the entire droplet/particle is used for the dry particle stage. The model includes the dissolution kinetics of the  $\text{Ca(OH)}_2$  particles within the droplet and has both backmix and plug flow reaction options. The pilot spray dryer/baghouse test facility used a slipstream of the University of Tennessee's stoker fired boilers. The pilot plant system consisted of a slaking system, a control room, a 7 ft (213 cm) diameter spray drying chamber with a variable speed Stork-Bowen AA-6 spray machine (5,000 - 21,000 rpm), and a 6 in. (15 cm) diameter centrifugal atomizer with six nozzle inserts. A baghouse, used to collect the product leaving the spray dryer, was periodically cleaned to minimize the pressure drop.

After conducting preliminary sensitivity analyses of the model and determining appropriate internal conditions for operation of the model, data analyses were conducted by comparing the measured efficiency versus stoichiometric ratio, curve for each data base to the model predicted efficiency versus stoichiometric ratio curve.

## Conclusions and Recommendations

The ability of SPRAYMOD to predict measured efficiencies was observed to depend on the operating conditions of  $\text{SO}_2$  concentration and/or slurry concentration as well as the user's choice of the model reaction rate coefficient (KR). Detailed comparative analyses were conducted of the predicted versus measured efficiencies for various assumed values of KR. The model was observed to be less sensitive to the effect of slurry concentration and  $\text{SO}_2$  concentration than the observed data. The model tended to underpredict at low slurry concentrations and overpredict at high slurry concentrations. This conclusion suggests that there is a lack of sensitivity in the model to handle the change in  $\text{Ca(OH)}_2$  dissolution and/or diffusion rate of reactants in the slurry droplet resulting from changes in the slurry concentration.

Further development could improve the model's ability to simulate spray dryer performance. Specifically, development could include modifying the dissolution equations in the model to account for potential effects of slurry concentration on the dissolution of

$\text{Ca(OH)}_2$  particles and diffusion of  $\text{SO}_2$  and calcium in the spray dryer slurry droplets. In addition, determining appropriate values of KR for inclusion in the model as a function of moisture content would eliminate the need for assuming a value of KR.

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*The complete report, entitled "Comparison of Pilot Plant Data with Predictions from the USEPA SPRAYMOD Computer Program," (Order No. PB 86-216 769/AS; Cost: \$11.95, subject to change) will be available only from:*

*National Technical Information Service*

*5285 Port Royal Road*

*Springfield, VA 22161*

*Telephone: 703-487-4650*

*The EPA Project Officer can be contacted at:*

*Air and Energy Engineering Research Laboratory*

*U.S. Environmental Protection Agency*

*Research Triangle Park, NC 27711*

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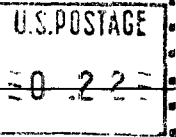
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