5.2.4 Nitrogen/Glycol-Water and Nitrogen/Glycol-Water/Sand Systems

Figures 48-57 graph the results of continuous experiments conducted with the glycol mixture to determine E_{zL}. Different liquid velocities at constant gas velocities were tested to determine the effect of liquid velocity. Table 17 lists the calculated E_{zL} numbers for the runs. Although the data were scattered, no definite trend of dependence on liquid velocity was observed.

The average value of E_{zL} over five-fold change in liquid velocity was plotted as a function of gas superficial velocity in Figure 58. The liquid dispersion coefficient increases with increasing gas velocity, in perfect agreement with the earlier observations in air/water and nitrogen/tetralin systems.

Table 18 compares experimental and calculated liquid dispersion coefficients. The data indicate that Towel's and Baird's correlations agree reasonably well with the averaged E_{zL} value. This agreement is consistent with the findings in nitrogen/tetralin system.

In the presence of solids, the E_{zL} value was similar to that found in two-phase system as shown in Table 17. However, such one-data-point comparison is probably inconclusive because of the large scatter in the two-phase system. Therefore, the true effect of solid particles on liquid dispersion coefficient will be based on the large data base from the air/water/sand and nitrogen/tetralin/sand systems.

5.3 Solids Dispersion

Solid dispersion experiments were performed in this study on a 5-inch and a 12-inch diameter column. The liquids used were water, tetralin and different concentration of ethylene glycol and water mixtures.

In the batch mode, gas was bubbled through the column, which was filled with liquid and a known weight of solid particles. During a 30-minute bubbling period at each gas velocity, steady-state conditions

Figure 48

Liquid Dispersion Coefficient

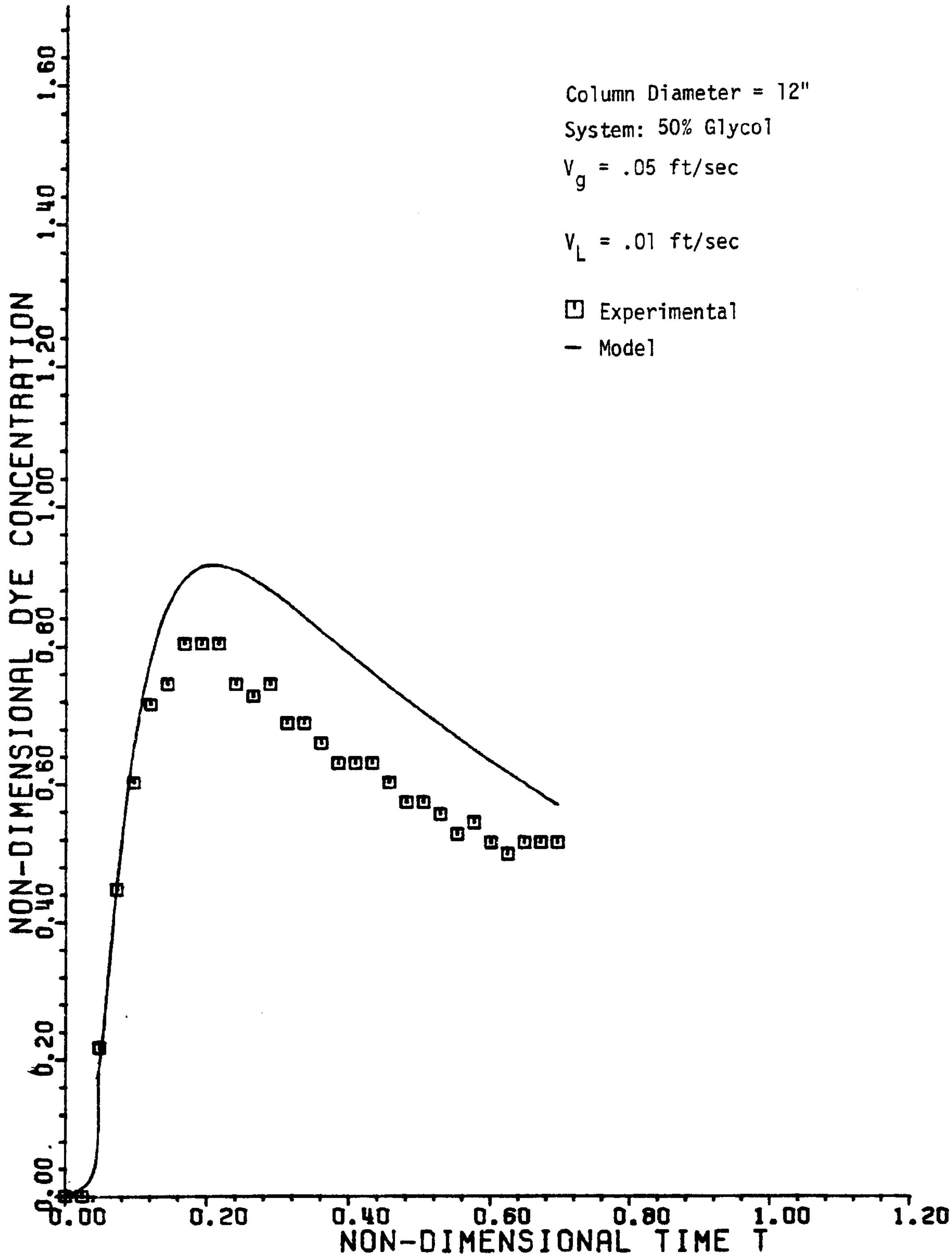

Figure 49

Liquid Dispersion Coefficient

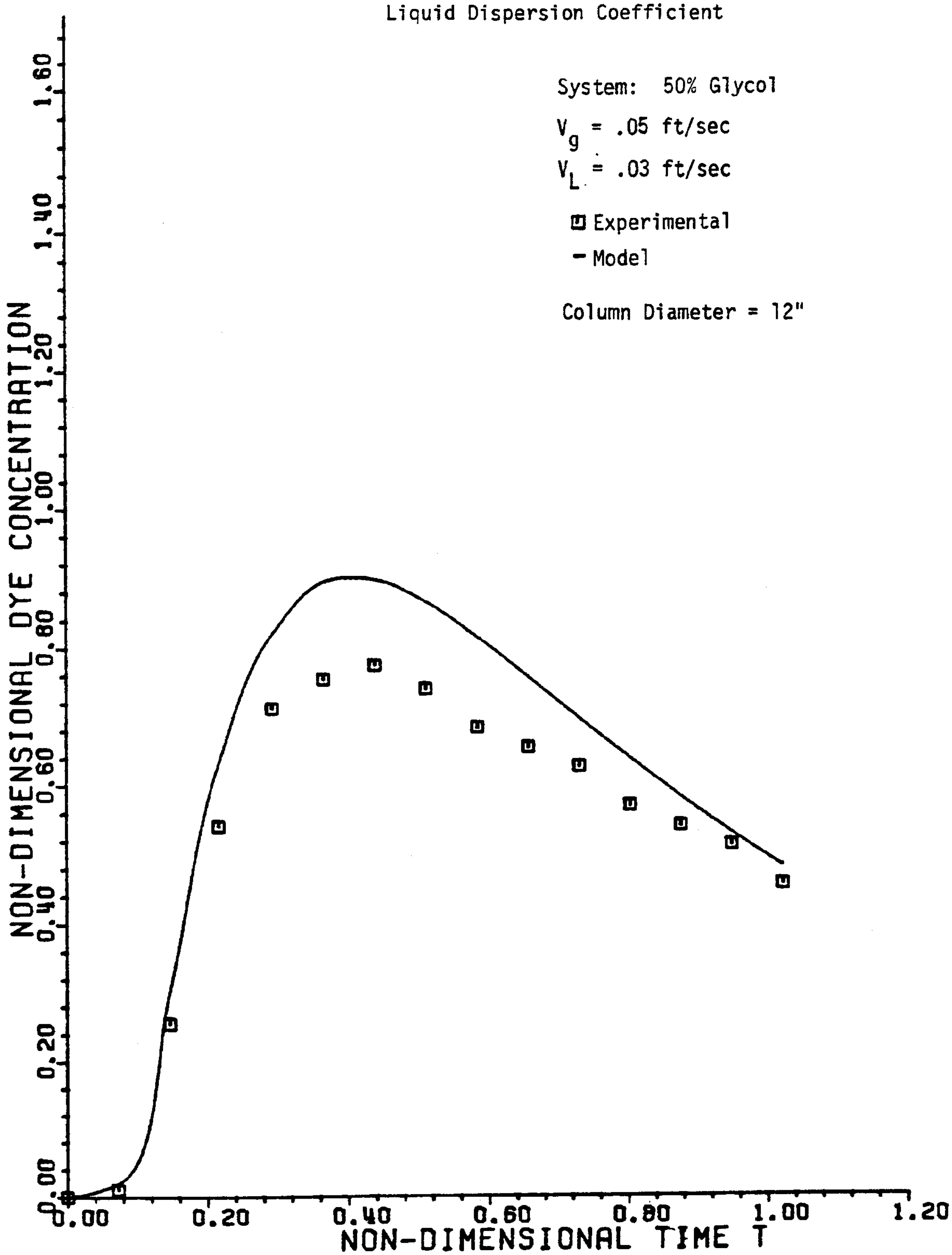

Figure 50

Liquid Dispersion Coefficient

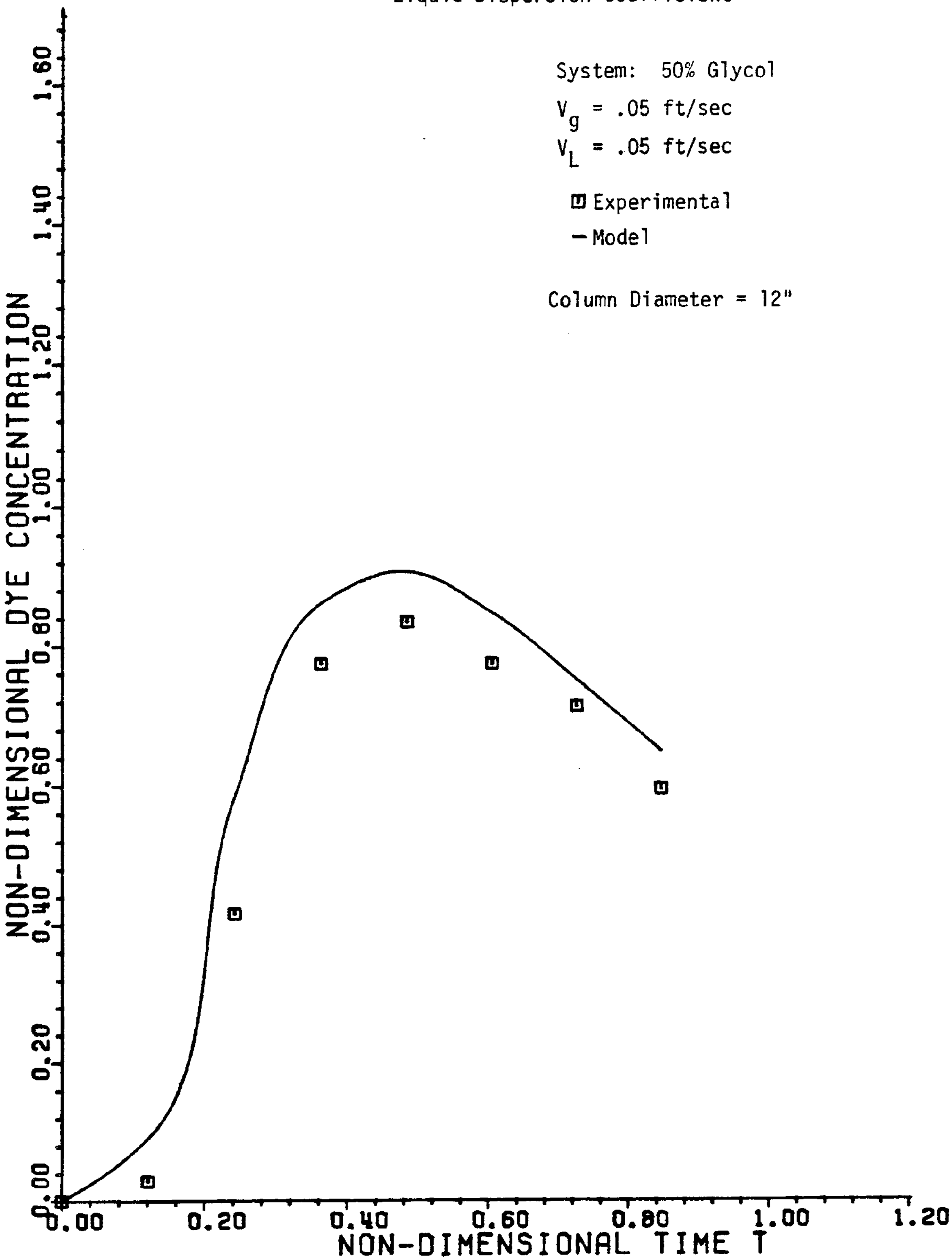

Figure 51

Li uid Dispersion Coefficient

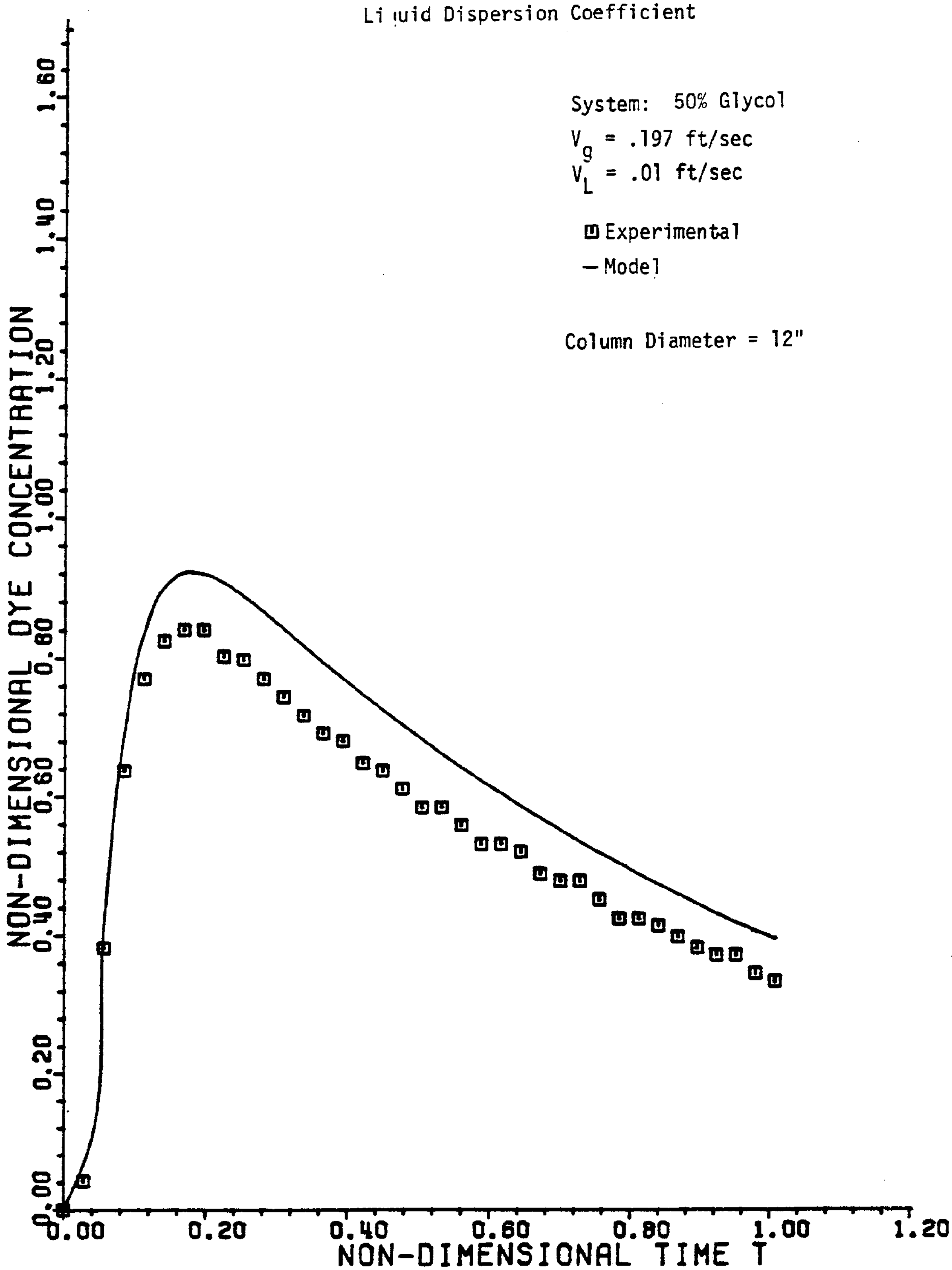

Figure 52

Liquid Dispersion Coefficient

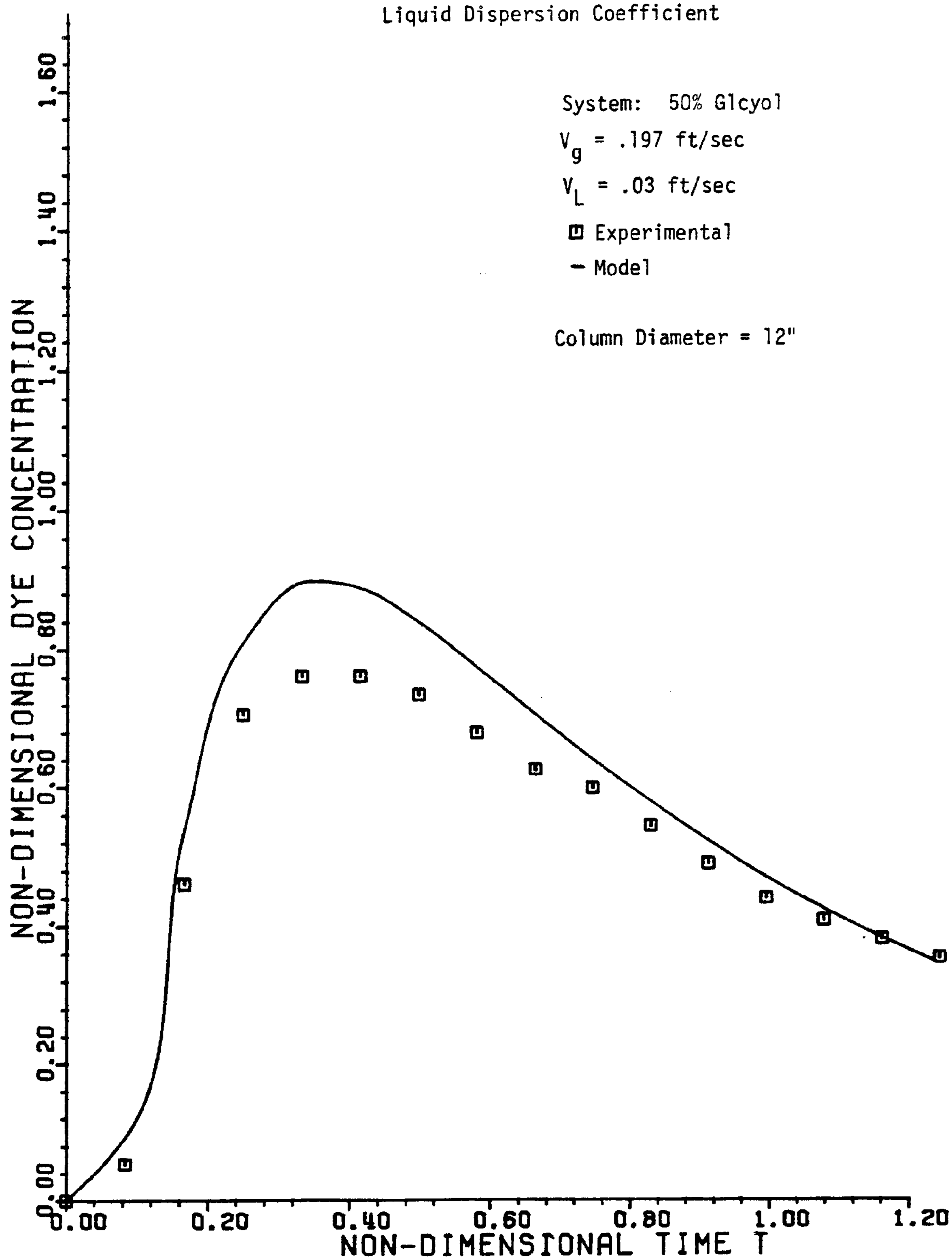

Figure 53

Liquid Dispersion Coefficient

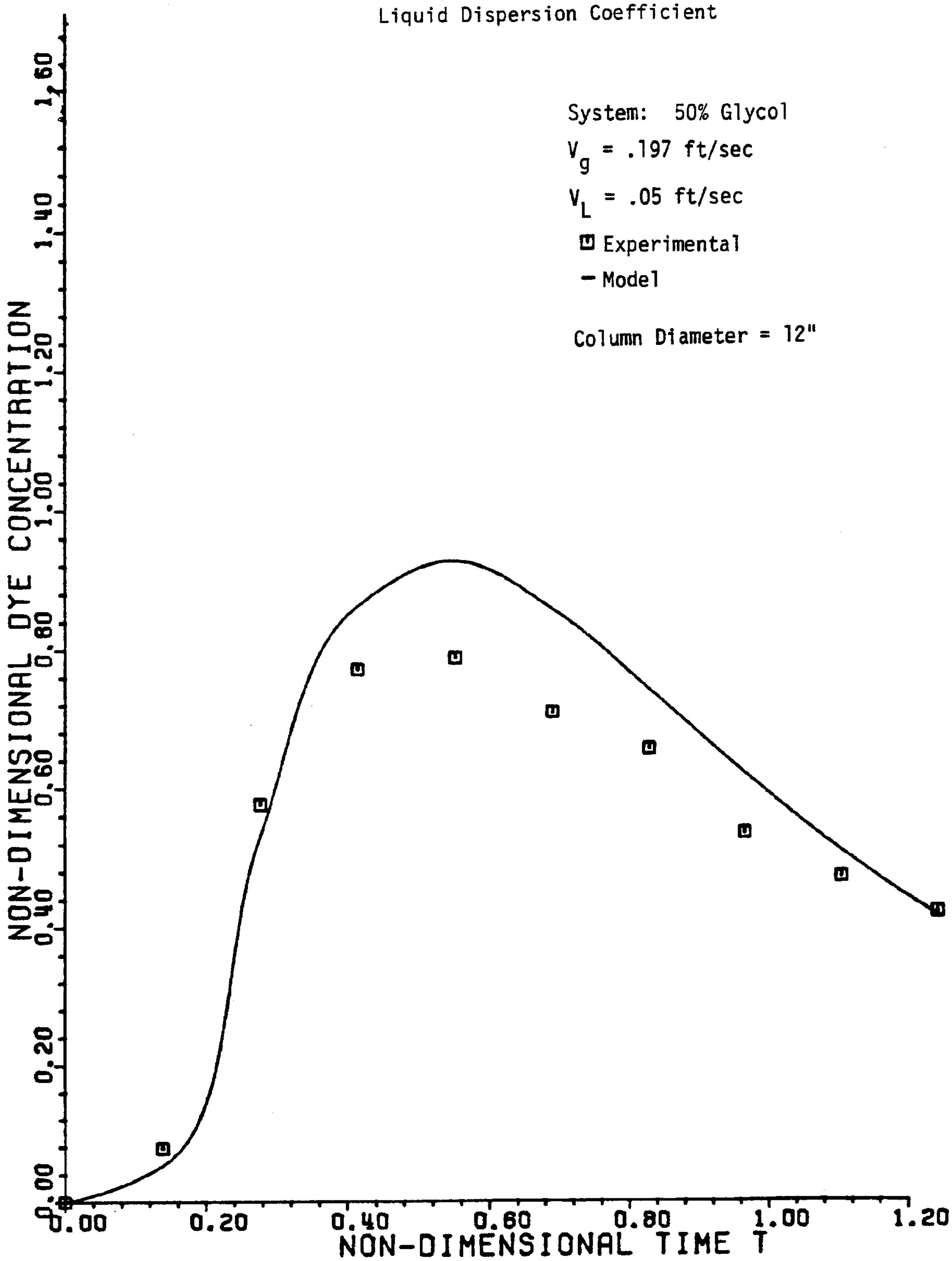

Figure 54

Liquid Dispersion Coefficient

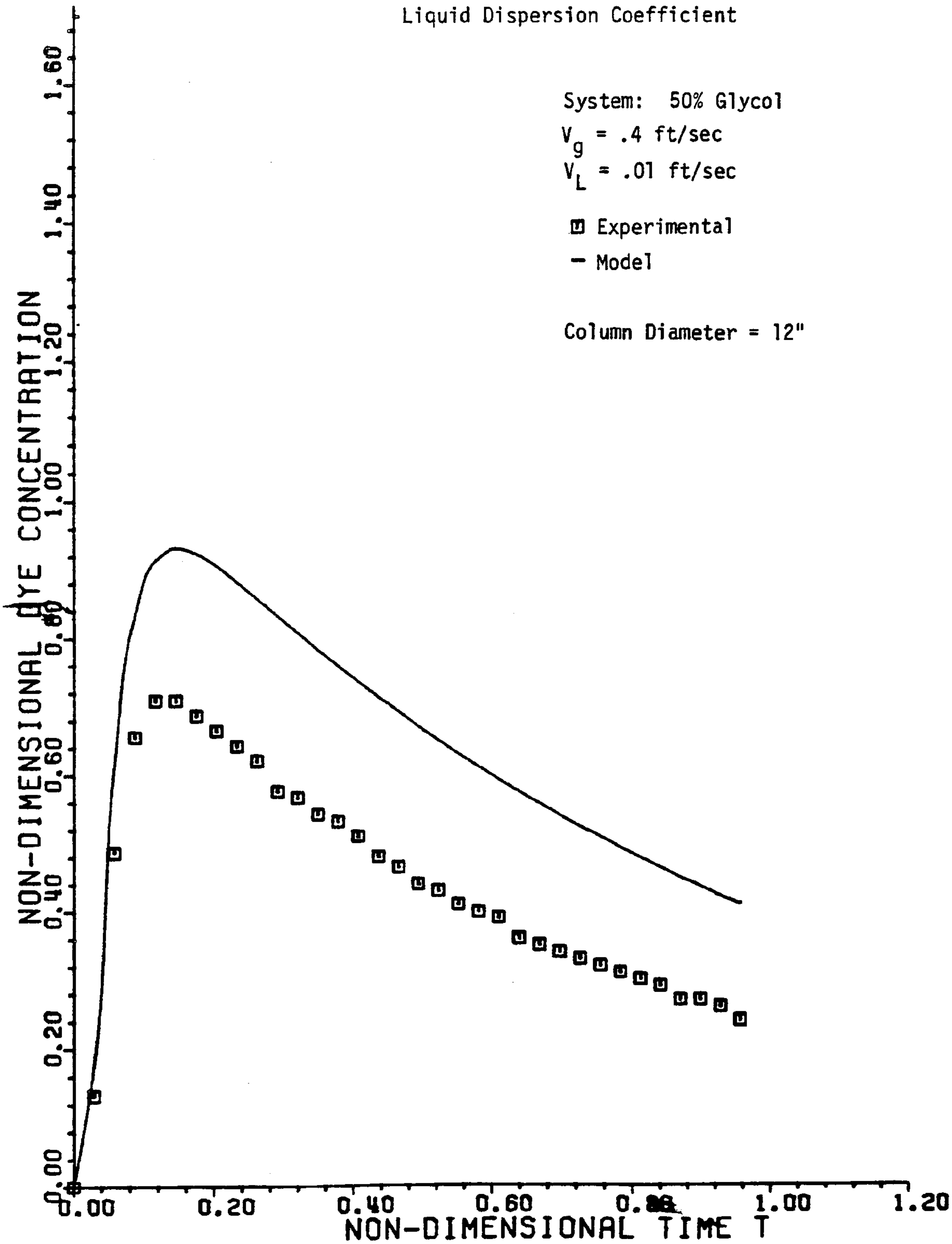

Figure 55

Liquid Dispersion Coefficient

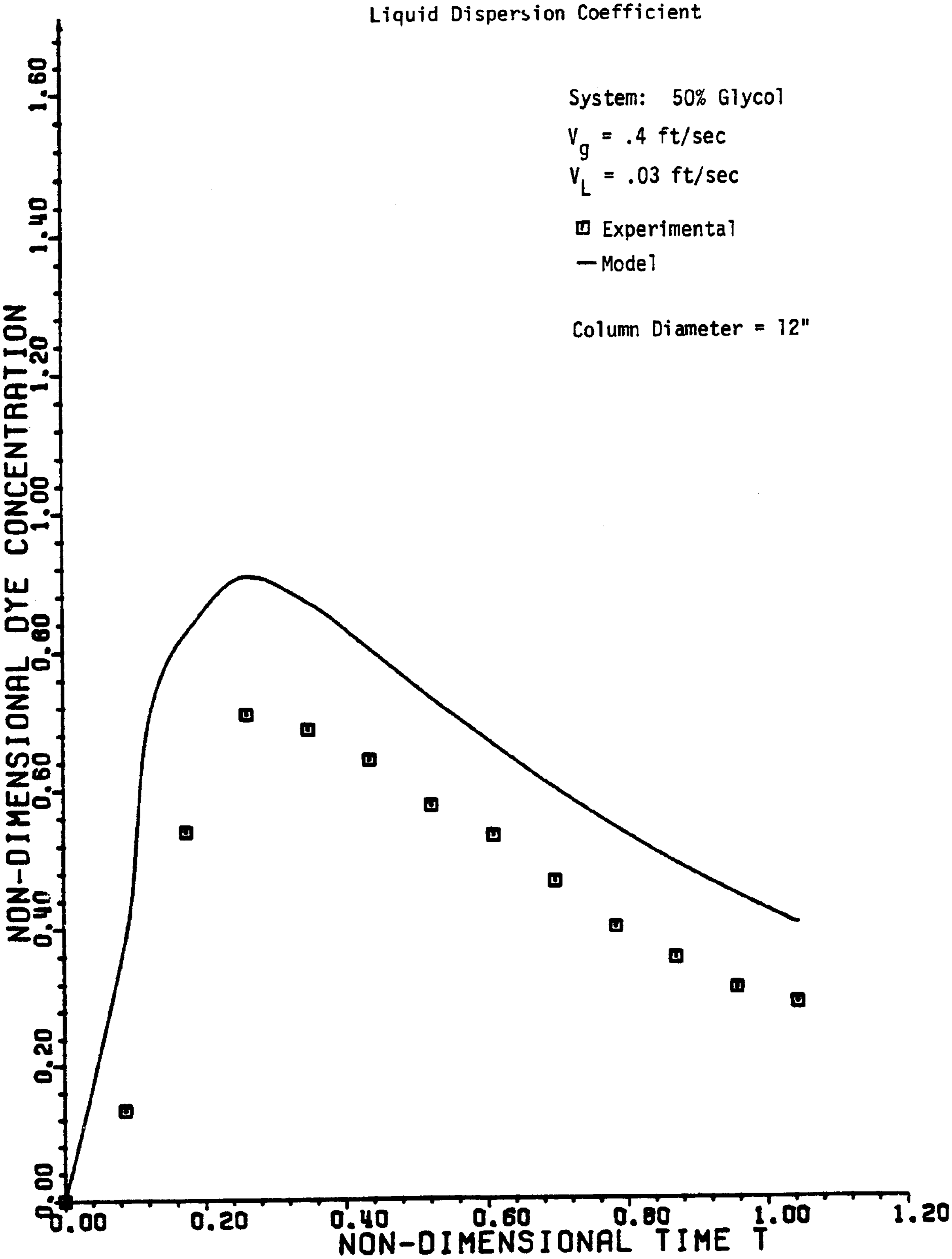

Figure 56

Liquid Dispersion Coefficient

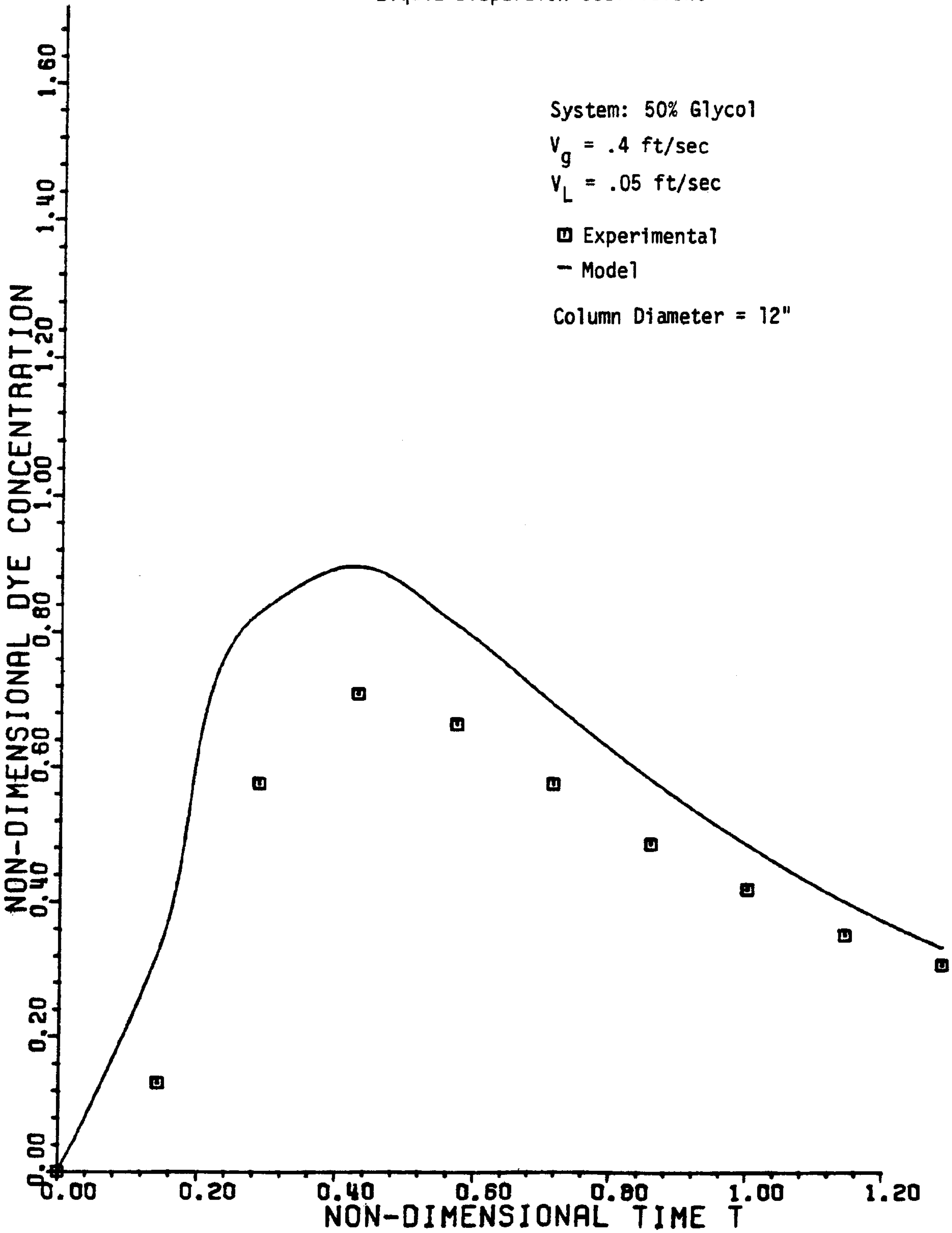

Figure 57

Liquid Dispersion Coefficient

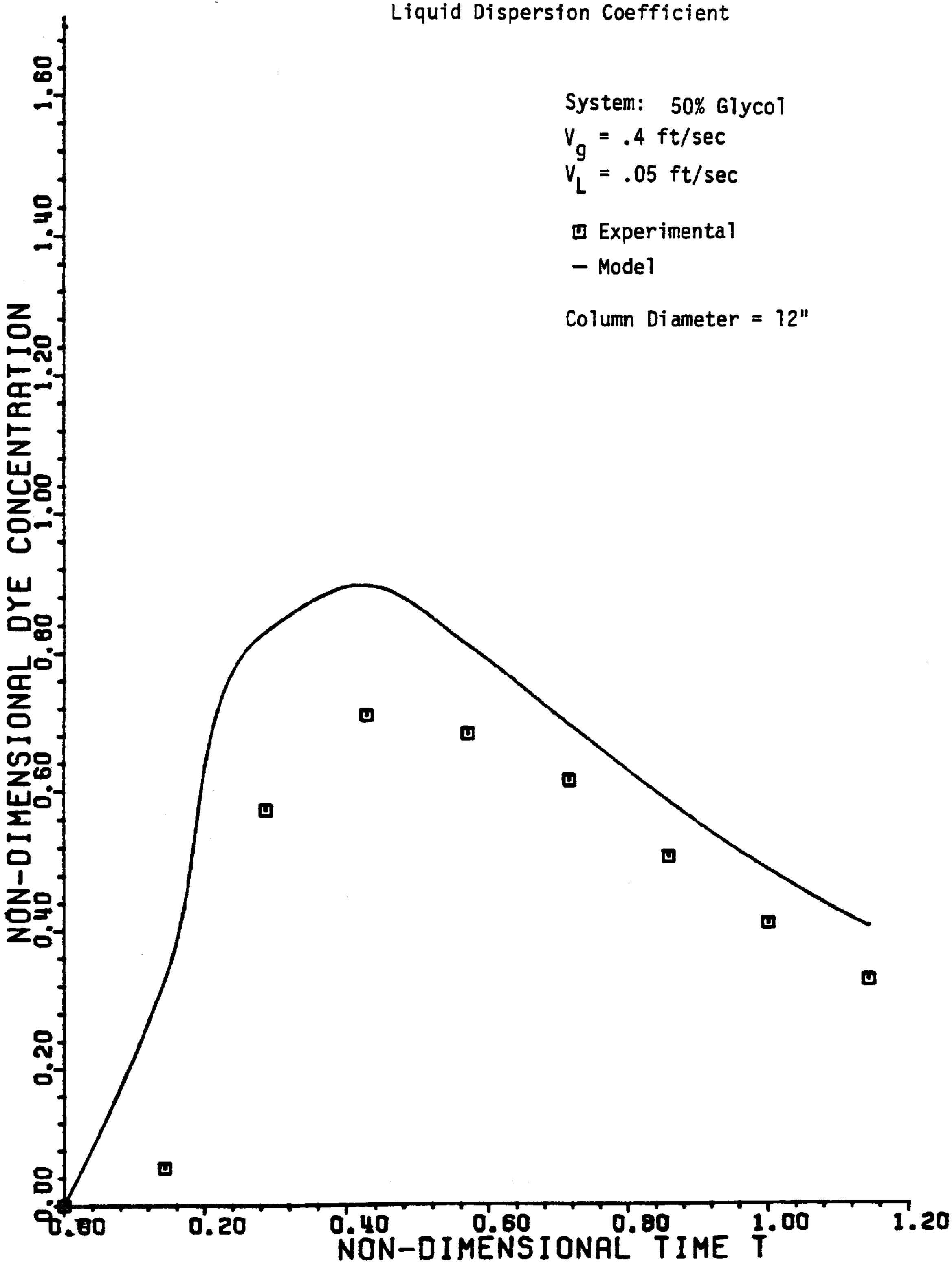

Table 17

Axial Liquid Dispersion Values (E_{zL}) in
a 50% Glycol Mixture with a 12-in. Column

V_g ft/sec	V_L ft/sec	ft^2/sec	Average Value (ft^2/sec)	Remarks
0.05	0.00	0.381		No solids
0.05	0.01	0.479		No solids
0.05	0.03	0.434	0.496	No solids
0.05	0.05	0.575		No solids
0.10	0.00	0.568		No solids
0.197	0.00	0.607		No solids
0.197	0.01	0.618		No solids
0.197	0.03	0.618	0.57	No solids
0.197	0.05	0.475		No solids
0.40	0.00	0.717		No solids
0.40	0.01	0.841		No solids
0.40	0.03	1.1	0.891	No solids
0.40	0.05	0.915		No solids
0.40	0.05	0.915	---	#60/80-mesh sand used 16.5-lb/ft^3 average concentration

FIGURE 58
COMPARISON OF E_{ZL} FOR BATCH
AND CONTINUOUS EXPERIMENTS (50% GLYCOL)

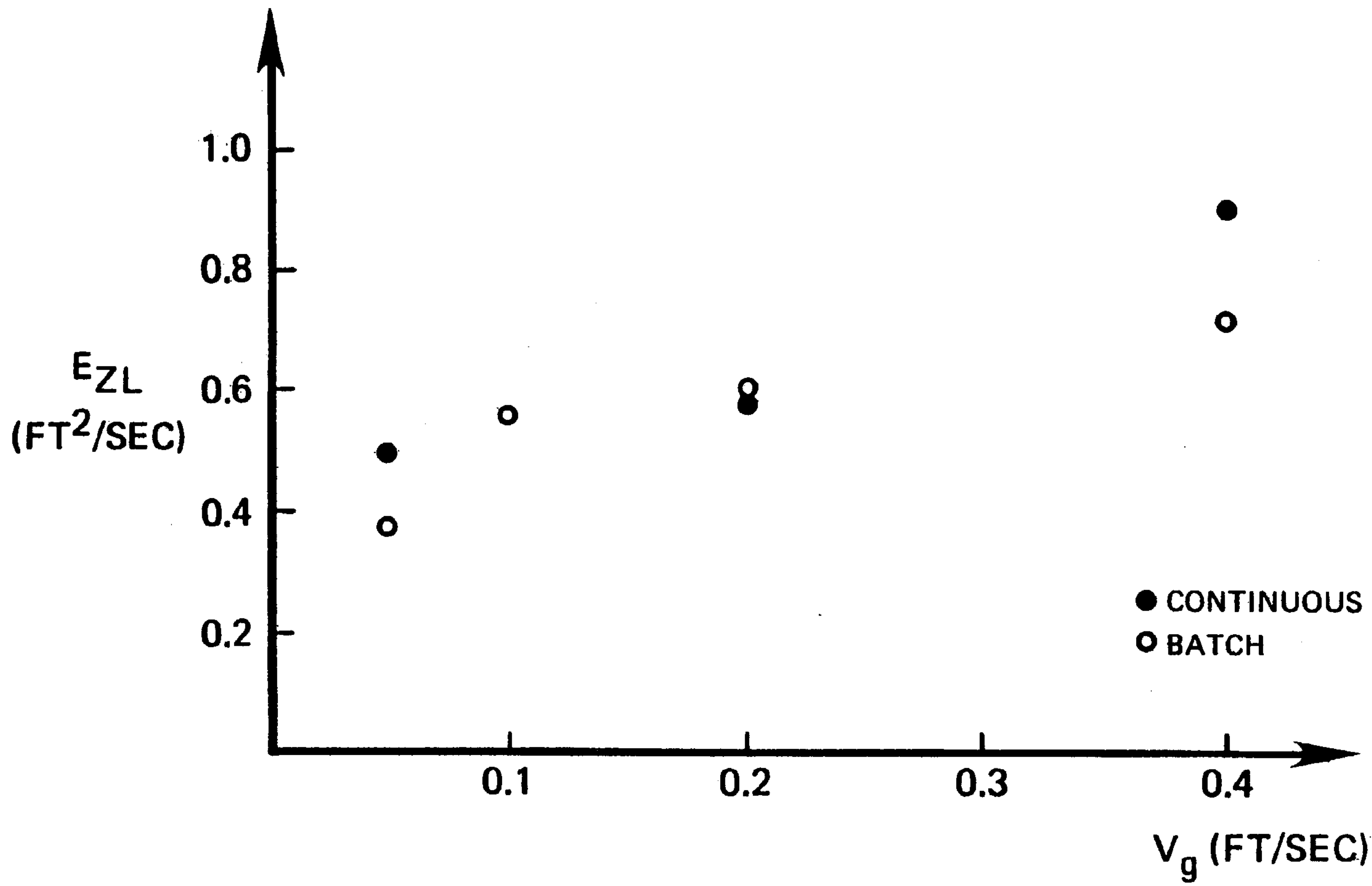

Table 18

Liquid Dispersion Coefficients in
50% Glycol with a 12-in. Diameter Column

V_g (ft/sec)	Avg. exp.	Towel	Cova	Deckwer	Hikita	Baird	Ying
0.05	0.438	0.275	0.177	0.276	0.440	0.409	0.279
0.10	0.568	0.389	0.221	0.340	0.538	0.515	0.358
0.20	0.589	0.550	0.276	0.418	0.704	0.647	0.459
0.40	0.804	0.778	0.344	0.515	0.987	0.813	0.590

were established. Then slurry samples were withdrawn from sampling ports at various heights of the column to determine solids concentration profile. In continuous operation, slurry flowed continuously through the column, and samples were withdrawn from all ports at periodic intervals over a few hours until a steady-state condition was achieved. Samples from each port were usually obtained near the wall region and the center of the tube. The average of these two samples is the average concentration considered to exist at this axial position.

5.3.1 Theoretical Background

In a batch operation (with no liquid flowing), at any cross section of the column, the mass balance of solid particles at steady-state conditions results in the following expression:

$$V_p C_s + E_{zp} \frac{dC_s}{dL} = 0 \tag{4}$$

where V_p = settling velocity of solid particles (ft/sec); C_s = concentration of solid particles in liquid (lb/ft^3); E_{zp} = dispersion coefficient of solid particles (ft^2/sec); and L = Distance from the bottom of the column (ft).

Equation 4 can be rewritten as:

$$\frac{d \ln C_s}{dL} = -V_p/E_{zp} \tag{5}$$

Therefore, a plot of ln C_s vs L should yield a straight line, provided that both V_p and E_{zp} are not functions of either solid concentration or column level. Figures 59 to 88 are semilogarithmic plots of C_s vs L as a function of gas velocity for all the experiments conducted in this research program. In general, the experimental points follow the straight-line relationship suggested by the theory.