

Figure 1
 Effect of Column Diameter on Gas Holdup
 (Tetrafin/Nitrogen; 5- and 12-in. Columns)

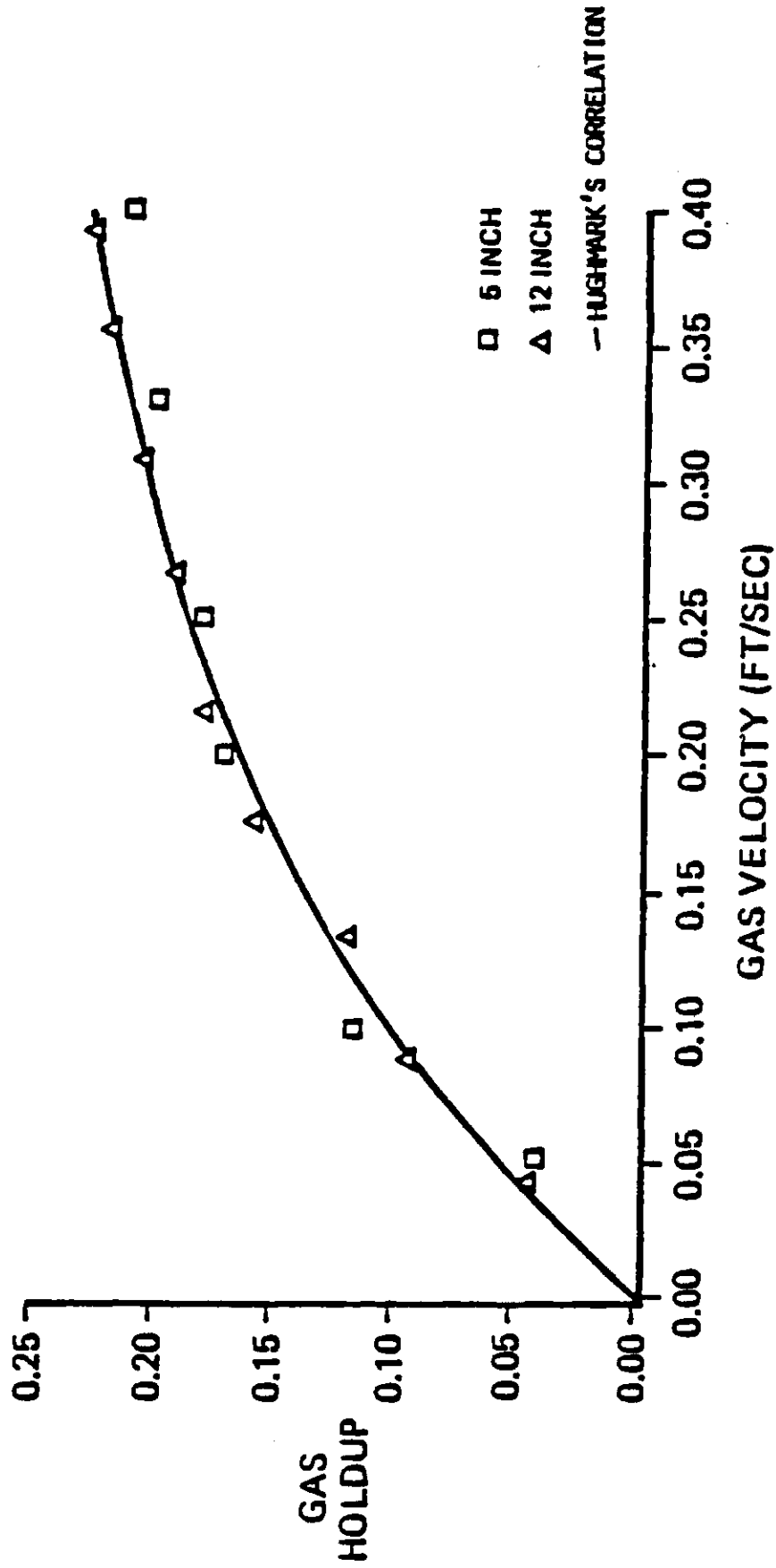
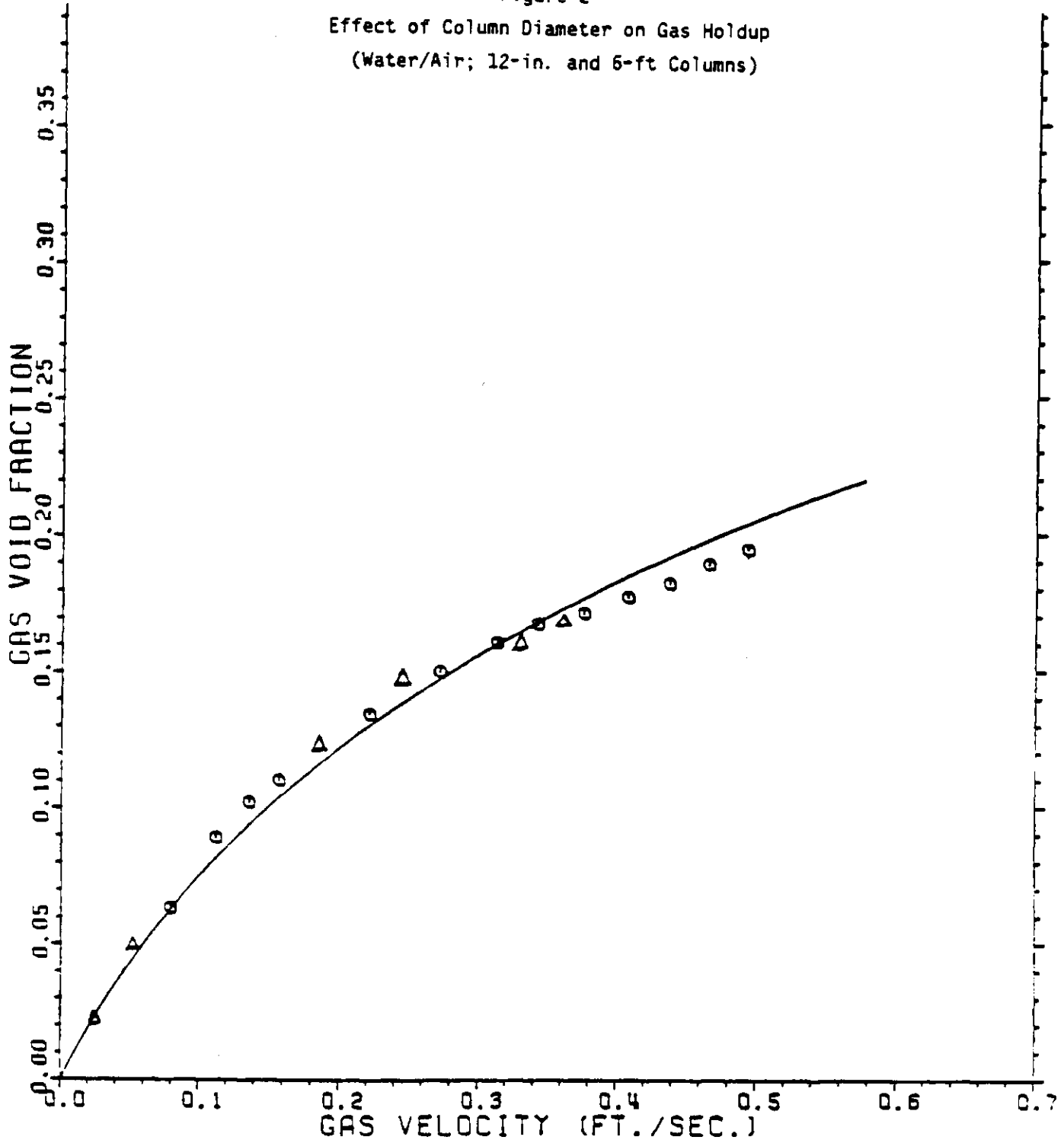


Figure 2
 Effect of Column Diameter on Gas Holdup
 (Water/Air; 12-in. and 6-ft Columns)



MEASURED VOID FRACTION	
NO INTERNALS BATCH OPERATION GAS FLOW THROUGH 12" LINE	▲ 6' COLUMN ● 12" COLUMN

Figure 3
Effect of Column Diameter on Gas Holdup
(Air/Glycol; 5- and 12-in. Columns)

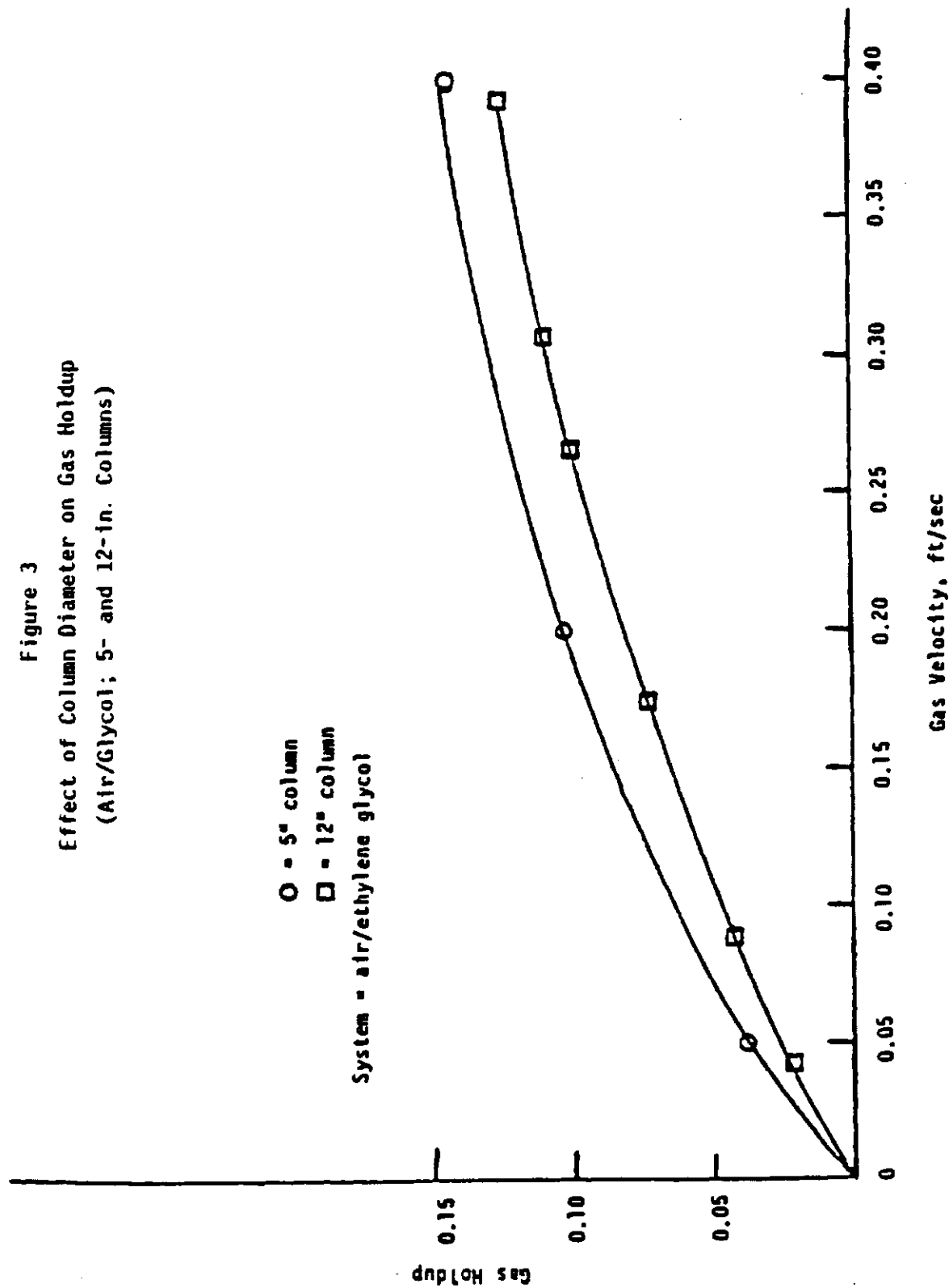


Figure 4
Effect of Liquid Velocity on Gas Holdup
(Air/Water; 12-in. Column)

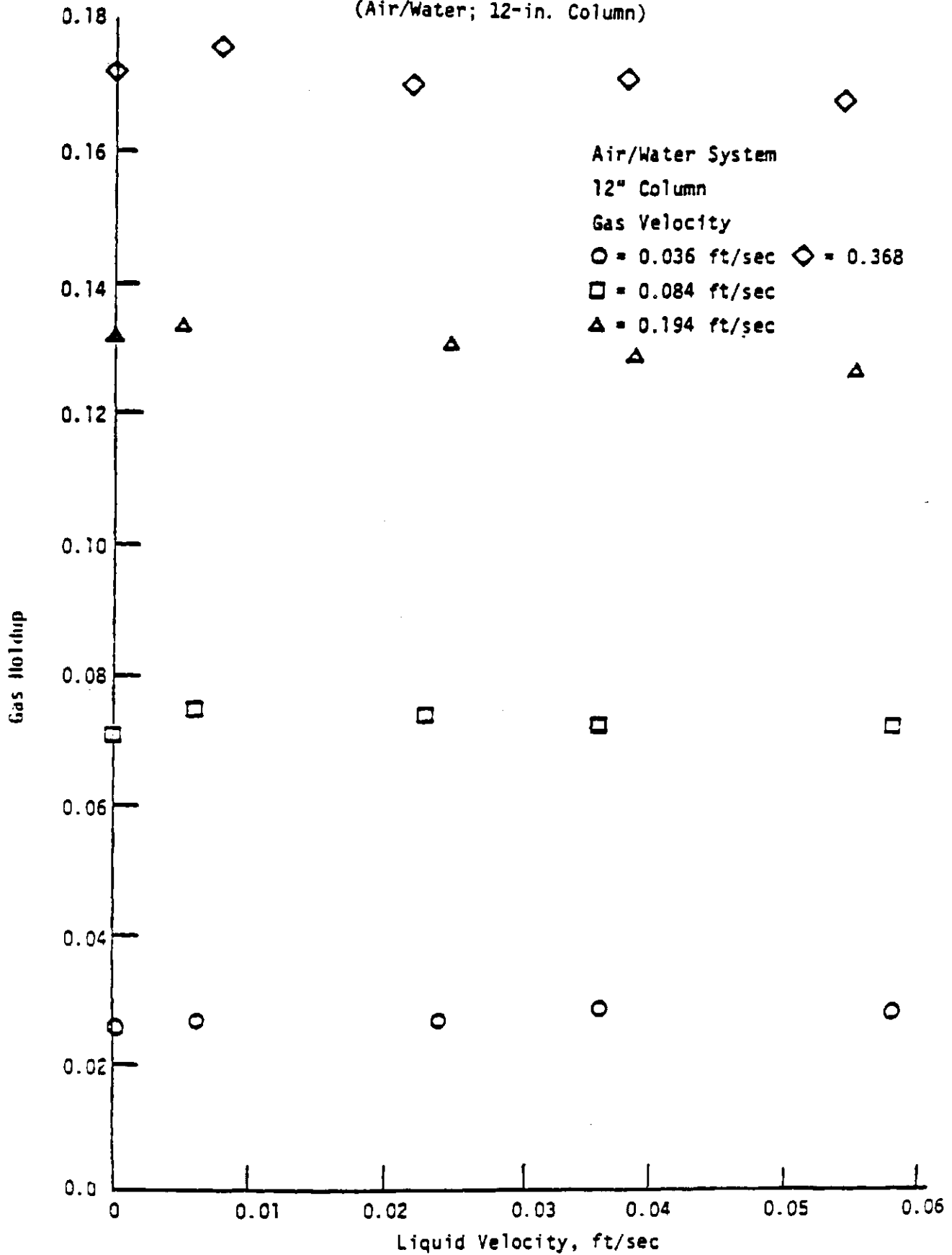


Figure 5
Effect of Liquid Velocity on Gas Holdup
(Tetralin/Nitrogen; 12-in. Column)

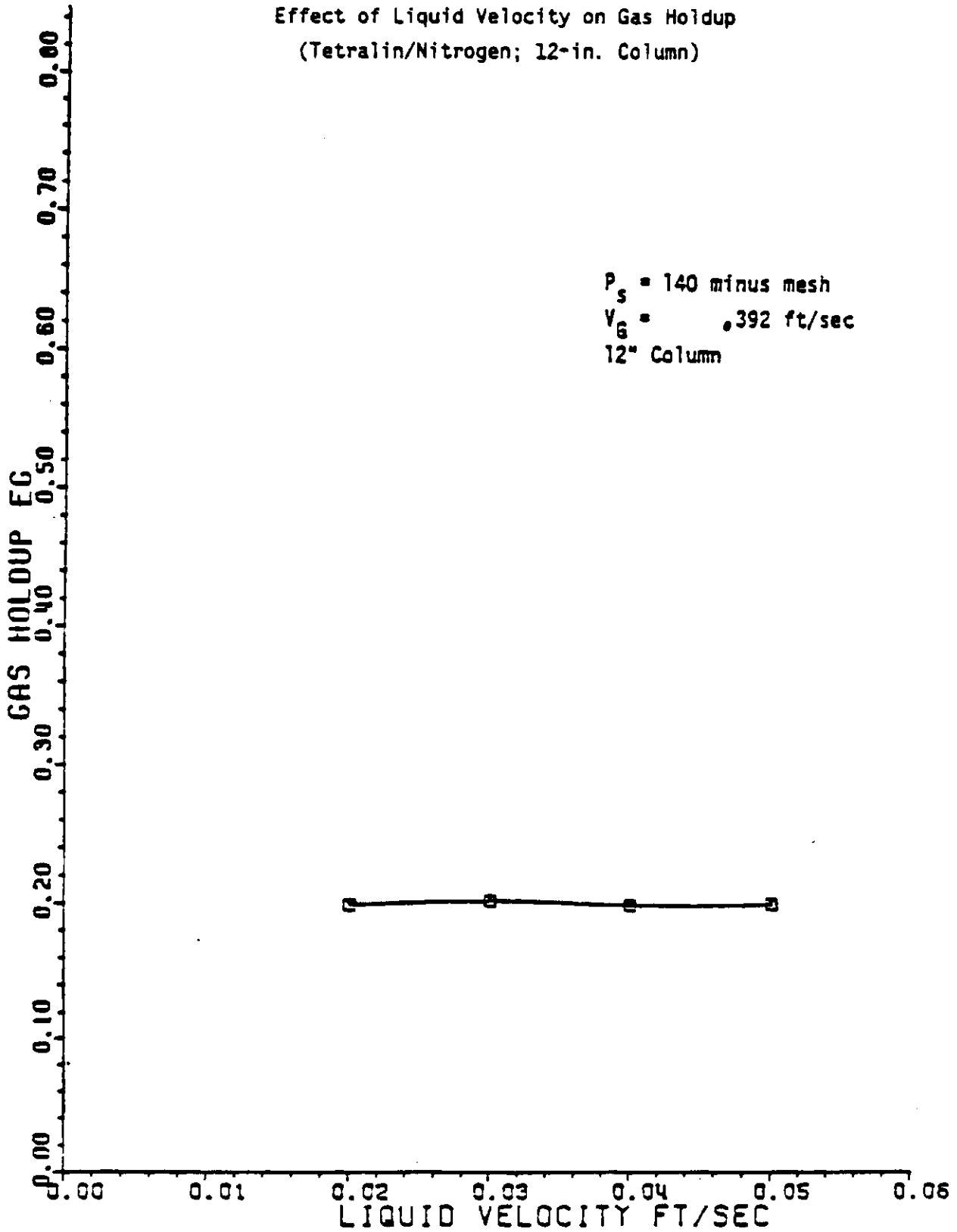
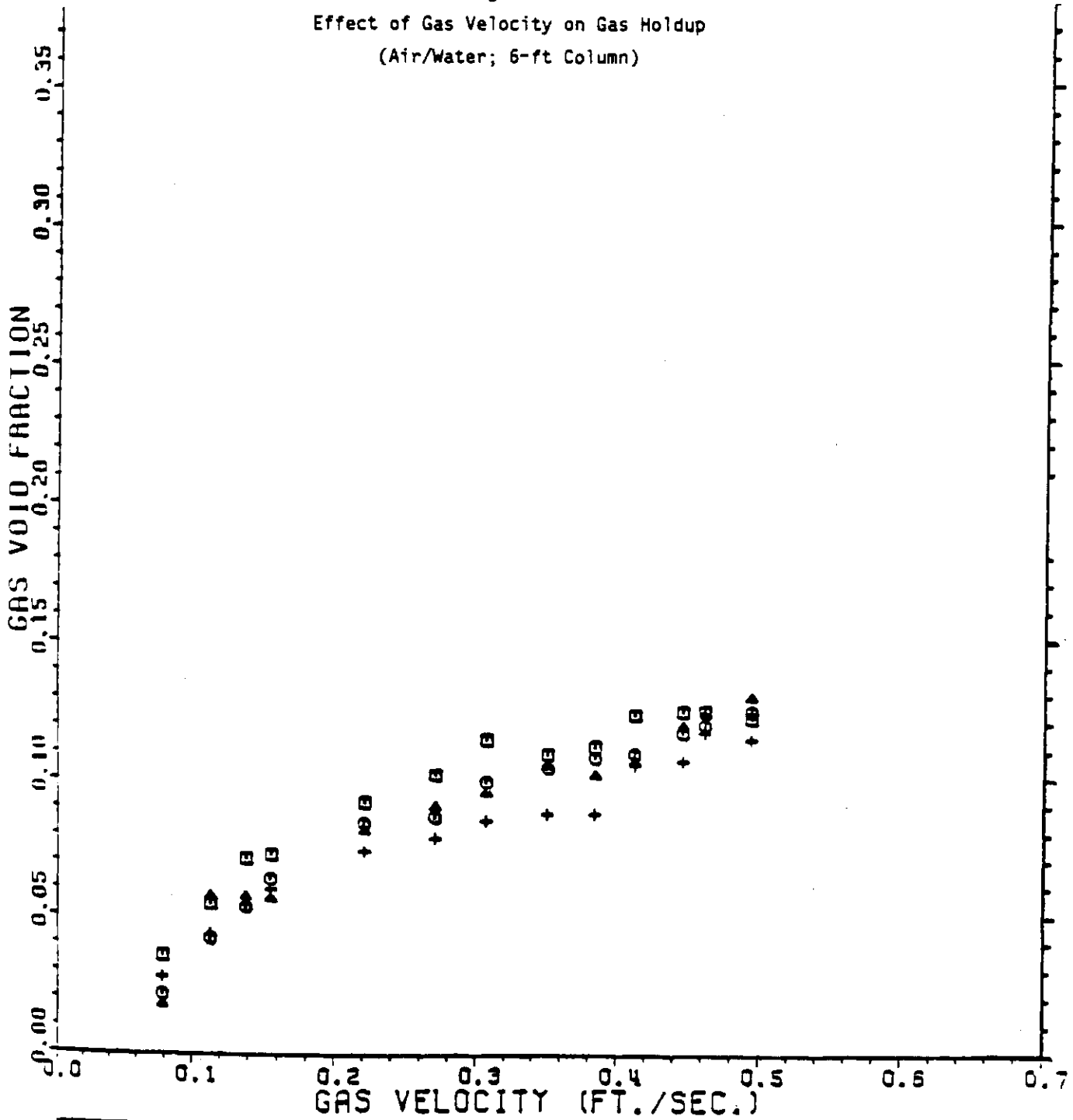


Figure 6
 Effect of Gas Velocity on Gas Holdup
 (Air/Water; 6-ft Column)



MEASURED VOID FRACTION		6' FT COLUMN	
NO INTERNALS		○	LIQUID FLOW = .01 FT/SEC
CONTINUOUS LIQUID FLOW		□	LIQUID FLOW = .02 FT/SEC
PROCESS FLOW THROUGH 12" LINE		△	LIQUID FLOW = .03 FT/SEC
HOLDUP 5 - 20 FT		+	LIQUID FLOW = .037 FT/SEC

Figure 7
 Effect of Solids on Gas Holdup
 (Air/Water and Air/Water/Sand; 12-in. Column)

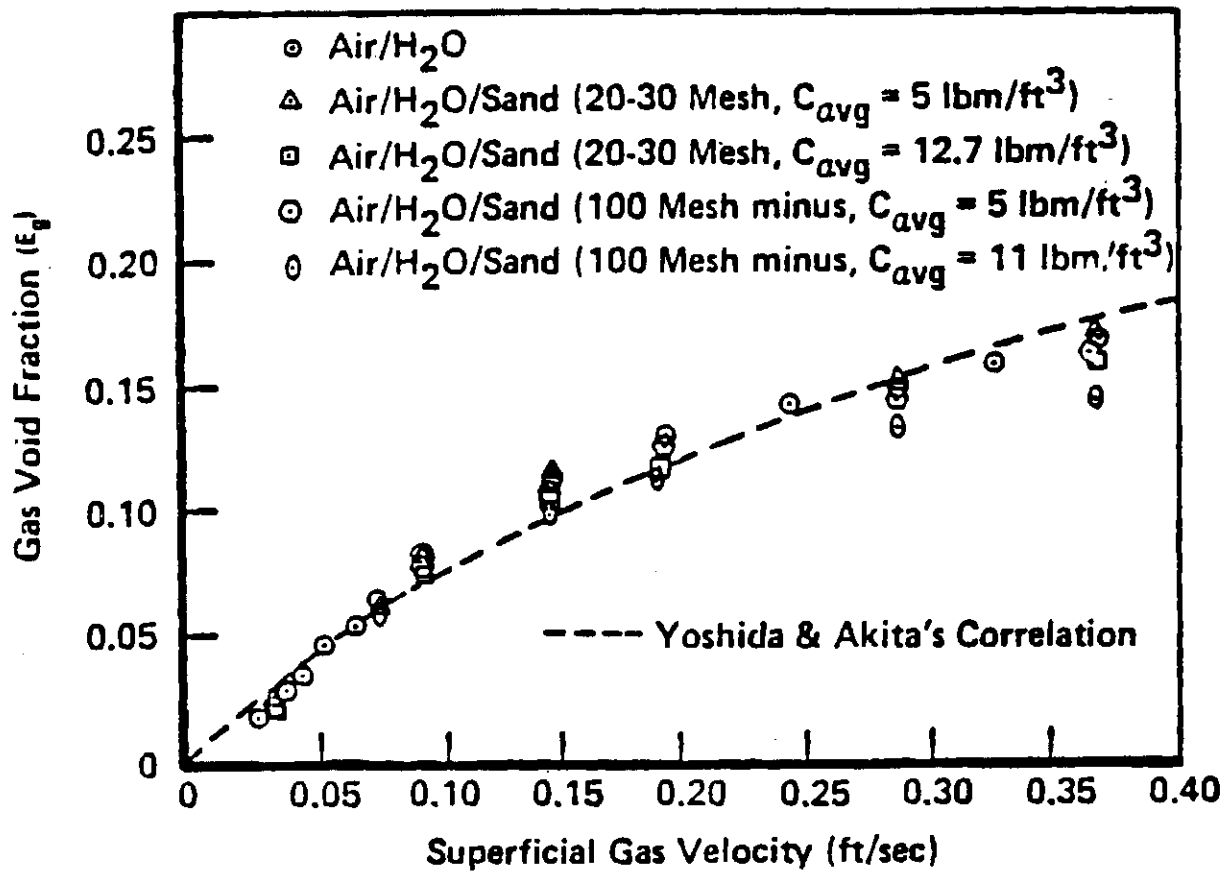


Figure 8
Effect of Solids on Gas Holdup
 (Nitrogen/Tetralin/Sand; 12-in. Column)

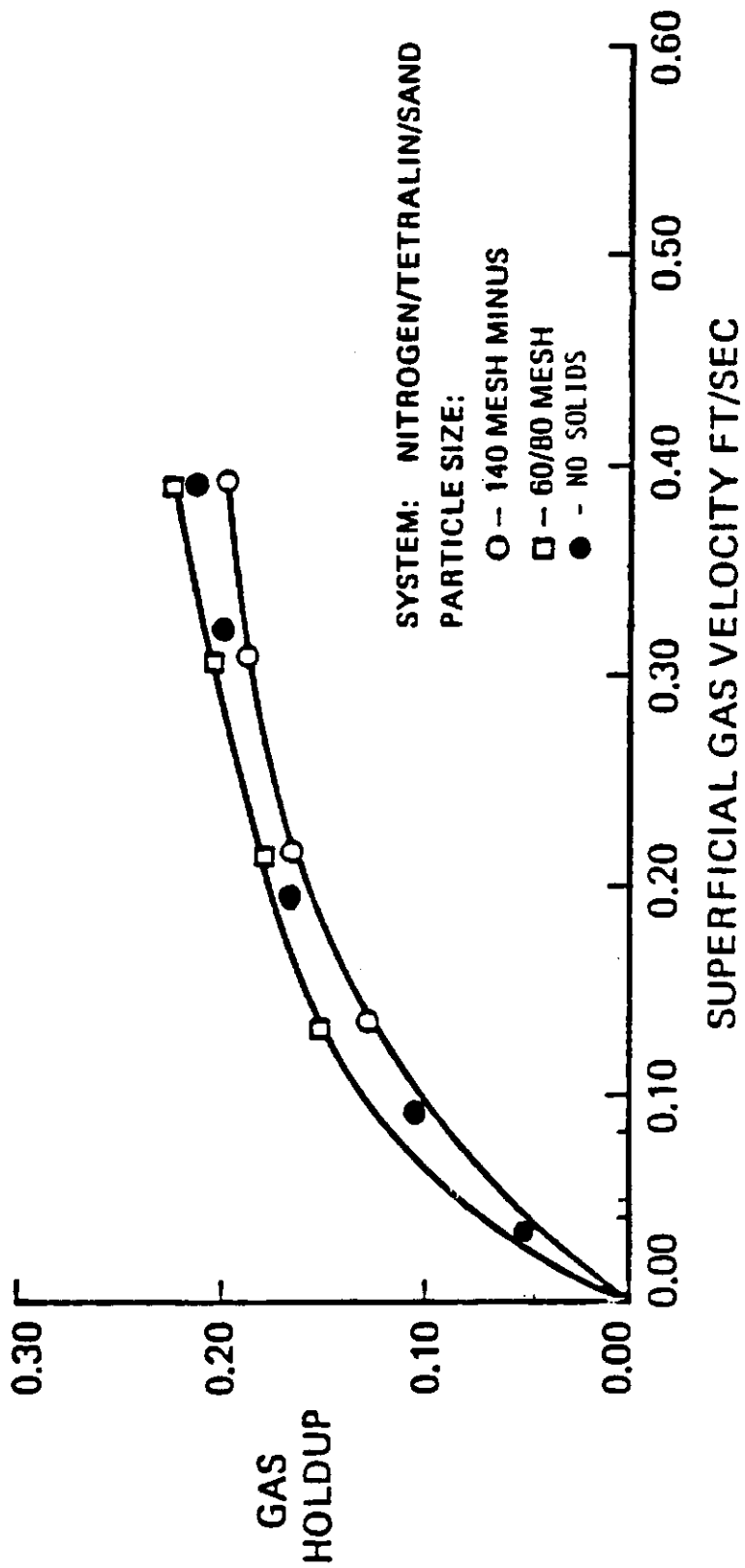


Figure 9
 Effect of Distributor Plate on Gas Holdup in
 the Absence of Liquid Flow and Solid Phase
 (12-in. Column)

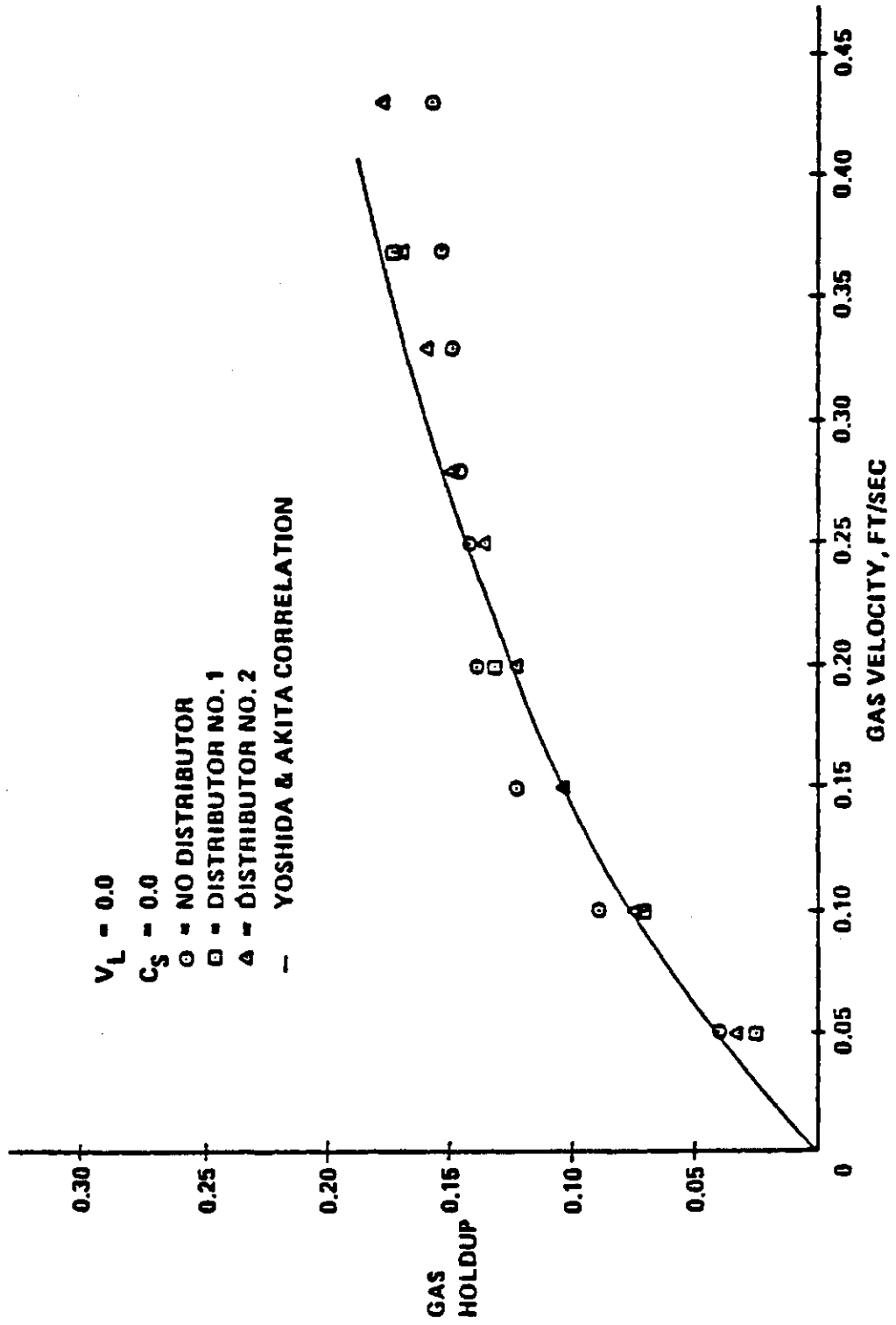


Figure 10
 Effect of Distributor Plate on Gas Holdup at
 Low Liquid Velocity with High Concentration
 of Large Solid Particles (12-in. Column)

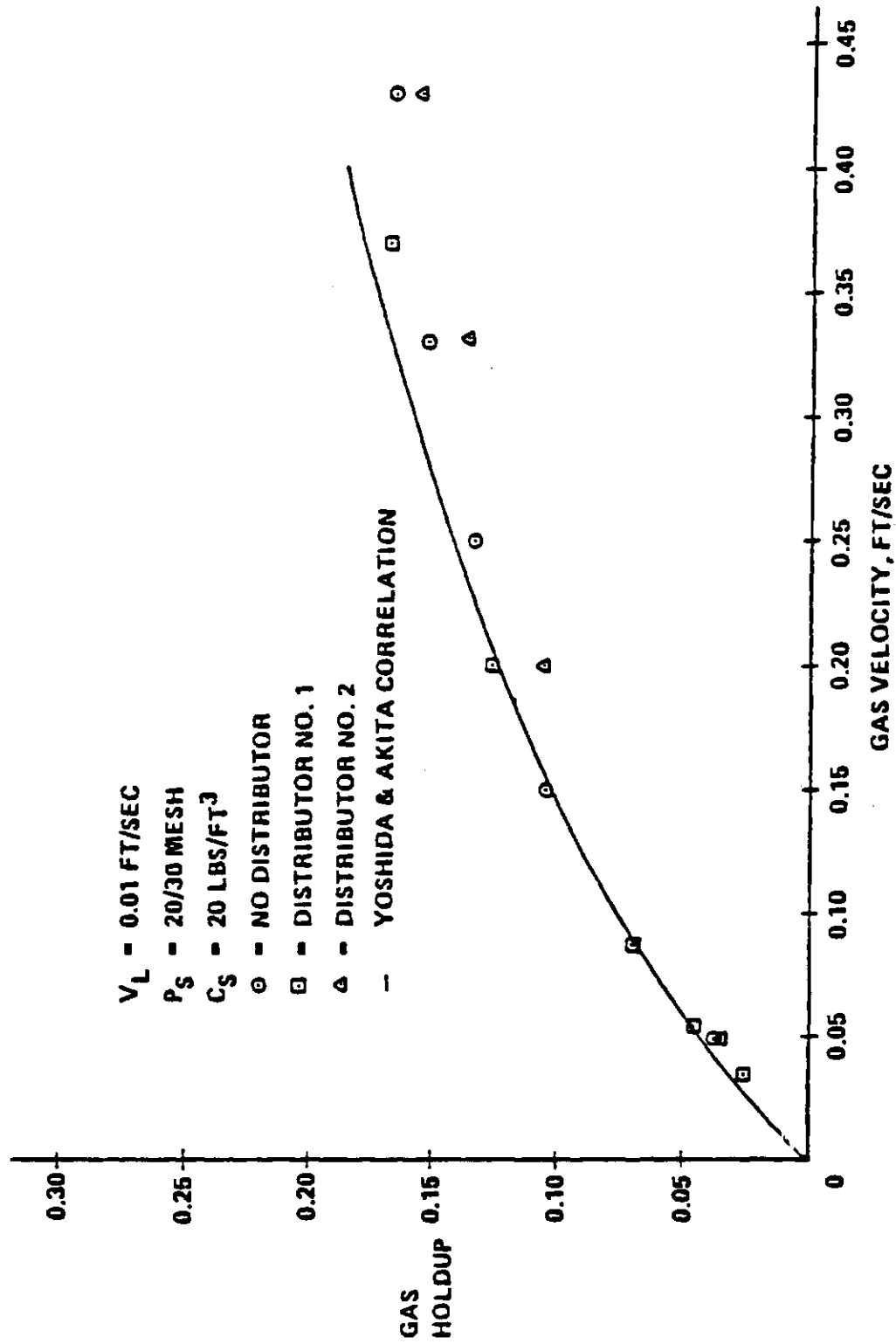


Figure 11
 Effect of Distributor Plate on Gas Holdup at
 High Liquid Velocity with Low Concentration of
 Large Solid Particles (12-in. Column)

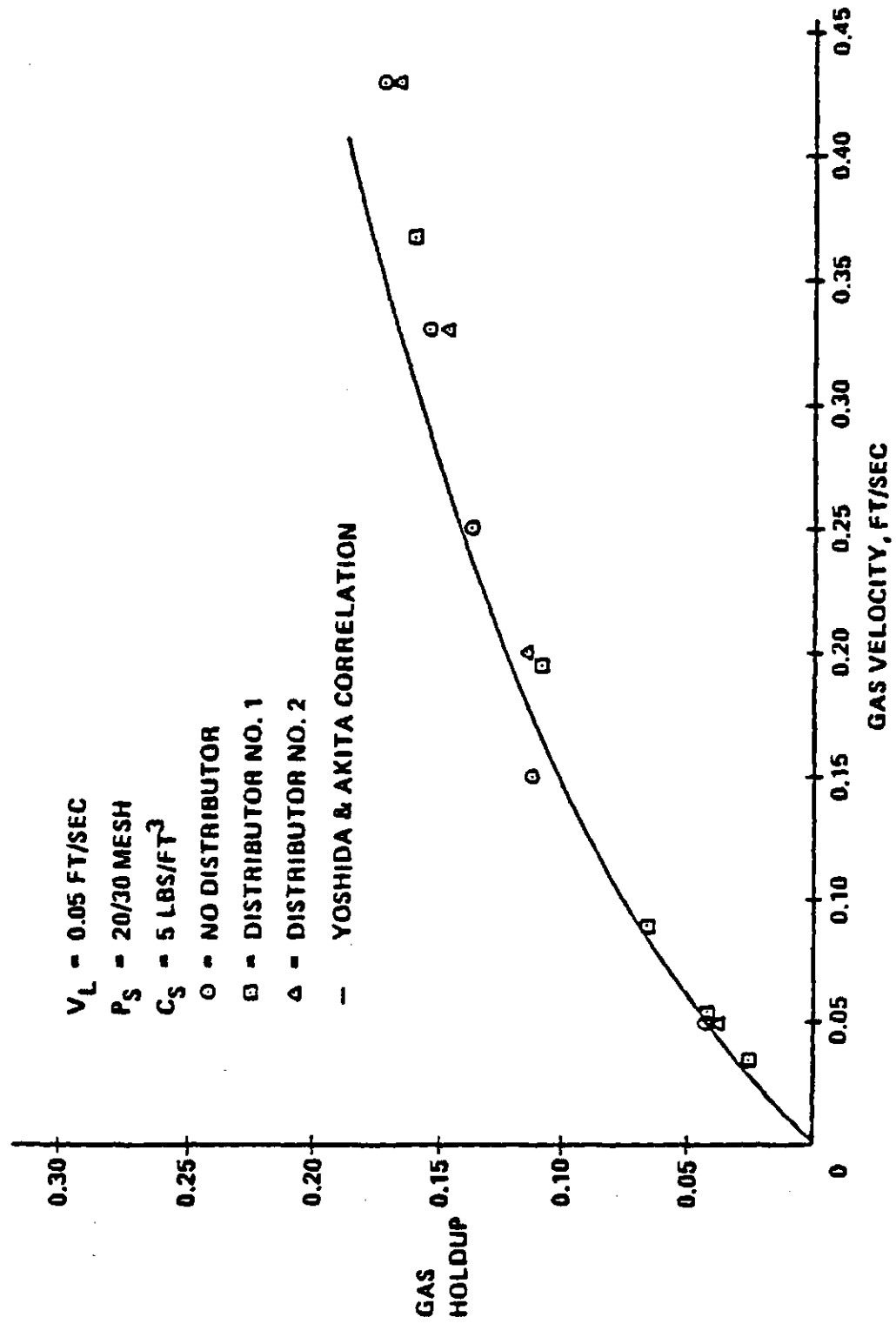


Figure 12
 Effect of Distributor Plate on Gas Holdup at
 Low Liquid Velocity with No Solids (12-in. Column)

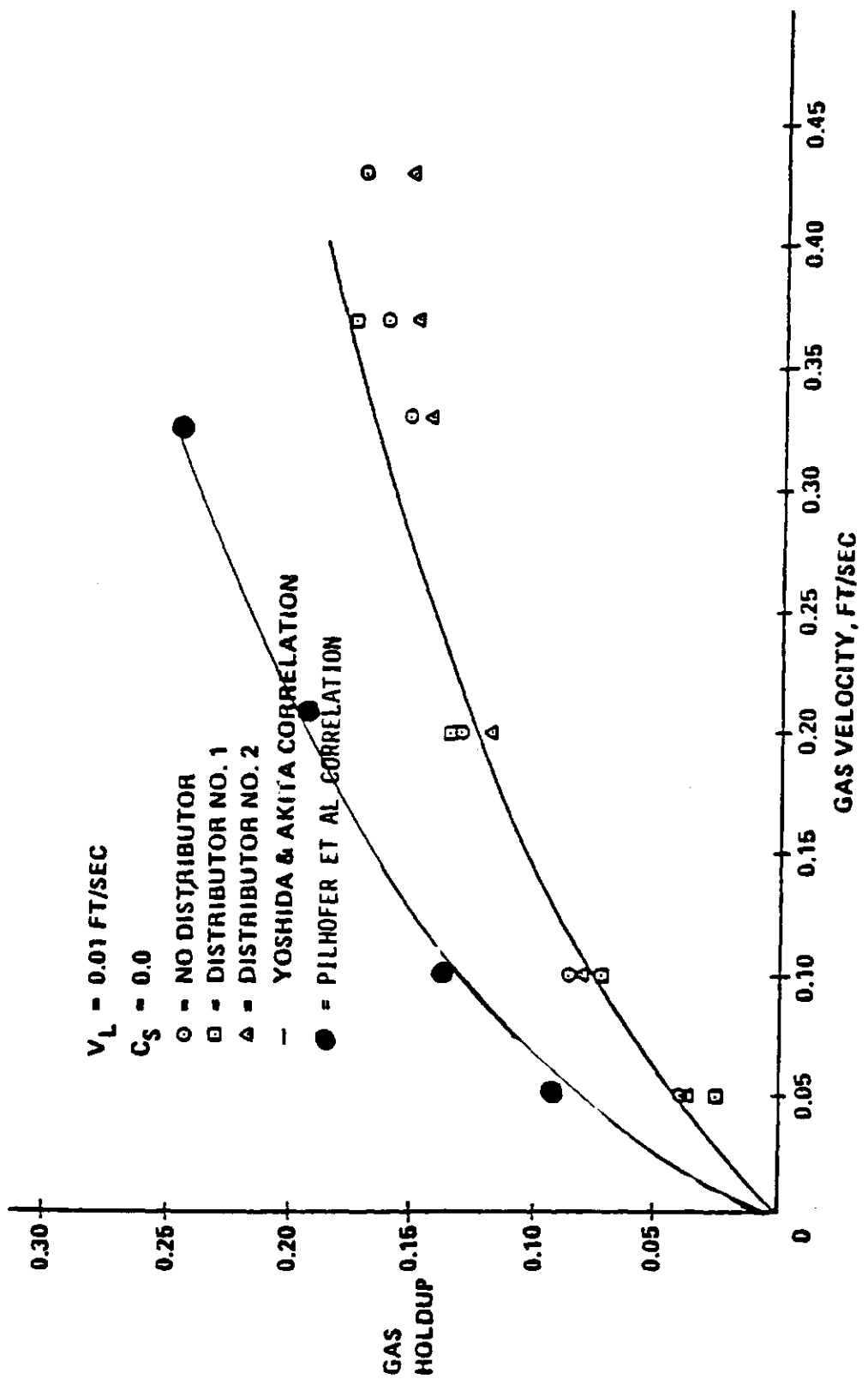


Figure 13
 Effect of Distributor Plate on Gas Holdup at
 High Liquid Velocity with Low Concentration of
 Fine Particles (12-in. Column)

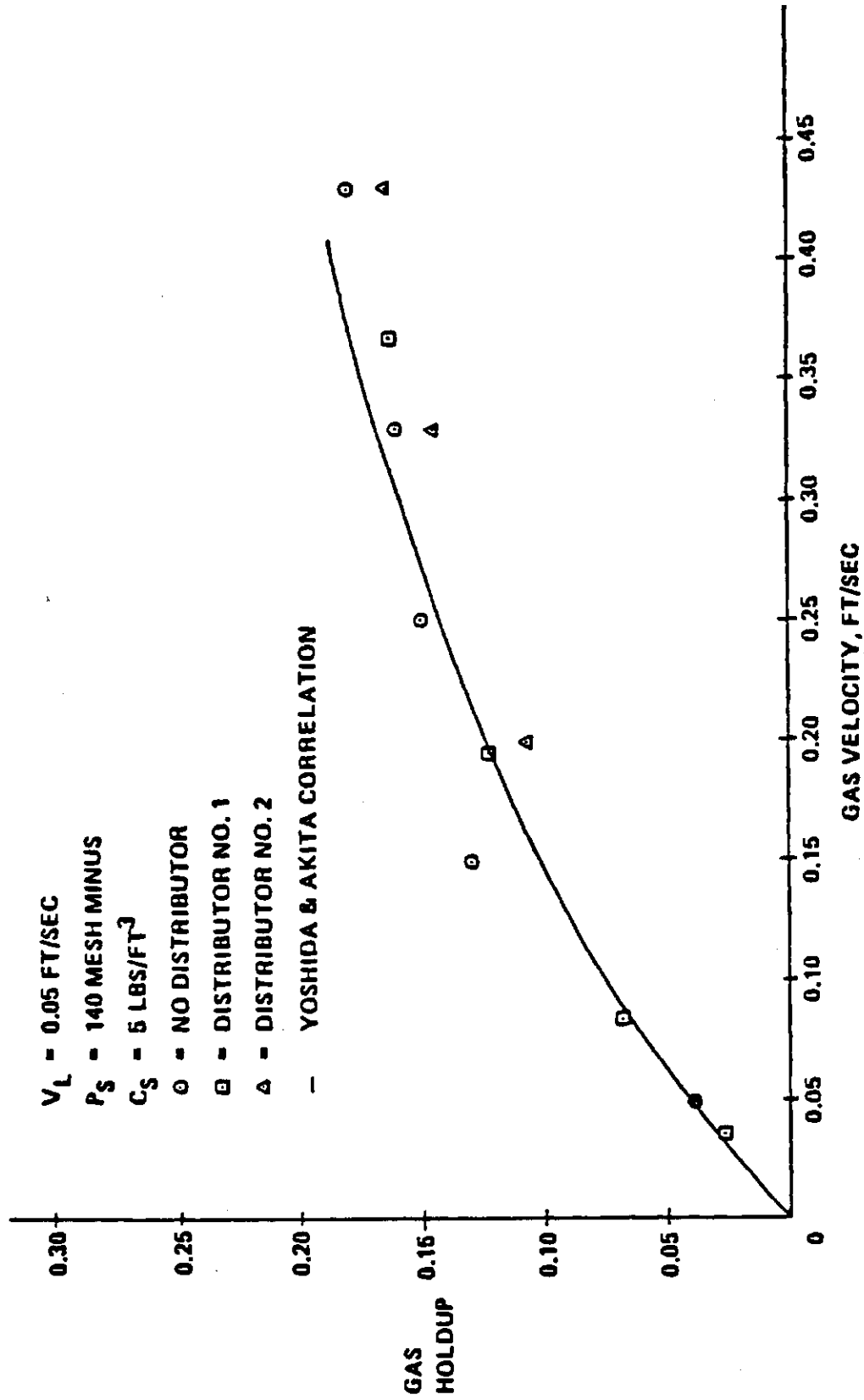


Figure 14
 Effect of Distributor Plate on Gas Holdup at
 Low Liquid Velocity with High Concentration of
 Fine Particles (12-in. Column)

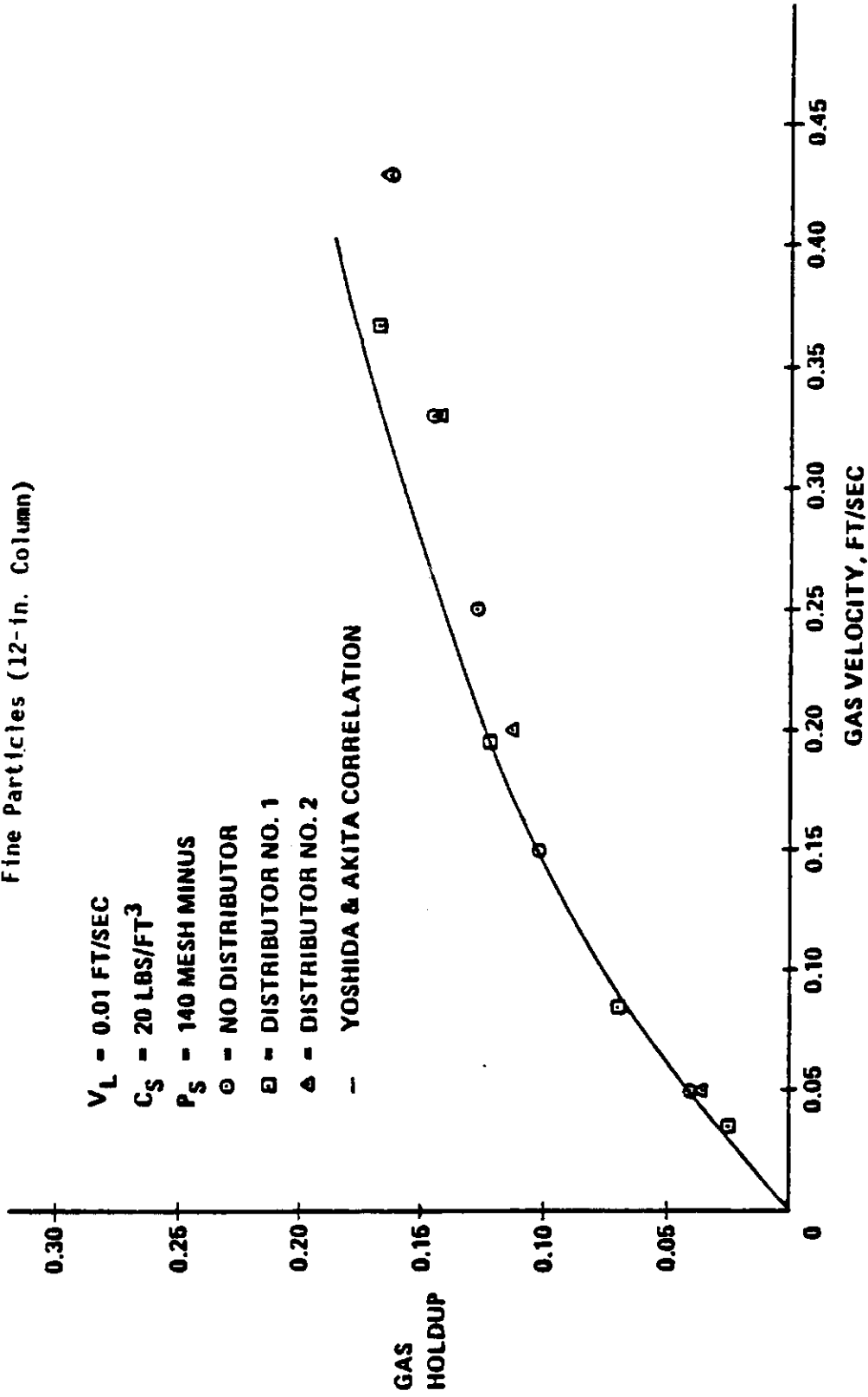
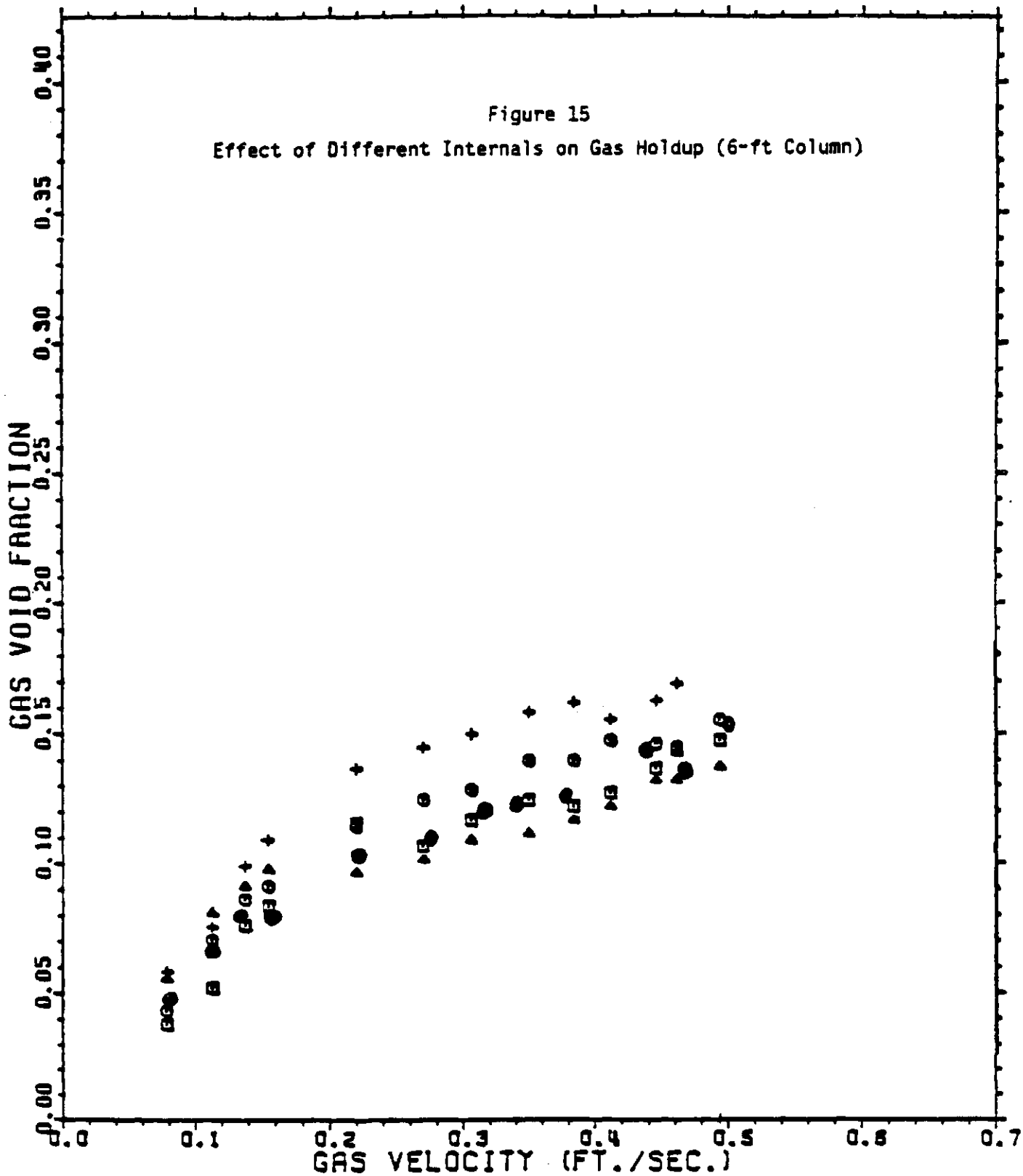


Figure 15
Effect of Different Internals on Gas Holdup (6-ft Column)



MEASURED VOID FRACTION	
COMPARISON OF INTERNALS MATCH OPERATION	
GAS HOLDUP DEPTH 5 - 20 FT	
<ul style="list-style-type: none"> □ 1 FOOT TARGET PLATE ○ 2 FOOT TARGET PLATE △ 3 FOOT BUBBLE CAP + GAS SPARGERS ● NO INTERNALS 	

Figure 16

Comparison of Hughmark's, Pilhofer's, and Akita and Yoshida's Correlations for the Data from 5- and 12-in. Columns (Tetralin/Nitrogen)

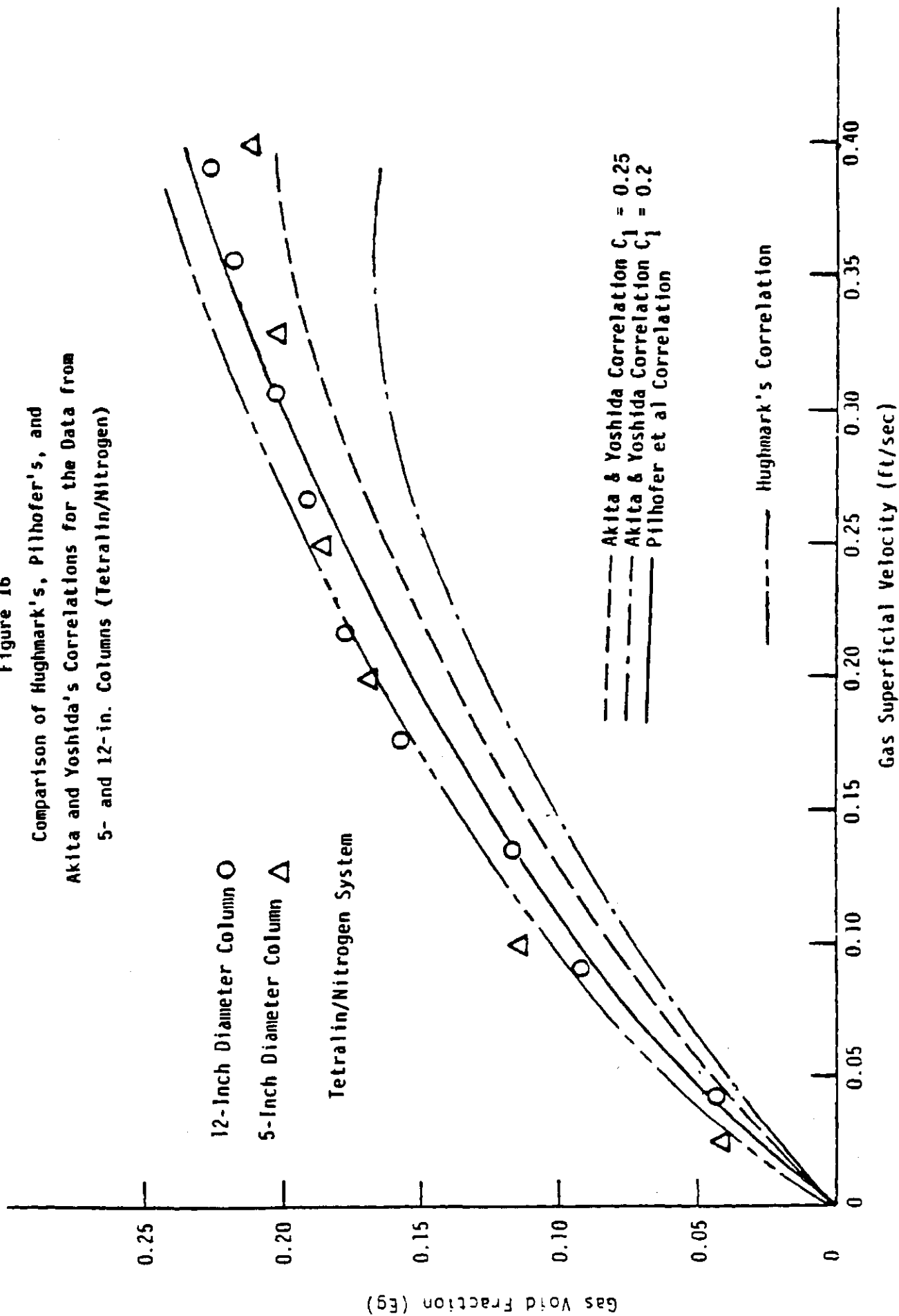
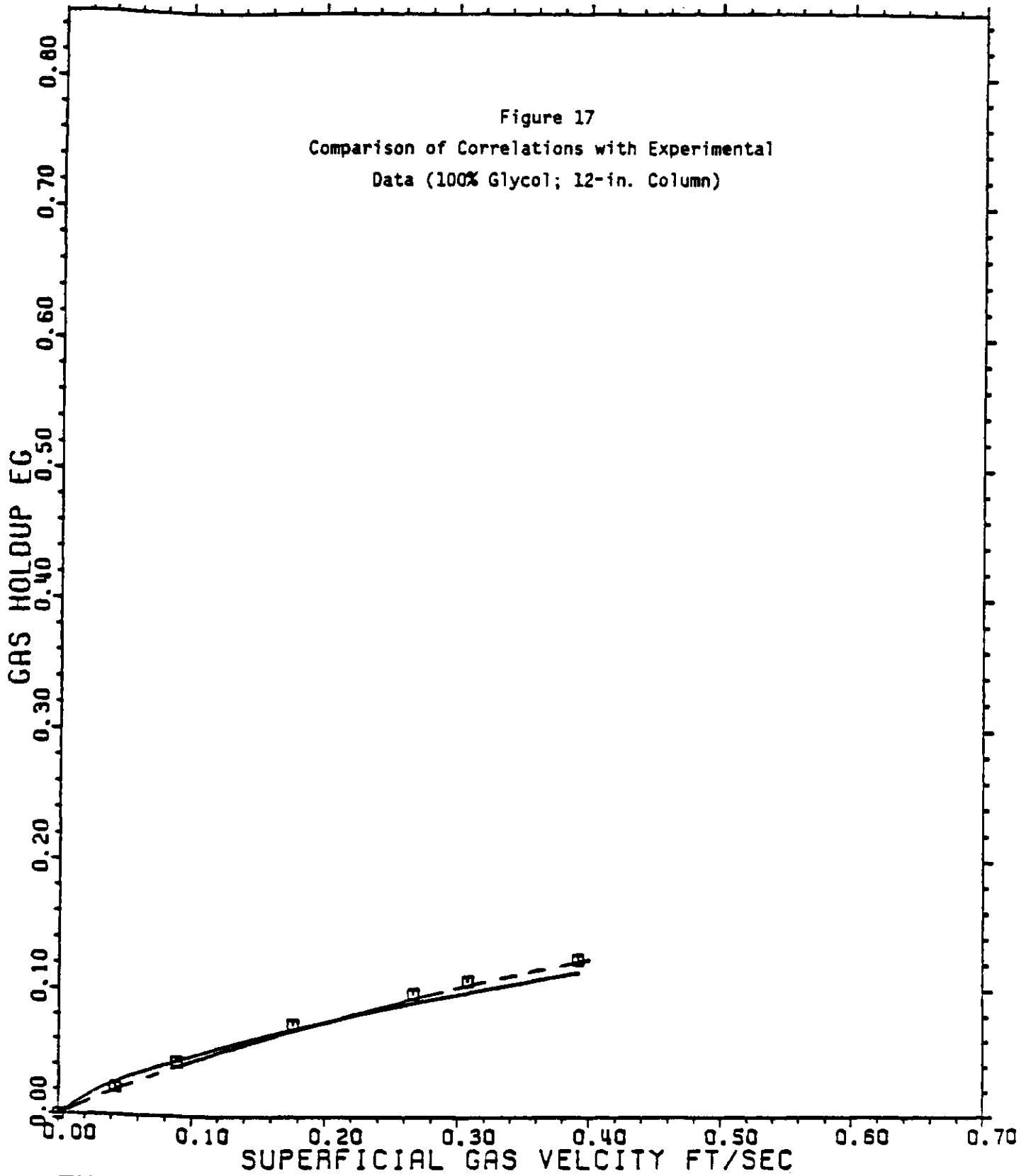
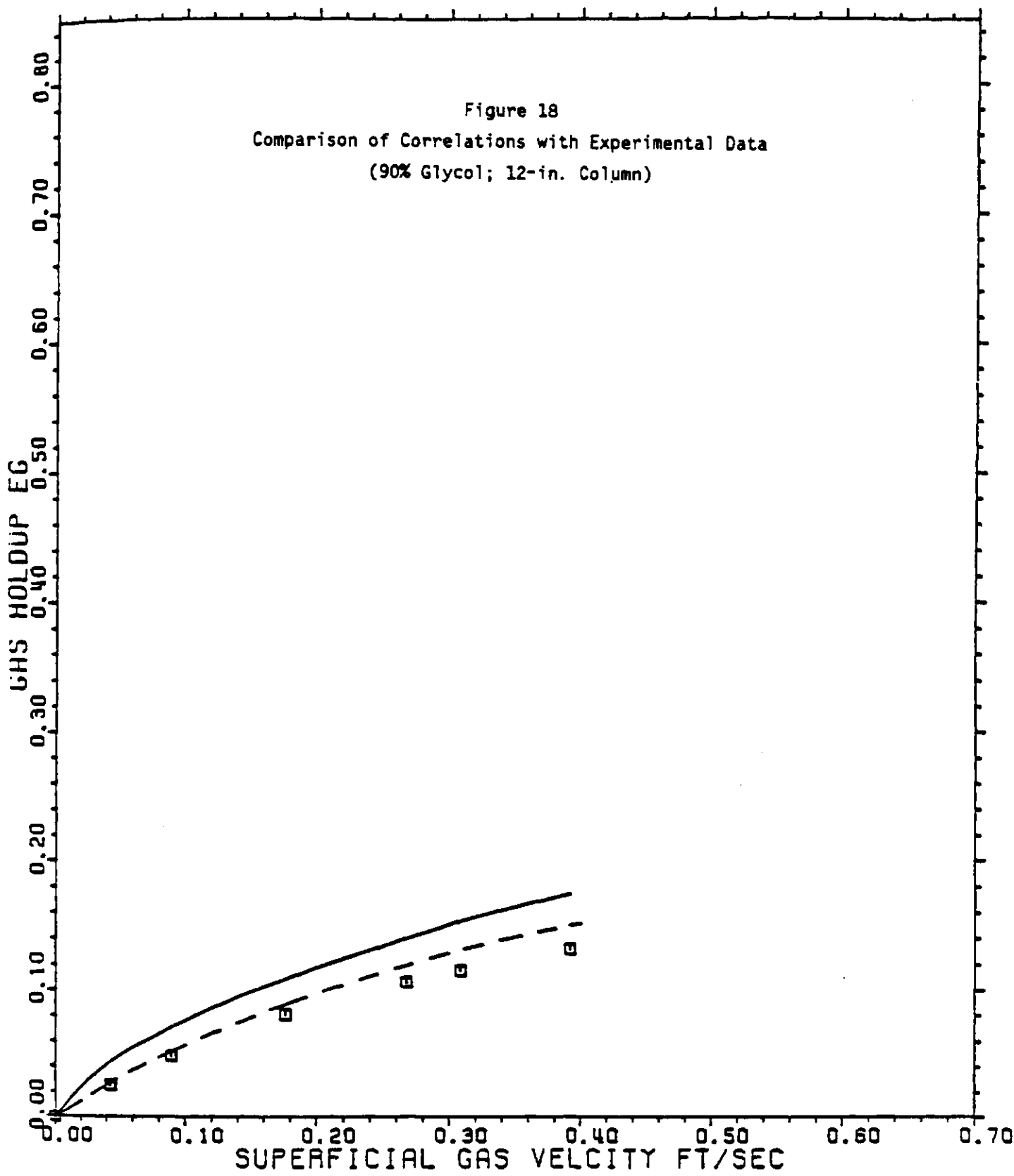


Figure 17
 Comparison of Correlations with Experimental
 Data (100% Glycol; 12-in. Column)



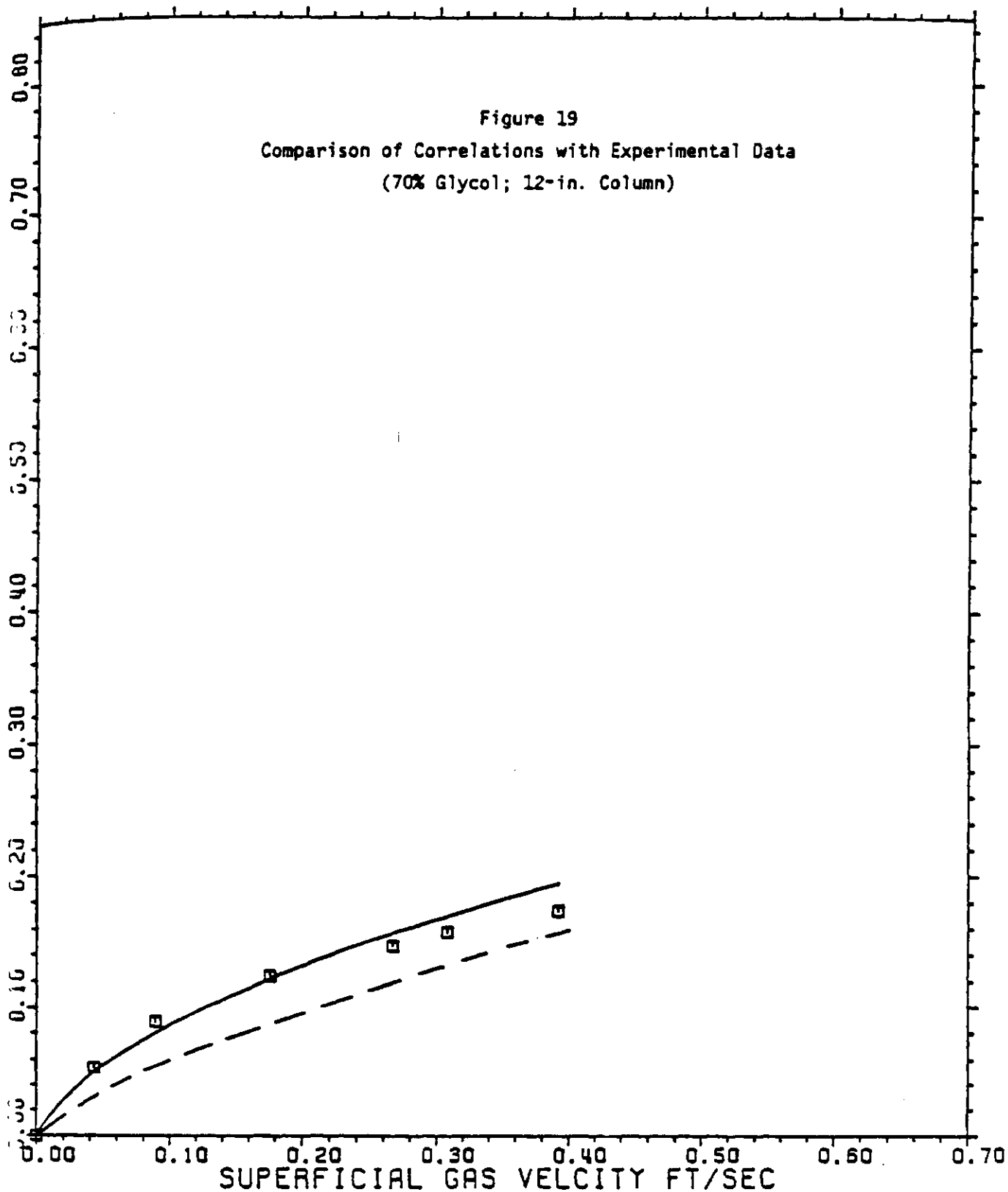
GAS HOLDUP	
100% GLYCOL GAS HOLDUP IN 12" COL.	66
EXPERIMENTAL VALUES OF EG PILHOFER ET AL. CORRELATION AKIDA AND YOSHIDA CORRELATION	

Figure 18
 Comparison of Correlations with Experimental Data
 (90% Glycol; 12-in. Column)



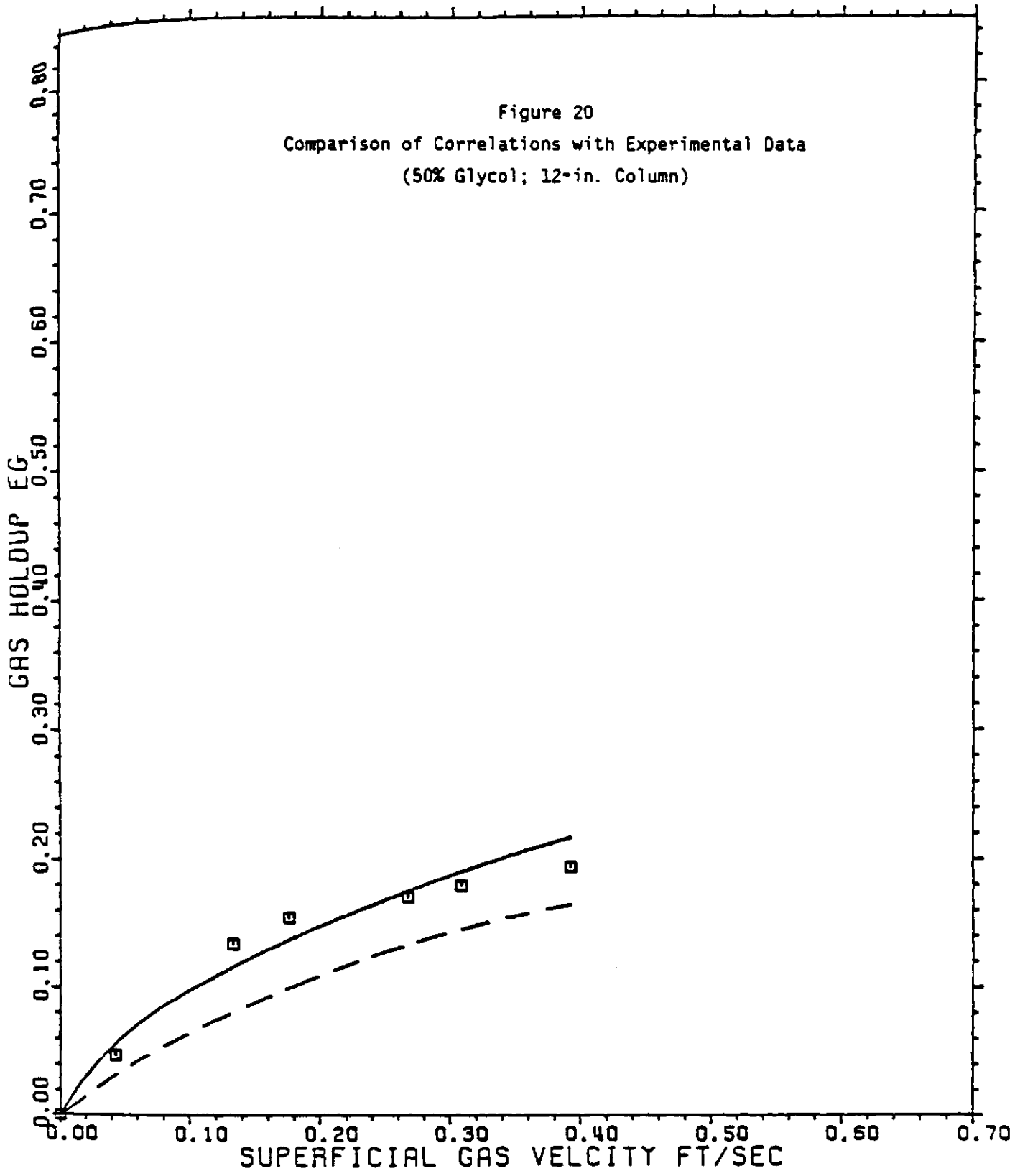
GAS HOLDUP	
90% GLYCOL GAS HOLDUP IN 12" COL.	□ EXPERIMENTAL VALUES OF EG — PILHOFER ET AL. CORRELATION - - - AKIDA AND TOSHIDA CORRELATION

Figure 19
 Comparison of Correlations with Experimental Data
 (70% Glycol; 12-in. Column)



GAS HOLDUP	
70% GLYCOL GAS HOLDUP IN 12" COL.	<ul style="list-style-type: none"> □ EXPERIMENTAL VALUES OF EG — PILHOFER ET AL. CORRELATION - - AKIDA AND YOSHIDA CORRELATION

Figure 20
 Comparison of Correlations with Experimental Data
 (50% Glycol; 12-in. Column)



GAS HOLDUP	
50% GLYCOL GAS HOLDUP IN 12" COL. 69	<ul style="list-style-type: none"> □ EXPERIMENTAL VALUES OF EG — PILHOFFER ET AL. CORRELATION - - - AKIDA AND YOSHIDA CORRELATION

Figure 21
 Variation of Gas Holdup at Elevated Pressures
 (Exxon's 1-tpd Pilot Plant; 2.6-in.-Diameter Vessel)

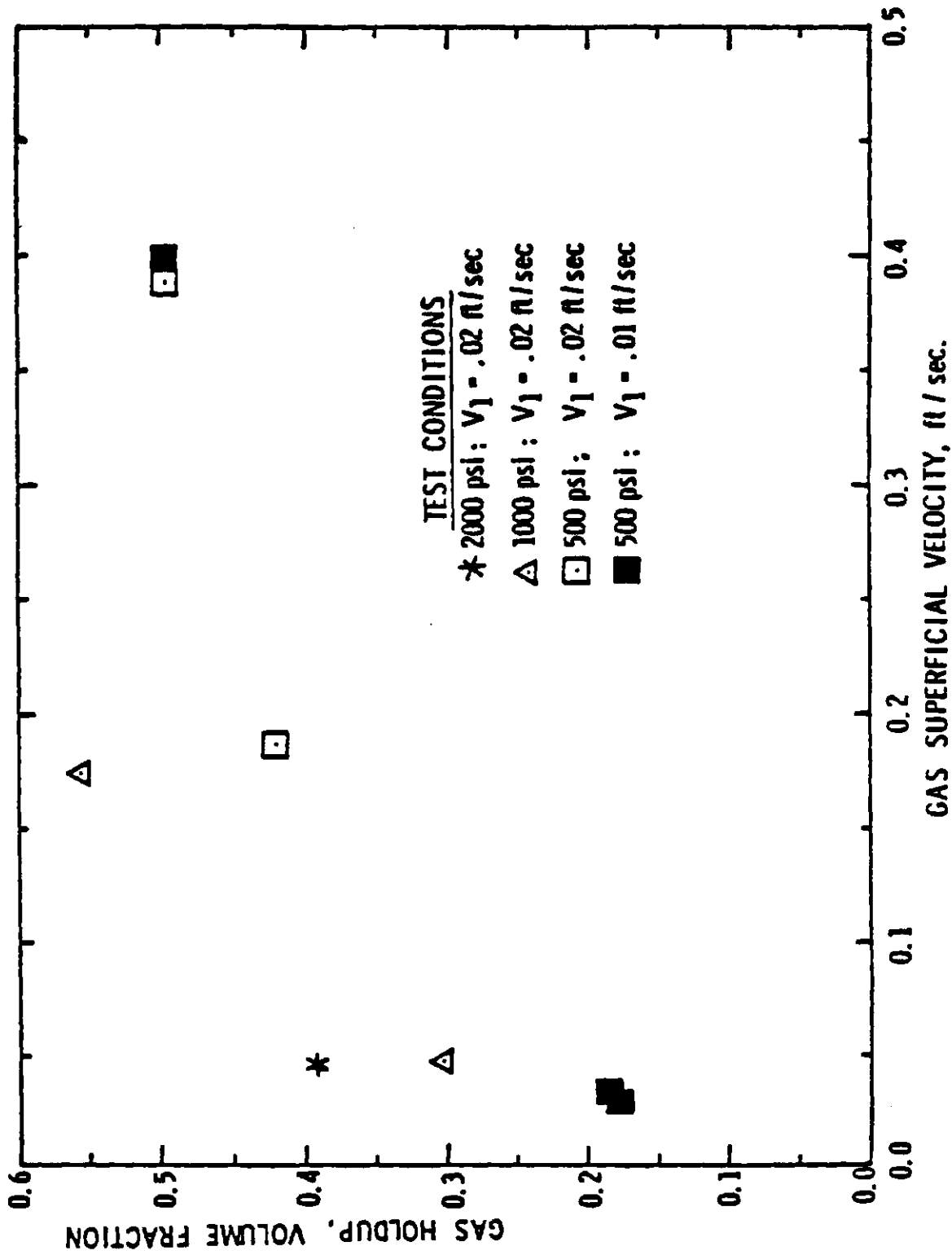


Figure 22
 Gas Holdup in Exxon Donor Solvent Reactors from
 Tracer, Data (250-tpd Pilot Plant; 2-ft-Diameter Dissolver,
 2.6-in. CLPP and 1-in. RCLU)

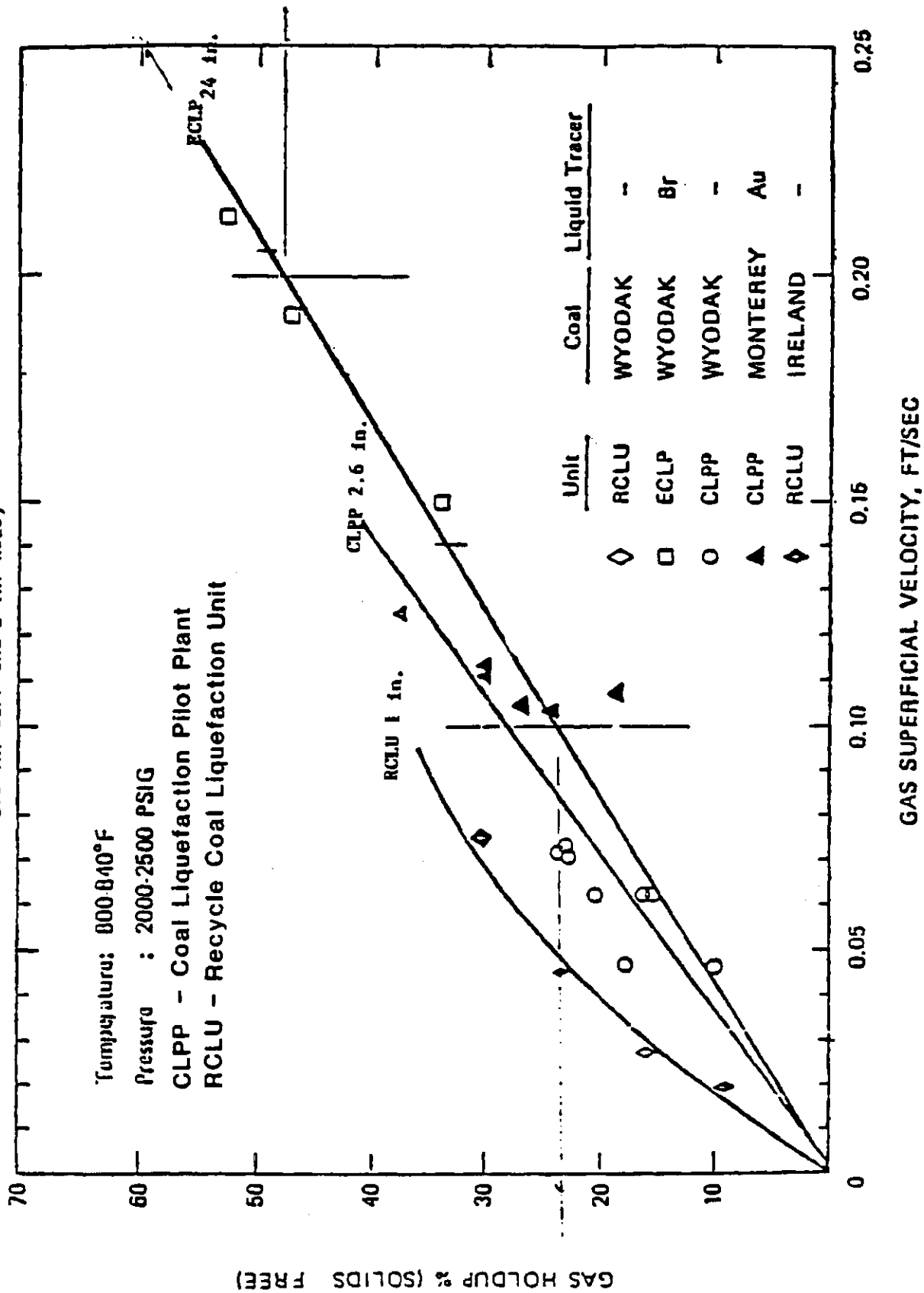


Figure 23
 Log/Log Plot of Liquid Axial Dispersion Coefficient vs.
 Gas Velocity (12-in. Column; Air/Water)

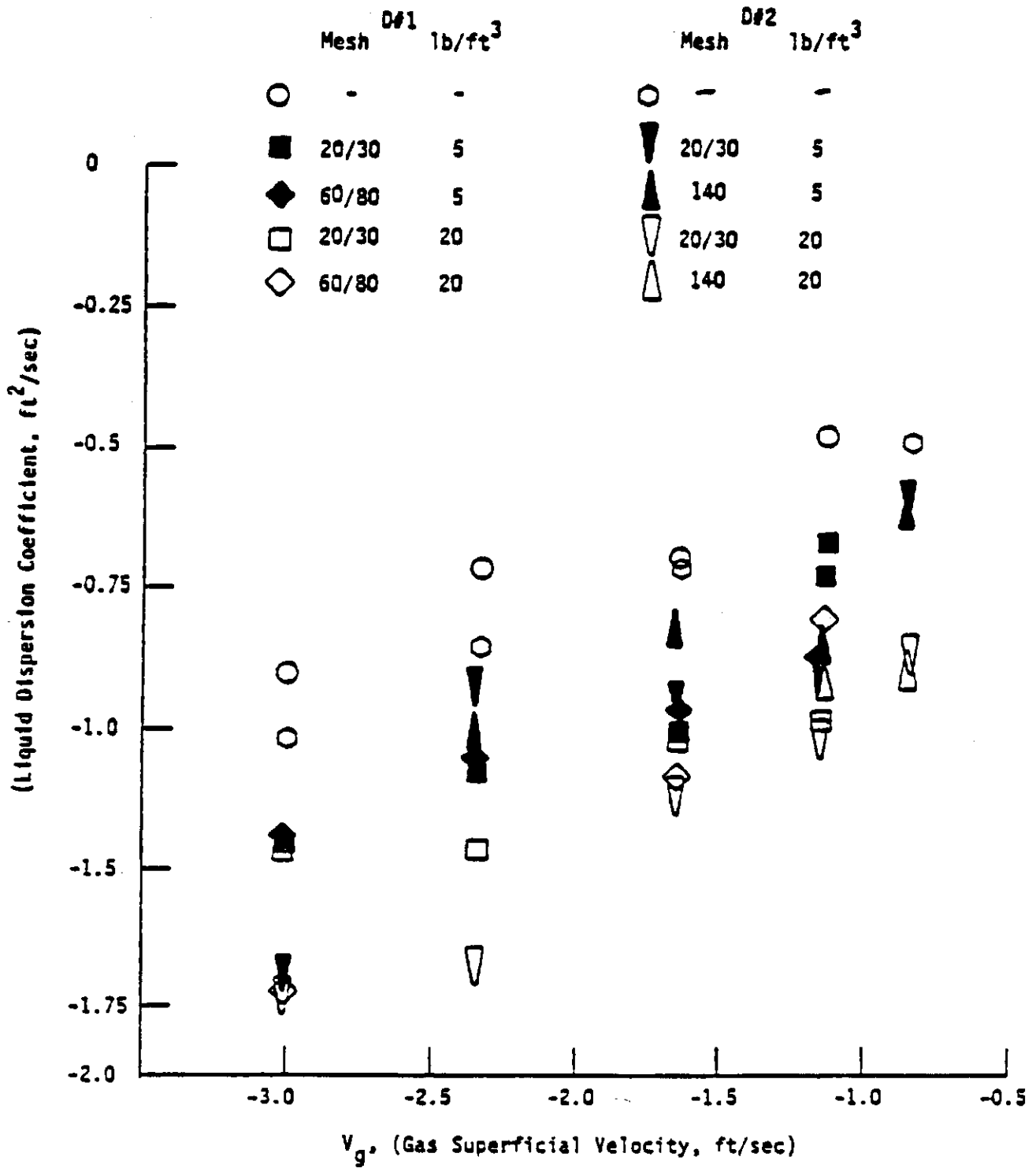


Figure 24

Effect of Gas Velocity on Axial Liquid Dispersion Coefficient
(12-in. Column; Tetralin/Nitrogen)

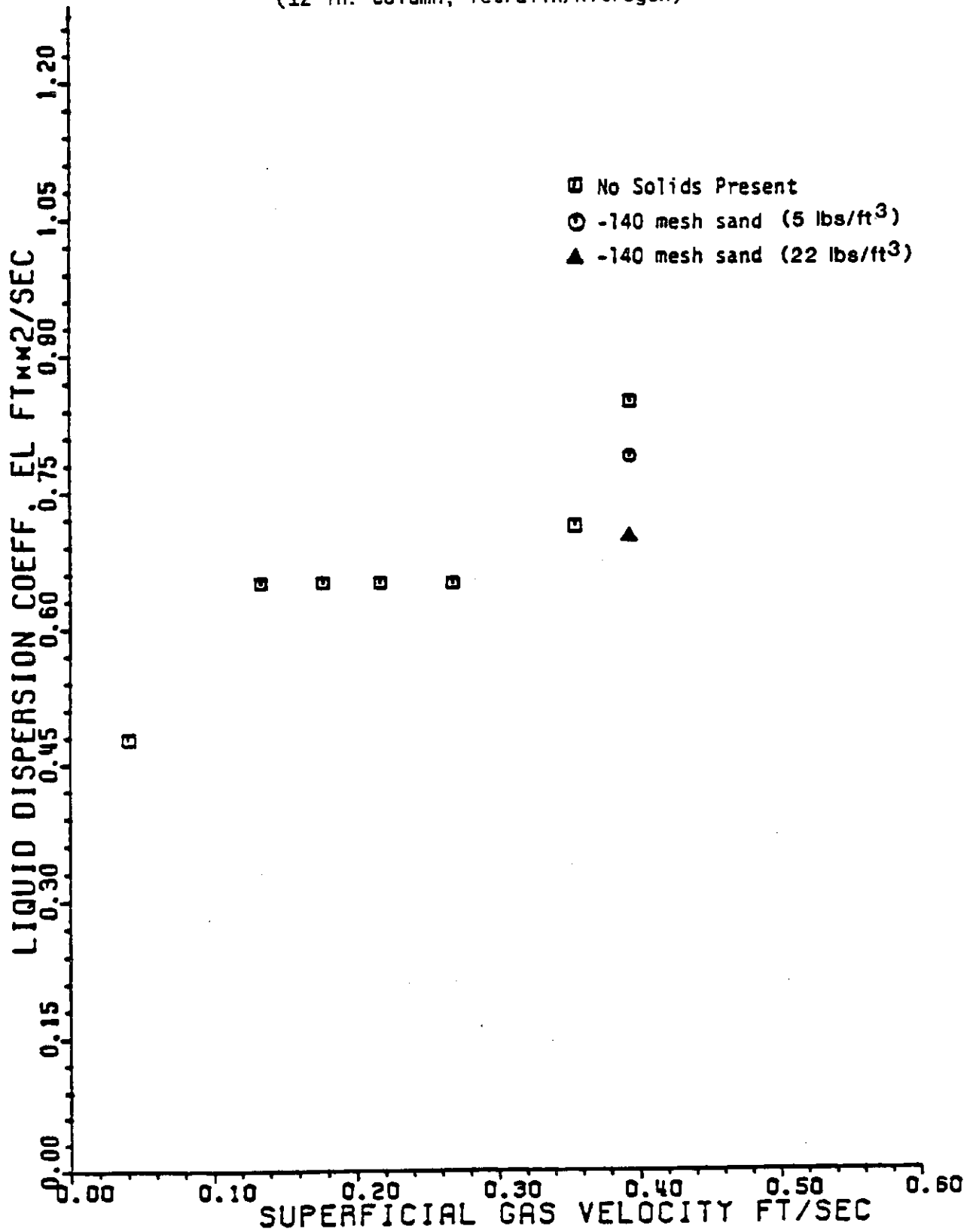


Figure 25
Comparison of E_{ZL} for Batch and Continuous
Experiments (50% Glycol/Air; 12-in. Column)

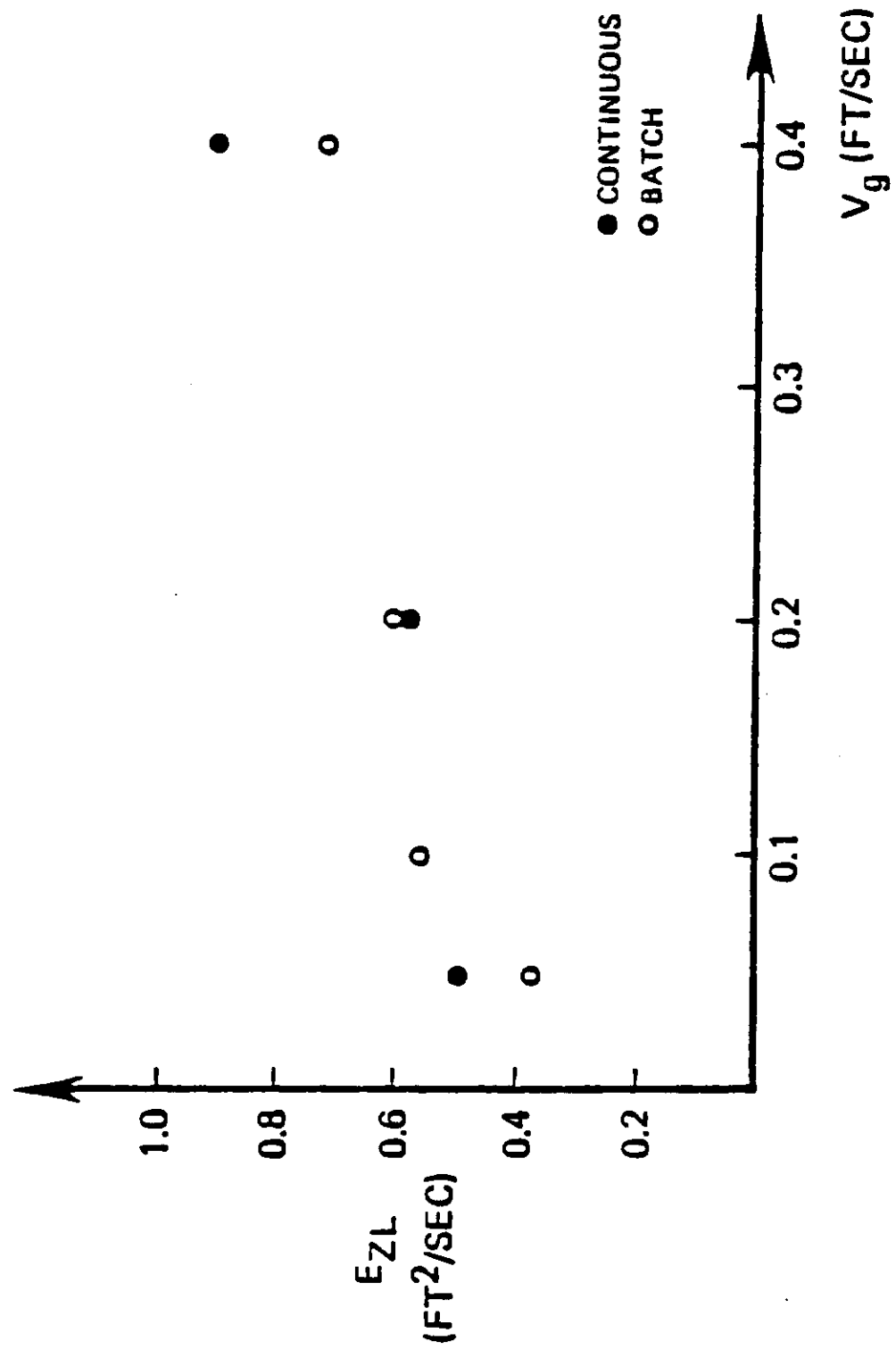


Figure 26
Axial Liquid Dispersion Coefficients vs.
Gas Velocity (6-ft Column)

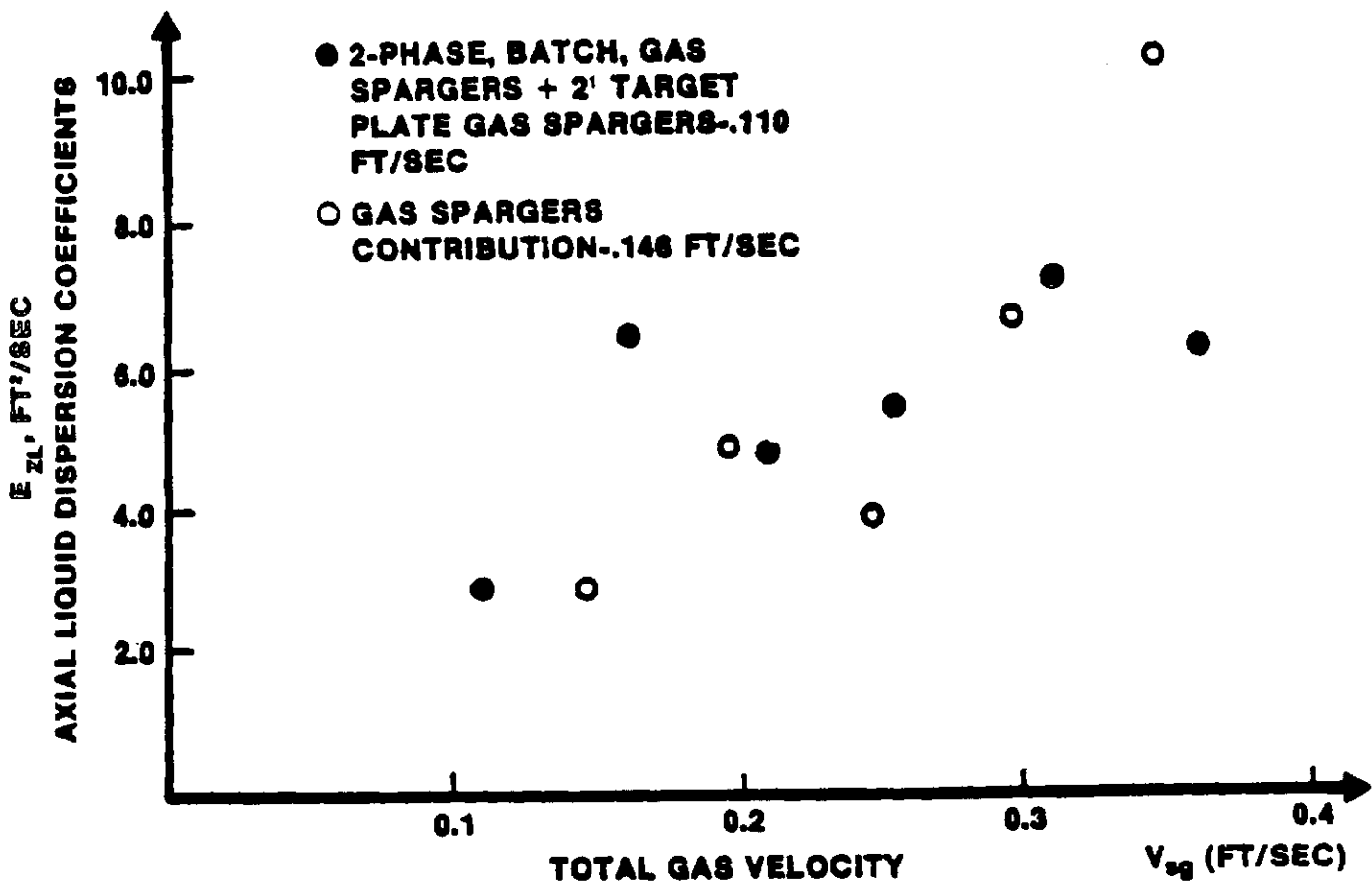


Figure 27
 Plots of E_{ZL} (Experimental and Correlation) vs. Superficial
 Gas Velocity for the 12-in. and 6-ft Columns

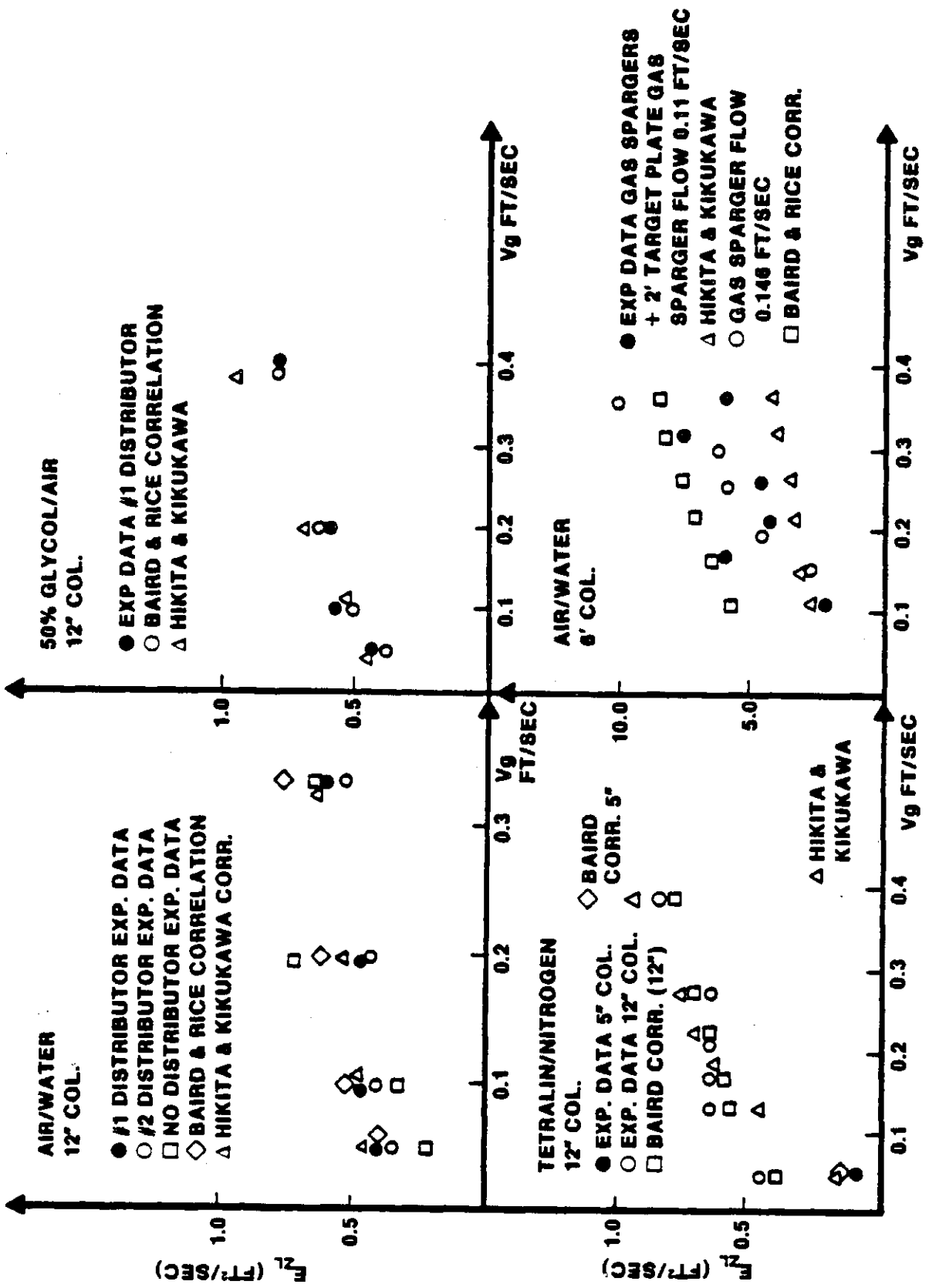


Figure 28
 Effect of Solids on Gas/Liquid Mass-Transfer Coefficients
 (5-in. Column; Air/Water and Air/Water/Sand)

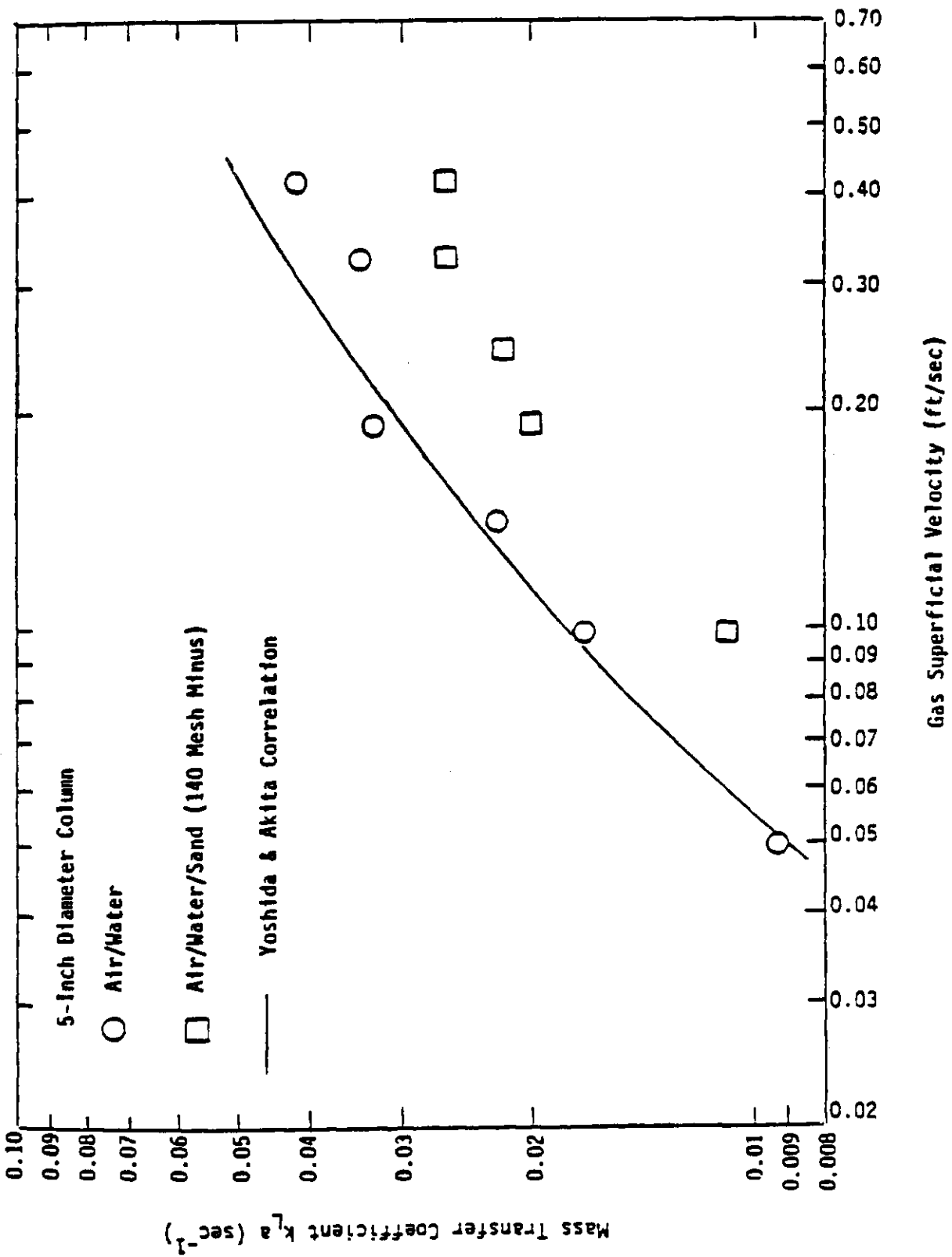


Figure 29
 Effect of Distributors on Gas/Liquid Mass Transfer
 in a 12-in. Column

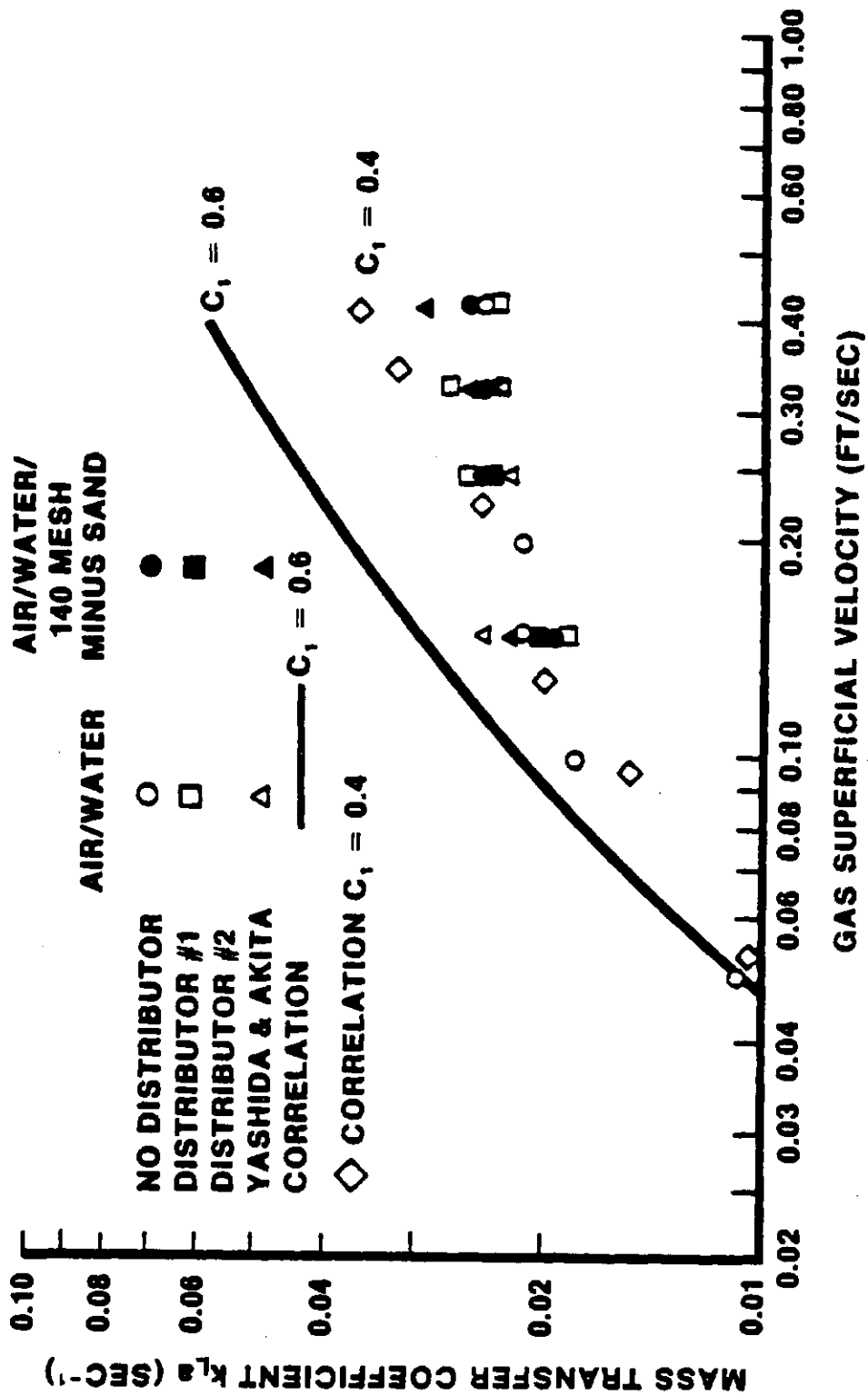


Figure 30
 Effect of Varying Gas Velocity through Spargers on
 Gas/Liquid Volumetric Mass-Transfer
 Coefficient in a 6-ft Column

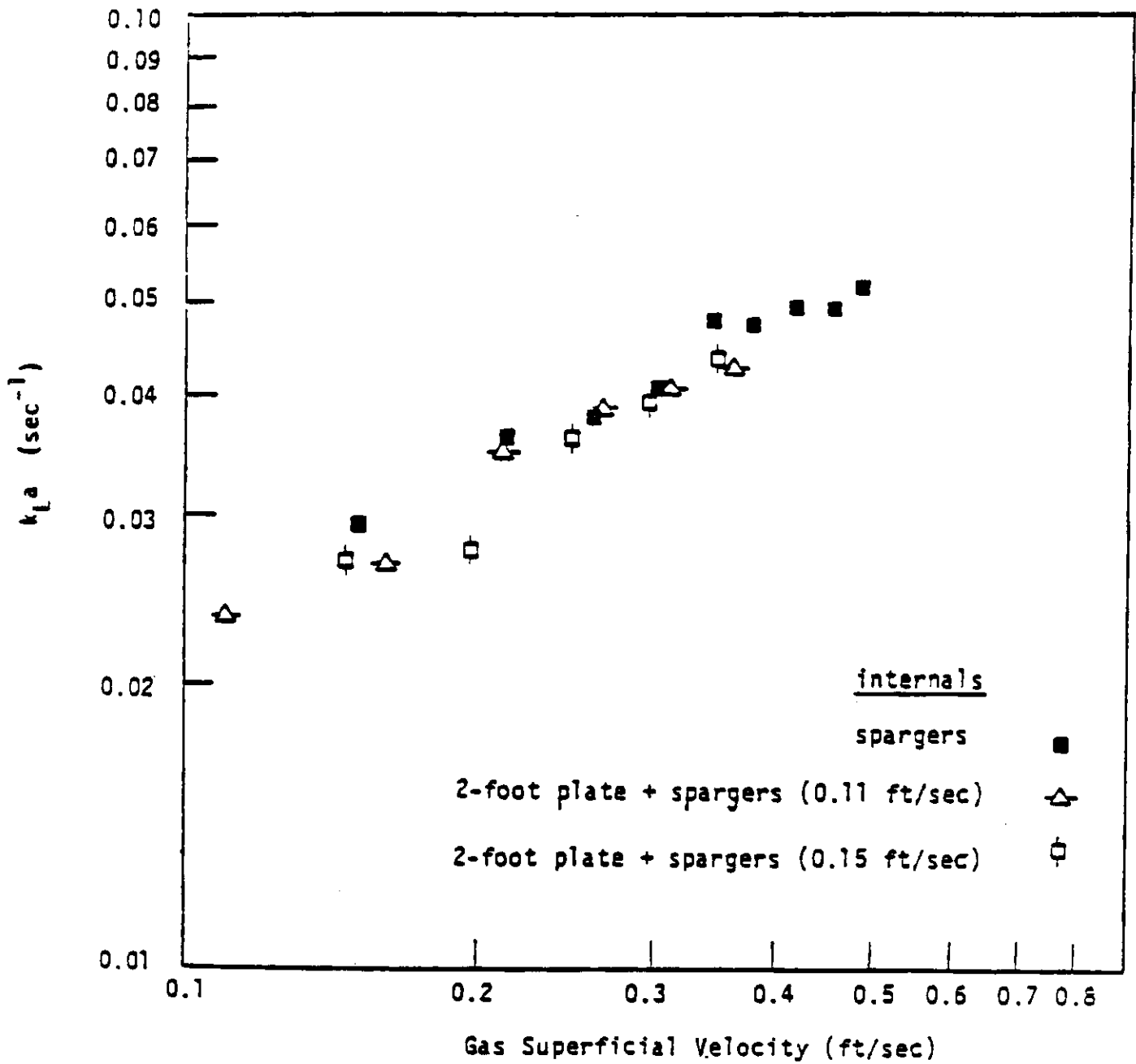


Figure 31
 Effect of Different Internals on Gas/Liquid Volumetric
 Mass-Transfer Coefficient in a 6-ft Column

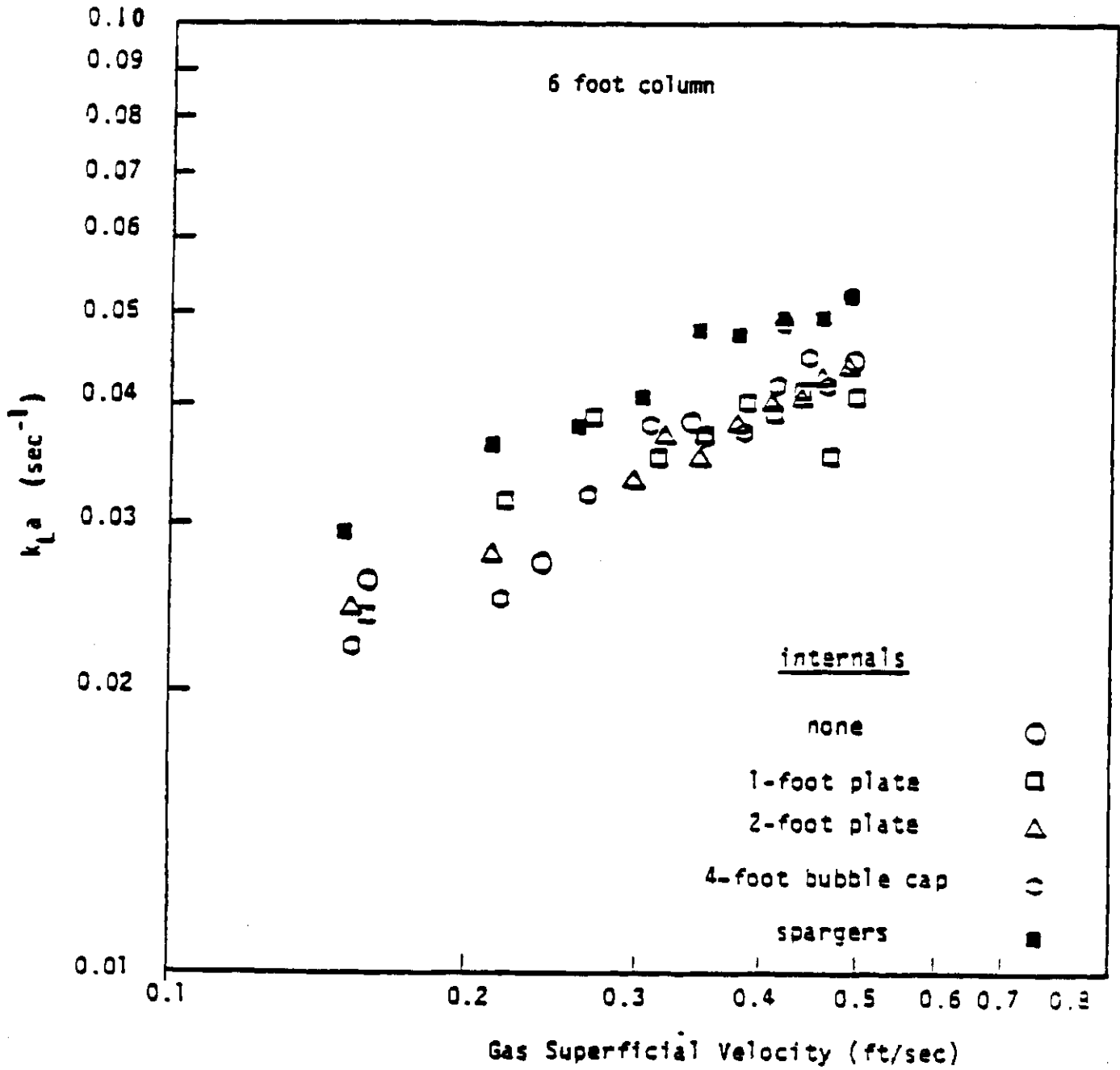


Figure 32
 Effect of Solids on Gas/Liquid Volumetric
 Mass-Transfer Coefficient (6-ft Column)

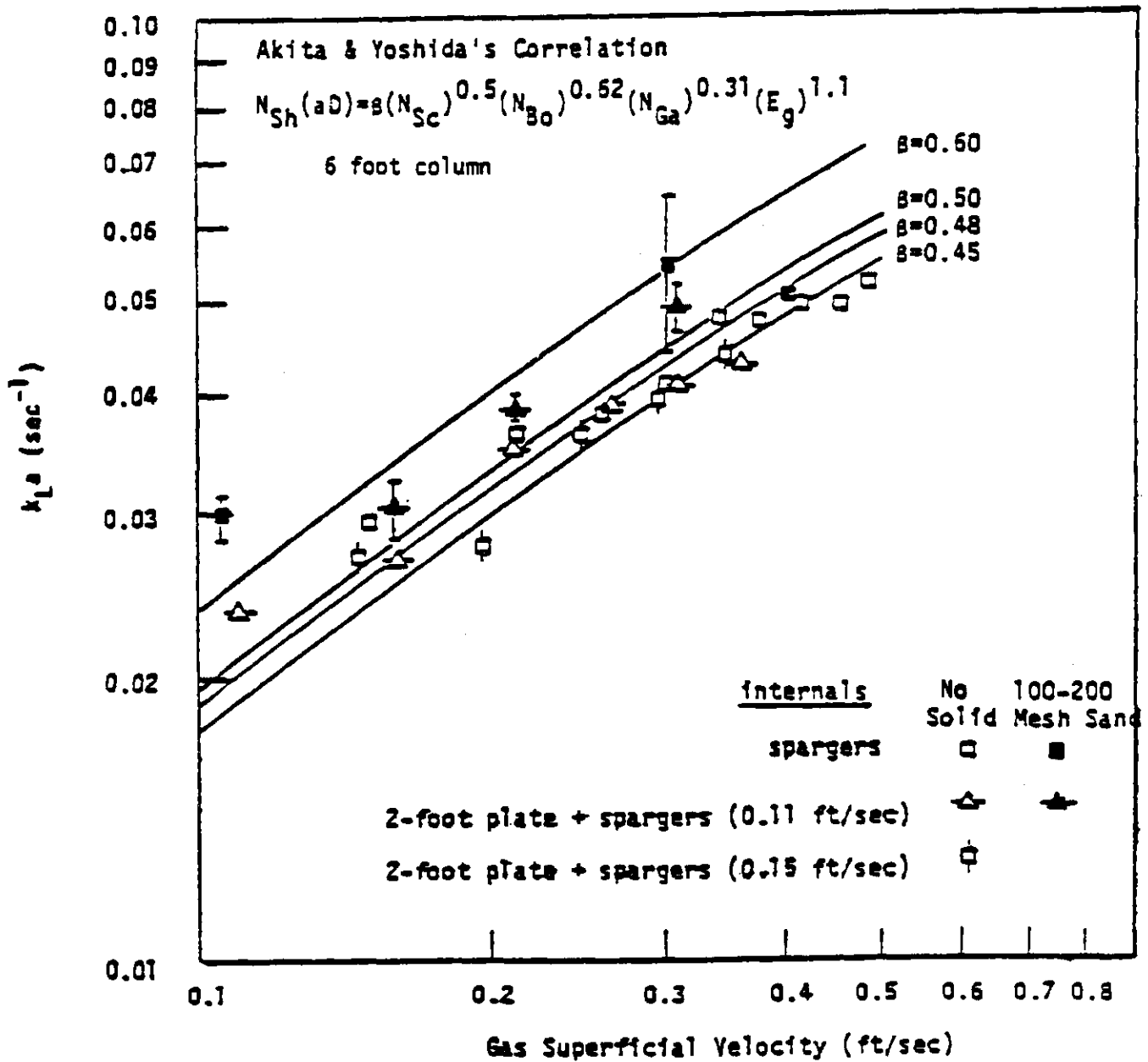


Figure 33
 Effect of Gas Velocity on Concentration vs. Length in a
 5-in. Column (Batch Mode, 140/170-Mesh Glass Beads)

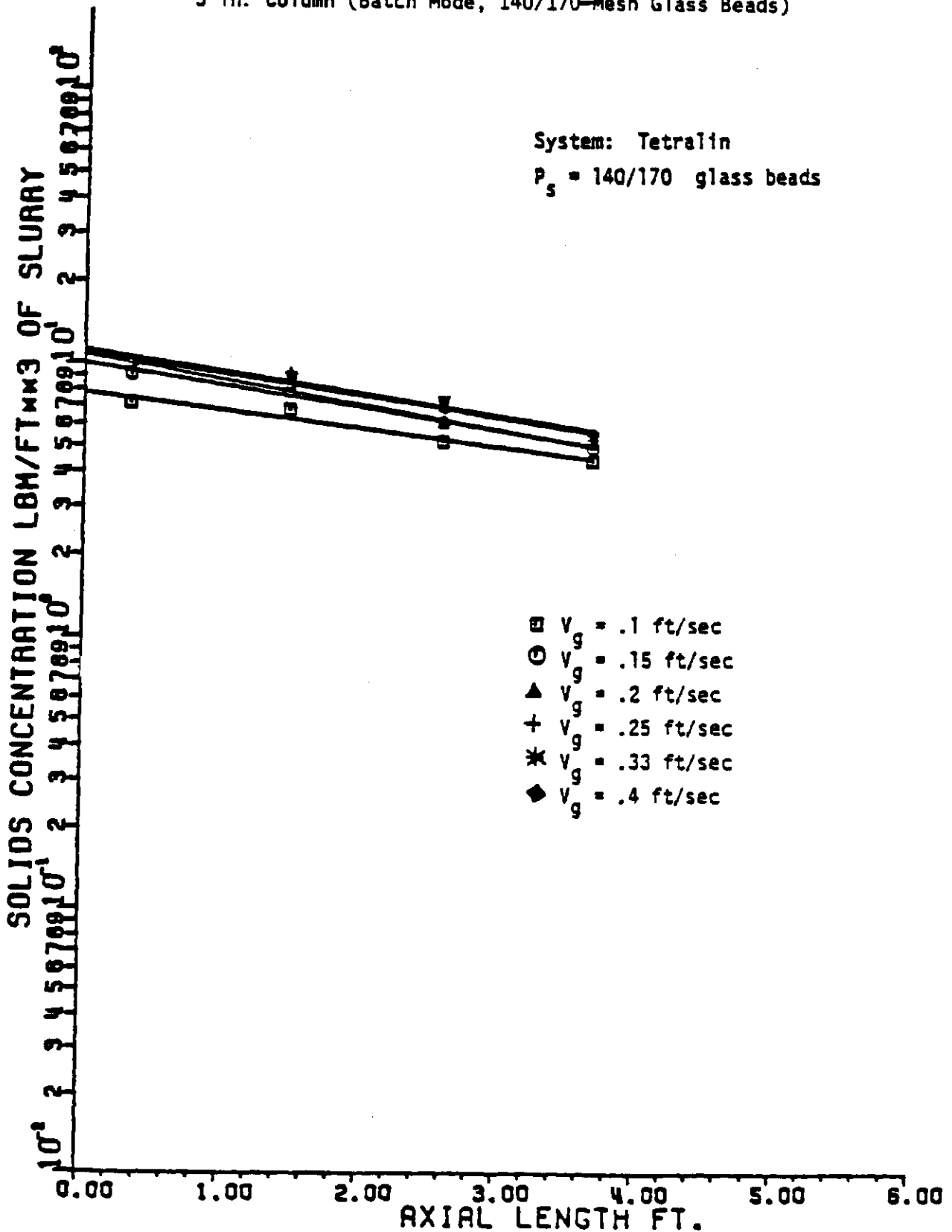


Figure 34

Effect of Gas Velocity on Concentration vs. Length in a
12-in. Column (Batch Mode; Tetralin/-140-Mesh Sand)

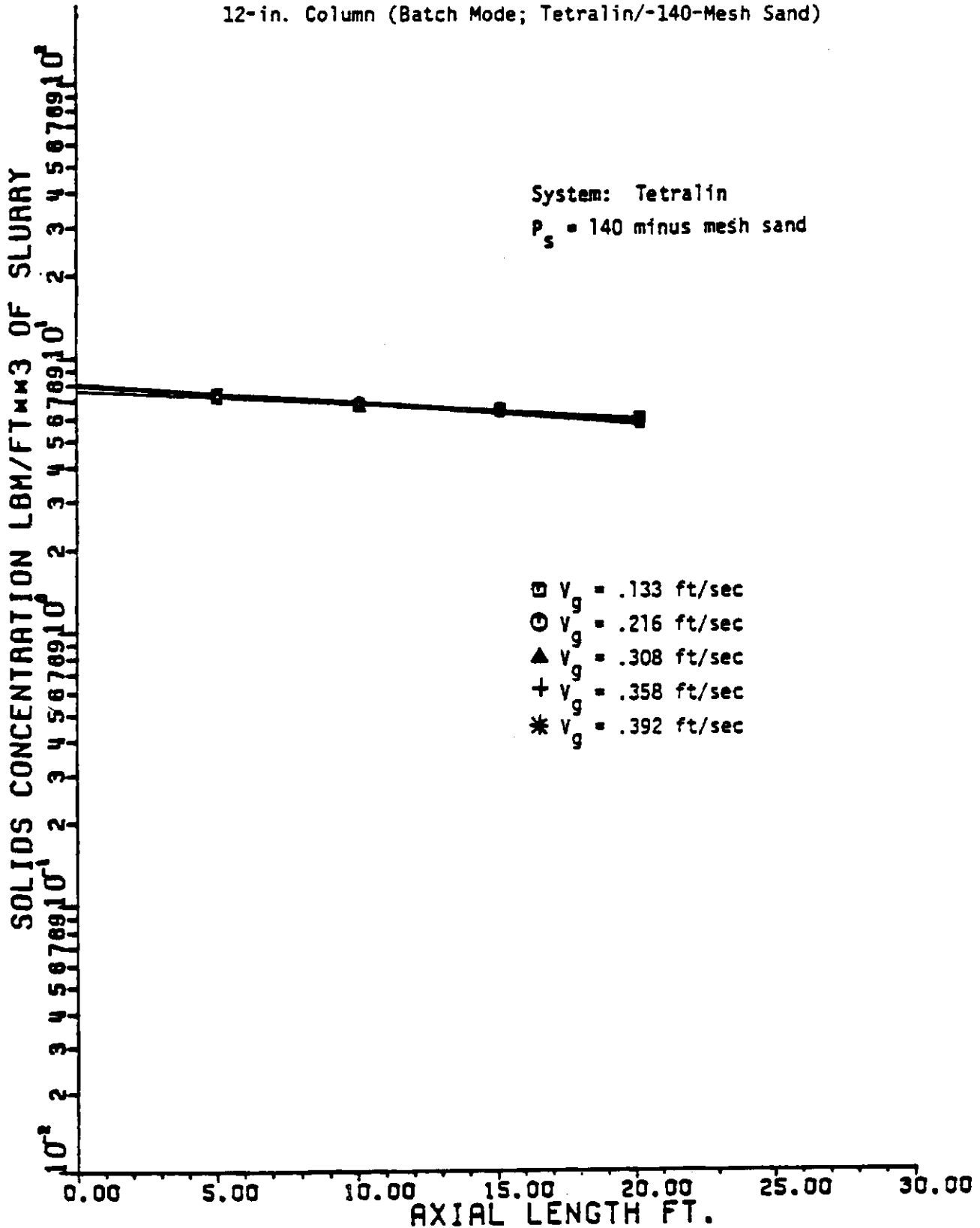


Figure 35
 Effect of Gas Velocity on Concentration vs. Length in a
 12-in. Column (Batch Mode; Glycol/-140-Mesh Sand)

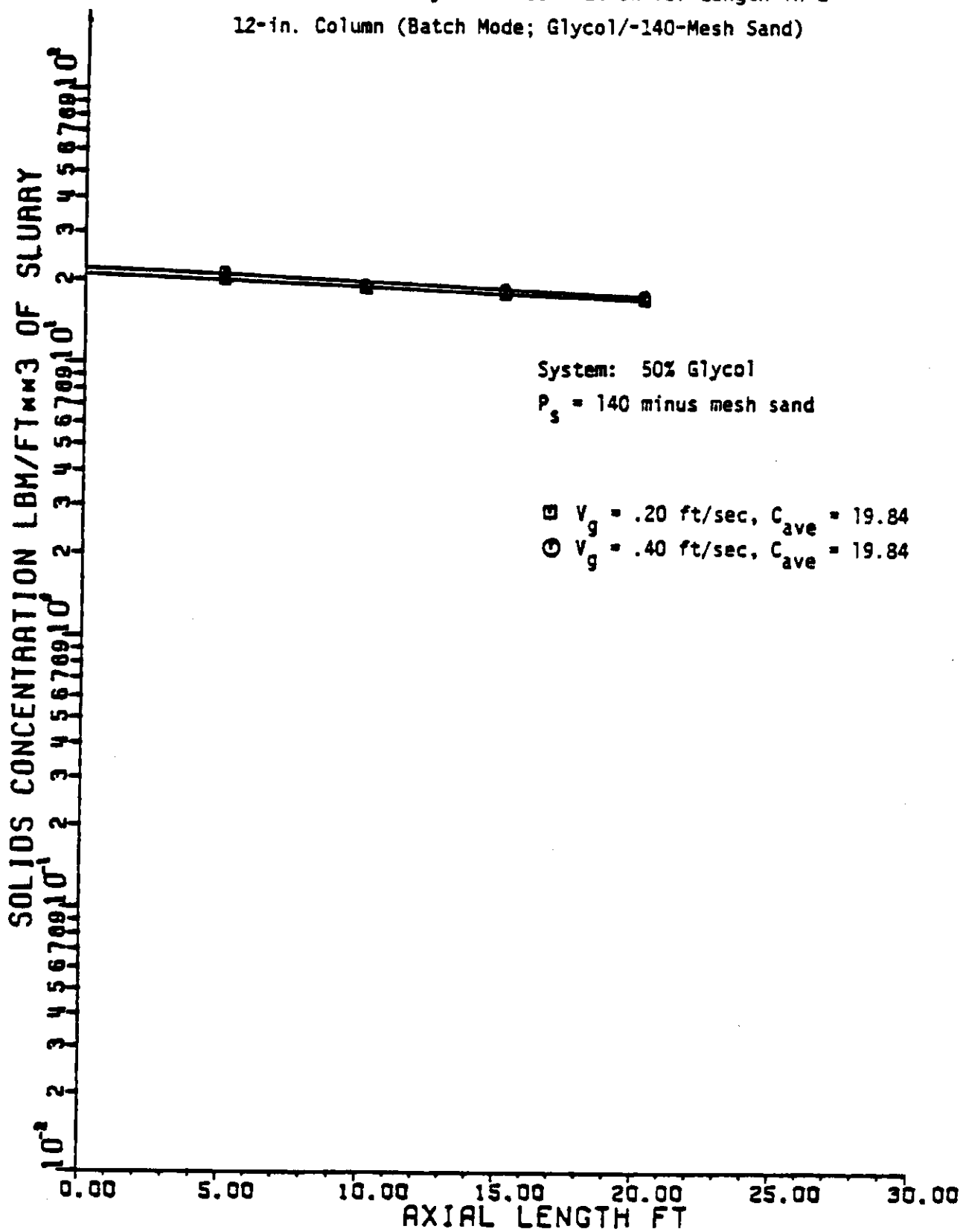


Figure 36

Effect of Gas Velocity on Concentration vs. Length in
a 5-in. Column (Batch Mode; Tetralin/60-70-Mesh Glass Beads)

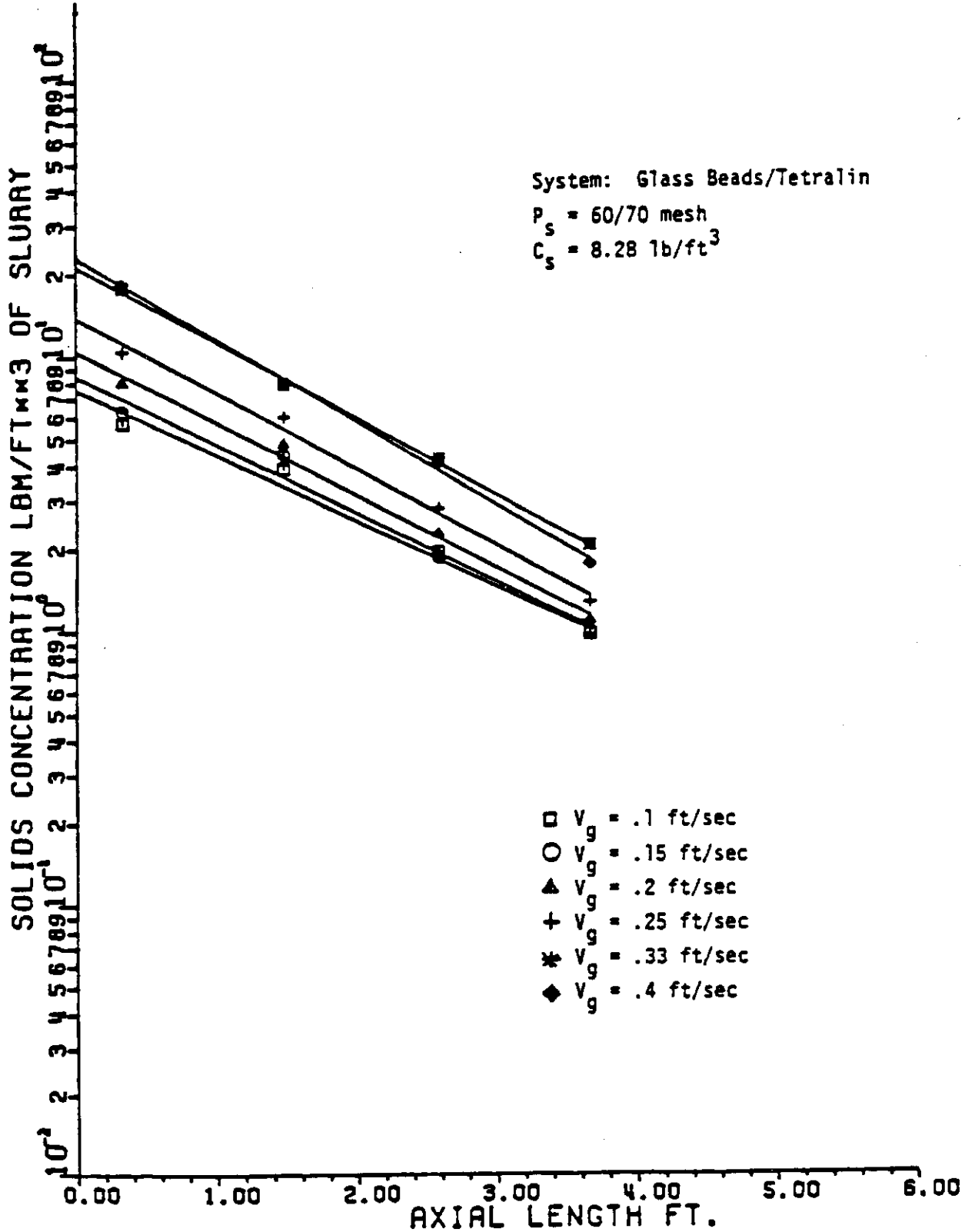


Figure 37
 Effect of Gas Velocity on Concentration vs. Length in a
 12-in. Column (Batch Mode; Tetralin/60-80-Mesh Sand)

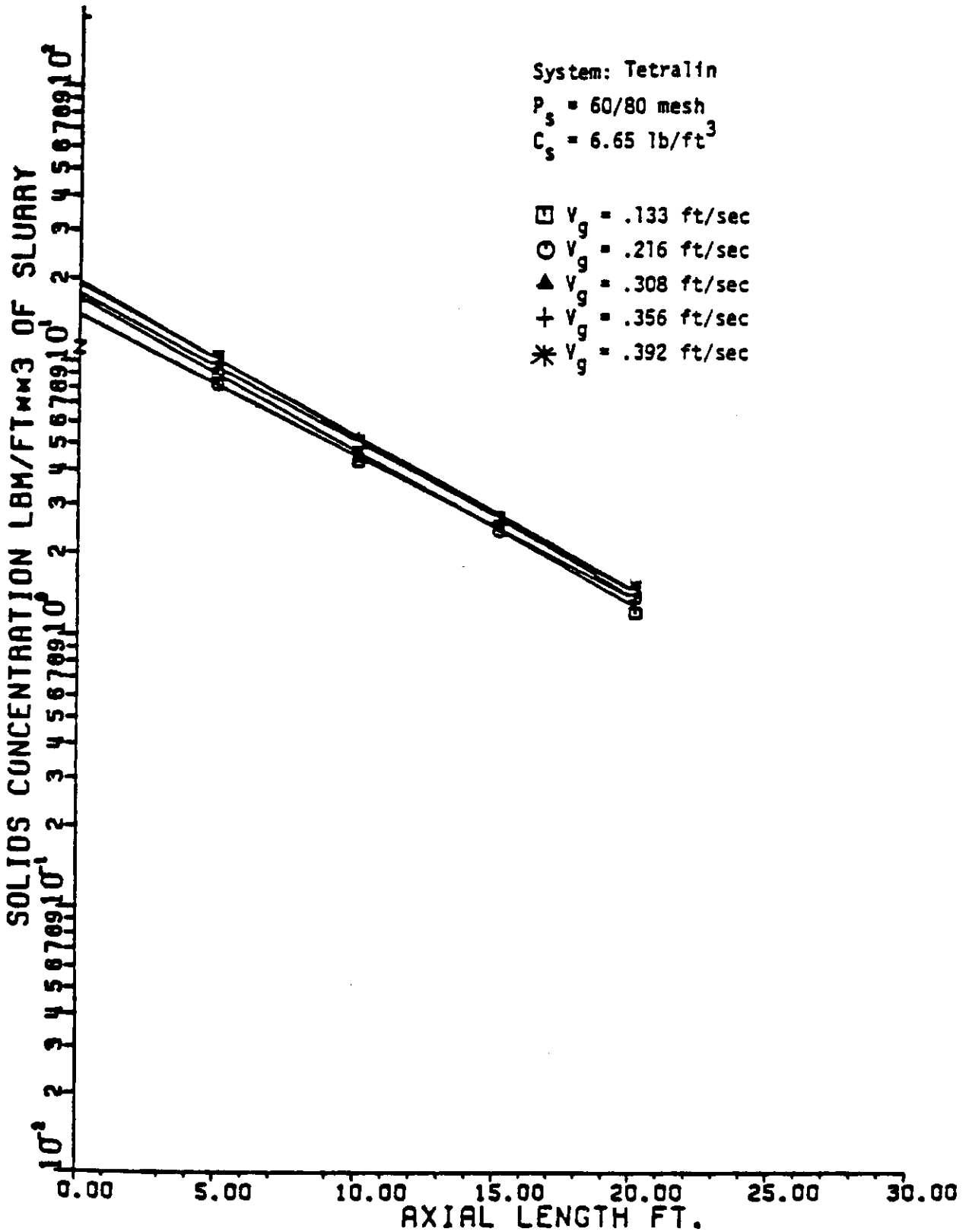


Figure 38

Effect of Gas Velocity on Solids Distribution Concentration vs. Axial Length (Batch Mode; 12-in. Column; Glycol/60-80-Mesh Sand)

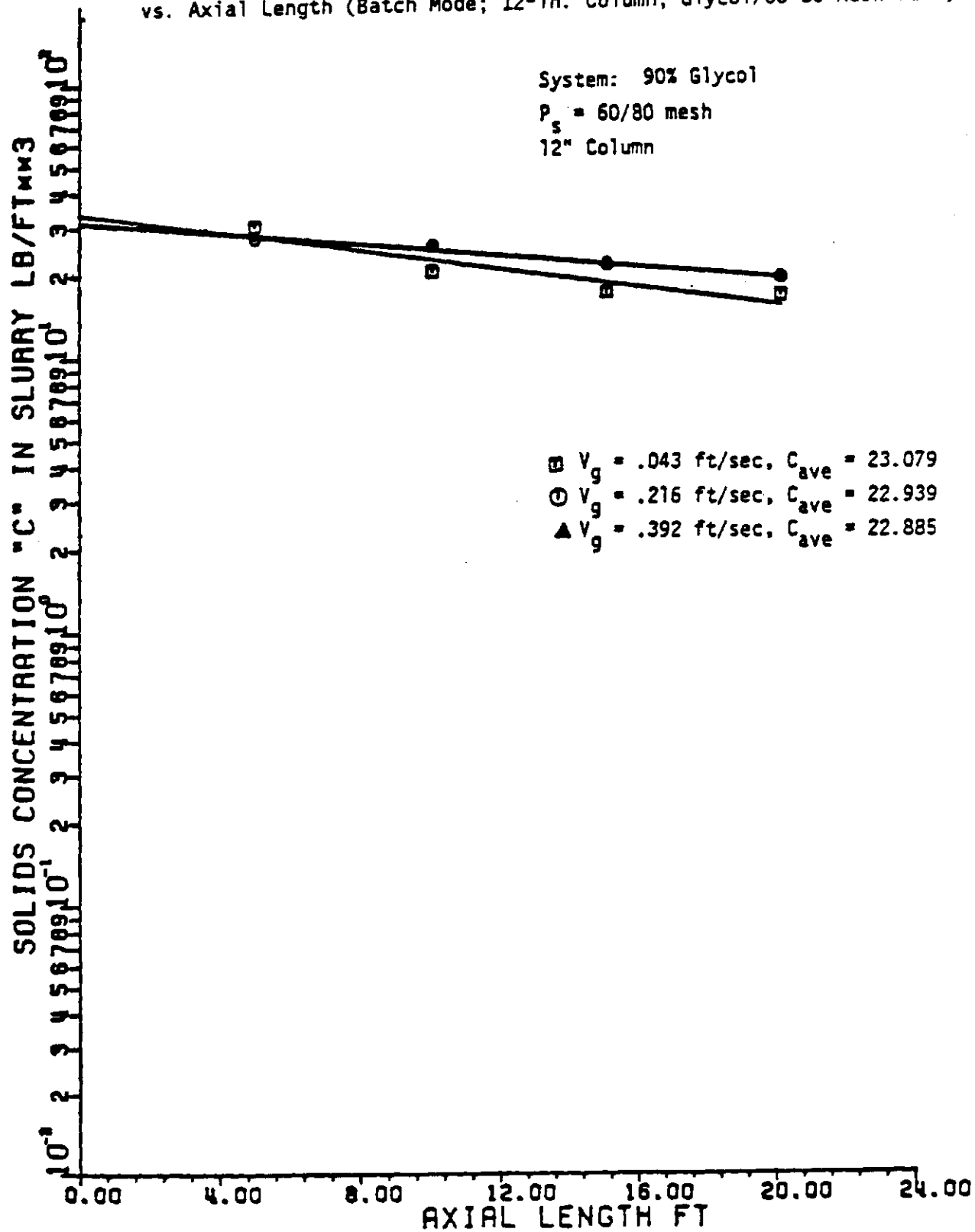


Figure 39
 Effect of Gas Velocity on Concentration vs. Length in a
 12-in. Column (Continuous Mode; Tetralin/-140-Mesh Sand)

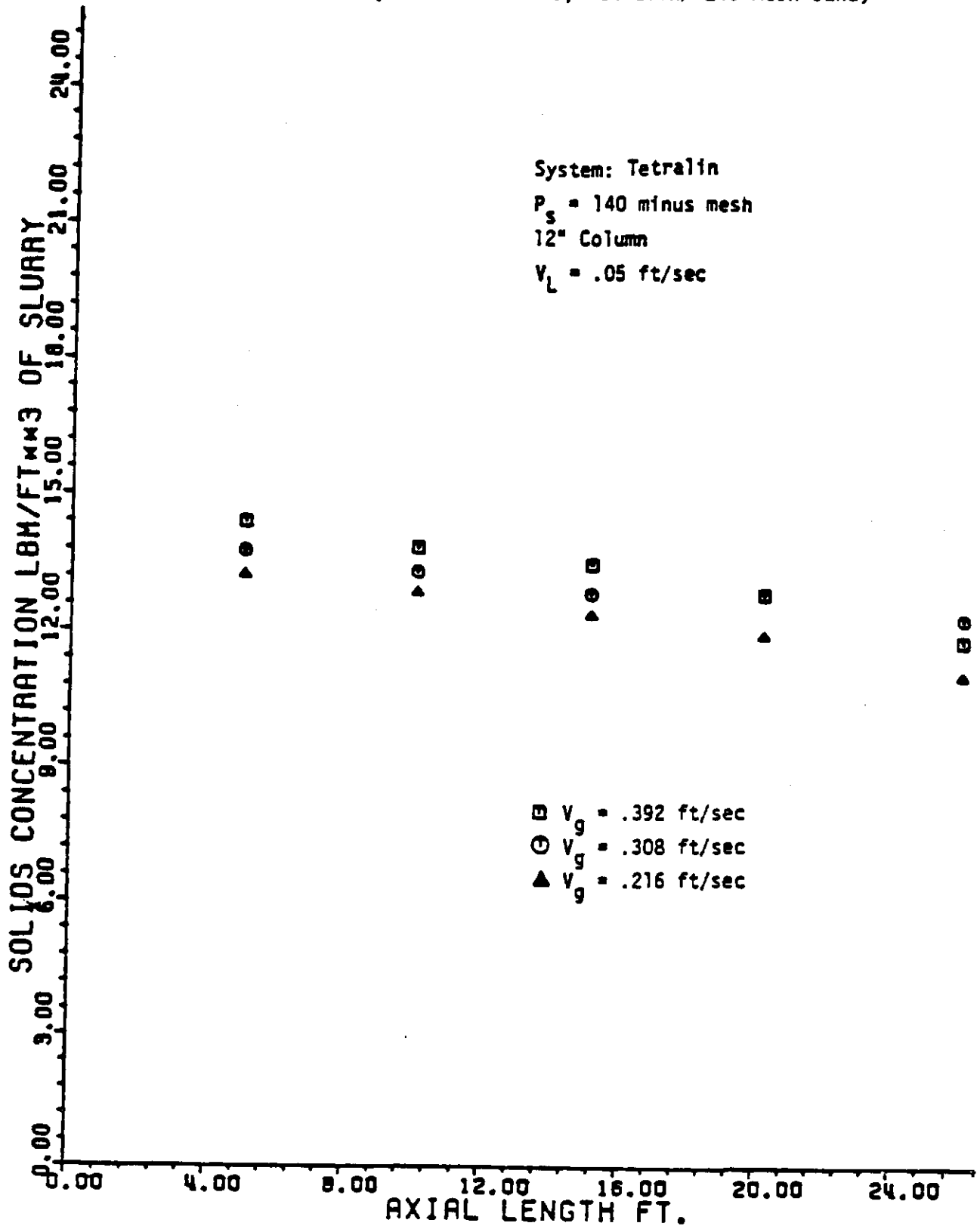


Figure 40
 Effect of Gas Velocity on Solids Distribution Profile in the
 12-in. Column (Continuous Mode; Glycol/-140-Mesh Sand)

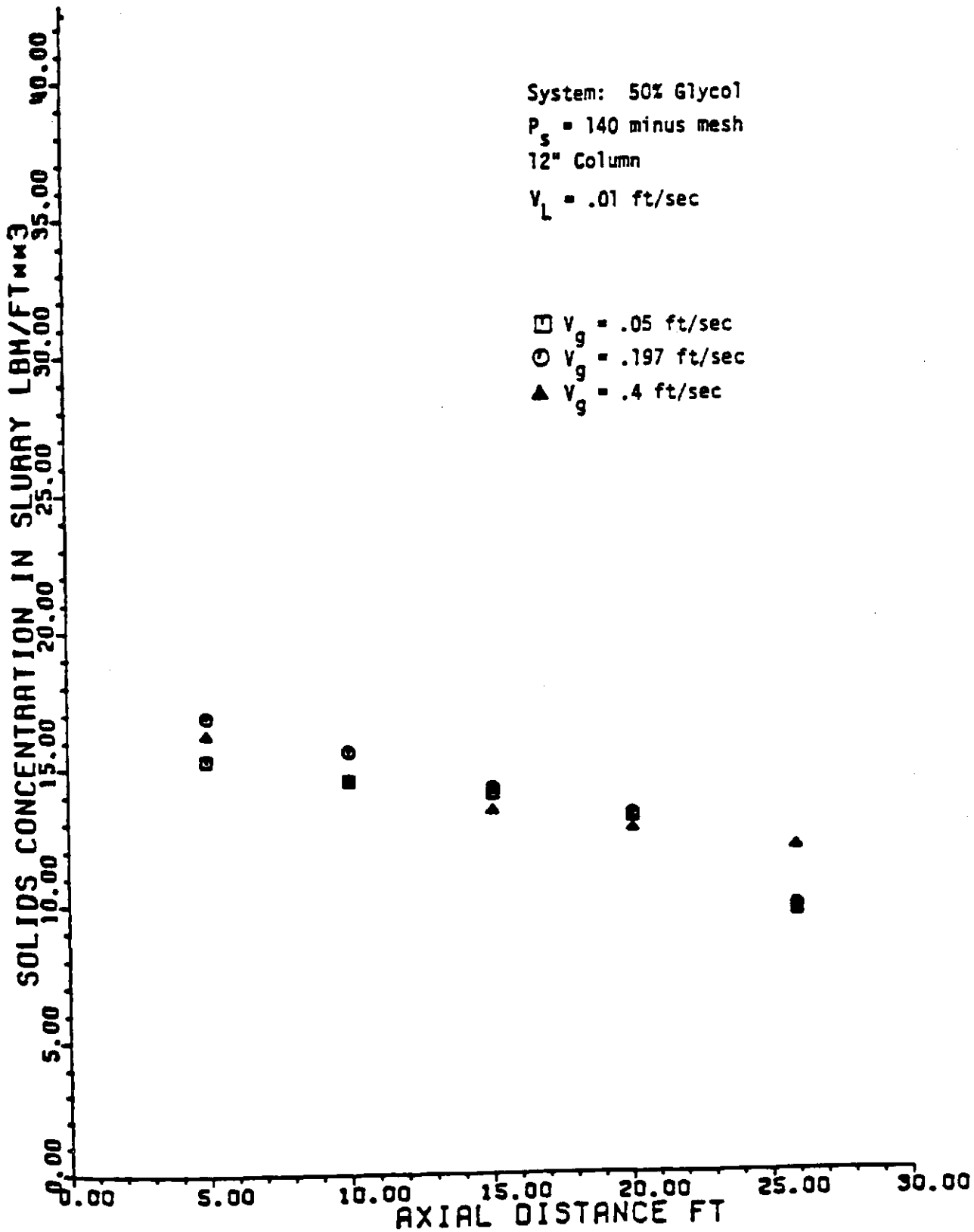


Figure 41
 Effect of Gas Velocity on the Distribution of
 Large Particles (12-in. Column)
 (Continuous Mode; 60/80-Mesh Sand)

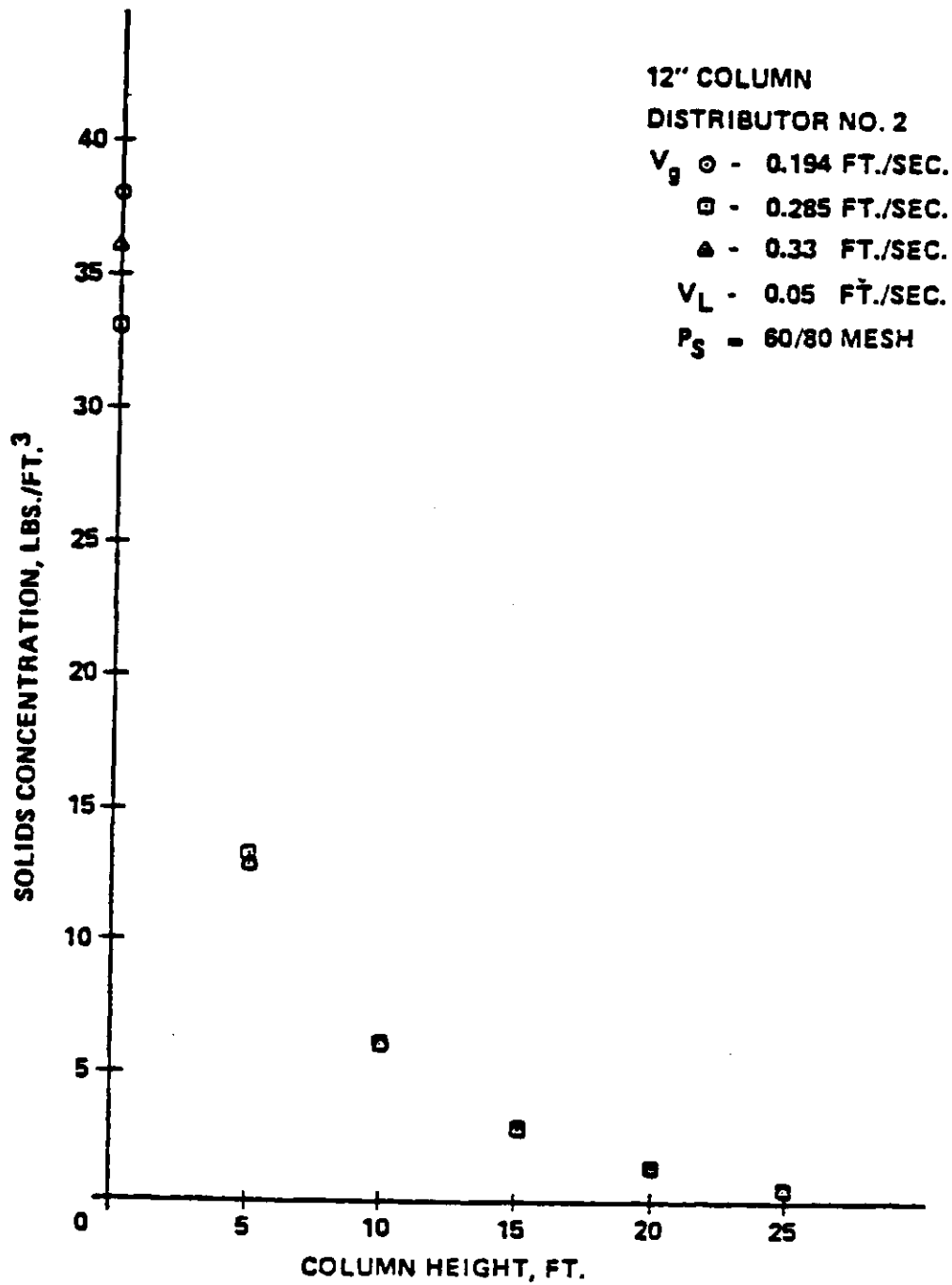


Figure 42
 Effect of Gas Velocity on Concentration vs.
 Length in the 12-in. Column (Continuous Mode;
 Tetralin/60-80-Mesh Sand)

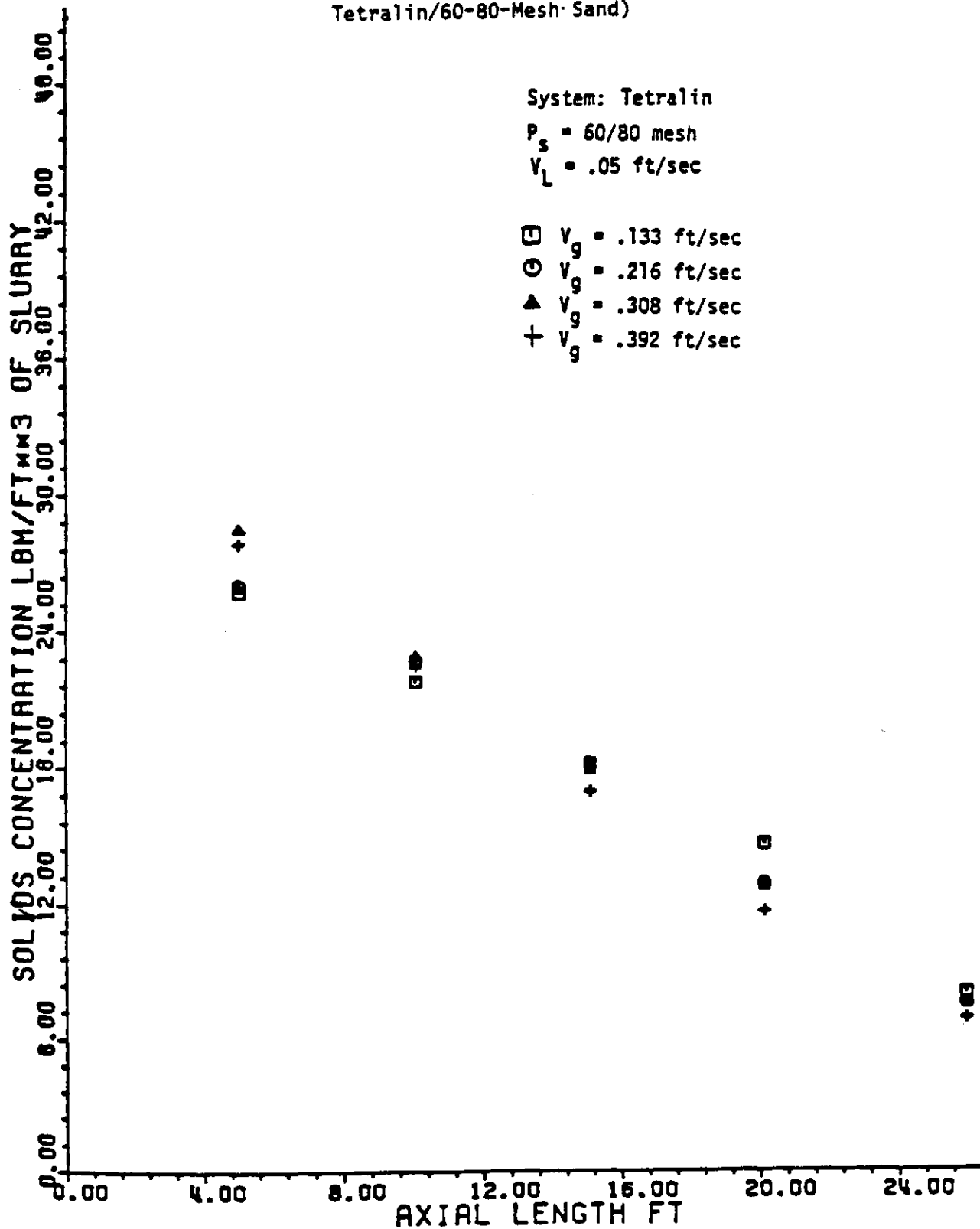


Figure 43
 Effect of Gas Velocity on Average Solids Distribution
 (12-in. Column; Continuous Mode;
 Tetralin/-140- and 60-80-Mesh Sand)

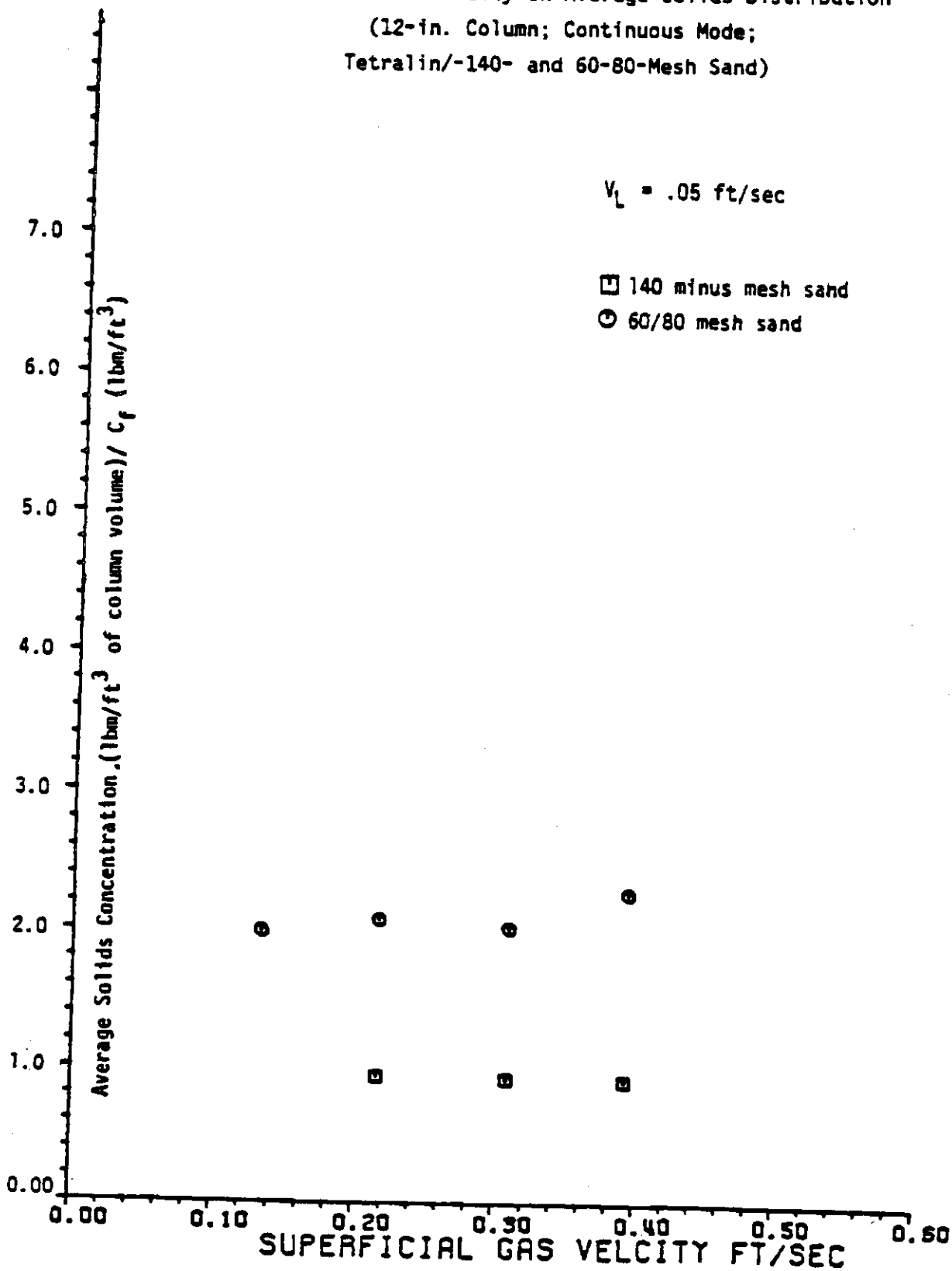
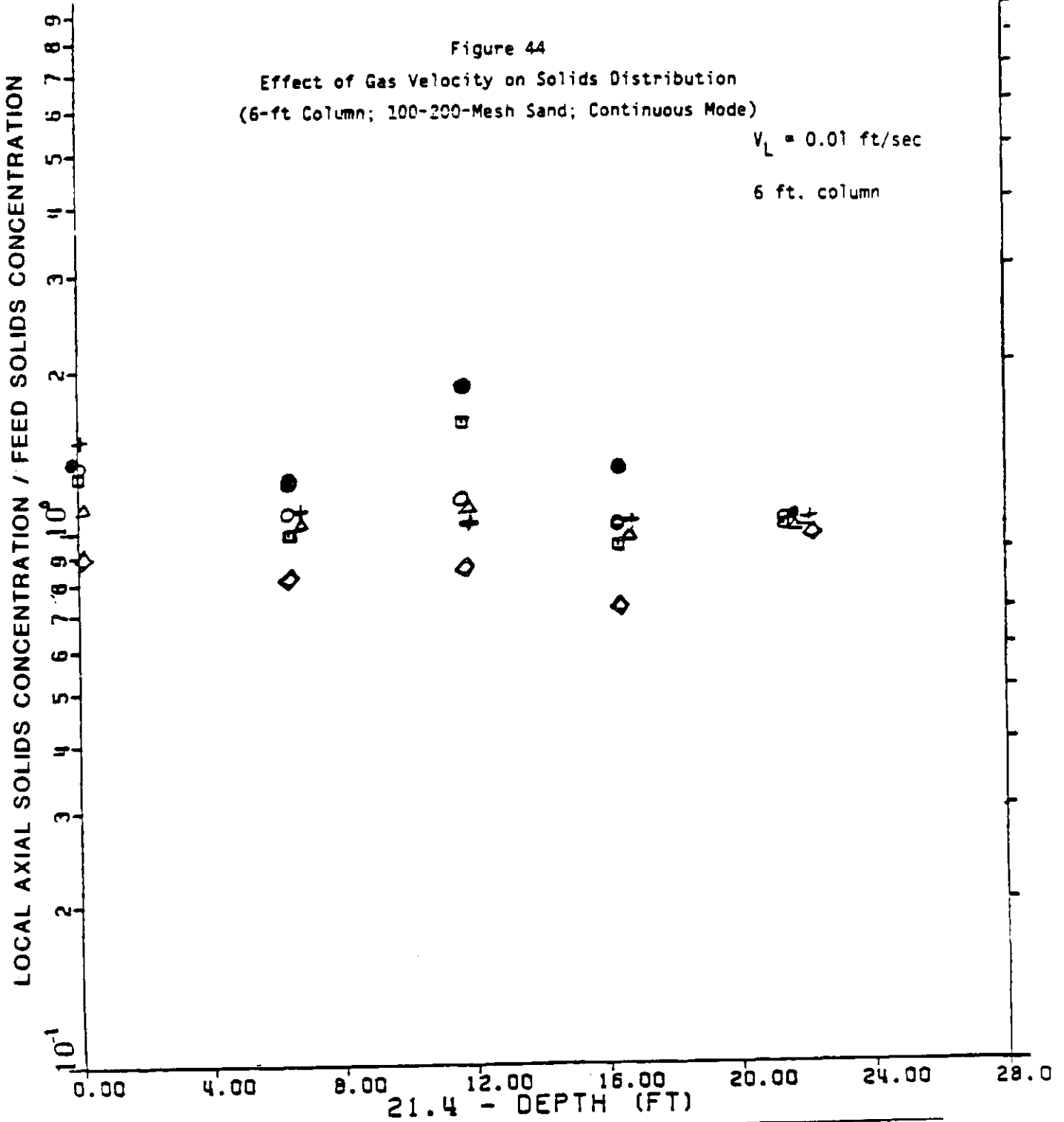


Figure 44

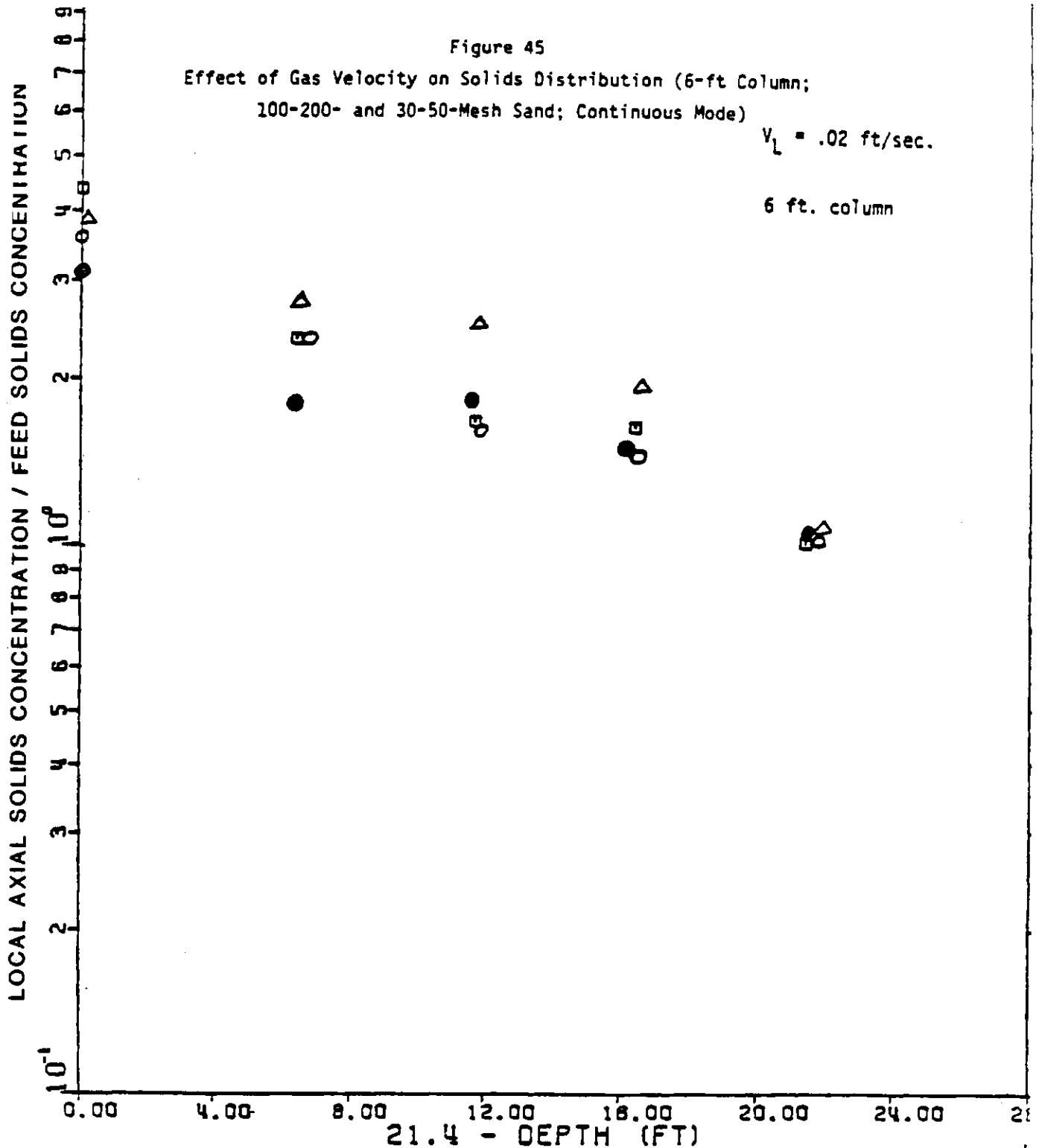
Effect of Gas Velocity on Solids Distribution
 (6-ft Column; 100-200-Mesh Sand; Continuous Mode)

$V_L = 0.01$ ft/sec

6 ft. column



AXIAL SOLIDS DISTRIBUTION	
SPARGERS = 2 FOOT PLATE	$\square V_g = 0.11$ ft/sec. $+ V_g = 0.31$ ft/sec
100-200 MESH SOLIDS	$\diamond V_g = 0.16$ ft/sec. $\diamond V_g = 0.36$ ft/sec
LIQUID VELOCITY = 0.01 FT/SEC	$\bullet V_g = 0.21$ ft/sec.
SPARGER GAS FLOW = 0.110 FT/SEC	$\triangle V_g = 0.26$ ft/sec.



AXIAL SOLIDS DISTRIBUTION	
SPARGERAS • 2 FOOT PLATE 100-200 AND 30-50 MESH SOLIDS LIQUID VELOCITY = 0.02 FT/SEC SPARGER GAS FLOW = 0.110 FT/SEC	<div style="display: flex; flex-direction: column; gap: 5px;"> <div>□ $V_g = 0.16$ ft/sec.</div> <div>○ $V_g = 0.21$ ft/sec.</div> <div>● $V_g = 0.31$ ft/sec.</div> <div>△ $V_g = 0.36$ ft/sec.</div> </div>

Figure 46
Effect of Liquid Velocity on Solids Distribution
(5-in. Column; Continuous Mode)

PARTICLE SIZE = 60/80 MESH

GAS VELOCITY = 0.327 FT/SEC

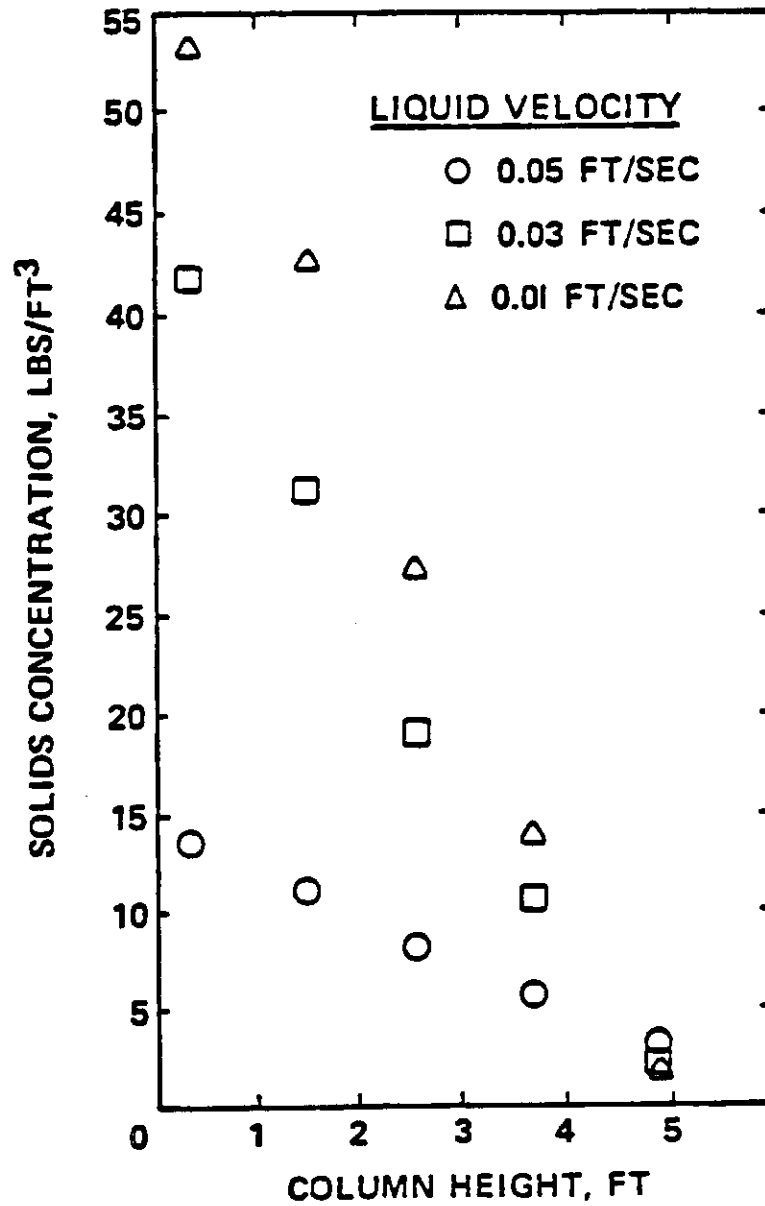


Figure 47
 Effect of Liquid Velocity on Axial Solids Distribution
 (12-in. Column; Continuous Mode)

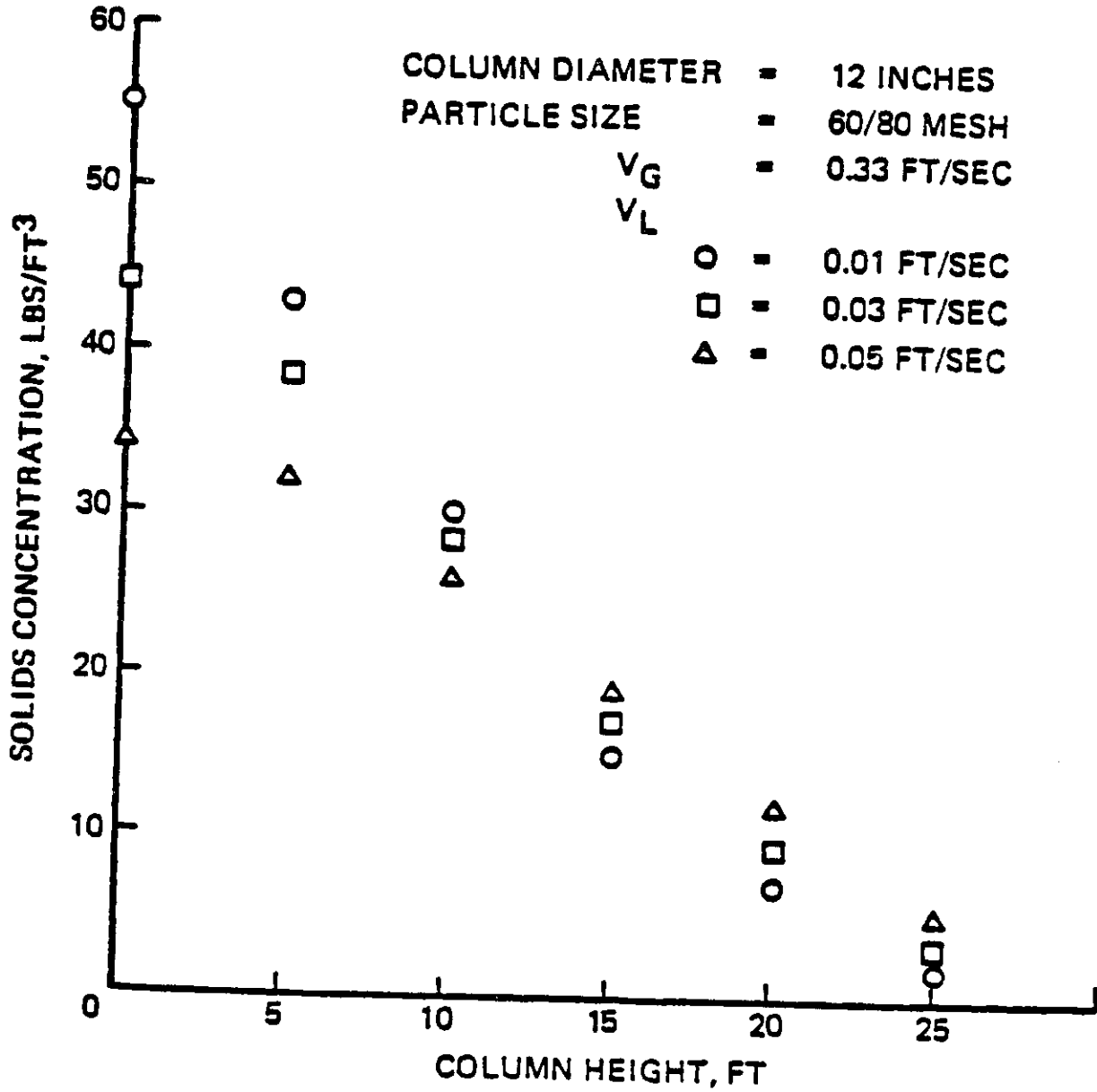


Figure 48
 Effect of Liquid Velocity on the Distribution of
 Fine Particles (12-in. Column; Air/Water/Sand; Continuous Mode)

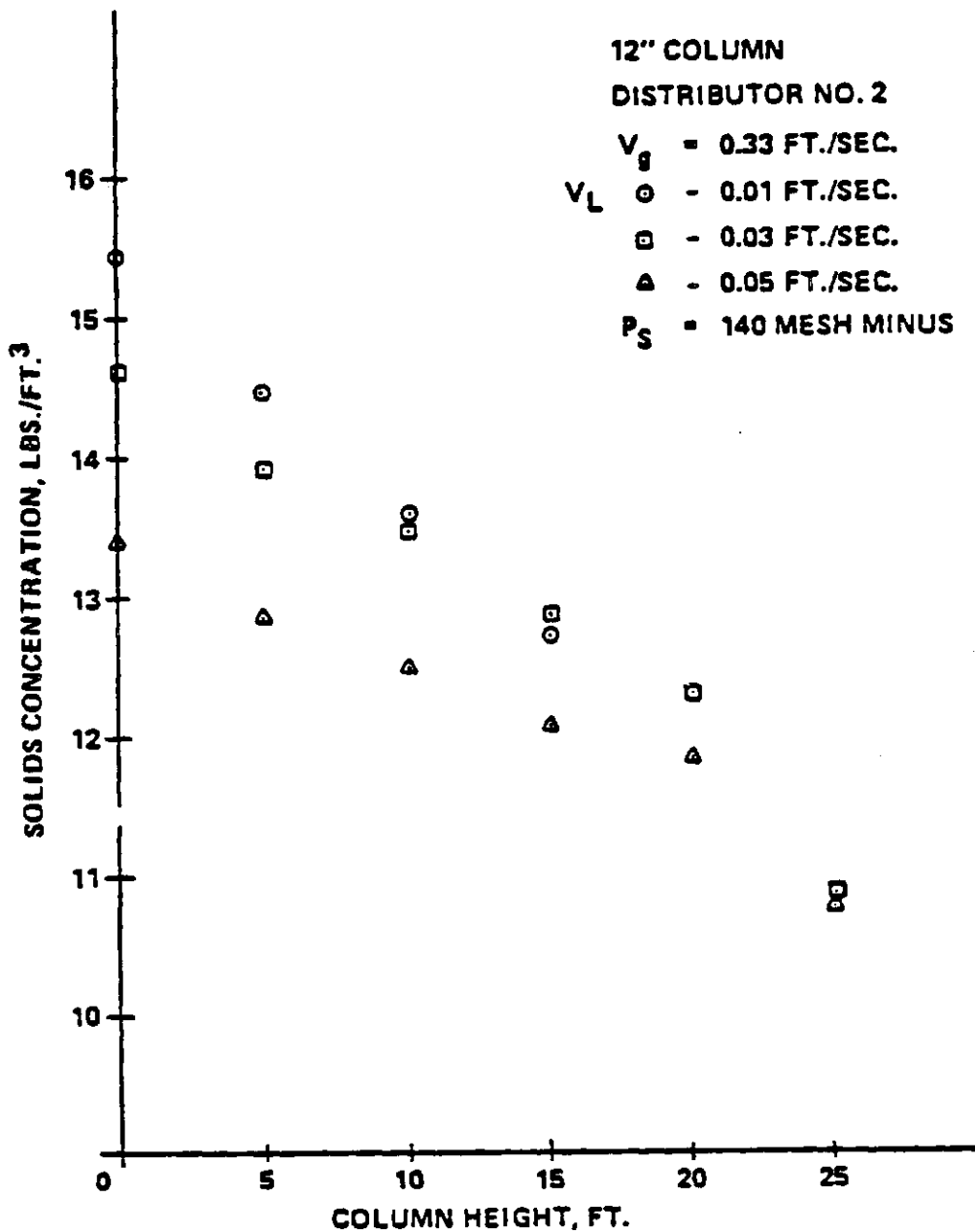
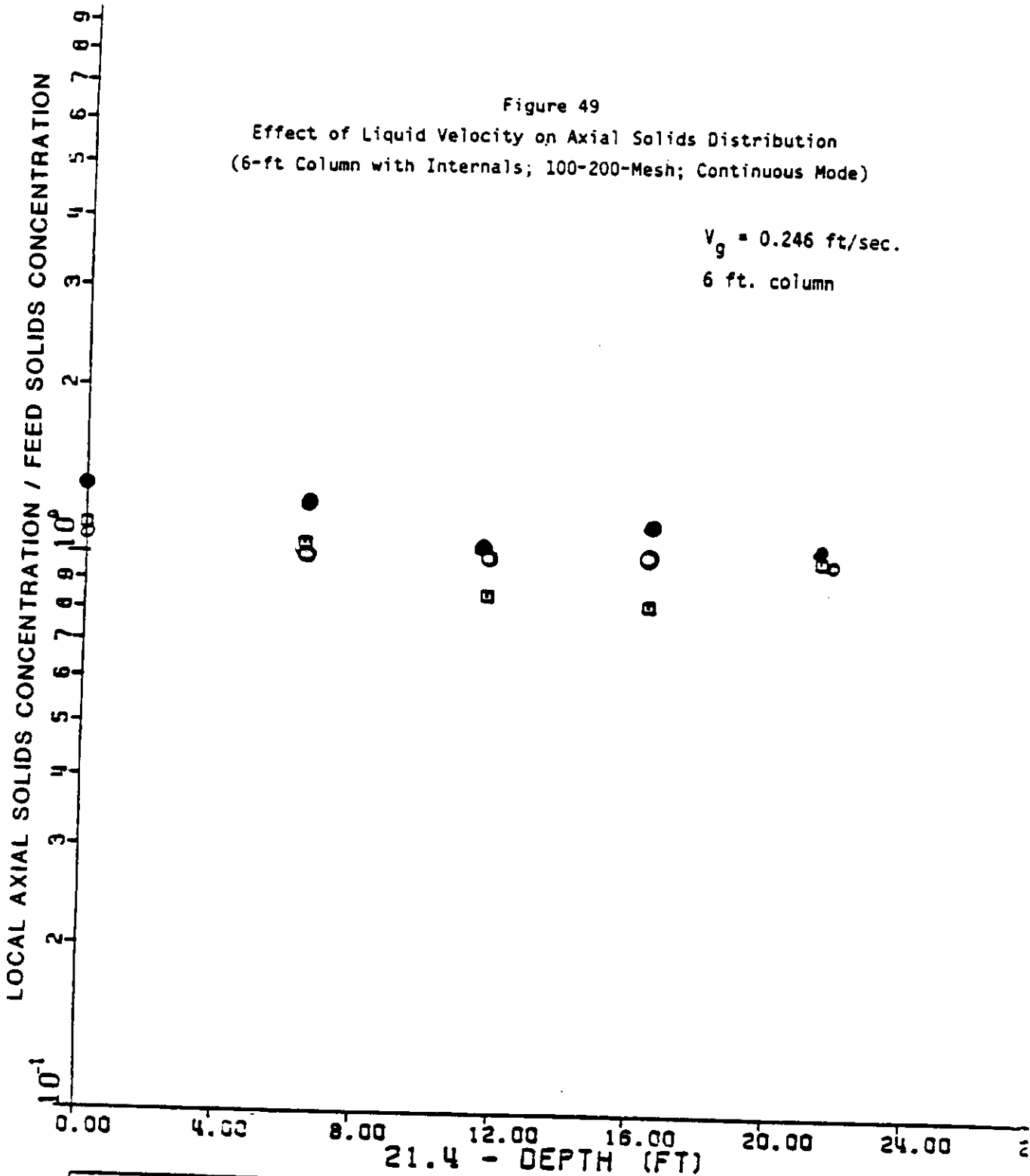


Figure 49

Effect of Liquid Velocity on Axial Solids Distribution
 (6-ft Column with Internals; 100-200-Mesh; Continuous Mode)

$V_g = 0.246$ ft/sec.

6 ft. column



AXIAL SOLIDS DISTRIBUTION

SPRAGERS - 2 FOOT PLATE
 100-200 MESH SOLIDS

□ $V_L = 0.01$ ft/sec.

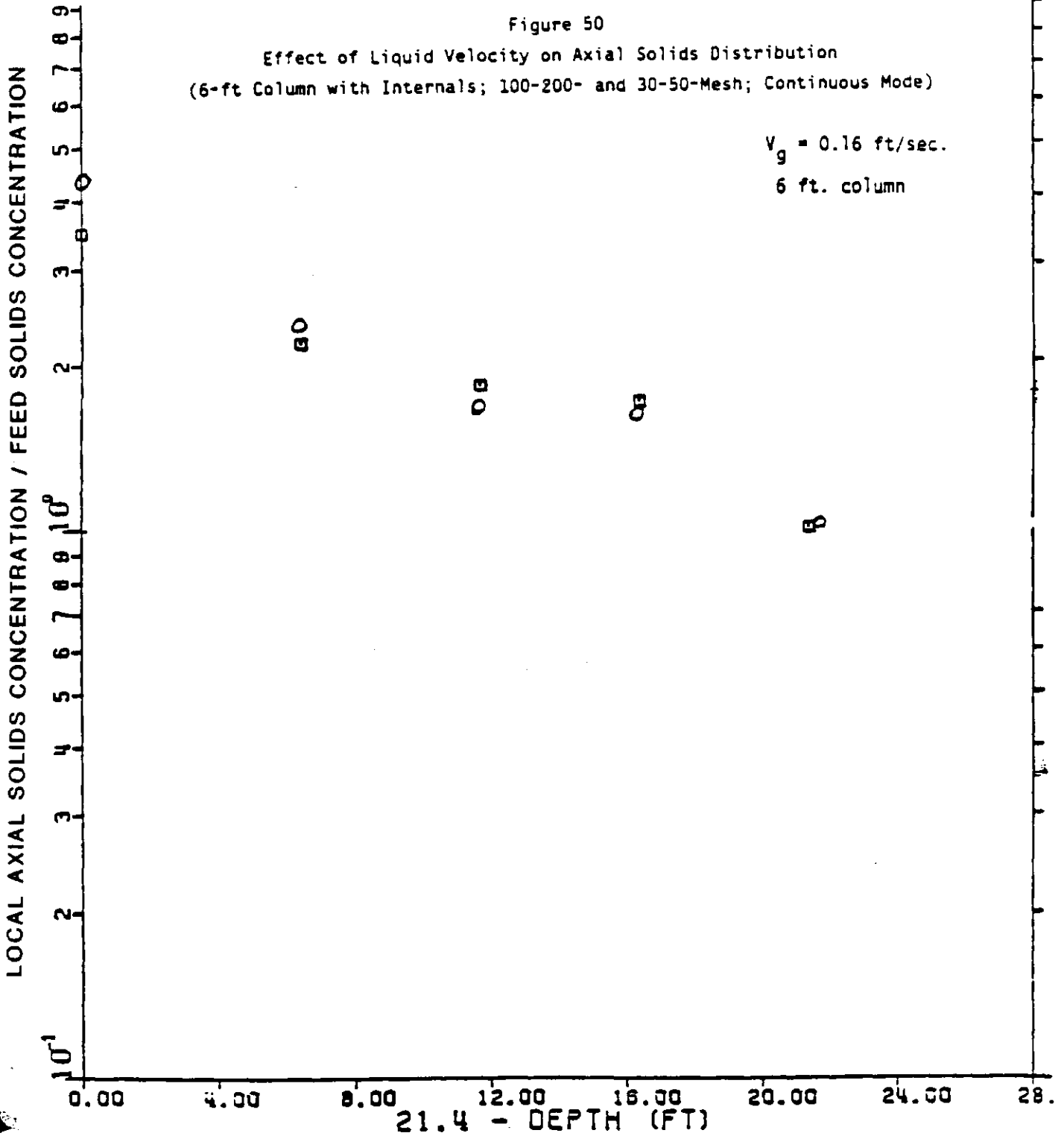
○ $V_L = 0.02$ ft/sec.

● $V_L = 0.33$ ft/sec.

Figure 50

Effect of Liquid Velocity on Axial Solids Distribution
 (6-ft Column with Internals; 100-200- and 30-50-Mesh; Continuous Mode)

$V_g = 0.16$ ft/sec.
 6 ft. column



AXIAL SOLIDS DISTRIBUTION SPRAGERS • 2 FOOT PLATE 100-200 AND 30-50 MESH SOLIDS	□ $v_L = 0.033$
	○ $v_L = 0.022$

Figure 51
Effect of Liquid Velocity on Solids Accumulation
(12-in. Column; Tetralin/60-80- Mesh Sand; Continuous Mode)

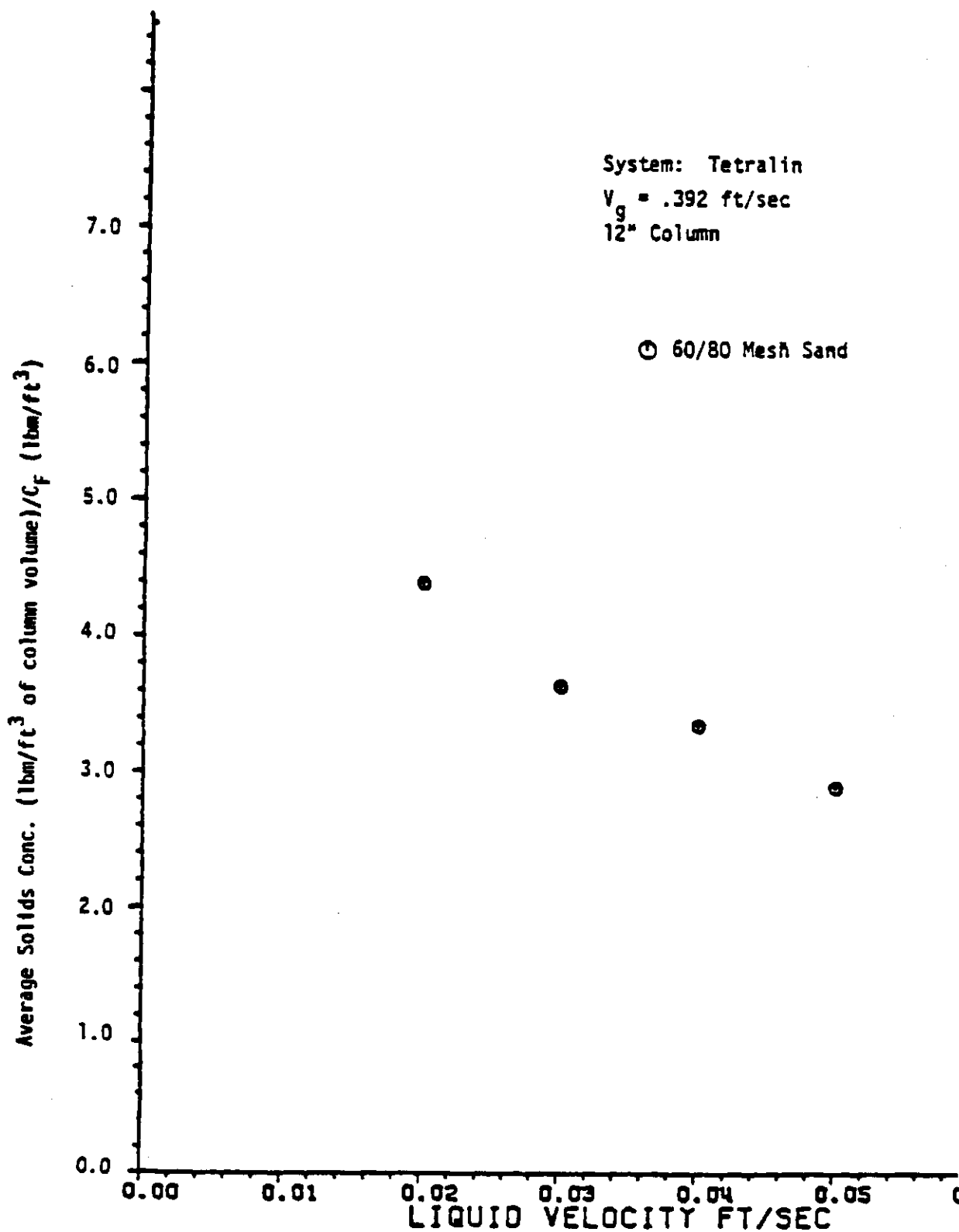


Figure 52
 Effect of Viscosity on Solids Distribution
 (12-in. Column; Continuous Mode)

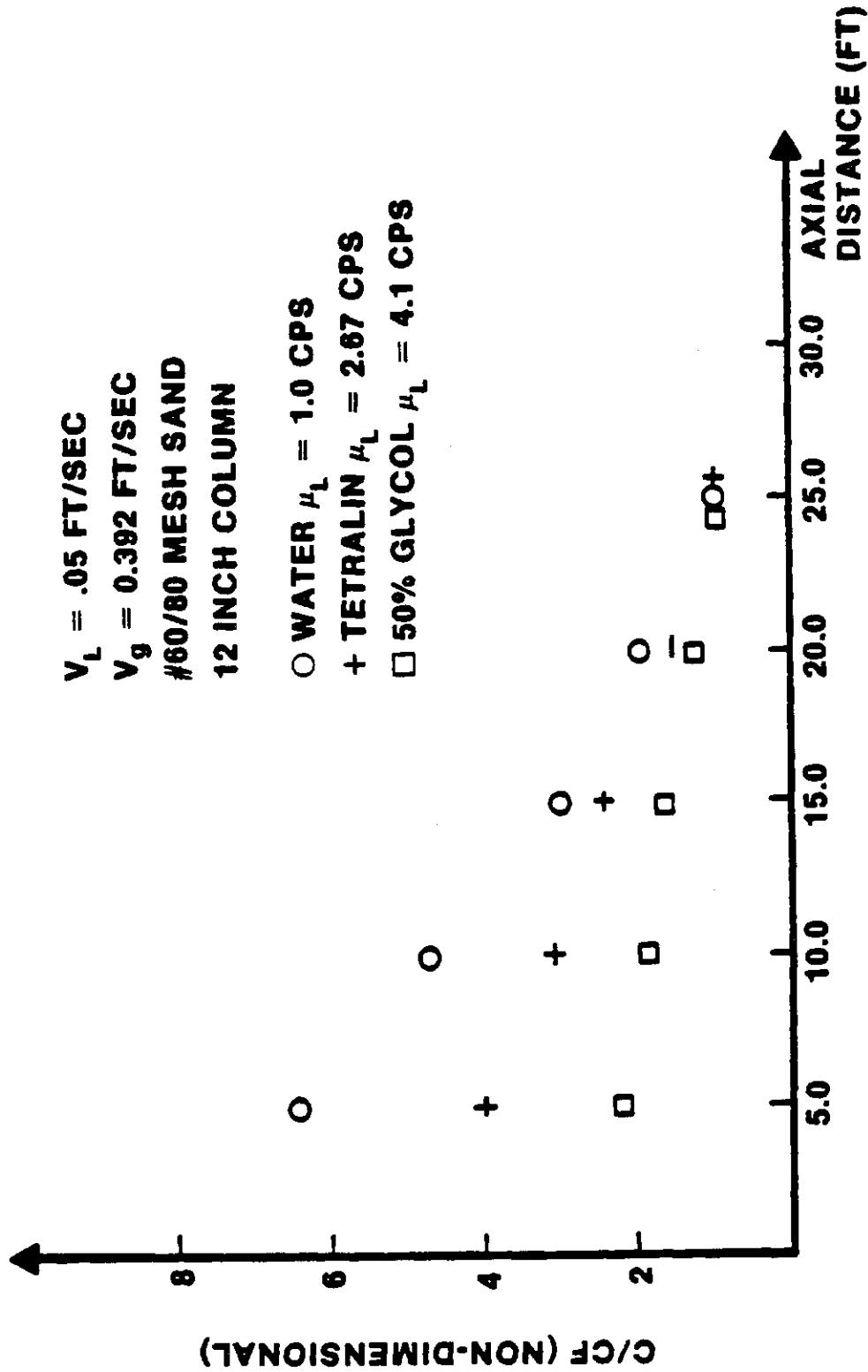


Figure 53
Effect of Particle Size on Solids Distribution
(5-in. Column; Continuous Mode)

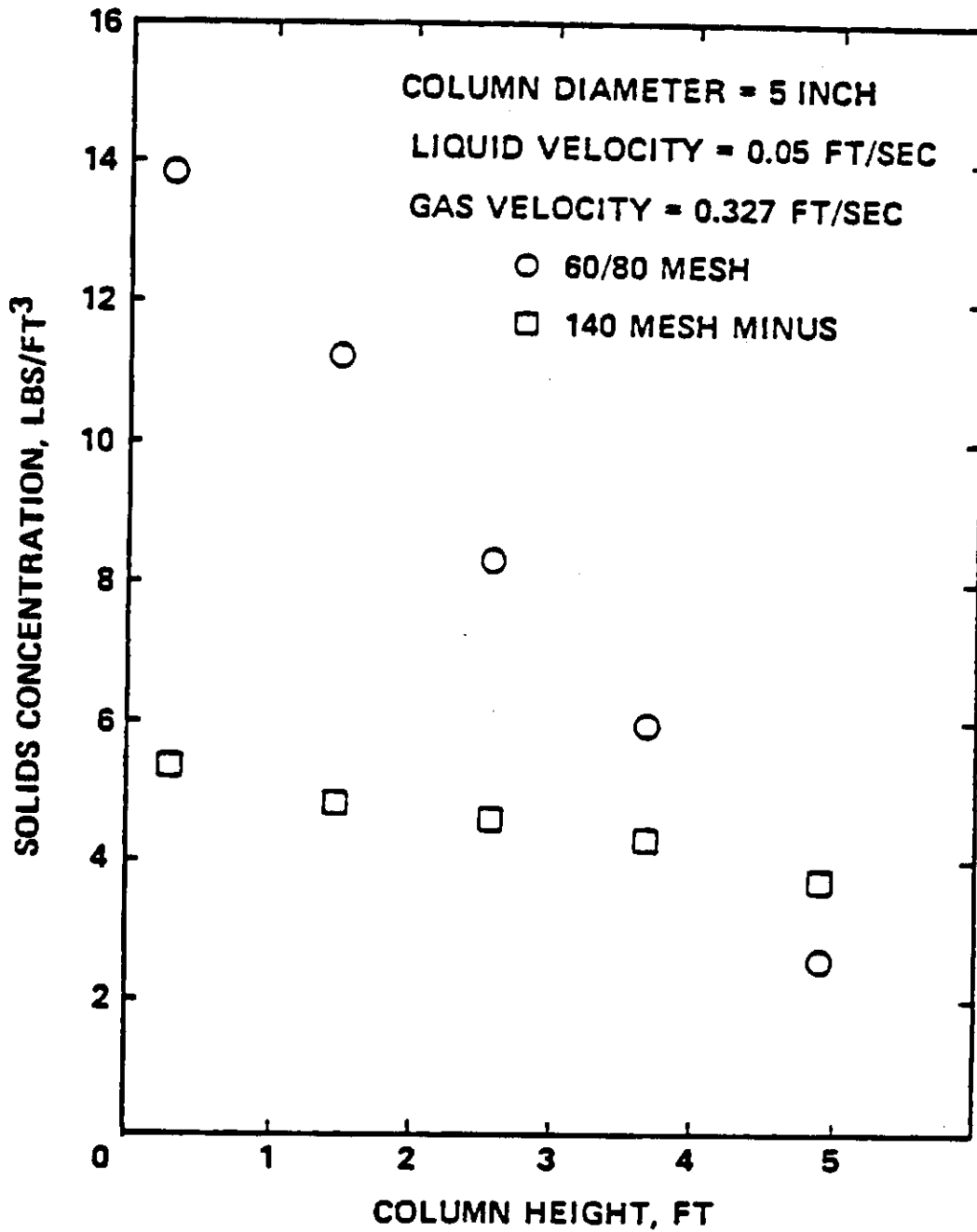


Figure 54
Effect of Particle Size on Solids Distribution
(12-in. Column; Continuous Mode)

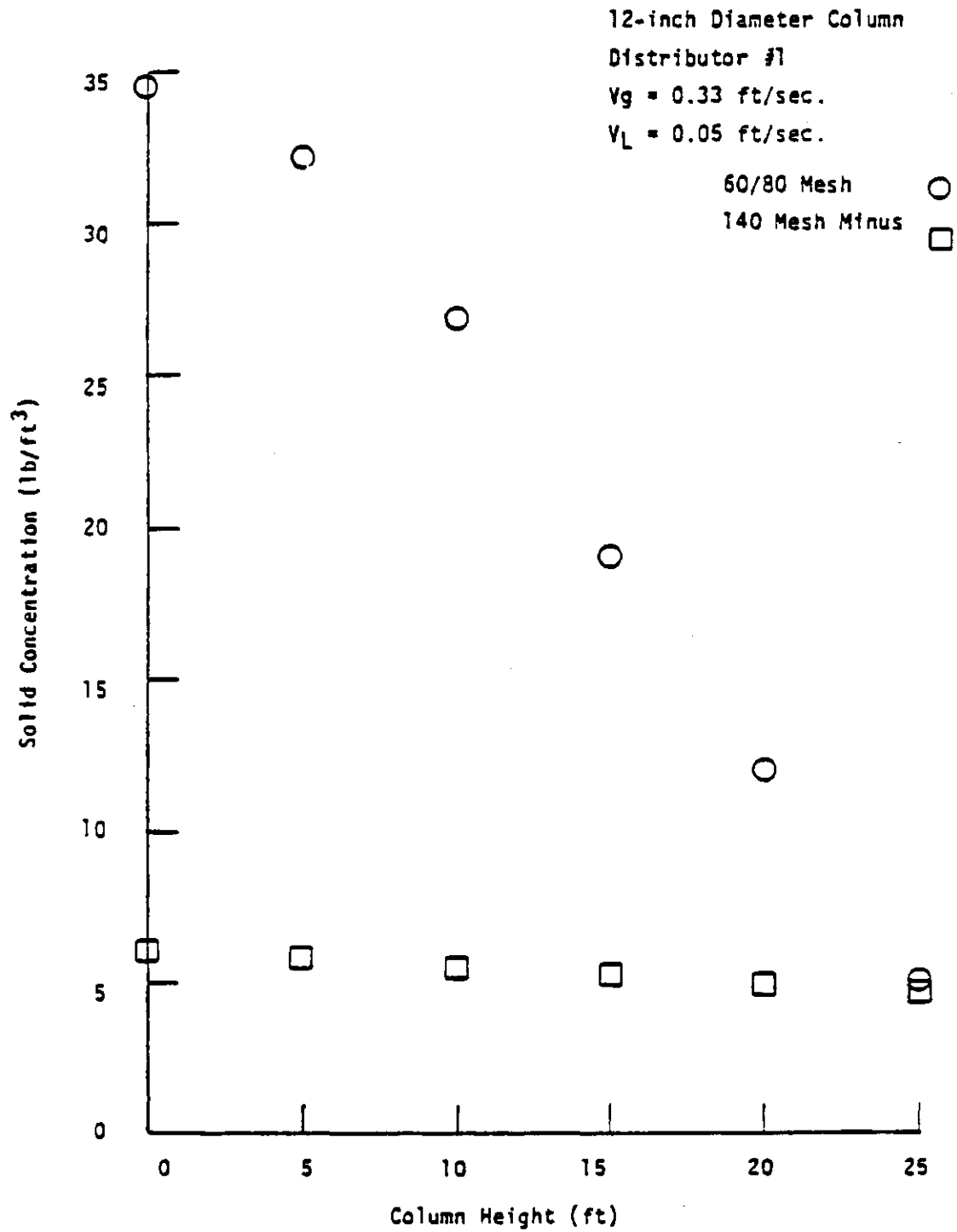


Figure 55

Effect of Particle Size on Solids Distribution
(6-ft Column; Continuous Mode)

$V_g = 0.21$ ft/sec.

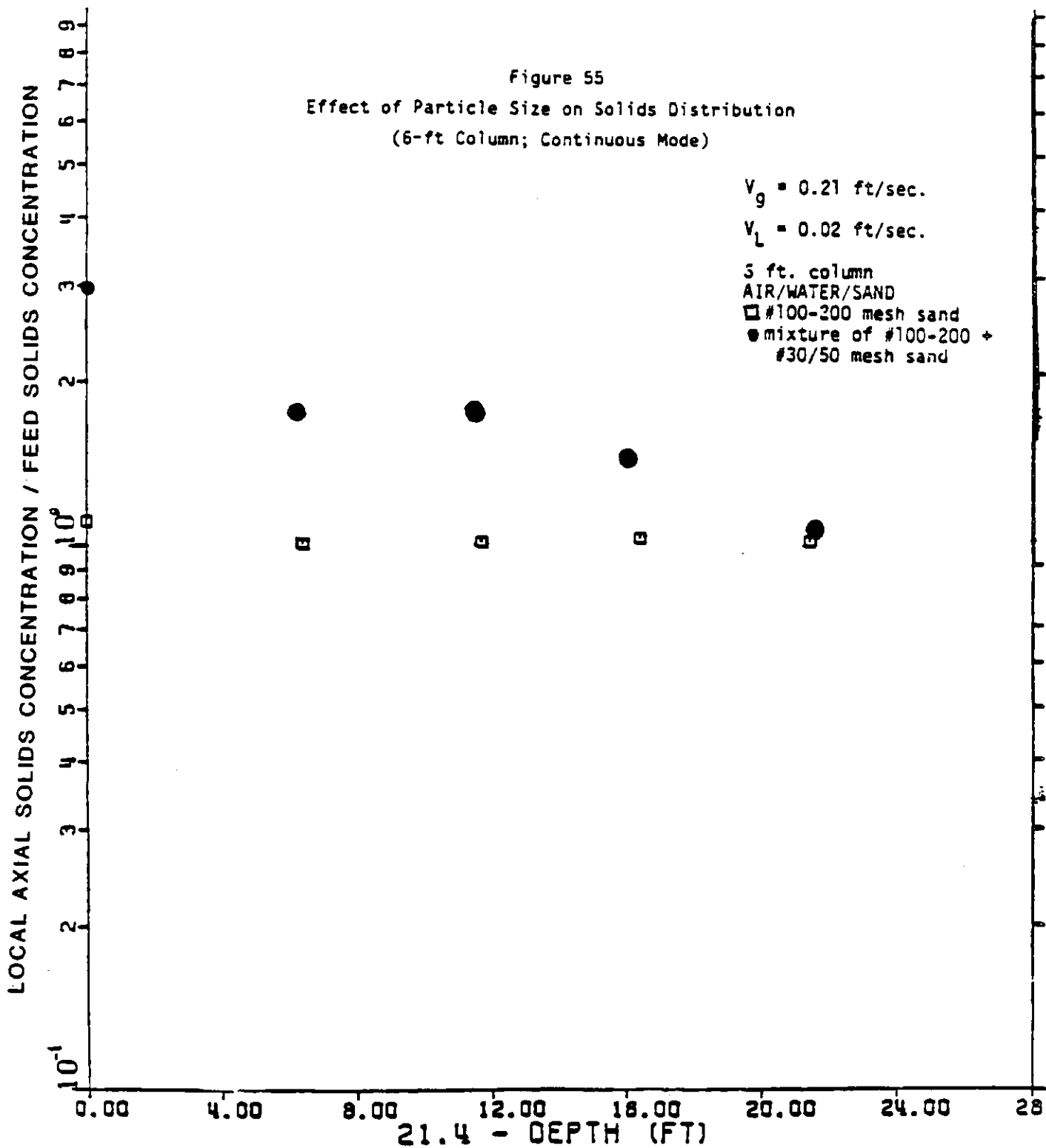
$V_L = 0.02$ ft/sec.

5 ft. column

AIR/WATER/SAND

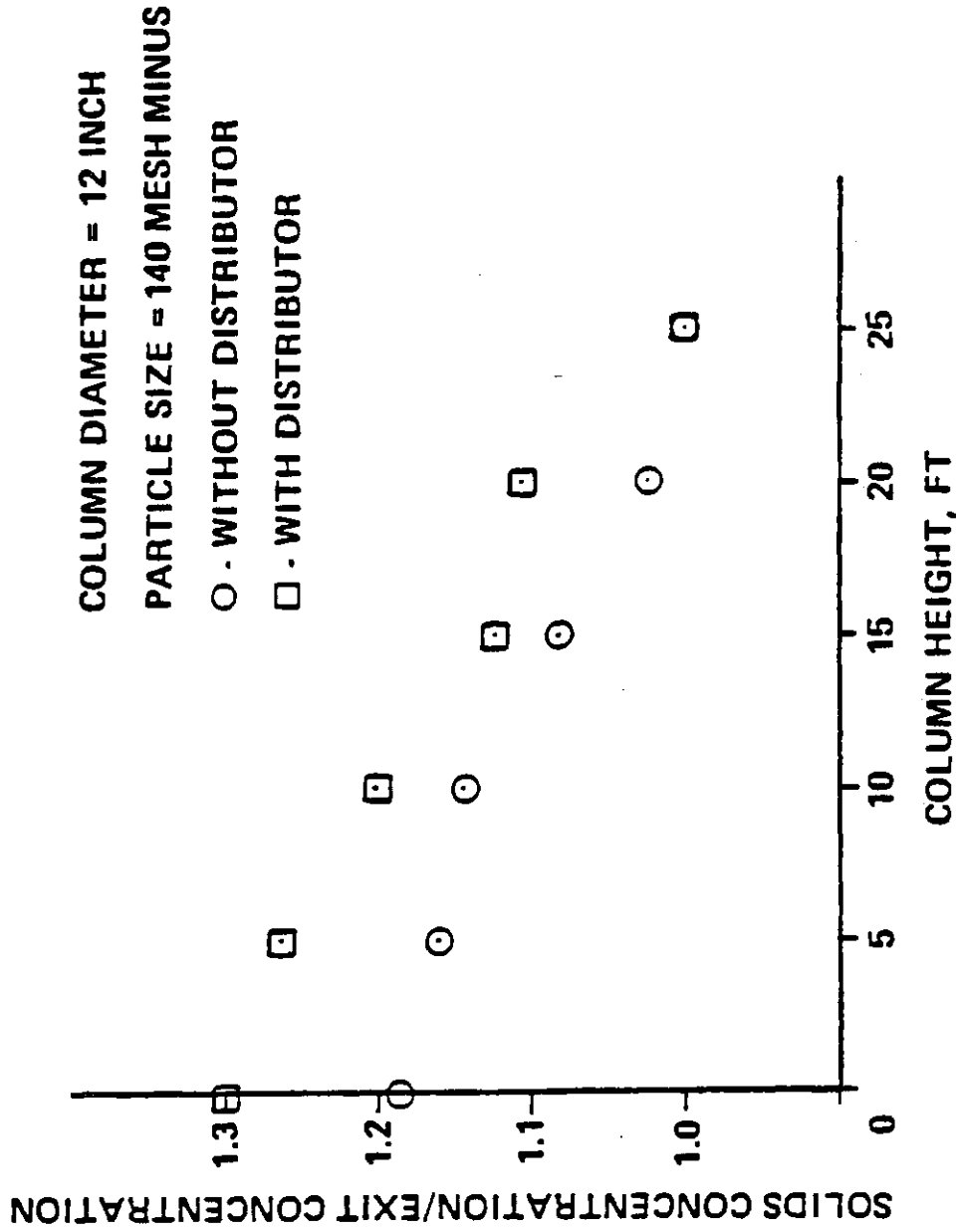
□ #100-200 mesh sand

● mixture of #100-200 +
#30/50 mesh sand



AXIAL SOLIDS DISTRIBUTION
SPRAGERS • 2 FOOT PLATE

Figure 56
 Effect of Distributors on Normalized Solids Distribution
 (12-in. Column; -140-Mesh Sand; Continuous Mode)



NON-DIMENSIONALIZED SOLID DISTRIBUTION

Figure 57
Effect of Distributors on Nondimensionalized Solids Distribution
(12-in. Column; 60-80-Mesh Sand; Continuous Mode)

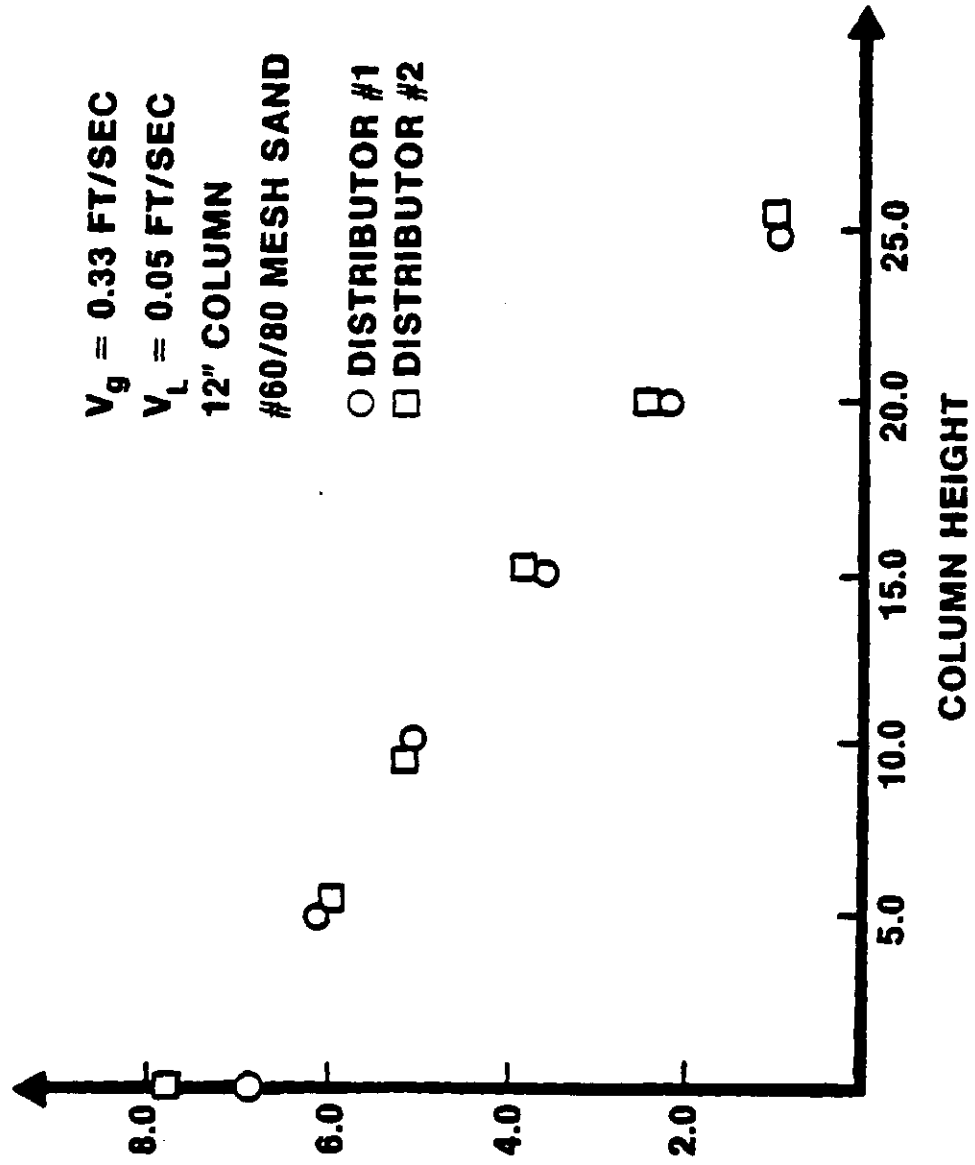


Figure 58
 Effect of Column Diameter on Nondimensionalized Solids Distribution
 (60/80- and -140-Mesh Sand; Continuous Mode)

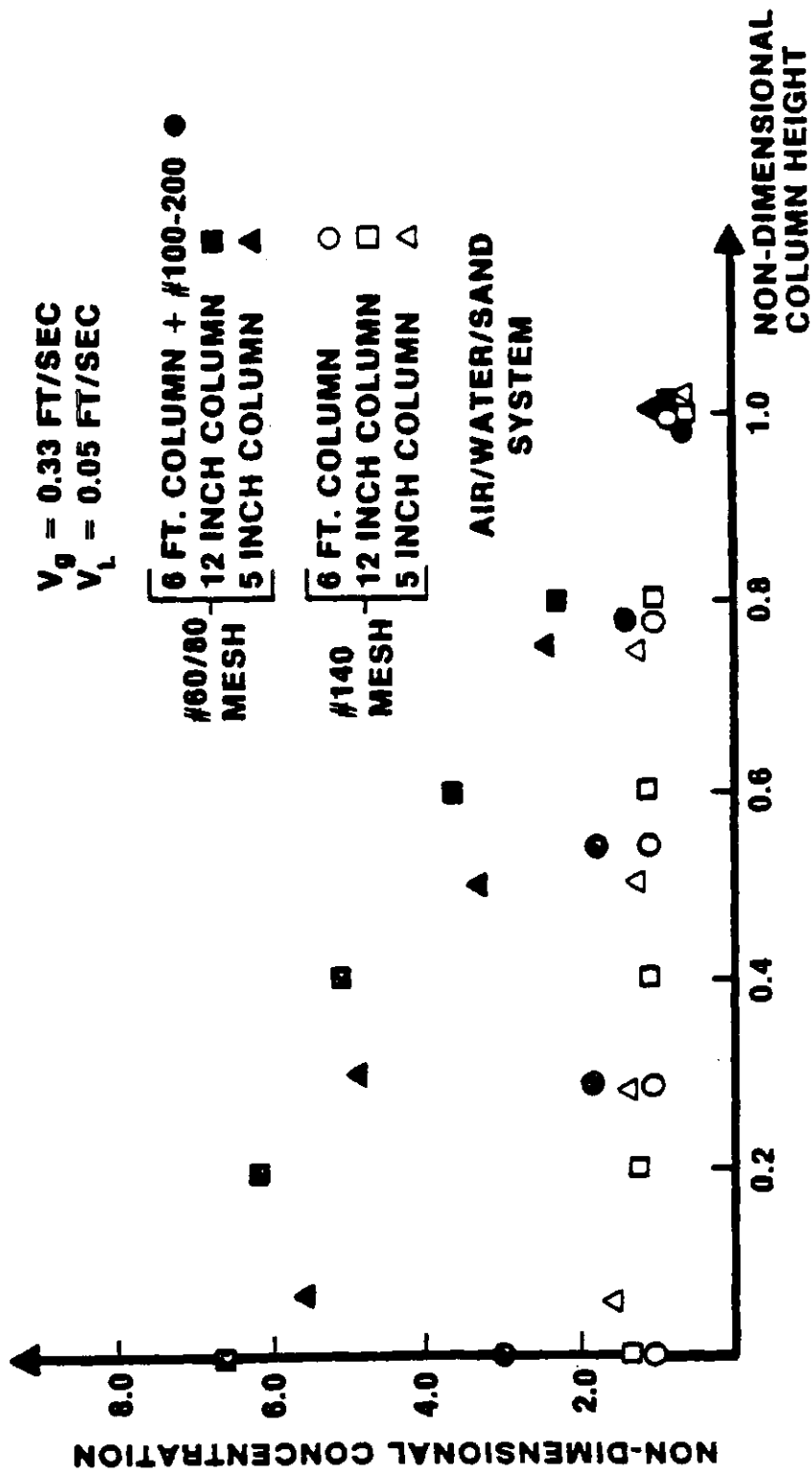


Figure 59
Effect of Column Diameter on Solids Concentration
(No Distributor; Continuous Mode; 5- and 12-in. Columns)

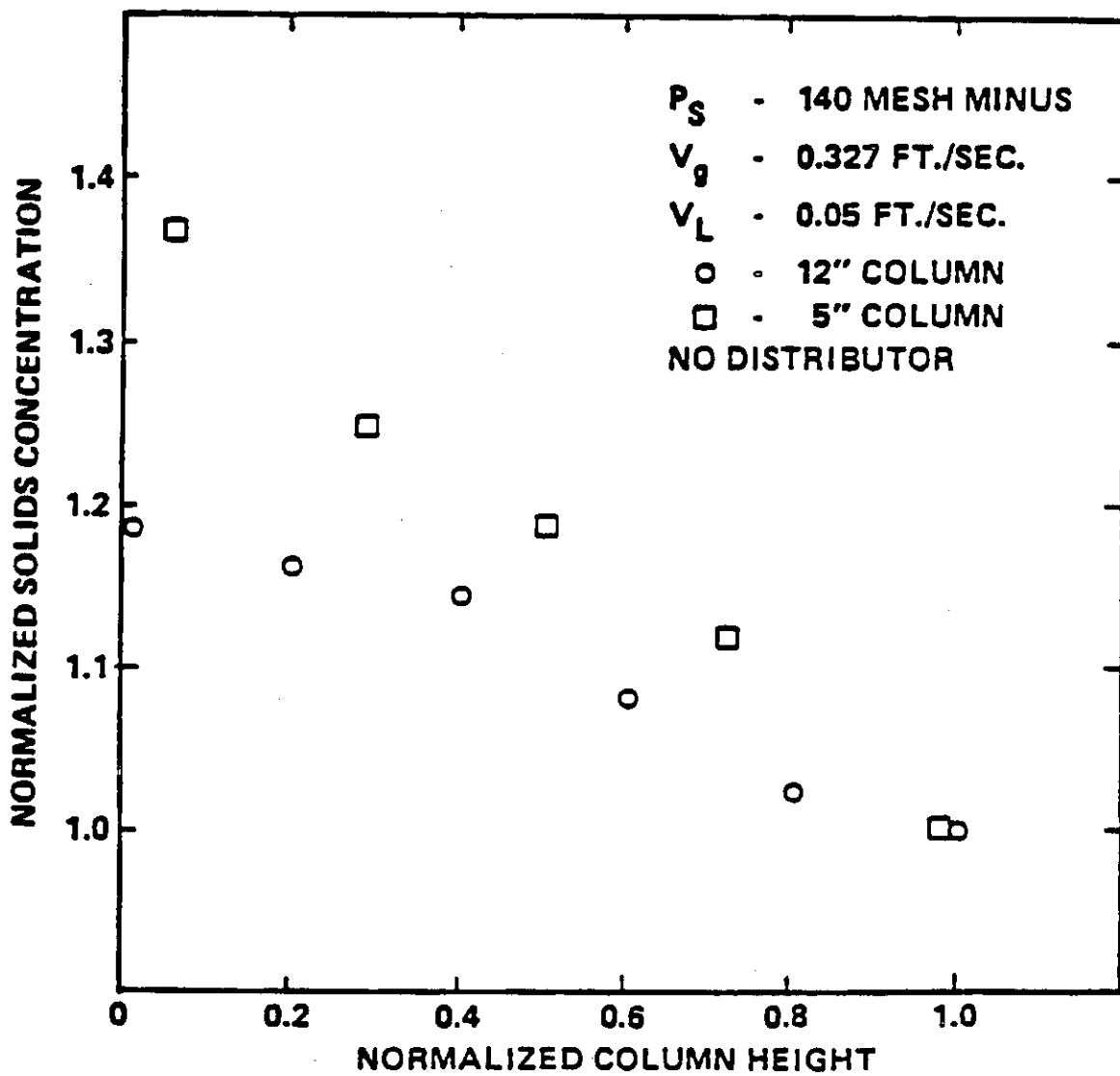


Figure 60
Effect of Column Diameter on Solids Concentration
(Distributor #1; Continuous Mode; 5- and 12-in. Columns)

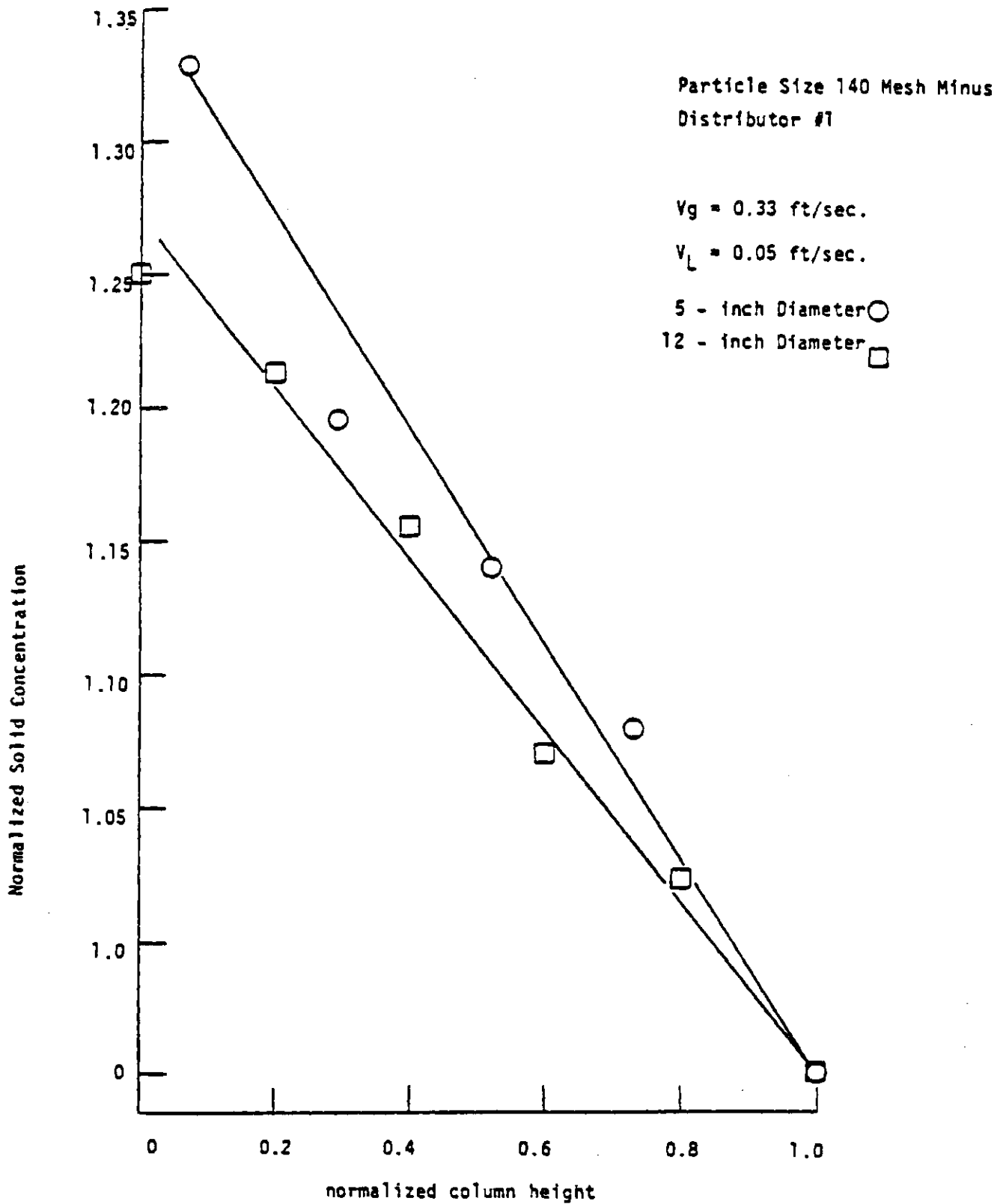
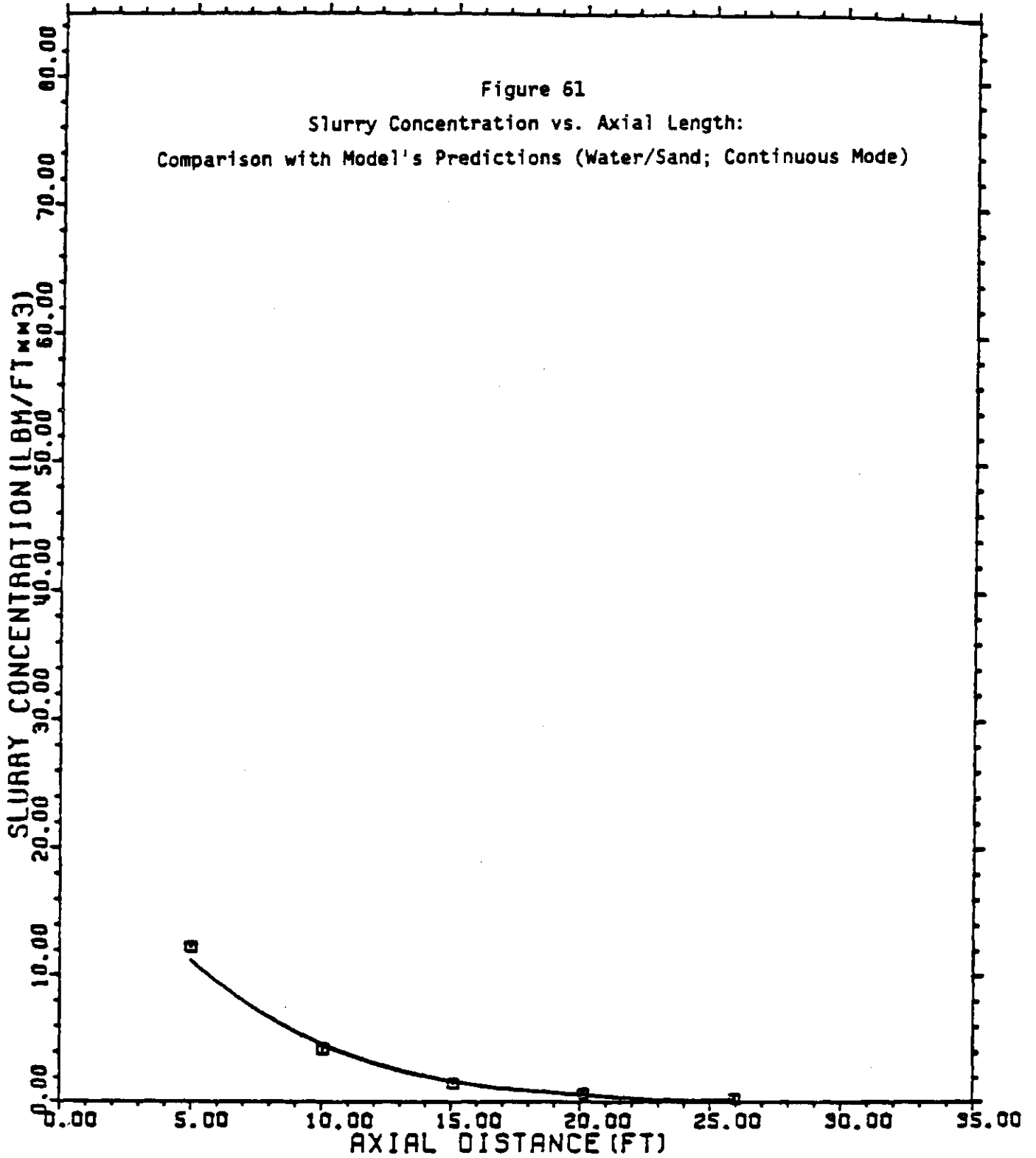
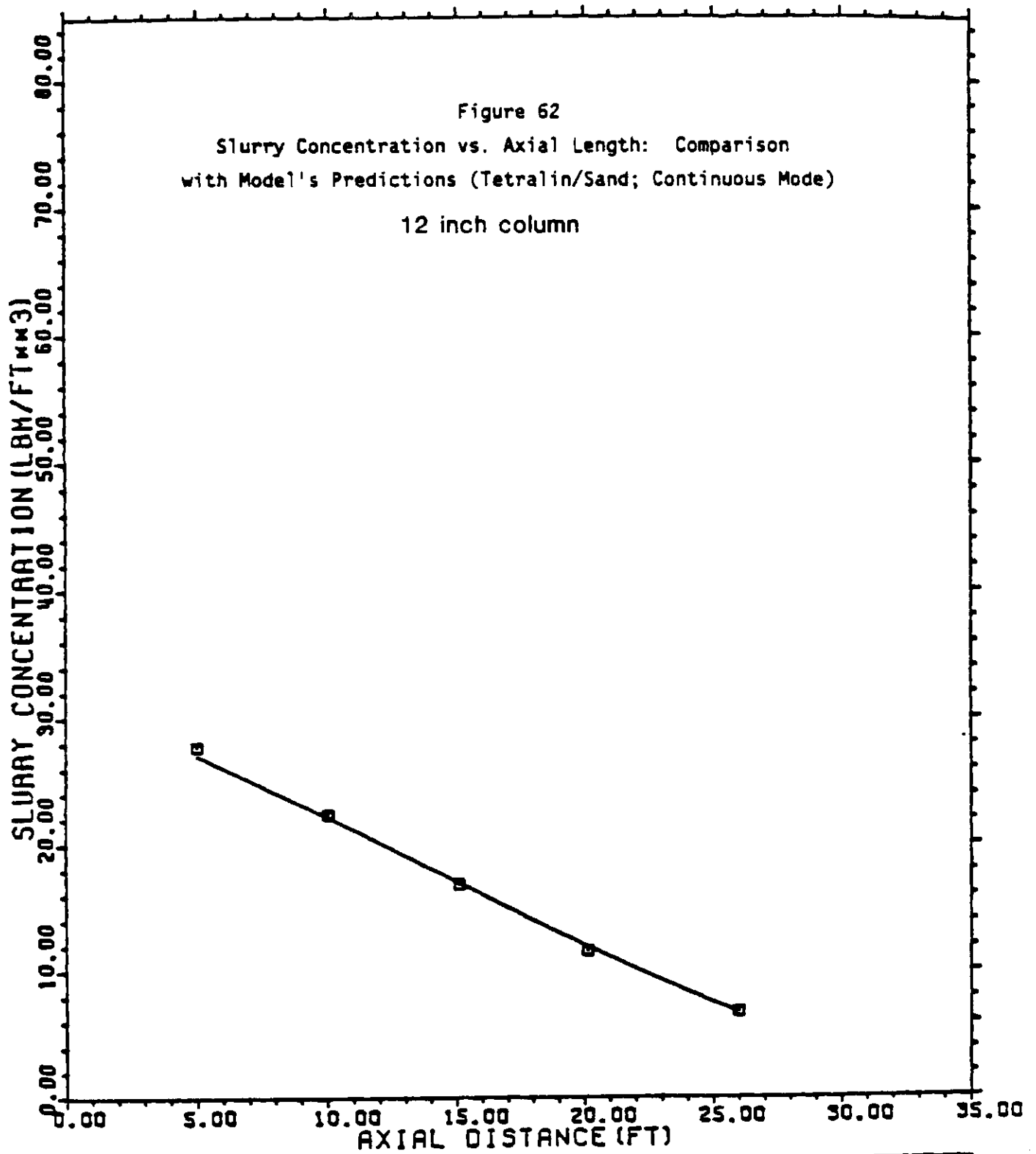


Figure 61
 Slurry Concentration vs. Axial Length:
 Comparison with Model's Predictions (Water/Sand; Continuous Mode)

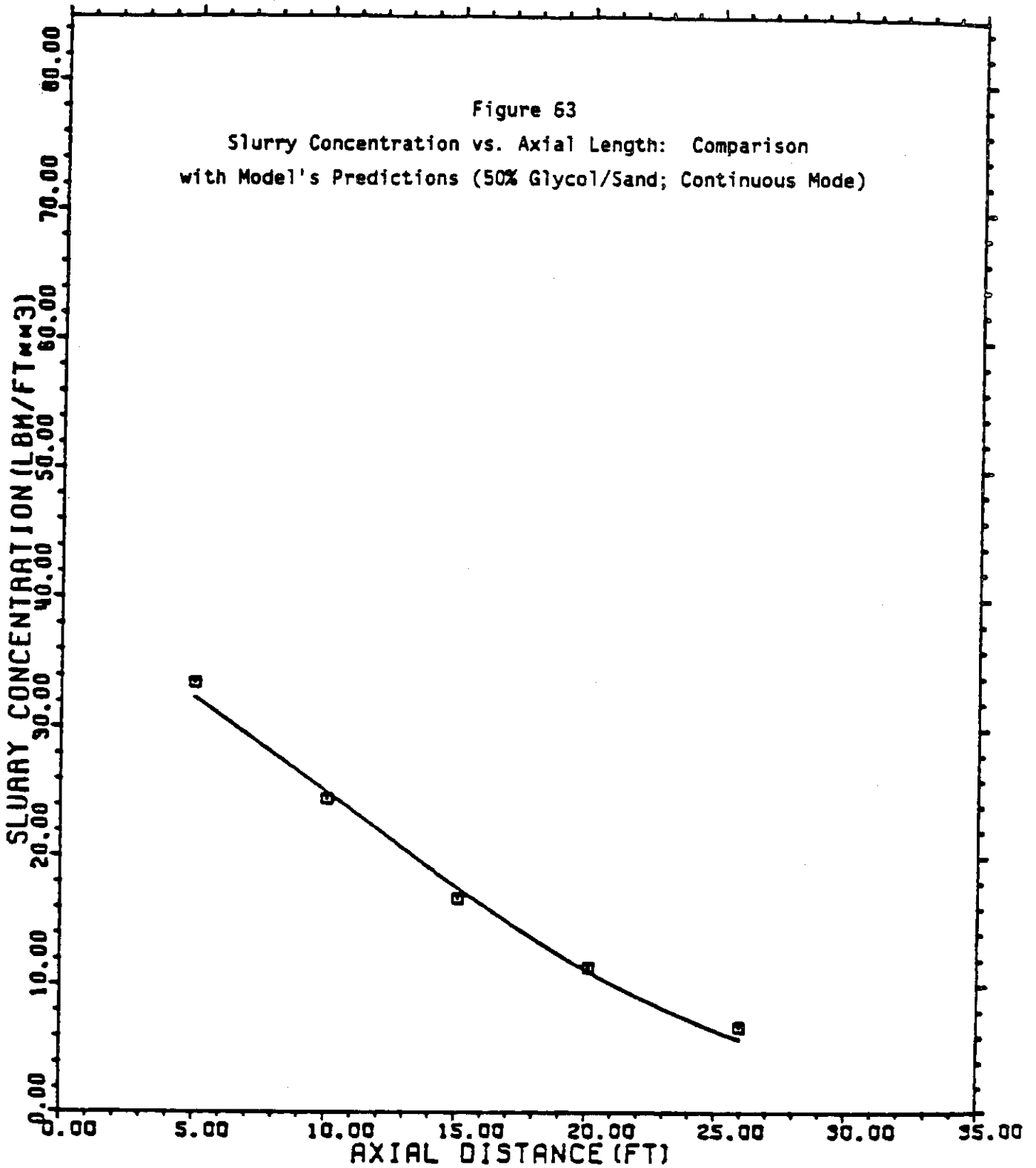


CONC. VS. L	
SLURRY CONCENTRATION VS. AXIAL LENGTH LIQUID: WATER SOLID: SAND; MESH SIZE: 6000 GAS VELOCITY (FT/SEC): .33 LIQUID VELOCITY (FT/SEC): .01 CL (FT ² /SEC): 1.62 COLUMN DIAMETER: 12 INCHES	□ EXPERIMENTAL POINTS — MODEL CURVE



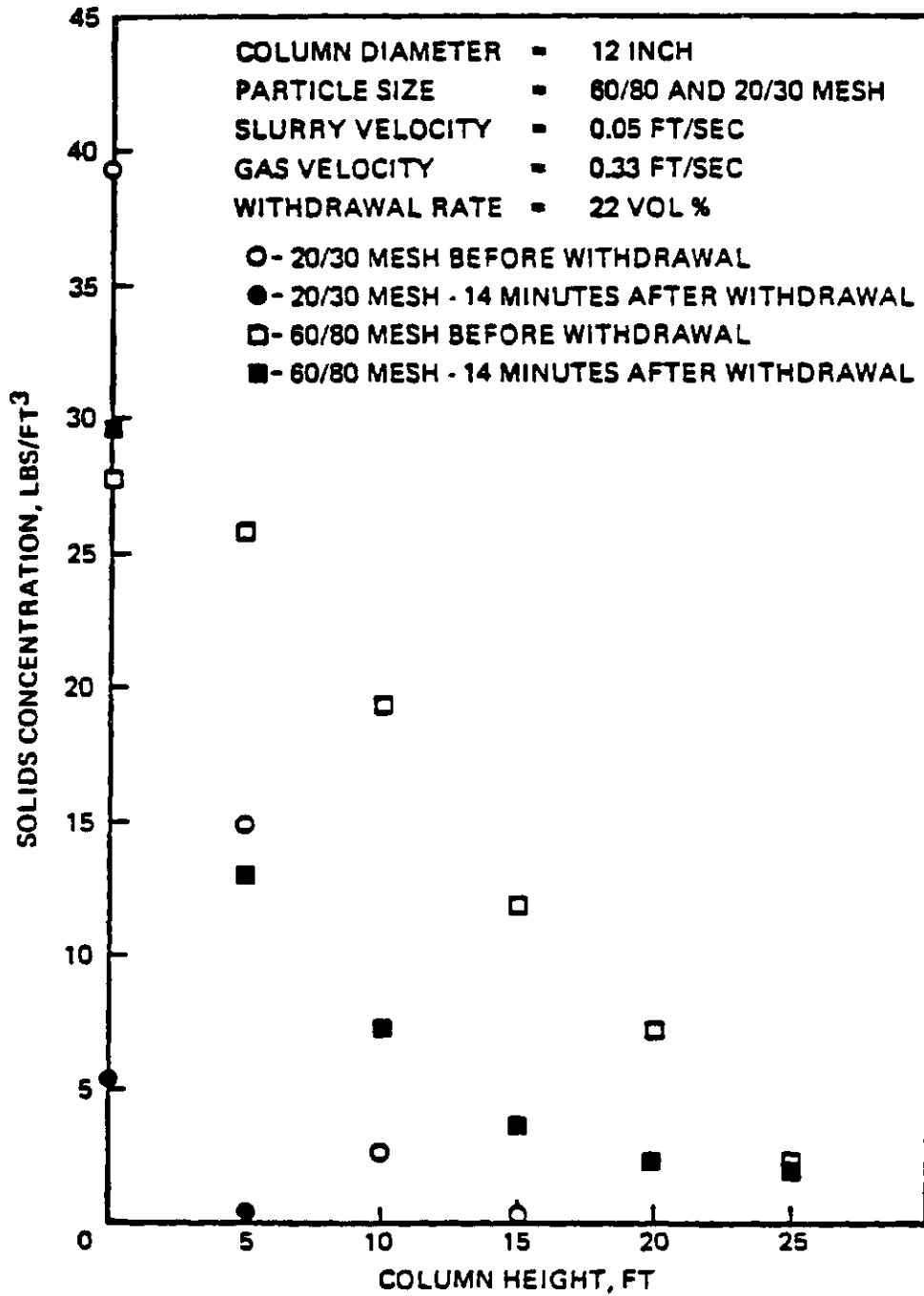
CONC. VS. L	
SLURRY CONCENTRATION VS. AXIAL LENGTH LIQUID: TETRALIN SOLID: SAND; NOM. SIZE: 60/90 GAS VELOCITY (FT/SEC): 1.342 LIQUID VELOCITY (FT/SEC): .05 CL (FT ² /SEC): .85	■ EXPERIMENTAL POINTS — MODEL CURVE

Figure 63
 Slurry Concentration vs. Axial Length: Comparison
 with Model's Predictions (50% Glycol/Sand; Continuous Mode)



CONC. VS. L	
SLURRY CONCENTRATION VS. AXIAL LENGTH LIQUID: 50% GLYCOL SOLID: SAND, ACHN SIZE: 6000 GAS VELOCITY FT/SEC: 1.00 LIQUID VELOCITY FT/SEC: .01 EL FT/SEC: .003 COLUMN DIAMETER: 12 INCHES	■ EXPERIMENTAL POINTS — MODEL CURVE

Figure 64
Effect of Large Particles on Solids Removal



Re = Reynolds number (nondimensional)
 t = time (sec)
 U_s = slip velocity between gas and liquid (ft/sec)
 V_L = slurry velocity (ft/sec)
 V_p = solid particles settling velocity (ft/sec)
 V_{sg} or V_g = superficial gas velocity (ft/sec)
 z = axial distance along column (ft)
 ϵ_g = gas holdup (nondimensional)
 μ_L = liquid dynamic viscosity (lb-ft/sec)
 ν_L = liquid kinematic viscosity (ft²/sec)
 ρ_L = liquid density (lb/ft³)
 σ, γ = liquid surface tension (lb/sec²)