

TABLE A-I

Literature on The Hydrodynamics of Fluidization

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B. Vertical Gas-Liquid Systems

| <u>Reference No.</u> | <u>Reference</u> | <u>Systems Covered</u> | <u>Significance to Project</u> |
|----------------------|--|---|--------------------------------|
| 60 | Turner, J. C. R. On Bubble Flow in Liquids and Fluidized Beds Chem. Eng. Science, Vol. 21, pp. 971-974, 1966 | Theoretical Study | Gas-Liquid Model |
| 61 | Wallis, G. B. One Dimensional Two-Phase Flow McGraw-Hill, N. Y., 1969 | Various | Background in Many Areas |
| 62 | Zieminski, S. A. and Raymond, D. R. Experimental Study of the Behavior of Single Bubbles Chem. Eng. Science, Vol. 23, pp. 17-28, 1968 | CO ₂ /Water | Background |
| 63 | Zuber, N. and Findlay, J. A. Average Volumetric Concentration in Two-Phase Flow Systems Journal of Heat Transfer, Vol. 87, C, p. 453, 1965 | Review of Literature Data | Gas-Liquid Flow Models |
| 64 | Addington, D. and Thompson, E. Desulphurization in Fixed and Fluidized Bed Catalyst Systems Proc. Euro. Symp. on Chem. React. Eng., p. 203, Pergamon Press, 1965 | Gas/White Spirit/Alumina Gas/Water/Sand | Three-Phase Data |
| 65 | Bhatia, V. K. and Epstein, N. Three Phase Fluidization: A Generalized Wake Model Proc. Euro. Symp. on Fluidization, p. 380, 1974 | Air/Water/Spheres | Model |
| 66 | Blum, D. B. and Toman, J. J. Three-Phase Fluidization in a Liquid Phase Methanator A.I.Ch.E. Symp., Vol. 73, No. 167, p. 115, 1977 | Nitrogen/Mineral Oil/Cylindrical Catalysts | Empirical Holdup Correlation |
| 67 | Bruce, P. N. and Revel-Chion, L. Bed Porosity in Three-Phase Fluidization Powder Technology, Vol. #4, pp. 243-249, 1974 | Air/Water/Glass Spheres | Three-Phase Data |
| 68 | Dakshinamurty, P., Subramanyam, V., and Rao, J. N. Bed Porosities in Gas-Liquid Fluidization Ind. Eng. Ch. Process Des. Devl., Vol. 10, No. 3, p. 322, 1971 | Air/Water and Kerosene/Rockwool Shot Glass Beads, Sand, Iron Shot | Empirical Hold-up Correlation |
| 69 | Dakshinamurty, P., Subramanyam, V., and Rao, J. N. Bed Porosities in Gas-Liquid Fluidization Ind. Eng. Ch. Process Des. Devl., Vol. 11, No. 2, p. 318, 1972 | Air/Water/Shot, " " /Glass Beads Nitrogen/Electrolyte/Glass Beads " " /Rockwool Shot | Empirical Hold-up Correlation |
| 70 | Darton, R. C. and Harrison, D. Gas and Liquid Hold-up in Three-Phase Fluidization Chem. Eng. Science, Vol. 30, pp. 581-586, 1975 | No Experimental Work | Model |

C. Gas-Liquid-Solid Systems:

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Literature on The Hydrodynamics of Fluidization

C. Gas-Liquid-Solid Systems:

| Reference No. | Reference | Systems Covered | Significance to Project |
|---------------|---|--|---|
| 71 | Darton, R. C. and Harrison, D. The Rise of Single Bubbles in Liquid Fluidized Beds Trans Instn. Chem. Eng., Vol. 52, p. 301, 1974 | Air/Water/Sand | Single Bubble Behavior |
| 72 | Efremov, G. I. and Vakhrushev, I. A. A Study of the Hydrodynamics of Three-Phase Fluidized Beds International Chem. Eng., Vol. 10, No. 11, p. 37, 1970 | Air/Water/Glass Beads | Model |
| 73 | Epstein, Norman Criterion for Initial Contraction or Expansion of Three-Phase Fluidized Beds Canadian Journal Chem. Eng., Vol. 54, p. 259, 1976 | No Experimental Work | Model |
| 74 | Epstein, N., Evans, K. A., and Bhalla, V. K. Effect of Solid Wettability on Expansion of Gas-Liquid Fluidized Beds Ind. Eng. Chem. Des. Dev., Vol. 11, No. 1, p. 151, 1972 | Air/Kerosene/Rockwool Shot Air/Water/Rockwool Shot | Background |
| 75 | Henriksen, H. K. and Ostergaard, K. On the Mechanism of Break-up of Large Bubbles in Liquids and Three-Phase Fluidized Beds Chem. Eng. Science, Vol. 29, pp. 626-629, 1974 | Air/Water/Glass Spheres Air/Water/Steel Spheres Air/Methanol/Glass Spheres | Bubble Break-up |
| 76 | Henriksen, H. K. PhD Dissertation Danmark Tekniske Højskole, 1972 | | Background |
| 77 | Henriksen, H. K. and Ostergaard, K. Characteristics of Large Two-Dimensional Air Bubbles in Liquids and in Three-Phase Fluidized Beds Chem. Eng. Journ., Vol. 7, p. 141-146, 1974 | Air/Water/Glass Beads Air/Water-Glycerol/Glass Beads Air/Water-Methanol/Beads | Single Bubble Behavior |
| 78 | Kim, S. D., Baker, C. G. J., and Bergougnou, M. A. Hold-up and Axial Mixing Characteristics of Two and Three-Phase Fluidized Beds Canadian Journ. Chem. Eng., Vol. 50, p. 695, 1972 | Air/Water/Gravel Air/Water/Glass Beads | Three-Phase Data Behavior of Bubble Swarms |
| 79 | Kim, S. D., Baker, C. G. J., and Bergougnou, M. A. Bubble Characteristics in Three-Phase Fluidized Beds Chem. Eng. Science, Vol. 32, pp. 1299-1306, 1977 | Air/Water/Glass Beads-Gravel Air/Water-Acetone/Glass Beads-Gravel Air/Aqueous Sugar-Carboxymethyl Cellulose/Glass Beads-Gravel | Behavior of Bubble Swarms |
| 80 | Kim, S. D., Baker, C. G. J., and Bergougnou, M. A. Phase Hold-up Characteristics of Three-Phase Fluidized Beds Canadian Journ. Chem. Eng., Vol. 53, p. 134, 1975 | Air/Solution/Glass Beads Air/Solution/Gravel | Empirical Hold-up Correlations |
| 81 | Lee, J. C. 4th Euro. Symp. Chem. Reaction Eng., p. 27, Pergamon Press, Oxford, 1971 | | Bubble Break-up |
| 82 | Lee, J. C. 3rd Euro. Symp. Chem. Reaction Eng., p. 211, Pergamon Press, Oxford, 1965 | Air/Water/Glass Beads | Effect of Particle Size on Bubble Coalescence |

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Literature on The Hydrodynamics of Fluidization

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C. Gas-Liquid-Solid Systems:

| Reference No. | Reference | Systems Covered | Significance to Project |
|---------------|---|---|--|
| 83 | Levsh, I. P., Krainev, N. I., and Niyazov, M. I. Calculations of the Pressure Drop and Heights of Three-Phase Fluidized Beds International Chem. Eng., Vol. 8, No. 2, p. 311, 1968 | Air/Water/Packing | Background |
| 84 | Mach, I. W. Suspension of Solid Bodies in the Turbulent Gas/Liquid Stream Chem. Eng. Tech., Vol. 42, p. 311, March 1970 | No Experimental Work | Background |
| 85 | Massimilla, L., Solimando, A., and Squillace, E. Gas Dispersion in Solid-Liquid Fluidized Beds British Chem. Eng., Vol. 6, p. 232, 1961 | Air/Water/Glass Beads | Single Bubble Behavior Bubble Coalescence |
| 86 | Michelsen, M. L. and Ostergaard, K. Hold-up and Fluid Mixing in Gas-Liquid Fluidized Beds Chem. Eng. Journal, Vol. 1, p. 37, 1970 | Air/Water/Ballotini | Three-Phase Data Gas and Liquid Tracers |
| 87 | Nemets, L. L., Razumov, and Manshillin, V. V. Volumetric Contents of Liquid and Solid Phases in Three-Phase Fluidized Bed in Relation to Viscosity of Liquid Medium Khimiya i Tekhnologiya Topliva Masel, No. 2, pp. 37-40, Feb. 1975 | Air/Heptane/Sand Air/Water/Sand Air/Water-Glycerol/Sand | Three-Phase Hold-up Data |
| 88 | Ostergaard, K. Gas-Liquid-Particle Operations in Chemical Reaction Engineering Advances in Chem. Eng., Vol. 7, p. 71, 1968 Academic Press. | No Experimental Work | Review |
| 89 | Ostergaard, K. Fluidization P. 58, Society of Chem. Industry, 1964 | Air/Water/Ballotini | Three-Phase Hold-up Data |
| 90 | Ostergaard, K. and Theisen, P. I. The Effect of Particle Size and Bed Height on the Expansion of Mixed Phase (Gas-Liquid) Fluidized Beds Chem. Eng. Science, Vol. 21, pp. 413-417, 1966 | Air/Water/Glass Ballotini | Three-Phase Hold-up Data |
| 91 | Ostergaard, K. and Michelsen, M. L. Hold-up and Axial Dispersion in Gas-Liquid Fluidized Beds, The Effect of Fluid Velocities and Particle Size 2nd Joint A.I.Ch.E.-I.I.Q.P.R Meeting, Preprint 31D, A.I.Ch.E., May 1968 | Air/Water/Particles | Three-Phase Hold-up Data |
| 92 | Ostergaard, K. Fluidization (edited by Davidson, J. F. and Harrison, D.) Academic Press, N. Y., 1971 | No Experimental Work | Review |
| 93 | Ostergaard, K. On Bed Porosity in Gas-Liquid Fluidization Chem. Eng. Science, Vol. 20, pp. 165-167, 1965 | No Experimental Work | Model |
| 94 | Ostergaard, K. Flow Phenomena of Three-Phase (Gas-Liquid-Solid) Fluidized Beds A.I.Ch.E. Symposium Series, Vol. 69, No. 128, p. 28, 1973 | No Experimental Work | Review of Fundamentals |

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Literature on The Hydrodynamics of Fluidization

C. Gas-Liquid-Solid Systems:

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| Reference No. | Reference | Systems Covered | Significance to Project |
|---------------|--|---|-------------------------------------|
| 95 | Ostergaard, K. On the Growth of Air Bubbles Formed at a Single Orifice in a Water Fluidized Bed Chem. Eng. Science, Vol. 21, pp. 470-472, 1966 | Water/Air/Sand | Bubble Coalescence |
| 96 | Ostergaard, K. and Fosbol, P. Transfer of Oxygen Across the Gas-Liquid Interface in Gas-Liquid Fluidized Beds Chem. Eng. Journal, Vol. 3, p. 105, 1972 | Oxygen/Water/Glass Ballotini | Background |
| 97 | Ostergaard, K. and Fosbol, P. Hold-up, Mass Transfer, and Mixing in Three-Phase Fluidization Paper, A. I. Ch. E., 60th Annual Meeting, Chicago, Nov. 28-Dec. 2, 1976 | Air/Water/Glass Ballotini | Background |
| 98 | Ragunov, V. I., Manshkin, V. V., and Nemets, L. L. The Structure of Three-Phase Fluidized Beds International Chem. Eng. Vol. 11, No. 1, p. 57, 1973 | Air/Water/Sand | Empirical Hold-up Correlation |
| 99 | Rigby, G. K., Van Blockland, G. P., Parks, W. H., and Capes, C. E. Properties of Bubbles in Three-Phase Fluidized Beds as Measured by an Electroresistivity Probe Chem. Eng. Science, Vol. 25, pp. 1729-1741, 1970 | Air/Water/Glass Beads Air/Water/Ballotini-Sand | Background Bubble Wake Structure |
| 100 | Roy, N. K., Guma, D. K., and Rao, M. N. Suspension of Solids in a Bubbling Liquid (Critical Gas Flow Rates for Complete Suspension) Chem. Eng. Science, Vol. 19, pp. 215-225, 1964 | Air/Pure Liquids/Quartz, Coal, or Catalyst Powder | Background |
| 101 | Schuman, S. C., Wolk, R., Chervenak, M. C. Hydrogenation of Oils U. S. Patent No. 3, 183, 180, May 11, 1965 | Hydrogen/Oil/Catalyst | Background |
| 102 | Stewart, P. S. B. and Davidson, J. F. Three-Phase Fluidization: Water, Particles and Air Chem. Eng. Science, Vol. 19, pp. 319-322, 1964 | Air/Water/Ballotini, Lead, and Iron Shot | Bubble Wake Structure |
| 103 | Stewart, P. S. B. PhD Dissertation University of Cambridge, 1965 | | Model |
| 104 | Turner, R. Proceedings of Chem. Eng. Group, Soc. Chem. Ind., Vol. 42, p. 47, 1963 | | Bed Construction Data |
| 105 | Turner, R. Fluidization Soc. of Chem. Ind., p. 147, 1964 | Air, Nitrogen/Water/Sand | Three-Phase Hold-up Data |

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Literature on The Hydrodynamics of Fluidization

C. Gas-Liquid-Solid Systems:

| Reference No. | Reference | Systems Covered | Significance to Project |
|-----------------------------------|---|---|-------------------------|
| 107 | Vail, Y. K., Manakov, N. K., and Manshilin, V. V. The Gas Contents of Three-Phase Fluidized Beds Intern. Ch. Eng., Vol. 10, No. 2, p. 244, 1970 | Air/Water/Glass Beads | Three-Phase Data |
| 108 | Verbitskii, B. G. and Vakhrushev, I. A. Rate of Ascent of Isolated Gas Bubbles in a Bed Fluidized by a Liquid Khim i Tek Mas., No. 4, p. 36-39, April 1974 | Air/Sunflower Oil, HCL Solution, Water/Glass Beads | Single Bubble Behavior |
| 109 | Viswanathan S., Kakar, A. S. and Murti, P. S. Effect of Dispersing Bubbles Into Liquid Fluidized Beds on Heat Transfer and Hold-up at Constant Bed Expansion CHEM Eng. Science, Vol. 20, pp. 903-910, 1964 | Air/Water/Quartz Air/Water/Glass Beads | Three Phase Data |
| D. Gas-Solid Fluidization: | | | |
| 110 | Batchelor, G. K. Low-Reynolds-Number Bubbles in Fluidized Beds Archives of Mechanics, Vol. 26, No. 3, pp. 339-351, 1974 | Theoretical Study | Background |
| 111 | Chatterjee, S. Spout-Fluid Bed Technique Ind. Eng. Chem. Proc. Des. Devl., Vol. 9, No. 2, p. 340, 1970 | Air/Sand Air/Coal | Background |
| 112 | Chiba, T. and Kobayashi, H. Gas Exchange Between the Bubble and Emulsion Phases in Gas-Solid Fluidized Beds Advances in Chem. Series, No. 109, p. 132 | Air-Ozone/Glass Beads | Background |
| 113 | Clift, R. Bubble Interaction in Fluidized Beds Disc. Abstr. Int., B32 (1), p. 261-B, July 1971 | Theoretical Study | Background |
| 114 | Collins, R. The Rise Velocity of Davidson's Fluidization Bubble Chem. Eng. Science, Vol. 20, pp. 788-789, 1964 | Theoretical Study | Background |
| 115 | Davidson, J. F. Bubble Motion in Liquids and Fluidized Beds Proc. Roy. Inst., Vol. 45, pp. 161-167, 1972 | No Experimental Data | Background |
| 116 | Fryer, C. and Potter, O. E. Bubble Size Variation in Two-Phase Models of Fluidized Bed Reactors Powder Technol., 6 (1972), p. 317 | Theoretical Study | Background |
| 117 | Gibbs, B. M. and Perry, M. G. Paper 29D, Experimental Test of the Bubbling Bed Model for the Prediction of Residence Time Distributions 69th National Meeting, A.I.Ch.E., May 1971 | Background | Background |

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Literature on The Hydrodynamics of Fluidization

| Reference No. | Reference | Systems Covered | Significance to Project |
|---------------|--|---|-------------------------|
| 118 | Grace, J. R. An Evaluation of Models for Fluidized-Bed Reactors A.I.Ch.E. Symp. Series, Vol. 67, No. 116, p. 159, 1971 | Gas-Solid | Background |
| 119 | Mikula, O. and Havalda, I. Discussion on the Two-Phase Model of Non-Uniformly Fluidized Beds According to Pyle and Harrison Chem. Zvesti, Vol. 27, pp. 634-642, 1973 | Air/Glass Ballotini | Background |
| 120 | Mori, S. and Wen, C. Y. Residence Time Distribution in Gasous Fluidized Beds A.I.Ch.E. Journal, Vol. 17, No. 9, p. 1096, 1971 | Air, Review of Various Systems | Background |
| 121 | Pyle, D. L. and Harrison, D. The Rising Velocity of Bubbles in Two-Dimensional Fluidized Beds Chem. Eng. Science, Vol. 22, pp. 531-535, 1967 | Air/Solid Particles | Background |
| 122 | Pyle, D. L. Fluidized Bed Reactors: A Review Chem. Reaction Eng., Ch. 3, p. 106, 1970 | No Experimental Work | Review |
| 123 | Ravindram, M. Significance of Residence Time Distribution Studies in the Design of Fluidized Bed Reactors Chemical Age India, Vol. 17, No. 6, p. 447-449, 1966 | | Background |
| 124 | Reuter, H. Fluid Particle Technology Chem. Eng. Progress Symp., Vol. 62, No. 62, 1966 | Experimental Work | Background |
| 125 | Rieke, R. D. and Pigford, R. L. Behavior of Gas Bubbles in Fluidized Beds A.I.Ch.E. Journal, Vol. 17, No. 9, p. 1096, 1971 | Air/Glass Beads | Background |
| 126 | Rowe, P. N. and Partridge, B. A. An X-Ray Study of Bubbles in Fluidized Beds Trans. Instn. Ch. Eng., Vol. 43, p. T-157, 1965 | Air/Ballotini Air/Sand | Background |
| 127 | Ruckenstein, E. and Muntean, O. On the Mechanism of Bubble Formation in a Fluidized Bed Canadian Journ. Ch. Eng., Vol. 45, p. 95, 1967 | Theoretical Study | Background |
| 128 | Schuegerl, K. Mixing Processes in Multiphase Flow Systems Chem. Ingr. Tech., 38, Nov. 1966 | Water/Soluble and Insol. Gases/ Small and Medium Particles | Background |
| 129 | Tigrel, A. Z. and Pyle, D. L. A Model for a Fluidized Bed Catalytic Cracker Chem. Eng. Science, Vol. 26, pp. 133-145, 1971 | No Experimental Work | Background |

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Literature on The Hydrodynamics of Fluidization

D. Gas-Solid Fluidization:

| <u>Reference No.</u> | <u>Reference</u> | <u>Systems Covered</u> | <u>Significance to Project</u> |
|----------------------|---|------------------------|--------------------------------|
| 130 | Wen, C. Y. Research Needs for the Analysis, Design, and Scale-up of Fluidized Beds 67th Annual A.I.Ch.E., paper 41-A, Dec. 1974 | No Experimental Work | Background |
| 131 | Werther, J. Bubble Chains in Large Diameter Gas Fluidized Beds Int. J. Multiphase Flow, Vol. 3, pp. 367-381, 1977 | Air/Quartz Sand | Background |
| 132 | Yates, J. G. Fluidized Bed Reactors The Chem. Eng., No. 303, p. 671, Nov. 1975 | No Experimental Work | Background |

TABLE A-II

Literature on Experimental or Analytical Techniques and Equipment

| Reference No. | Reference | Technique | Application |
|---------------|---|--|--|
| 133 | Alonso, C. V. Comparative Study of Electrical Conductivity Probes Journal Hydraulic Res., Vol. 9, No. 1, p. 1, 1971 | Conductivity Probes | Characterize Liquid Flow |
| 134 | Arunachalam, V., Hummel, R. L., and Smith, I. W. Flow Visualization Studies of a Turbulent Drag Reducing Solution Canadian Journ. Chem. Eng., Vol. 50, p. 337, 1972 | Dye Tracers | Characterize Liquid Flow |
| 135 | Bartholomen, R. N. and Casagrande, R. M. Measuring Solids Concentration in Fluidized Systems by Gamma-Ray Absorption Ind. and Eng. Chem., Vol. 49, No. 3, p. 428, 1957 | Gamma Ray Absorption | Algorithm for Establishing Point Densities from Gamma-Ray Measurement |
| 136 | Blasson, V. L. Flow Measurement Under Any Condition Inst. and Control Systems, p. 45, Feb. 1975 | Survey of Flow Measurement Techniques | Background |
| 137 | Botton, R. J. Gas-Solid Contacting in Fluidized Beds A.I.Ch.E. Symp. Ser. No. 166, Vol. 10, p. 1970 | Gas Tracers | Background |
| 138 | Brown, M. Pulsed Ultrasonic Measurements of Fluid Flow Review of Scientific Instr., Vol. 37, No. 9, p. 1181, 1966 | Ultrasonics | Flowmeter |
| 139 | Furges, R. J. M. and Calderbank, P. H. The Measurement of Bubble Parameters in Two-Phase Dispersions Chem. Eng. Science, Vol. 30, pp. 743-750, 1975 | Impedance Probe | Determine Bubble Characteristics |
| 140 | Calderbank, P. H., Evans, F., and Rennie, J. The Mass-Transfer Efficiency of Distillation and Gas-Absorption Plate Columns Inter. Symp. on Dist. (1960) | Gamma-Ray Absorption | Density Determination Using Gamma-Ray Scans |
| 141 | Cameron, J. F. Fluid Density Measurements in Enclosed Systems Int. Conf. on Radio Isotopes, Paper No. NS/Ric/195, p. 426 | Radiation Detectors | Density Determination Using Gamma-Ray Scans |
| 142 | Chen, B. H. and Osberg, G. L. Radial Gas Dispersion in a Column Packed with Screen Cylinders Canadian Journ. Chem. Eng., Vol. 45, p. 46, 1967 | Tracer Gas | Background |
| 143 | Crescitelli, S., Egiziano, L., and Macchiaroli, B. Glow Discharge Probes for Fluid Bed Applications Ing. Chim. Ital., Vol. 10, No. 2, p. 23, 1974 | Glow Discharge | Background |
| 144 | Darton, R. C. and Harrison, D. Some Properties of Gas Bubbles in Three-Phase Fluidized Beds Inst. Ch. Eng. Symp. Series No. 38, Vol. 1, Paper B-1, 1974 | Impedance Probe | Determine Bubble Characteristics |

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Literature on Experimental or Analytical Techniques and Equipment

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| Reference No. | Reference | Technique | Application |
|---------------|---|---------------------------------------|---|
| 145 | Delhaye, J. M. and Jones, O. C., Jr. Measurement Techniques for Transient and Statistical Studies of Two-Phase, Gas-Liquid Flows Paper, Heat Transfer Conf., A.S.M.E., San Francisco, Calif., Aug. 1975 | Review of All Techniques: Light Probe | Determination of Gas and Liquid Hold-up |
| 146 | Delhaye, J. M., Semeria, R., and Flamand, J. C. Void Fraction and Vapor and Liquid Temperatures: Local Measurements in Two-Phase Flow Using a Micro Thermocouple Journ. of Heat Transfer, p. 365, Aug. 1973 | Phase Measurement by Thermocouple | Background |
| 147 | Farley, R. and Ray, D. J. Gamma Radiation Absorption Measurement of Density and Gas Hold-up in a Three-Phase Catalytic Reactor British Ch. Eng., Vol. 9, No. 12, p. 830, 1964 | Gamma-Ray Scanning | Density Determination |
| 148 | Fries, B. A. Chemical Engineering Progress Symposium Series Nuclear Engineering, Part XXII, Vol. 66, No. 106, p. 1, 1970 | Radioactive Tracer | Background |
| 149 | Geake, J. E. Linear Refractometers for Liquid Concentration Measurement Chem. Eng., Vol. 297, p. 305, May 1975 | Light Probe Measurement | Background |
| 150 | Gilliland, E. R. and Mason, E. A. Gas Mixing in Beds of Fluidized Solids Ind. Eng. Chem., Vol. 44, p. 218, Jan. 1952 | Tracer Gas | Background |
| 151 | Hancox, W. T., Forrest, C. F., and Harms, A. A. Void Determination in Two-Phase Systems Employing Neutron Transmission Paper, A.I.Ch.E.-A.S.M.E. Heat Transfer Conf., Aug. 1972 | Neutron Transmission | Background Applied to Gamma-Ray Scans |
| 152 | Hancox, W. T. and Harms, A. A. Discrete-Time Neutron Interrogation of Liquid Flow Systems Trans. Am. Nuclear Soc., Vol. 14, p. 1, 1971 | Neutron Scanning | Background |
| 153 | Hull, R. L. and Von Rosenberg, A. E. Industrial and Engineering Chemistry, Vol. 52, No. 12, p. 989, 1960 | Radioactive Tracer | Externally Detected Tagged Catalyst |
| 154 | Hunt, R. H., Biles, W. R., and Reed, C. O. Find Catalyst Density With Isotopes Petr. Refiner, Vol. 36, No. 4, p. 179, 1957 | Gamma-Ray Absorption | Algorithm for Establishing Point Densities from Gamma-Ray Measurement |
| 155 | Jones, Jr., O. C. and Delhaye, J. M. Transient and Statistical Measurement Techniques for Two-Phase Flows Int. J. Multiphase Flow, Vol. 3, No. 2A, p. 89, 1976 | Review of Measuring Techniques | Optical Probes |
| 156 | Keeler, R. N., Petersen, E. E. and Prausnitz, J. M. Mixing and Chemical Reaction in Turbulent Flow Reactors A.I.Ch.E. Journal, Vol. 11, No. 2, p. 221, 1965 | Conductivity Probe | Background |

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Literature on Experimental or Analytical Techniques and Equipment

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| Reference No. | Reference | Technique | Application |
|---------------|--|---|----------------------------|
| 157 | Kim, B. O. and Harris, T. R. The Experimental Measurement and Theoretical Analysis of Flow-System Tracer Curves by a Line-Sampling Method Chem. Eng. Science, Vol. 28, pp. 1653-1659, 1973 | Conductivity Probe | Background |
| 158 | Kohl, J., Zentner, R. D., and Lukens, H. R. Radioisotope Applications Engineering D. Van Nostrand Co., Princeton, New Jersey, 1961 | Gamma-Ray Scans and Radioactive Tracers | Radioactive Experiments |
| 159 | Magrini, U. Flowmeter for Measurement of Low Velocities in Liquids with Weak Electrical Conductance Review of Scientific Inst. Vol. 37, No. 35, p. 627, 1966 | Conductance Probe | Background |
| 160 | Mariéh, A. A. Sensing the Height of a Gas-Fluidized Bed Chem. Eng., p. 112, Aug. 1973 | Conductivity Measurement | Background |
| 161 | Mann, P. and Crosby, E. J. Cycle Time Distribution in Circulating Systems Chem. Eng. Science, Vol. 28, pp. 623-627, 1973 | Use of Gas Tracers to Determine Cycle Time Distribution | Background |
| 162 | McDonald, D. P. Ultrasonics are Moving Into Unconventional Processing Applications Process Eng., p. 82, June 1973 | Ultrasonics | Background |
| 163 | McShane, J. L. and Geil, F. G. Measuring Flow Res./Devl., Vol. 26, No. 2, p. 30, 1975 | Survey of Measurement Devices | Flow Rate of Coal Slurries |
| 164 | Metcalf, T. B. Chemical Engineering Progress Vol. 60, No. 2, p. 71, 1964 | Radioactive Tracer | Sampled Tagged Catalyst |
| 165 | Morikawa, S., Lanz, O., and Johnson, C. C. Laser Doppler Measurements of Localized Pulsatile Fluid Velocity I.E.E.E. Trans. on Bio-Medical Eng., Vol. BML-18, No. 6, p. 46, Nov. 1971 | Optical Doppler Meter | Background |
| 166 | Nakatani, N., Fujiwara, K., Matsumoto, M., and Yamada, T. Measurement of Flow Velocity Distributions by Pulse Luminescence Method Journ. Physics E: Scientific Instr., Vol. 8, p. 1042, 1975 | Pulse Luminescence | Liquid Flow Visualization |
| 167 | Nam-Koong, S. and Sae-Ki, M. A Dynamic Response Study of Gas Residence Time in a Fluidized Bed. Int. Chem. Eng., Vol. 6, No. 4, p. 668, Oct. 1966 | Absorbing Tracer Gases | Background |
| 168 | Nauman, E. B. and Collinge, C. N. Measurement of Contact Time Distributions in Gas Fluidized Beds Chem. Eng. Science, Vol. 23, pp. 1317-1326, 1968 | Weakly Absorbing Tracers | Background |

TABLE A-II
Literature on Experimental or Analytical Techniques and Equipment

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| Reference No. | Reference | Technique | Application |
|---------------|--|---|-------------------------|
| 169 | Noble, F. W. Dual Frequency Ultrasonic Fluid Flowmeter Review of Scientific Inst., Vol. 39, No. 9, p. 1327, Sept. 1968 | Ultrasonics | Background |
| 170 | Nye, J. O. and Brodkey, R. S. Light Probe for Measurement of Turbulent Concentration Fluctuations Rev. Sc. Inst., Vol. 38, No. 1, p. 26, Jan. 1967 | Light Probes | Background |
| 171 | Singer, E., Todd, D. B., and Guinn, V. P. Industrial and Engineering Chemistry Vol. 49, No. 1, p. 11, 1957 | Radioactive Tracer | Sampled Tagged Catalyst |
| 172 | Sorrentino, C. D. F.C.U. Radioactive Tracer Studies N77-10, Amoco Oil Co., Feb. 1977 | Radioactive Tracers | Experimental Techniques |
| 173 | Tiley, P. F. Opening New Windows to On-Stream Analysis Process Eng., p. 89, Nov. 1974 | Orifices: Fluid Jet Measurements | Background |
| 174 | Yasui, G. and Johanson, L. N. Characteristics of Gas Pockets in Fluidized Beds A.I.Ch.E. Journal, Vol. 4, No. 4, p. 445, 1958 | Light Probe | Background |
| 175 | Zientars, D. E. Measuring Process Variables Chem. Eng., Deskbook Issue, p. 19, Sept. 11, 1972 | Review of Techniques to Measure Process Variables | Background |

TABLE A-III

Literature on Physical Properties of Coal-Oil Mixtures

| Reference No. | Reference | Coal Concentration | Significance to Project |
|---------------|---|--------------------|------------------------------------|
| 176 | Barrett, D. and Sergeant, G.D. Coal-Oil Mixtures Pace, 27, No. 4, April 1974 | 0 - 40%, 40 - 60% | Background |
| 177 | Droegge, J.W., Hassell, J.A., Kleinschmidt, W.W., and Chauhan, S.P. Final Technical Report on Physical Properties of Synthoil Products ERDA, Contract No. E (46-1)-8009 Battelle Laboratories, Columbus, Ohio, July 6, 1977 | | Viscosity Measurement Technique |
| 178 | Petrolite Corp., (News Report) Chemical Additive Keeps Crushed Coal in Slurries on the Move Coal Age, p. 140, Dec. 1974 | 0 - 65% | Experimental Operation |
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