FORMAL LABORATORY REPORTS

WRITING GUIDELINES
FOR
ChE 310 & 410

by

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Introduction

This document provides information concerning the content, style, and format requirements for ChE 310 formal laboratory reports. This document, of course, is not exhaustive. If you have any doubts, consult some of your favorite textbooks or journals as examples. Keep in mind that the objective of any report is to effectively communicate results and ideas to a large range of readers: the casual reader, the reader very familiar with the work, or the reader only interested in results. Proper organization, clarity of thought, and good grammar are essential to meeting this end. A report that does not look professional creates a negative impression.

Many features of report writing are conventions. Arrangements of the parts, layout of tables and figures, the order of the presentation and the substance of the summary are examples of these conventions. While convention can be boring, it has found use in technical reports because it is an efficient way to communicate information. The time of both the reader and writer is used efficiently. Many of the conventions presented below are directed towards generating a professional report suitable for reproduction and subsequent distribution to a wide variety of readers.

General Requirements

The prime requirements of good technical writing are clarity and precision. Statements that are vague, qualitative, or open to dual interpretation should never appear in a technical report.

To write a good report, the author must have a clear under-standing of the material that he is trying to present and know how he wishes to present it. Poor English in reports often arises from faulty and unclear thinking rather than from unfamiliarity with grammatical rules. A highly respected sage is fond of saying (Thomas, 1988), "In order to be able to write something well, you need to know 10 times as much as what you write down."

Another requirement is that the material included in the report be complete and carefully selected. Many reports are unsatisfactory because the writer includes insufficient material for a clear understanding of the discussion. On the other hand, the writer must exercise caution against adding material irrelevant to the discussion. In other words, the report should be **complete but concise**. Quoting Michaelson's text (Michaelson, 1986), How to Write and Publish Engineering Papers and Reports, he writes “The concise paper is full of substance that pertains to its main theme; it says much in few words. A manuscript that is merely brief may or may not have the important quality of conciseness.”

Not only must you choose the subject matter carefully, you must also organize it properly. Develop all discussions systematically. Each section of the discussion should follow logically from the preceding discussion, and lead naturally to subsequent discussion. Writing from a detailed report outline helps you accomplish this organization.

The seasoned or trained author also knows that the first section in a report (the summary), the first paragraph in a section, and the first sentence in a paragraph is the most important. Typically the summary is the first part of your report looked at by your readers, while the first paragraph is the first part looked at in a section, etc. Thus these pieces are your first opportunity to interest them into reading more about your work. Due to their importance the writer should spend relatively more time on perfecting these parts as compared to the rest of the report.

You are to produce the report including figures, tables and equations with a word processor. Only for special reasons may parts of the report be neatly done in black ink. No colored inks should be used in the report. All the paper should normally be the same size.

The subjective effect on the reader of a neat and well-prepared report cannot be over emphasized. You are to submit the report in a report folder using two or three punched holes or bound in some fashion. Standard margins of 1.5 inches for the left margin (the punched or bound edge) and 1 inch for all other margins are used. Typically paragraphs are single or one and a half spaced with double spacing used between paragraphs.

The grammar and style should be consistent with good technical usage. See Industrial and Engineering Chemistry or AIChE Journal for examples. The writer must recognize that writing a technical report is a highly stylized art. Individuality in style, however commendable in principle, is for the experienced writer only. Therefore, one should avoid the first person and always write in the third person, either active ("one can calculate the result by ....") or passive ("the result can be calculated by .... ").

One should avoid unjustified changes in tense. There is seldom justification for changing tense in the middle of a paragraph. Since the experimental work is usually finished when a report is written, you should make references to experimental work in the past tense. Likewise, write your presentation and discussion of results in the present tense. The tense generally used according to section is:

1) The Summary and Experimental Method sections are written in the past tense.

2) The Introduction and Background, Results and Discussion, and Conclusions sections are written in the present tense.

Detailed Requirements

1. Title Page

1.1 The title page should contain the following items, arranged in any neat and convenient form:

1) The course number
2) The report number
3) The experiment name
4) The department
5) Department address
6) Team section and number
7) Name, email address and phone number of all team members
8) Date experiment was performed
9) Date report was submitted

1.2 A sample title page is shown in Appendix A for a suggested format.

2. Table of Contents, List of Figures and List of Tables

2.1 The table of contents presents the names of the principal sections and page numbers.

2.2 The "List of Figures" and "List of Tables" are placed on separately numbered report pages. Appropriately title each page.

2.3 These two lists are placed under one heading in the table of contents, "List of Figures and Tables."

2.4 Include titles for each Appendix.

2.5 The titles in the table of contents should be identical to those used for the sections, tables, figures and appendices.

2.6 Number the pages following the scheme:

1) Title page is not numbered
2) Table of Contents is numbered ii
3) List of Figures is numbered iii
4) List of Tables is numbered iv
5) Summary is numbered 1

3. **Summary**

3.1 Start this section with the single word "SUMMARY" at the top of the page. Do not include the report title.

3.2 Give a **concise** statement of the problem, objective of the work, and the methodology used in meeting the objective.

3.3 The summary should not be more than one page long except in special circumstances. Often the summary is limited to a specified number of words such as 200.

3.4 Include a summary of both the qualitative and quantitative aspects of the results (for example, the numbers, error ranges, and percentage errors based literature values).

3.5 Give a **concise** statement of the major conclusions and suggestions for the major error sources between the results and literature values. Give the equations or definitions used to calculate the errors and report their signs.

3.6 The summary should be capable of standing alone.

4. **Introduction and Background**

4.1 Begin with a somewhat detailed statement of the problem or problem area, the objectives of the work, and the overall methodology. Usually, this involves an experimental program with the results compared to similar results in the literature.

4.2 Use subheadings where appropriate, e.g., "Experimental Investigations"; "Analytical Methods"; "Kinetic Theory"; "Material Balances"; etc.

4.3 Introduce appropriate material from the literature here, including qualitative summaries, typical values, equations, correlations, tables of data, and figures, as might be referenced in the Results and Discussion section.

4.4 Develop, present and number all equations, correlations, and definitions used in the Results and Discussion section. Explicitly state the assumptions, restrictions and requirements that must be met for the equations or correlations to apply, e.g., Reynolds number > 10,000.

4.5 As appropriate, include any theories or equations referenced in the Results and Discussion section. This could include such things as material and energy balance equations, kinetic theory and equations, heat transfer or mass transfer correlations, reaction rate coefficients, etc.

4.6 All the details of derivations are not necessary, unless the resulting equations are “new”. Literature references to equation derivations can be useful. Brief sketches of equation derivations may be useful in making certain points. Explicitly state the assumptions used in equation derivations.

4.7 Include physical property data used in ensuing sections; for example, viscosities, densities, thermal conductivities, etc. Present this material as tabulated properties, figures, equations or estimation techniques. Present this material in a general format. Do not tie it explicitly to your specific lab.

4.8 Note that this section does **NOT** contain results.

5. Experimental Method

5.1 Provide a concise overview of the experimental plan. It is often helpful to suggest why this plan and experimental method were used instead of some alternate method or methods.

5.2 Sub–headings are recommended.

5.3 Give an overview of the experimental system referring directly to the appropriate points or locations on the flow sheet. Lead the reader “by the hand” through the flow sheet.

5.4 Provide detailed step by step operational procedures that you followed in the lab to carry out your tasks. Could someone else use your description to **repeat your work**? Even if, you were not there?

5.5 Where appropriate, provide details of the apparatus such as reactor dimensions, pipe diameters, and packing sizes. An efficient way to present such data is in tabular form. Keep in mind that all parameters used in the calculations must be presented in this section. Information and details of secondary importance can be included in an Appendix.

5.6 Give details of the instrumentation, analytical methods, and reagents used.

5.7 Note that this section does **NOT** contain results.

6. Results and Discussion

6.1 Present a detailed overview of the experimental plan. State clearly and specifically the objectives of your work. Discuss the individual runs and the conditions under which they were done, such as temperature range, flow rate range, etc.

6.2 Present the experimental data. Discuss the data and variable ranges in some detail, referring to tables by number. Point out anomalous data points.

6.3 Sketch out the data reduction and interpretation, referring by number, to the equations used in the Background section. Tabulate the calculated results, referring to tables by number. Place details of the calculations in an Appendix, referring to that Appendix by letter.

6.4 Present the data and results in graphical form if appropriate, referring to the figures by number. Are the trends plausible? If curve fitting was performed, tell how (e.g., linear regression analysis, nonlinear regression analysis) the fitting was achieved. Give a reference for the software that was used.

6.5 Compare your results with literature values or values calculated from correlations in the literature (referring to equation numbers in the Background section).

6.6 Explicitly state assumptions used in your work. Justify any assumptions that were used, e.g., "In the absence of measurements of bubble size, it is assumed they are two millimeters in diameter. This size is consistent with rough visual observations."

6.7 Provide quantitative comparisons between the results and literature values, such as percentage errors, etc.

6.8 Suggest and discuss plausible explanations for the differences between your results and literature values.

7. Conclusions

7.1 Introduce this section with a **concise** summary paragraph of the work, keeping the objectives in mind.

7.2 Everything contained in the conclusions must be presented and discussed in detail in other report sections. This is not a surprise section.

7.3 List conclusions by number.

7.4 Give quantitative results and percentage errors based on literature values.

7.5 Some of the conclusions may need to be qualitative, for example: a description of trends.

7.6 Discuss whether the experimental method and procedures were an appropriate or effective method for obtaining the objective. If not, make suggestions for improvements.

8. Nomenclature

8.1 All symbols in the report are grouped according to origin (e.g., Roman or Greek). Subscripts and superscripts are also grouped separately.

8.2 Name or define all symbols.

8.3 Provide units that are used in calculating all dimensional quantities. If a quantity is dimensionless, it is so stated.

8.4 The Nomenclature page in Appendix B provides an example format.

9. Literature Cited

9.1 Two styles are in common use.

9.2 One style lists the author name and date within parenthesis in the text. For example, “It has been reported in the literature (Hughmark, 1962) that the effect of system pressure is not negligible.” If there are two authors for a given reference, the listing would be by both names: (Beggs and Brill, 1973). For more than two authors, the listing would be: (Cusumano, et. al., 1978). The references cited are organized alphabetically by first author in the Literature Cited section. An example of this style is contained in Appendix C.

9.3 A second style is to number the references in order of appearance in the text. The reference is then made by enclosing the reference's number in parenthesis. For example, "The effect of the solvent used in the Solvent Refined Coal Process has been reported in the literature [3]." The listing in the Literature Cited section is then by number. An example of this style is given in Appendix D.

9.4 Either style is acceptable; however, an advantage of the first style is that references do not have to be renumbered throughout the text should one discover that a reference was omitted during the preparation of the report.

9.5 Reference the software that you use for your calculations and regression fits.

10. Appendices

10.1 Name each Appendix with a capital letter: Appendix A, etc.

10.2 The Appendices should contain at least the following information, in order:

Appendix A.	Laboratory Instructions Including Calibration Curves and Drawings
Appendix B.	All Laboratory Journal Entries
Appendix C.	Sample Calculations
Appendix D.	Error Analysis, Lengthy Derivations; as required
Appendix E.	Supplementary Material from the Literature
Appendix F.	Other Information of a Secondary Nature

11. **Figures**

Figures in technical reports are generally of several principal types: graphs, process flow sheets, drawings of equipment, piping and instrumentation diagrams (P & ID), photographs, or plant site layouts. Examples of figures containing information in graphical form are shown as Figures 1 and 2. An example of a process flow sheet is given in Figure 3. Examples of other types of figures may be found in the engineering literature.

All figures should be clear and neatly formatted. Other features common to all figures are that they should meet margin requirements (generally 1 1/2 inches on the left and one inch on all other sides). Each should have a figure number and a title. Additional conventional features of a figure containing information in graphical form are listed below. Conventional features of a flow sheet are provided in the section titled Flow Sheets.

11.1 All Figures are given a number and a title, preferably located at the bottom and within the margin requirements. All figures are referred to in the text by their number. The figure is located immediately following the page on which it is first mentioned.

11.2 Descriptive titles are preferred. For example, “Process and Instrumentation Diagram for the New Heat Exchanger Facility.” A title such as "Experimental Equipment Flow Sheet" or “Scale Reading Versus Flow Rate” is absolutely unacceptable. Figure titles should not contain the word “versus” or an equivalent.

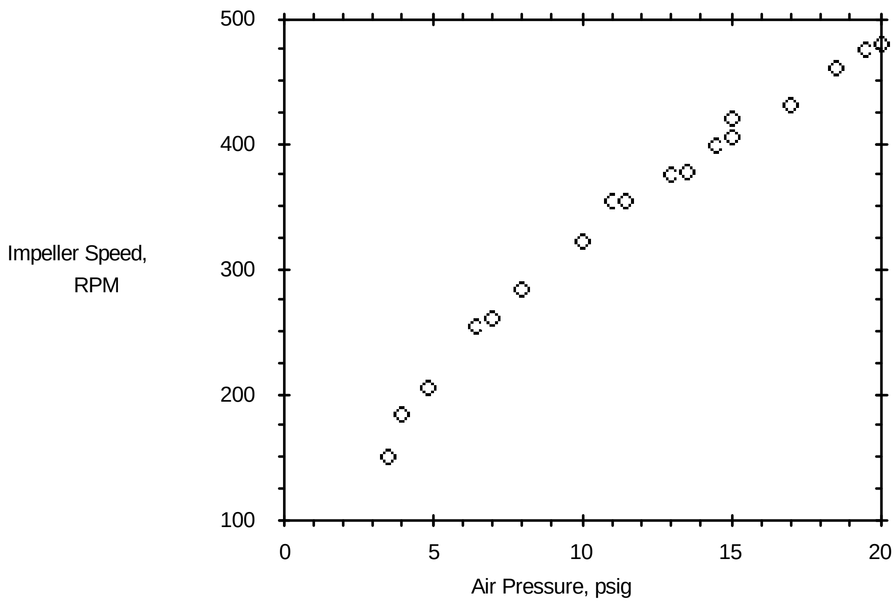


Figure 1. Air Impeller Performance Characteristics

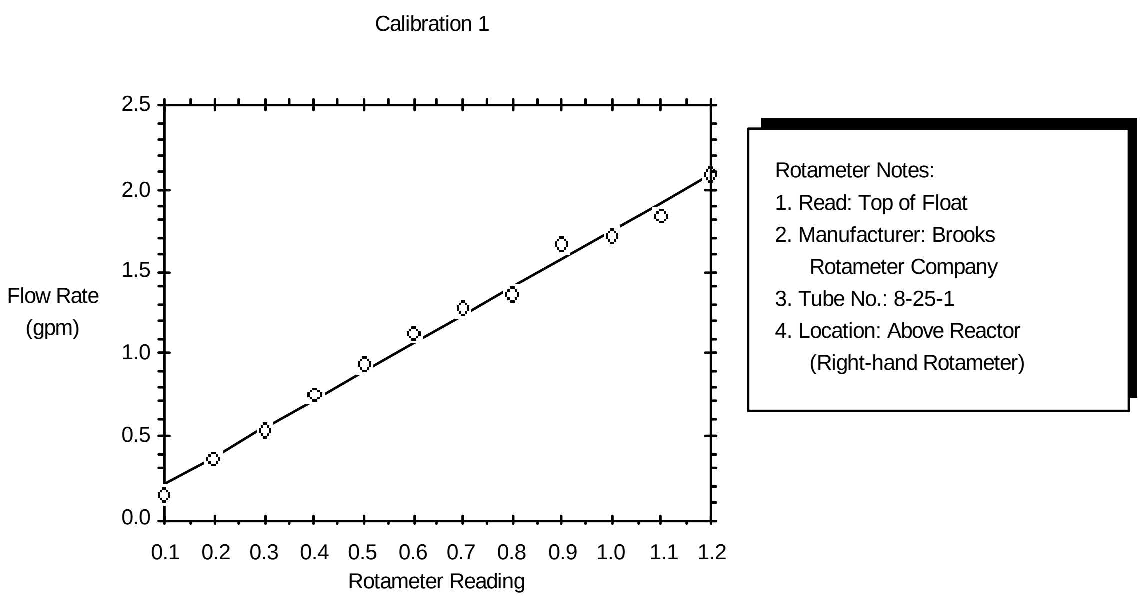


Figure 2. Homogeneous Kinetics Flow System (TLC, 3/17/92):
Rotameter Calibration Curve for ChE Laboratory 410

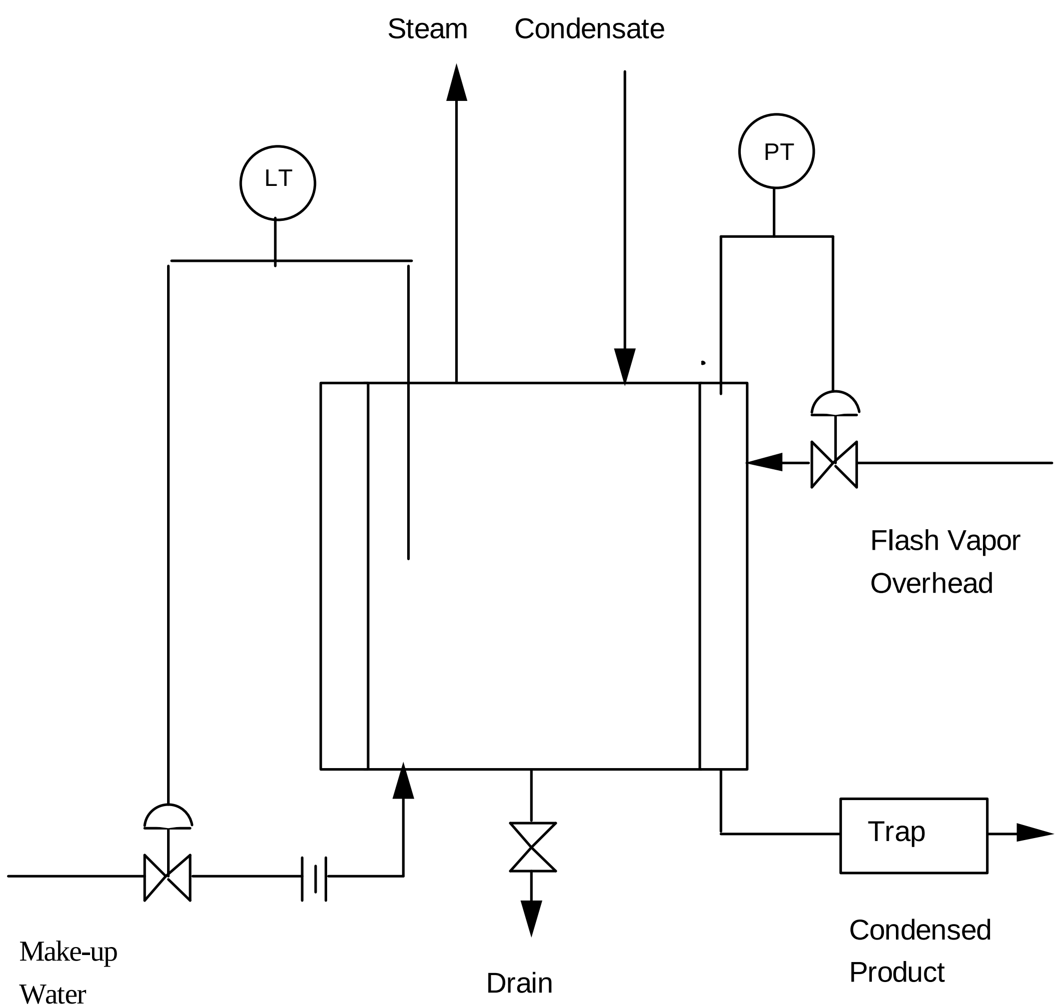


Figure 3: Pilot Plant Energy Recovery Steam Generator

11.3 Minimum margin requirements are 1 1/2 inches on the left (the binding edge of the page) and one inch on the other three edges. Larger margins are acceptable, but scale the axes so that the framework of the figure occupies at least half the page.

11.4 Data points are indicated by small circles, squares, triangles, etc. If for some reason a figure is made by hand, use black ink. Avoid color printing or colored inks, as they require more costly color reproduction for the report.

11.5 Reference the software used for computer generated figures.

11.6 **Do not straight line connect data points.**

11.7 Do not use symbols (e.g., small circles) to indicate "data points" from a theoretical model or correlation. Plot the curve obtained from the model or correlation.

11.8 Distinguish between curves or curve fits by using solid and broken lines. The same restrictions on color apply as for the data points.

11.9 **Do not** draw a curve fit through data points.

11.10 If there is more than one type of curve or data point, provide a key in the figure:

l Run 1, 120 min
m Run 2, 160 min

The key is located within the _Figure itself, not in the title.

11.11 Both axes are labeled with a title and the symbol of the quantity being plotted. Units are provided at the end of this label.

11.12 The graph should be boxed and subsidiary axes drawn without labels or numbers. These subsidiary axes improve the read-ability of the _gure.

11.13 If at all possible, the _gures should be scaled to _t on the standard 8 1/2 by 11 sheet of paper. Folding of the _gure is to be discouraged.

12. **Flow Sheets**

Flow sheets are simple line drawings showing the arrangement and relationship of the process units and material streams. An example of a process flow sheet is attached as Figure 3. The following conventions are given for process flow sheets:

12.1 Show all input and output material streams by name.

12.2 Include each piece of process equipment with the equipment name on (or below) the unit (see item 12.7 below).

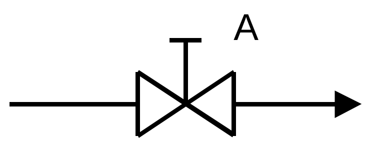
12.3 Show the material flow lines between process units with arrows to indicate the direction of fluid flow.

12.4 Give any recycle steams, as appropriate.

12.5 Show the locations of instrumentation devices such as flow meters.

12.6 Show the location of control or regulation devices such as valves.

12.7 Include a key to identify any symbols or letters used to designate a particular element of the process. This approach is especially useful for those elements that are too small to contain a name.

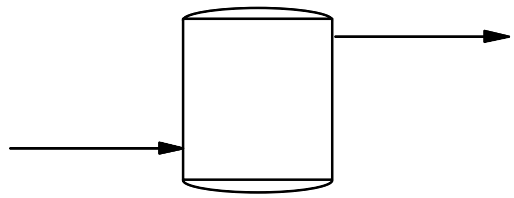


A. Needle Valve

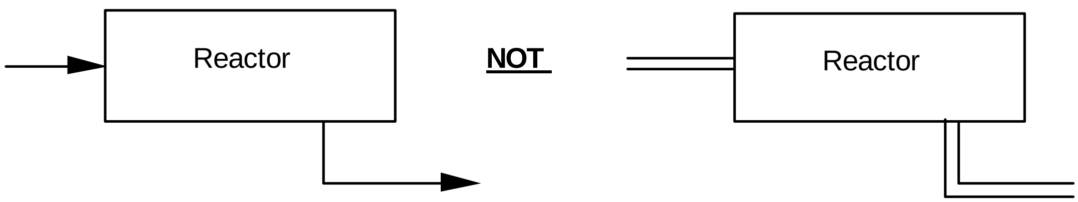
12.8 The general material flow is normally shown from left to right.

12.9 For process units where orientation is important for operation (such as distillation columns and packed absorption towers) inputs and outputs are shown at the top or bottom of the unit as appropriate. (Do not depict individual distillation columns “lying on their sides!")

12.10 Shape a process unit somewhat like its actual shape. For example, depict a pressure vessel as follows:



12.11 A single line is always used for tubes and other conduits:



12.12 All constructions should be computer generated whenever possible. All hand drawings are made with a straight edge and appropriate templates.

13. **Tables**

An example of a common table layout is attached as Table 1. Conventional features of tables are given below.

13.1 The number and title of the table are located at the top. All tables are referred to by number in the text. Tables are located immediately following the page where they are first mentioned. Small tables may be inserted in the text, but spaces should be provided so that they standout.

13.2 Horizontal lines are used as indicated in the attached examples. Vertical lines are rarely, if ever, used.

13.3 The units of all dimensional quantities are provided, e.g., Pressure (KPa).

Table 1. Range of Wilsonville SRC–1 Preheater Operating Conditions Producing Coke[a]

Quantity	Range Min.	Range Max.
Inlet hydrogen pressure, psia	1120.0	2030.5
Slurry coal content, wt %	33.2	40.1
Slurry flow rate, lb/h	697.3	1465.0
Gas flow rate (inlet), lb/h	28.9	248.7
Skin temperature at location of coke deposits, °F	464.0	854.0
Solvent quality (short), %	62.0	74.1
Slurry mean residence time, min	b	b

[a]Source: FE–2270–36, –46, –48, –60, and –68
[b]Not Reported

Appendices

Appendix A. Sample Title Page

Chemical Engineering 310
Report III

Climatic Reactions in Packed Beds

by

Team 5.α

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Submitted: 8/17/93

Appendix B. Sample Nomenclature

Roman

a Exponent in Eq (1), dimensionless

A Flow cross–sectional area, m^2

C_a Concentration, kg–mole/m^2

D Diameter, m

E Activation energy, kJ/kg–mole

G Mass velocity, kg/m^2–s

k First order reaction rate coefficient, 1/s

K Constant in eq (2), dimensionless

L Reactor length, m

p Total pressure, Pa

Q Volumetric flow rate, m^3/s

Re Reynolds Number, f(vDρ,μ), dimensionless

v Velocity, m/s

Greek

μ Viscosity, kg/m–s

π Total pressure, kPa

Subscripts

a Component A

i Inside

o Outside

Appendix C. Sample Literature Cited Ordered Alphabetically

Beggs, H.D. and J.P. Brill, "A Study of Two–Phase Flow in Inclined Pipes," J. Pet. Technol. XXV, 606–617 (1973).

Cassidy, D.R., Solvent Re_ned Coal, International, Inc., personal communication, April 1981.

Cusumano, J.A., R.A. Dalla Betta, and R.B. Levy, Catalysis in Coal Conversion, Chap. 6, Academic Press, New York, 1978.

Froehling, P.E., and L.T. Hillegers, "Solubility Parameters of Ternary Solvent Mixtures: Calculation of the Solvent Composition with Maximum Polymer Interaction," Polym. 22(2), 261–262 (1981).

Henry, H.C., and J.B. Gilbert, "Scale–up of Pilot Plant Data for Catalytic Hydroprocessing," Ind. Eng. Chem. Proc. Des. Dev. 12(3), 329–340 (1973).

Hildebrand, J.H., and R.L. Scott, The Solubility of Non–Electrolytes, 3rd ed., Reinhold, New York, 1950.

Hughmark,G.A., "Holdup in Gas–Liquid Flow," Chem. Eng. Prog. 58,62–65 (1962).

Hughmark, G.A., "Holdup and Heat Transfer in Horizontal Slug Gas–Liquid Flow," Chem. Eng. Sci. 20,1007–1010 (1965).

Kang, C.C., G. Nongbri, and N. Stewart, "The Role of the Solvent in the Solvent Re_ned Coal Process," in Liquid Fuels from Coal, ed. by Rex Ellington, Academic Press, New York, 1977.

Lockhart, R.W., and R.C. Martinelli, "Proposed Correlation of Data for Isothermal Two Phase Two–Component Flow in Pipes," Chem. Eng. Prog. 45(1), 39–48 (1949).

Michaelson, H.B., How to Write and Publish Engineering Papers and Reports, 2nd ed., ISI Press, Philadelphia, 1986.

Preparation of a Coal Conversion Systems Technical Data Book (Project 8979 Annual Report, for the period May 1, 1976 – April 30, 1977), prepared by the Institute of Gas Technology, FE–2286–16 (January 1978).

Thomas, C.O., "Address to Students in a Chemical Engineering Unit Operations Class," private communication, University of Tennessee, Knoxville, TN, Fall 1988.

Appendix D. Sample Literature Cited in Order of Appearance

1. C.O. Thomas, "Address to Students in a Chemical Engineering Unit Operations Class," private communication, University of Tennessee, Knoxville, TN, Fall 1988.

2. H.B. Michaelson, How to Write and Publish Engineering Papers and Reports, 2nd ed., 4, ISI Press, Philadelphia, 1986.

3. Kang, C.C., G. Nongbri, and N. Stewart, "The Role of the Solvent in the Solvent Re_ned Coal Process," in Liquid Fuels from Coal, ed. Rex Ellington, Academic Press, New York, 1977.

4. J.A. Cusumano, R.A. Dalla Betta, and R.B. Levy, Catalysis in Coal Conversion, Chap. 6, Academic Press, New York, 1978.

5. H.C. Henry and J.B. Gilbert, "Scale–up of Pilot Plant Data for Catalytic Hydroprocessing," Ind. Eng. Chem. Proc. Des. Dev. 12(3), 329–340 (1973).

6. J.H. Hildebrand and R.L. Scott, The Solubility of Non–Electrolytes, 3rd ed., Reinhold, New York, 1950.

7. P.E. Froehling and L.T. Hillegers, "Solubility Parameters of Ternary Solvent Mixtures: Calculation of the Solvent Composition with Maximum Polymer Interaction," Polymer 22(2), 261–262 (1981).

8. R.W. Lockhart and R.C. Martinelli, "Proposed Correlation of Data for Isothermal Two Phase Two–Component Flow in Pipes," Chem. Eng. Prog. 45(1), 39–48 (1949).

9. G.A. Hughmark, "Holdup in Gas–Liquid Flow," Chem. Eng. Prog. 58,62–65 (1962).

10. G.A. Hughmark, "Holdup and Heat Transfer in Horizontal Slug Gas–Liquid Flow," Chem. Eng. Sci. 20,1007–1010 (1965).

11. H.D. Beggs and J.P. Brill, "A Study of Two–Phase Flow in Inclined Pipes," J. Pet. Technol. XXV, 606–617 (1973).

12. D.R. Cassidy, Solvent Re_ned Coal, International, Inc., personal communication, April 1981.

13. Preparation of a Coal Conversion Systems Technical Data Book (Project 8979 Annual Report, for the period May 1, 1976 – April 30, 1977), prepared by the Institute of Gas Technology, FE–2286–16 (January 1978).