Chemical Engineering Department
University of Florida

UNIT OPERATIONS LABORATORY

ECH 4224 L and ECH 4404 L

GUIDELINES FOR WRITING LABORATORY REPORTS

by

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PREFACE

These notes are intended to serve as a guide for writing engineering reports for the Unit Operations Laboratory courses at the University of Florida. A number of propositions on writing style and organizational strategies are given to assist students in the preparation of clear and accurate reports.

Writers can accomplish their mission of conveying information using a great variety of composition formats, grammatical constructs, and creative language. The possibilities available to the author are virtually limitless. On the other hand, this inherent richness of possibilities can easily become an overwhelming burden to the inexperienced technical writer. Subtle choices must be made regarding the depth of coverage of each topic, the clear identification of final and intermediate results, the unambiguous statement of the conclusions of the experiment, *etc.* The intention of the guidelines offered in this document is to make students aware of relevant issues that must be addressed in technical writing, and assist them in the task of producing clear documentation of their experimental work.

Major industrial corporations most often have rigid document formats that must be strictly followed. Such standardization is sometimes mandated by governmental regulations, by legal requirements to establish rights to patents and to protect intellectual property, or simply established with the desire to facilitate the transmission of information throughout the organization. Under this perspective, the students are required to follow closely the restrictions and rules given in this guide.

A proposed format is given for each of the two reports that must be prepared for the experiments, namely the **Preliminary-Design Report**, and the **Final Report**. These formats have been developed over the years through the contribution of multiple faculty teaching the Chemical Engineering Unit Operations Laboratory courses at UF, including in particular Mr. Jim Sharp, and Professor Lewis Johns. The formats are not fixed standards; they must be interpreted as proposed guidelines that may be altered whenever necessary to improve the clarity and legibility of the report. *However, students are warned that in this course any deviations from the proposed guidelines will be considered as acceptable only when the modified format succeeds in producing a more persuasive and better-structured report.*

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REPORTS REQUIRED FOR EACH EXPERIMENT

Each experiment must be documented in two reports:

- Preliminary-Design Report
- Final Report

The **Preliminary-Design Report** indicates what specific experiments are to be carried out and documents details of the experimental strategy to be followed. The **Final Report** documents the results of the experiments and summarizes the conclusions that are inferred from the results.

PROPOSED REPORT FORMATS

The following formats are proposed as a guide. The students may add or delete sections as needed for each specific experiment in order to obtain a logical, self-contained document.

1. PRELIMINARY-DESIGN REPORT

The Preliminary-Design Report documents your *design of an appropriate experiment* to achieve clearly specified objectives. Typically this report is prepared before the first experiments are carried out and is based on data available from the literature or from computer simulations. The major sections of the report are outlined below, including brief descriptions of the expected contents of each section.

- **Title page**

  Identify the experiment with a descriptive title. Include names of all participants, date of submission, and dates when experiments were carried out. This page must also bear the subtitle: "Preliminary-Design Report".

- **Table of Contents**

  Lists each major section and subsection and their page numbers.

- **Objectives**

  Indicate precisely the objectives of the experiment, *i.e.*, identify the specific results sought. Be succinct, clear, and unambiguous. Do not exceed one page.

- **Introduction**

  Indicate what is the overall plan of the experiment: what must be done and how, which variables are manipulated and which are measured. Clearly indicate what the reader should expect to find in each of the subsequent sections.

- **Theory**

  Describe the applicable equations and their assumptions. Establish that these assumptions are reasonable for this experiment. Do not derive any equations that can be found in a standard textbook; simply state the equation with a reference to the source. All symbols must be defined. Do not include theoretical discussions or equations that are not relevant to the experiment. Do not include unnecessary symbols or variables. Clearly indicate which equations, and in what order, are invoked to design the experiment, interpret the results, and achieve the objectives. Refer the reader to the Appendix for all auxiliary information.

- **Experimental Plan**

  Describe the runs you plan to make and how they relate to the objectives. Include a table summarizing the conditions for each run. The table should list the proposed setting for all the manipulated variables, but should not include any of the measured variables.

- **Experimental Problems**

  Describe the problems you anticipate in getting the data you need and how you plan to solve them. Discuss all issues that may be relevant to the outcome of the experiment, such as inaccuracy of instrumentation, excessive times required to reach steady states, *etc*.

- **Supporting Calculations**

  Using your best estimates of unknown parameters, you should establish, insofar as possible, that the planned experimental conditions are reasonable. You must discuss how your calculations support the experimental plan.

- **References**

  List all the literature sources that are cited in the report.

- **Appendix**

  Include information that, though relevant, is not of sufficient relevance to the objectives of experiment to merit inclusion in the body of the report. Include additional appendices as needed.

  - **Data notebook** ("Blue Book")

    Before experimentation can begin, tables for the receipt of raw data must be constructed in the blue book and approved by the instructor.

  - **Equipment diagrams**

    Include equipment and layout diagrams that may be essential for characterizing the features of the experimental units.

2. FINAL REPORT

The Final Report documents the conclusions obtained from analyzing the results of the experiment. This report is prepared after all the experimental work is done, and it discusses the results in terms of the specific objectives of the study. The major sections of the report are outlined below.

- **Title page**

  Identify the experiment with a descriptive title. Indicate names of all participants, date of submission, and dates when experiments were conducted. This page must also bear the subtitle: "Final Report".

- **Table of Contents**

  Include each major subsection and its page number.

- **Abstract**

  Summarize the important results. The abstract must be self-contained: do not refer to figures and tables located in other sections of the report. Do not include tables, figures, and equations, unless absolutely necessary. Do not assume that the reader can unambiguously identify undefined symbols. Be precise and succinct. Do not exceed one page. The Abstract should be written with great care because it is a most important part of the Final Report and has a very large impact on the grade assigned to the work.

- **Objectives**

  It is convenient to restate the objectives even if they had been already mentioned in the Preliminary Design Report. The objectives serve as a guide to the results. Indicate precisely the objectives of the experiment. Be succinct, clear, and unambiguous. Do not exceed one page.

- **Results**

  Include all tables and graphs that document your final results. Include all relevant information so that you can later refer to these figures in the Discussion section to support your conclusions. If possible, present the results in the same order that you listed the objectives. Do not discuss the significance of the results. Include only final results that satisfy the objectives of the experiment; lengthier tables and intermediate figures should be included in the Appendix. Introduce the reader to each figure and table with a brief paragraph indicating what variables are plotted or tabulated. Each figure and table must have a unique number and a title or caption.

- **Sample Calculations**

  Give one example of each calculation that leads to a result reported in the document. Include one calculation for each figure or table reported in the Results section. Introduce each calculation with a brief paragraph indicating to the reader which

specific point in a figure or entry in a table is being calculated. These calculations are samples only and must be annotated. Extensive calculations should be included in the Appendix; the Sample Calculations section can then include appropriate references to the Appendix.

- **Discussion**

  Discuss the significance of each result documented in the Results section; address each table and figure in the order that they were presented. Use the available theory to explain why the relevant variables behaved in the observed fashion.

- **References**

  List all the literature sources that are cited in the report.

- **Appendix**

  Include information that, though relevant, is not necessary to mention in the body of the report to support the experimental design plan. Include additional appendices as needed.

  - **Data notebook** ("Blue Book")
  - **Calculation files**
    - Tables with intermediate results
    - Computer printouts
  - **Preliminary-Design Report** (always include as <u>last</u> appendix)

GUIDELINES FOR PREPARING TECHNICAL REPORTS

In this section a number of common errors made in technical writing are identified to help the authors make good stylistic and logical decisions and to avoid typical pitfalls. Some general guidelines are given first, followed by comments organized according to the sections that appear in the reports required for this course. The student can use these itemized comments as a checklist while proofreading a completed draft of a report.

1. GENERAL GUIDELINES

1 G Number all the pages.

2 G Number all figures and all tables. The figures and tables should be numbered according to the order in which they appear in the report.

3 G Each figure must have a descriptive caption (and optionally a title). Each table must have a caption.

4 G Each figure and table appearing in the report must be mentioned in an appropriate accompanying paragraph in the text. Unreferenced ("floating") figures and tables are unacceptable.

5 G No figure or table should appear before its introductory paragraph.

6 G Use different line types or plotting symbols to denote different curves in a figure. Avoid using colors because they do not reproduce in standard copying machines.

7 G Define all symbols appearing in the equations.

8 G No symbol should be used before it is appropriately defined.

9 G Do not introduce unnecessary symbols.

10 G Avoid using unconventional or non-standard scientific symbols.

For example, avoid using "*alphazero*" to denote α_o, "*a^2*" to denote "a^2", or "*qs*" to denote "q_s". If your word-processing software does not support Greek symbols or subindices, write them neatly by hand. Do not use FORTRAN-like arithmetic characters in scientific formulas. For example, avoid writing "$Q = m*C_p*\Delta T$"; it is preferable to write "$Q = m\ C_p\ \Delta T$".

11 G Avoid starting sentences with symbols or acronyms.

12 G Use a consistent verb tense throughout the document.

For example, the following sentences have inconsistent verb tenses:

The pressure drop <u>is</u> measured using two methods. The first method <u>was</u> based on ...

Note that the verb tenses are consistent in the following sentences:

The pressure drop <u>is</u> measured using two methods. The first method <u>is</u> based on ...

13 G In this course it is required that the present tense be used throughout the report <u>whenever possible</u>, as if the actions and calculations of the experimentalists were taking place when the document is being read. Avoid using past and future verb tenses; more specifically, avoid using "*will*" and "*was*" whenever possible.

For example, "*The experimental plan is described in the following section"* is preferable to " *The experimental plan will* be *described in the following section*."

Note that the use of the future-tense verb "*will"* is only necessary when the sentence refers to an event that will indeed occur in the future, such as in the statement *"The distillation column will be repaired by the Teaching Assistant next week"*. Likewise, use the past-tense verb "*was*" to refer to an event that must be identified as having taken place earlier in time, as in the statement *"The distillation column was installed in 1990"*. In every case where a future or past tense is used, the writer should consider whether an alternative present-tense sentence construction is possible, and then proceed to rewrite the statement in the present tense if it is a logical option.

14 G Avoid redundant expressions.

For example, the following sentence is redundant: "*The calculation of pressure is given in the following calculation*."

15 G Avoid awkward expressions.

For example, the following sentence is awkward because the reader has to make an effort to understand what the author means:

The friction factor is adjusted by a correcting variable that is multiplied to it.

A better alternative sentence could be, for example:

The friction factor is corrected by multiplication by a variable.

16 G Avoid colloquial or informal expressions.

For example, the following sentence is informal because it uses imprecise expressions that are often acceptable in the spoken language:

The value of the friction factor is plugged in equation (1).

A better alternative sentence is:

The value of the friction factor is substituted into equation (1).

17 G Avoid wordy sentences. Separate a long sentence into smaller logical sentences.

18 G Avoid imprecise expressions that can be misinterpreted. Choose words that convey precise meaning.

For example, the following sentence is imprecise because, contrary to the intention of the writer, it incorrectly states that "the equilibrium line is not physically possible":

The data are inconsistent because the operating line crosses the equilibrium line which is physically impossible.

The intention of the author might better be stated through the alternative sentence:

Since it is physically impossible for the operating line and the equilibrium line to cross, it is concluded that the data are inconsistent.

19 G Whenever possible, it is good practice to avoid the repetitive use of the pronoun "*we*". Also avoid using the forms "*our*" or "*us*." On the other hand, use "we" to claim personal responsibility for an important decision made:

For example, the sentence "*We discarded the data from run 1 because the temperature had not reached steady state*" emphasizes that the authors assume the responsibility for making the decision to ignore some of the data collected.

20 G Handwritten corrections or special symbols can be included in the report provided that the annotation is done neatly in ink. It is not necessary to type lengthy calculations; a neat handwritten calculation file written with a pencil is acceptable.

21 G Do not assume that the reader knows any details about the FORTRAN programs you use.

For example, it is <u>not sufficient</u> simply to state "The p*rogram EFFA is used for calculating efficiencies*". For completeness the authors must clearly indicate (1) the program's name, (2) the programming language used, (3) what the program does (what theoretical equations or theories it evaluates numerically), (4) what inputs are required, and (5) what outputs are produced. Such program descriptions must be complete but brief. It is usually reasonable to present the most relevant features of the computer programs in the Theory section, and if appropriate, more detailed information the Appendix. All the important equations solved by the program should be listed in the Theory section.

22 G Do not refer to an equation by their number *before* the equation has been introduced and numbered. You can refer to equations by their numbers only in the paragraphs that follow the appearance of the numbered equation.

For example, the following sentence is unacceptable because the author refers prematurely to "Equation (1)" before that particular equation is actually presented and numbered:

The temperature difference ΔT is used in Equation (1) to determine the heat flux

$$Q = m\, C_p\, \Delta T \qquad (1)$$

In cases like the example above it is recommended to omit the premature reference to the equation number. For example, an improved version of the sentence is:

The temperature difference ΔT is used to determine the heat flux

$$Q = m\, C_p\, \Delta T \qquad (1)$$

23 G It is not necessary to precede every equation by a sentence that ends with a colon. In most cases the equation should be presented as it if is part of the introductory sentence, without using any punctuation marks (such as a colon or a period).

For example, the <u>colon is not necessary</u> at the end of the first sentence shown below:

The temperature difference ΔT is used to determine the heat flux::

$$Q = m\, C_p\, \Delta T \qquad (1)$$

where m is the mass and C_p is the specific heat of the object.

A better introductory sentence can be constructed simply by omitting the colon as follows:

The temperature difference ΔT is used to determine the heat flux

$$Q = m\, C_p\, \Delta T \tag{1}$$

where m is the mass and C_p is the specific heat of the object.

2. PRELIMINARY-DESIGN REPORT

1. P Title page

1.1 P Identify the report type: Preliminary-Design Report or Final Report.

1.2 P Identify all the authors and list them in alphabetical order (by last name).

1.3 P Give a descriptive title to the report. Avoid uninformative titles, such as "*Experiment No. 1*". Use content-rich titles such as "*Determination of heat-transfer coefficients in a recovery boiler*". On the other hand, it is also important to avoid excessively long titles.

1.4 P Indicate the date of submission of the report.

1.5 P Indicate dates of experimental work.

1.5 P Indicate dates of experimental work.

1.6 P All authors must sign the report. The signatures lines may appear at the bottom of the cover page, or on a separate sheet on a second page.

2. P Table of Contents

2.1 P List all major sections with their corresponding page numbers.

3. P Objectives

3.1 P All the important objectives of the experiment must be clearly identified.

3.2 P Use precise and succinct statements. Avoid using vague statements.

For example, a good statement of an objective is given in the sentence: "*The first objective is to determine the dependence of the heat-transfer coefficient on the pressure drop across the evaporator*".

An example of a vague and imprecise statement that is not acceptable is: "*The objective is to characterize the heat-transfer coefficient of an evaporator*". This sentence is imprecise and vague because the word "characterize" may have multiple interpretations.

As a second example of a vague construction consider the sentence: "*The objective of this experiment is to determine the performance of a chemical reactor*". This sentence is vague because the word "performance" may have multiple interpretations. An improved statement could be "*The objective of this experiment is to determine the yield and selectivity of a chemical reactor*".

3.3 P The Objectives section must be self-contained. Do not make references to figures, tables or equations found elsewhere in the report.

3.4 P Try to minimize or avoid altogether the use of mathematical symbols in the Objectives section. Use symbols instead of the name of variables only when the name must be repeated several times.

3.5 P The Objectives section should contain no undefined symbols (preferably, it must include no symbols whatsoever).

3.6 P If possible, avoid using figures, tables, or equations to state the experimental objectives.

3.7 P If possible, avoid listing the objectives as a series of bullets. Use descriptive narrative in a paragraph form instead.

4. P Introduction

4.1 P Indicate what activities are to be done in this experiment and how you propose to carry it out these activities. Outline the general plan by indicating which variables are adjusted, which ones are kept constant, *etc*. Do not give unnecessary details; simply share with the reader the approach you plan to adopt for achieving the objectives.

4.2 P Indicate what are the expected results of the experiments.

4.3 P Do not refer to figures, tables, or graphs that appear in subsequent sections.

4.4 P Include only minimal equipment descriptions in the Introduction. Point out only equipment details that are of particular relevance to the attainment of the experimental objectives. All other details (such as complex diagrams, experimental set-up descriptions, *etc*.) should be relegated to the Appendix. The authors can then easily refer the interested reader to the material in the Appendix.

4.5 P Do not include a discussion of why this experiment is important or relevant. You should assume that you have been given the engineering task of carrying out the experiment by a supervisor who already knows that this work is important.

4.6 P Finalize this section by writing one paragraph that tells the reader about the contents of each section that follows.

5. P Theory

5.1 P Number all equations for easy and unambiguous reference.

5.2 P Define all variables and symbols. For example, do not assume that the symbol *U* universally stands for "heat-transfer coefficient".

5.3 P Do not include unnecessary or irrelevant variables.

5.4 P Do not include equations that are irrelevant to the experiment and its objectives.

5.5 P Do not rederive equations available in standard references such as textbooks or other scientific publications. Simply write the final equation and cite the source.

5.6 P All equations transcribed from the literature (books, papers, *etc*.) should be appropriately referenced.

5.7 P Use the format indicated in Section 9 P for citing references.

5.8 P Precede each equation with a brief introductory sentence to make the theory more accessible to the reader.

For example:

The heat transfer coefficient, U_O, is given by the equation

$$U_o = \frac{Q}{A_{eff}\ \Delta T_{lm}} \qquad (1)$$

where Q is the heat lost through the walls, A_{eff} is the effective area for heat transfer, and ΔT_{lm} is the log-mean temperature difference.

5.9 P Indicate how each equation is used in the experiment.

For example:

Equation (1) is used to determine the heat transfer coefficient U_o. All the variables in the right-hand side of (1) are measured in the experiment, except for the effective area, A_{eff}, which is estimated from equation (2).

5.10 P Indicate clearly which equations, and in what order, are invoked to design the experiment, interpret the results, and achieve the objectives.

5.11 P An effective strategy for organizing the Theory section is to first establish all the relevant equations, and then follow up with a discussion of how each equation is used to obtain the objectives of the experiment.

5.12 P All equations and statements taken from the literature must be referenced in the body of the report. For example, to indicate that an equation is taken from the textbook for this course, you could use the following citation format:

Equation (3) is given in (McCabe *et al*., p. 445, 1993).

Note that (1) the reference is identified by enclosing it in parenthesis, (2) since the book referenced has three or more authors the reference only shows the last name of the first author, while co-authors are represented by the italicized Latin abbreviation *et al*. which means "and others", (3) the abbreviation "p." precedes the number of the page where the equation appears in the book, and finally, (4) the year of publication of the reference is indicated before the closing parenthesis, preceded by a comma.

6. P Experimental Plan

6.1 P Use a table to describe the runs you plan to make. The table should include the proposed values for the manipulated variables but must not include any entries for the dependent variables (data you intend to gather). The table should not include blank columns (*i.e*., empty columns), blank rows, or blank cells intended to be filled up with data after the experimental data is gathered because the tables included in this report should describe the experimental plan proposed and hence should not be constructed as future data repositories.

6.2 P Use succinct paragraphs to explain how the runs relate to the objectives of the experiment.

For example, if one of the objectives of the experiment is to determine the effect of pressure drop on the of a heat-transfer coefficient, you may include the following statement:

Table 1 summarizes the runs planned to determine the dependence of the heat-transfer coefficient on the pressure drop. Runs 1 through 4 are carried out at four different pressure

drops spanning the pressure range of interest for this equipment. Run 5, a duplicate of Run 2, is used to investigate the reproducibility of the results.

6.3 P Indicate how you intend to proceed to carry out the experiment.

For example, in a particular experiment you may describe your procedure as follows:

First the flow rate of steam is adjusted as indicated in Table 1; second, the system is allowed to reach steady state; third, the temperature at the inlet and the outlet ports of the heat exchanger are recorded; and finally, the volume of steam condensate is measured.

7. P Experimental Problems

7.1 P Identify problems that you anticipate with the experimental work.

7.2 P Discuss how you plan to overcome the experimental problems.

7.3 P Establish whether the assumptions in the theory are met to a reasonable extent (say within a ±3% error, a typical level of confidence in engineering practice).

8. P Supporting Calculations

8.1 P You must discuss how the calculated values support the experimental plan; simply listing a series of calculation results does not suffice. Be succinct and precise in your discussion. Use a brief introductory paragraph for each calculation, clearly indicating to the reader what is the motive or intention of the calculation.

8.2 P Refer each supporting calculation to an equation or technique described in the Theory section.

8.3 P Output from FORTRAN programs or other software such as MathCAD, Mathematica, MATLAB, or various spreadsheet packages are not acceptable in "raw" form. The Supporting Calculations Section should contain only calculations that support the experimental plan. Additional calculations as well as programming code should be relegated to an Appendix. If necessary, selected output from the software tools (say, relevant columns from an output file) can be transcribed to the Supporting Calculations section, and annotated with appropriate column headers, table titles, *etc.*

9. P References

9.1 P Include references to the texts, manuals, or scientific papers that serve as the source for the equations appearing in the report.

For example, you should list as a reference the textbook for this course using the following citation format:

McCabe, W. L., J. C. Smith, and P. Harriet, *Unit Operations of Chemical Engineering*, Fifth Edition, McGraw-Hill, Inc., NY (1993).

Note that (1) the initials of the first author are listed after his last name while the initials of the other authors appear before the last name, (2) the title of the book is written in italics

(alternatively, book titles can be underlined), and (3) the year of publication of the book is listed at the end enclosed in parenthesis. Other formats are also possible, but this one follows the conventions of the *AIChE Journal* is therefore appropriate for us to adopt it.

9.2 P Each references listed in this section must have been cited in other sections of the report, and vice versa. Exclude all references that are not cited in other sections.

10. P Appendix

10.1 P Label all subsections of the Appendix and give each subsection a descriptive title.

For example, the second subsection of the Appendix could be identified with the title: "*Appendix 2. Equipment Diagram*".

10.2 P Each Appendix subsection must be referred to in the body of the report.

10.3 P Each subsection must be self-contained. An introductory paragraph should be used to inform the reader about the contents of each subsection.

11. P Data notebook ("Blue Book")

11.1 P The blue book must be included as part of the report.

12. P Equipment diagrams

12.1 P All drawings of equipment, experimental set-up, and various diagrams should be preceded with an introductory paragraph.

3. FINAL REPORT

1. F Title page

1.1 F Identify the report type: Preliminary-Design Report or Final Report.

1.2 F Identify all the authors and list them in alphabetical order (by last name).

1.3 F Give a descriptive title to the report. Avoid uninformative titles, such as "*Experiment No. 1*". Use content-rich titles such as "*Determination of heat-transfer coefficients in a recovery boiler*". On the other hand, you are also advised to avoid excessively long titles.

1.4 F Indicate date of submission.

1.5 F Indicate dates of experimental work.

2. F Table of Contents

2.1 F List all major sections with their corresponding page numbers.

3. F Abstract

3.1 F Include all the important results.

3.2 F Do not include results that are irrelevant to the objectives of the experiment or to the purpose of the Abstract.

3.3 F The Abstract should be worded in highly *precise* language and must be *brief*. Avoid vague or ambiguous sentences. Do not exceed one page.

3.4 F Make *quantitative* statements about the results and observations.

For example, the following sentence is strong because it makes a quantitative statement:

The experimental values agree with the theoretical predictions within ±3%.

In contrast, the following phrase is weak because it makes only a qualitative statement:

The experimental values agree with theoretical predictions.

3.5 F Avoid whenever possible referring to specific experimental run numbers in the Abstract.

3.6 F Try to minimize or avoid altogether the use of mathematical symbols in the Abstract. Use symbols instead of the name of variables only when the name must be repeated several times.

3.7 F The Abstract should contain no undefined symbols (preferably, it should include no symbols whatsoever).

3.8 F Do not include equations, tables, or figures in the Abstract.

3.9 F The Abstract should be self-contained. Do not make references to tables, figures, or equations appearing elsewhere in the report.

3.10 F Avoid using bullets in the Abstract unless strictly necessary. Ideally, the Abstract should be written in narrative form rather than in outline form.

4. F Objectives

4.1 F All important objectives of the experiment must be clearly identified.

4.2 F Avoid including statements that do not describe objectives.

4.3 F Use precise and succinct statements. An example of a good statement of an objective is the sentence: "*The first objective is to determine the dependence of the heat-transfer coefficient on the pressure drop across the evaporator*". An example of a vague and imprecise statement that is not acceptable is: "*The objective is to characterize the heat-transfer coefficient of an evaporator*". This sentence is imprecise and vague because the word "characterize" may have multiple interpretations.

4.4 F The Objectives section must be self-contained. Do not make references to figures, tables or equations found elsewhere in the report.

4.5 F Try to minimize or avoid altogether the use of mathematical symbols in the Objectives section. Use symbols instead of the name of variables only when the name must be repeated several times.

4.6 F The Objectives section should contain no undefined symbols (preferably, it should include no symbols whatsoever).

4.7 F Avoid vague and imprecise statements.

For example, "*The objective of this experiment is to determine the performance of a chemical reactor*" is a vague sentence because the word "performance" may have multiple interpretations. An improved statement could be "*The objective of this experiment is to determine the yield and selectivity of a chemical reactor*".

4.8 F If possible, the objectives should not be expressed using figures, a tables, or equations.

5. F Results

5.1 F Introduce each figure with a brief paragraph to help the reader identify its contents. Do not discuss the significance of the figures (this should be done in the Discussion section). The description should clearly state what is plotted in each figure and give any additional information that might be useful to the reader. No figure should be missing an accompanying descriptive paragraph in the body of the report.

For example:

> *Figure 1 shows plots of the heat-transfer coefficient as a function of pressure at two different flow rates. The figure includes experimentally obtained values (solid line) as well theoretically predicted values (dashed line). All theoretical predictions are obtained using the FORTRAN program "HTC" discussed in the Preliminary-Design Report.*

5.2 F Introduce each table with a brief paragraph to help the reader identify the contents of the table. Do not discuss the significance of the table (this should be done in the Discussion section). The description should clearly state what is tabulated in each column, and include any additional information that might be useful to the reader. No table should be missing an accompanying descriptive paragraph in the body of the report.

For example:

Table 1 shows the experimental and predicted values for the heat transfer coefficient for different pressure drops. The first column tabulates the values of the pressure-drops investigated in the experiment. The following two columns show the experimental and predicted values of the heat-transfer coefficient, and finally, the last column shows the percentage error in the prediction.

5.3 F Do not include tables with raw data. Such tables belong in the Appendix.

5.4 F Do not include plots and tables of intermediate results since all intermediate results and calculations should be relegated to the Appendix. Eliminate all table columns that do not contain final results. If the results lead to a lengthy table, then consider reporting the results in a figure and placing the long table in the Appendix.

5.5 F Do not present the results by referring to specific "run numbers". Reference to specific runs may useful in the Preliminary-Design report; however, it is non informative and most often irrelevant to associate specific results with corresponding run numbers in the Results section of a Final Report.

5.6 F Do not report details of experimental conditions unless they are strictly necessary for the complete and unambiguous statement of the results obtained.

5.7 F Do not include program listings in the Results section. All listings should be included in the Appendix.

6. F Sample Calculations

6.1 F The Sample Calculations should contain examples of each calculation done to obtain the graphs and tables shown in the Results section. A comprehensive calculation file is unacceptable here (it should be relegated to the Appendix). Each sample calculation is an illustration of how the author proceeded to obtain relevant values presented in the Results section.

6.2 F Each calculation (or series of calculations) must be linked to a specific data point reported in the Results section.

6.3 F The authors must clearly indicate in a brief introductory paragraph what each sample calculation illustrates.

For example, the following paragraph can be used to identify the relevance of a sample calculation:

The following calculation illustrates the generation of the heat-transfer coefficient value plotted at a pressure of 17 mm Hg on the experimental curve of Figure 1.

Analogous paragraphs are necessary for the introduction of results reported in tables.

6.4 F Each sample calculation must explicitly include the physical units of each variable.

6.5 F When writing the report, it is good practice to first include all the detailed calculations in an Appendix entitled Calculation File, and then transcribe to the Sample Calculations sections selected calculations that can serve as clear examples of the results obtained. Add annotations and explanatory remarks as needed.

6.6 F Do not include program listings in the Sample Calculations section. All listings should be included in the Appendix.

7. F Discussion

7.1 F The Discussion section must indicate whether the experimental results can be explained using the theory available. Plausible explanations should be given for the cases where the experiments and the theory disagree,

7.2 F The Discussion should preferably be organized following the same order of presentation of figures and tables adopted in the Results section.

7.3 F Discuss all the results presented in the Results section.

7.4 F The authors should write the discussion paragraphs in such a way that the reader is clearly and unambiguously informed about which specific table, figure, or other relevant result is being discussed.

7.5 F Make recommendations for further experimental work to resolve issues that may remain open

8. F References

8.1 F Include references to the texts, manuals, or scientific papers that serve as the source for the equations appearing in the report.

For example, you may list as a reference the textbook for this course using the following format:

McCabe, W. L., J. C. Smith, and P. Harriet, *Unit Operations of Chemical Engineering*, Fifth Edition, McGraw-Hill, Inc., NY (1993).

Note that (1) the initials of the first author are listed after his last name while the initials of the other authors appear before the last name, (2) the title of the book is written in italics (alternatively, book titles can be underlined), and (3) the year of publication of the book is listed at the end enclosed in parenthesis. Other formats are also possible, but this one follows the conventions of the *AIChE Journal* is therefore appropriate for us to adopt it.

8.2 F All equations and statements taken from the literature must be referenced in the body of the report. For example, to indicate that an equation is taken from the textbook for this course, you could use the following format:

Equation (3) is given in (McCabe *et al*., p. 445, 1993).

Note that (1) the reference is identified by enclosing it in parenthesis, (2) since the book referenced has three or more authors the reference only shows the last name of the first author, while co-authors are represented by the italicized Latin abbreviation *et al*. which means "and others", (3) the abbreviation "p." precedes the number of the page where the equation appears in

the book, and finally, (4) the year of publication of the reference is indicated before the closing parenthesis, preceded by a comma.

8.3 F Each references listed in this section must have been cited in other sections of the report, and vice versa. Exclude all references that are not cited in other sections.

9. F Appendix

9.1 F Label all subsections of the Appendix and give each subsection a descriptive title.

For example, the second subsection of the Appendix could be identified with the title: "*Appendix 2. Equipment Diagram*".

9.2 F Each subsection of the Appendix must have been referred to in the body of the report.

9.3 F Each subsection must be self-contained. An introductory paragraph should be used to inform the reader of the contents of each subsection.