West Virginia University
Department of Chemical Engineering

Written Reports for the Senior Laboratory and Design Projects

The format for presenting a written design report differs from that of a laboratory report. A laboratory report is more of a scholarly endeavor in which a scientific story is told starting with theory, proceeding through results, discussion, and conclusion. It is usually assumed that the reader will read the entire report. In a design report, the most important conclusions should appear early in the report, with more detail presented later in the report for the reader who reads further. Such is the way of business, where you must effectively convey the bottom line to someone who may not have the time to read the entire report.

GRAMMAR, PUNCTUATION AND SPELLING

It is important to write using correct spelling, grammar, and punctuation. Incorrect spelling, incorrect grammar, incorrect word usage, and incorrect punctuation make a poor impression on the reader. They can deflect attention from quality technical work. There is no reason for incorrectly spelled words in any report. Of course, spell checkers identify incorrectly spelled words, and they also identify words that are often confused with each other. However, a careful proofreading must still be carried out, since a spell checker will not identify an inappropriate word which is correctly spelled (*e.g.* “too” instead of “two.”).

For the correct use of punctuation, grammar, etc., a good reference is the web site http://grammar.ccc.commnet.edu/grammar.

The Design Report should be written as a recommendation, not as if the process is already built (unless it is already built!). Therefore, “A 10 m^3 reactor was installed” should not be used; instead, “It is recommended that a 10 m^3 reactor be used”. For the Laboratory Report, the experiment, of course, has already been performed, and the report should follow the usual convention for past and present tenses: past for action completed (“the reactor was flushed”) and present for opinion or fact (“the distillation column has six real stages”).

In general, the first person (pronouns “I,” “we,” “me”) should be avoided. The passive voice should be used. (“It was performed” instead of “I/we performed it.”) The passive voice may be flagged by the grammar checker in word-processing software unless that option is disabled. Others may instruct not to use the passive voice; however, the passive voice is more formal, and therefore “better,” than the alternative. References to individuals or groups of individuals should also be avoided, as in “The students did this.” or “The team tried to do this.” Addressing the reader (for example, “You should do this.” or “Seek medical attention.”) should also be avoided. Therefore, if information is taken from a manual written as a set of instructions (such as may be found in a material safety data sheet (MSDS sheet), then the wording must be changed to follow these guidelines.

Active verbs should not be used with inanimate objects. For example, "This report optimizes …" is incorrect, because a report, which is inanimate, cannot optimize. Instead, try "This report contains the optimization of …"

The most common punctuation errors are the omission of commas and the misuse of colons and semi-colons.

Commas must be used to break up the elements of a list and to separate introductory phrases and subordinate clauses from the subject of the sentence. For example, there must be a comma in the following sentence before optimization: "On the other hand, optimization yielded …" Similarly, conjunctive adverbs (therefore, however, although) at the beginning of sentences must be followed by commas.

Commas precede coordinating conjunctions (and, but, or) if the clause following the conjunction contains a new subject. For example, a comma is needed before "and" in the following sentence: "The reactor was optimized, and the optimum temperature was found to be 100°C." A comma should not be used in the following sentence because what follows the conjunction refers to the original subject of the sentence: "The reactor was optimized and found to require a temperature of 100°C."

Both semi-colons and colons are used (for literary effect) to separate clauses, where each clause might have been a complete sentence. The distinction between semi-colons and colons for this purpose is faint. Typically, the semi-colon is used between two closely-related clauses without mentioning the relationship explicitly. The colon is used between a clause that can stand by itself and an explanation (or example, or elaboration). Thus, "A three-compressor configuration is not used; it was found to be ten times more expensive." "A three-compressor configuration was found to be more expensive: it requires chilled water and high-pressure steam instead of boiler-feed water and low-pressure steam."

More commonly, semi-colons are used instead of commas to break up the elements of a list in which (at least) one element includes a comma. "Additional pieces of equipment required include a distillation column, with a reboiler and a condenser; a holding tank; and three pumps." Colons are used to separate subtitles from titles (not frequently of use in a report, except on the title page) and to start lists. "Additional pieces of equipment will need to be purchased: a holding tank, a pump, and a membrane separator."

It should be observed that the compound adjective "three-compressor" used above is hyphenated. Another example is "high-pressure steam". However, hyphenation only occurs when the compound construction is used as an adjective (for example, "High-pressure steam was used" but "The steam used was of high pressure").

GROUP REPORTS

Group reports (as required for the design projects) must be edited for consistency. Each group member should read every section and provide feedback to the section authors. Simply assembling individually written sections without editing almost always results in a very poor report. One group member should be designated as the editor. This person should make certain that all figures, tables, equations, etc., are numbered consistently, that font types and sizes are consistent, that formatting details such as the indentation spacing, paragraph spacing, justification, etc., are all consistent.

REPORT FORMAT

The suggested report format is as follows:

Document of Transmittal

This is a memorandum (if internal) or a letter (if external) to the appropriate person introducing the report. The report is actually an enclosure to this letter. The original memorandum (memo) or problem statement should be referenced (subject and date). It is essential that several sentences be written summarizing the bottom line; this gets the reader's attention . This document should always be signed or initialed by all team members. It stands alone; it contains no figures or tables, and does not reference any figures or tables contained within the report.

Title Page

This must include the title, names of all contributors to the report, the business name (class number and name will suffice), and the date. The title itself should be concise but should contain key words that identify the subject and convey the thesis of the message.

Abstract or Executive Summary

An abstract or executive summary should start on a new page. Nothing else should appear on that page.

The abstract or executive summary should convey to the reader, in a rapid and concise manner, what was done, what was concluded, and what the recommendations are. This is for the reader who may not read any further or for the reader who is deciding whether or not to read any further. The bottom line should be summarized. Computational details should not be discussed, unless they are unique and applicable beyond the report at hand.

An executive summary is essentially a long abstract. Whereas an abstract is usually less than 200 words, an executive summary may be several pages. An executive summary is usually reserved for a very long report, while an abstract is appropriate for shorter reports. In an executive summary (but not in an abstract), a few well-chosen graphs, pie charts, or histograms may be used to emphasize important points, but these items should be chosen wisely, in order to keep down the length of the executive summary. Very long reports may have executive summaries approaching ten pages. It is probably best for the executive summary to be less than 10% of the total report length. Some multi-volume reports may contain both an abstract for each volume and an overall executive summary. For most laboratory and design reports, an abstract is appropriate; however, the year-long, senior design project and the third major may be extensive enough to require an executive summary.

At times, an entire report may be an executive summary plus appendices, usually if the report is short. This is essentially a short report without an abstract. In this case, the executive summary should have the same organization as a full report, without separate section headings. It should include key figures and tables, but need not include as much discussion as a full report. In this case, the Results section may be abbreviated, with additional tables and figures well organized in the appendix.

A key difference between an abstract and an executive summary, besides length, is that an abstract stands alone. It contains no figures or tables, only rarely contains an equation, and does not refer to any tables or figures (such as references to a process flow diagram (PFD), including stream numbers and equipment numbers) contained within the report.

These instructions suggest that the contents of the abstract and the document of transmittal mentioned previously are similar. Since both sections are supposed to provide a summary of important conclusions, there will be significant repetition of content. However, the abstract usually contains more information than the document of transmittal.

Again, in all cases, the bottom line, which may be an economic analysis, should be emphasized!

Table of Contents

At the top of the page, the proper title is “Contents,” not “Table of Contents.” All pages of the report should be numbered, preferably at the top right corner or top center (the latter permits easy two-sided copying). All sections, subsections, etc., should be numbered, indented, or otherwise indicated, along with the corresponding starting page number in the Table.

Introduction

This is for the reader who continues past the abstract. The introduction is a one- or two-paragraph summary of what was assigned, what was done, and (very briefly) how it was done. The introduction should state the subject, purpose, and scope of the work. It should provide the reader with background information and should explain the motivation for the work. For the Laboratory Report, the introduction should include conditions and limitations under which the experiment was performed. For the Design Report, a summary of the constraints on the problem is appropriate, as well as some perspective on the specific problem in the context of the larger business picture. In either report, literature references on the subject could be included, if appropriate. (Instructions for proper citation of references are given in the References section below.) There should be no results or conclusions in the Introduction section. In short, the introduction should be an overview of the area of the work, and should set the stage for what follows.

Theory

This section is typically used only in a Laboratory Report. Any theory or equations needed in analyzing or computing data should be included. This section may be combined with the introduction if brief, or may be presented in a separate section if lengthy. Only the fundamental principles upon which the equations are based should be stated, along with convenient references. Lengthy derivations should not be presented, unless unique.

Experimental Methods

This section too is typically not found in a Design Report. For the Laboratory Report, the testing methods, equipment and materials used should be described in sufficient detail so that the experiment can be repeated. All unusual features of the apparatus should be cited, particularly if they limit the test results in any way. The test procedures should be described concisely and should include any operational features that were discovered during the course of the experiment; for instance, time to reach steady state, length of a run, and techniques used in sampling are important. The measurement and precision of other operational variables such as temperature, pressure, and flow should be described here as well. Additionally, the health and safety implications of working with chemicals in the experiment should be discussed in a separate subsection.

Results

The Results section states what was found. It is usually presented without detailed explanations, which are in the Discussion section.

The following are essential components of a Results section for a Design Report:

1. Labeled and dated process flow diagram (PFD) – Chemcad PFDs are unacceptable at this point.
2. Stream flow tables – These must include temperature, pressure, phase, total mass flowrate, total molar flowrate, and component molar flowrates for every numbered stream.
3. Manufacturing cost summary – Yearly revenue and expense (income from product sales, expenses for raw materials, utilities [itemized], equipment costs if calculated as an annual cost, personnel, etc.) must be included.
4. Investment summary – The cost to build and install the plant now (if appropriate to goals of problem) is required. This should be itemized by piece of equipment.
5. Equipment summary – A listing of equipment to be purchased and installed, with specifications is required. This could be combined with item 4 if the list is not too long.

The above should not simply appear without description. This section is held together by prose that provides the reader with a road map through the tables and figures of items 1 through 5 above. The PFD should be mentioned early in the text of this section and cited as often as needed.

For the Senior Laboratory Report too, the basic results are most effectively presented in tabular or graphical form. An estimate of the precision of the results, in terms of a relative uncertainty or confidence limit, should be included. As in the Design Report, the text in this section should contain frequent references to figures, tables, and equations, and an analysis of the data should be included.

For both types of reports, the impact of the report, and the proof of the work, is in the presentation of data to support the findings (and the results of other investigations that lend credence to the effort done). It is critical to present the data clearly, legibly, and in a way to present a clear picture to the reader. What is desired to convey to the reader should help decide how the most important points are clearly presented in the most straightforward way possible.

A choice must be made as to whether figures or tables are used to convey information. Generally, a figure is used when the trends or relative relationships are more important than the actual numbers. A figure and a table both illustrating the same point are redundant -- a choice must be made!

Overly fancy figures and tables are not necessary. Rather, it is important to present the data in such a way so as to highlight the most significant findings in the text. More specifics on figures and tables are provided later.

Discussion

This section is for the reader who wants even more information and is willing to read even further. The Discussion section contains explanations of the results. It explains how the results were obtained and what they mean.

For both the Design Report and the Laboratory Report, trends in the results should be evaluated, along with any conclusions that can be drawn. However, a detailed log of how (or in what order) calculations were done should be avoided.

In a Design Report, the reasons for making choices and the reasons for discarding alternatives are discussed. This is where the optimization is explained. Non-routine or unique computational aspects can also be discussed. For the Design Report, a sub-section pertinent to each class is appropriate.

For the Laboratory Report, the results should be compared with theory or previous work, where applicable. Points of similarity or divergence should be noted, and the sources of these discrepancies should be given, if possible. It is proper to include the curves of other authors on your plots, with appropriate citation.

For both the Design Report and the Laboratory Report, development of conclusions must begin in this section. Here the conclusions can be supported by the logical arguments advanced in the Discussion. The conclusions are summarized by themselves in the following section.

Conclusions

Nothing new is presented in this section. The conclusions should be reiterated from the previous section. (The most important of these conclusions should have already been stated in the abstract, the executive summary, and/or the letter of transmittal.) For the Design Report, usually the conclusions will involve economics and process modifications. For the Laboratory Report, the significance of the experimental results should be noted. In any case, conciseness and clarity are important; lengthy paragraphs should be avoided. Once again, the bottom line must be remembered!

Recommendations

This section includes recommendations for further action and/or further study. If there are few conclusions and recommendations, these two sections can be combined. Recommendations that are "pie in the sky," like finding a better catalyst (unless a specific catalyst can be recommended and supported with experimental evidence), should be avoided. Also, in the Design Reports, recommendations that will clearly be studied in subsequent semesters should be avoided. Finally, recommendations that are analyses not carried out due to time constraints should not be mentioned, for example, to perform additional optimizations (in the Design Report) or to carry out a complete kinetic analysis (in the Laboratory Report).

Nomenclature

Symbols used in equations should be defined here. The units should be included in the definition; SI units are preferred. If only a few symbols are involved, they are more easily defined in the text rather than in a special section.

References

Every reference cited in the text should appear as a full citation in the Reference section. Conversely, no reference should appear in this section that is not specifically cited in the text of the report. Software should not be referenced unless it is used it as a source of data, as might be the case with the Chemcad data base. Figures taken from books or the Web must be cited; failure to do so is considered plagiarism.

There are two places in the report that this section can be presented. If the Reference section is put before the Appendices, as it is in this ordering method, the reference section should contain only references cited in the sections of the report preceding this section. If this method is chosen, any references to data sources appearing thereafter (i.e., in the Appendix) should appear on the page on which that calculation is presented. The other alternative is to place the reference section at the very end of the report (i.e., after the Appendices). In this case, the section would include citations to all items referenced in the entire report.

Regardless of the location of the Reference section, references may be cited (in the text/appendix of the report) and listed (in the Reference section) in two ways. In the first, the reference is cited in the text by a serial number (1, 2, etc., in order of first appearance), and listed in the Reference section by this number. In the text, the serial number may appear as a superscript, or as a number in parentheses (usually reserved for equations), or in square brackets (preferred). In the Reference section, the full citations are listed with the serial number, again in the order in which they first appear in the text. The second way is to cite the reference in the text by the author and year, and to list the full citation in the Reference section alphabetically by the last name of the (first) author. Using this way, if the same author has published more than one reference during the same year, then "a", "b", etc., are inserted after the year in the text and the references; for example, "Newman (1965a) has shown ...". If there are more than two authors, then in the text only the name of the first is listed, followed by et al. For both methods, note that all authors are listed in the complete citation in the References section.

The end of a chapter or the end of the book in any chemical engineering text may be consulted for valid citation formats of one type or the other. Accepted practice is to cite previous work in the References section as follows:

- In journals, mention Author(s), Journal, volume, page (year). For example:

  Nerdly, I. M., J. Insignificant Results, 16, 321 (1972).

- In books, mention Author(s), Title, edition, Publisher, city of publication, year, page. For example:

  Littleknown, I.M., The Impact of Inconsequential Results, 2nd ed., Grove Press, New York, N.Y., 1965, p. 201.

For books or journals with more than one author, succeeding author names are often listed with the initials first. For example:

Nerdly, I. M. and U. R. Too, ...

Other Sections

Sometimes, especially for longer reports, specialized additional sections are included, such as: Safety, Assumptions, Environmental Concerns, Risks, etc. The author should check with the prospective users of the document to determine the appropriate additional sections and what these sections should include.

Appendix

Detailed technical information, which would slow down development of the results and ease of reading in the main body of the report, should be included in this section. An Appendix (if used) contains information that would enable the reader to go into specific details or may include model and equation developments in some depth. Information essential to the report should NEVER be placed in an appendix.

A specific Table of Contents for the appendix is essential so that the reader can easily find a particular calculation. Therefore, pages in the appendix must also be numbered. This numbering may be continuous with the main report, or numbering may start over. Numbering may also start over for each appendix. In the latter case, a letter should be used in the page enumeration indicating the appendix in which the page is contained. (*e.g.*, page B-5 means page 5 of Appendix B) Calculations may be typed or written by hand but should be legible and easy to follow.

If Chemcad software is used in a Design Report, a copy of the consolidated Chemcad report (including the flowsheet) for the final case should be included at the end. This must be a consolidated report, not a collection of separate Chemcad-determined "unit-operation specifications" and stream reports. The consolidated report must include stream connectivity, the overall material balance, thermodynamic information, convergence information, unit operations information, and stream flow information (in both mass and mole units). Stream properties should not be printed in the consolidated report. A Chemcad flowsheet should accompany the consolidated report here, so the stream numbers corresponding to all equipment inputs and outputs can be identified.

OTHER ASPECTS OF THE REPORT

Figures and Tables

There are only figures and tables. Nothing is labeled a graph, sketch, etc. Figures and tables are numbered in the order in which they appear in the report. They are cited by their name, not just by a location (above, below). For example, "…in Figure 2…" or "…in Table 1 above …" is correct; "… in the table below …" is not.

When referring to a figure or table, Figure #, Stream #, or Table # should be considered a proper name and, therefore, capitalized. If a figure or table is not cited, it should not appear in the report.

Figures and tables should be embedded in the text where they are first cited, or appear on the pages immediately following where they are first cited in the text. Figures and tables have a specific format. Tables have a title at the top, and figures have a caption at the bottom. Nothing should appear at the top of a figure. (The fact that most software puts a figure title at the top is not a reason for the report to have a title at the top.) If a title is placed at the top of a figure for an oral presentation, the title should be removed for the version used in the written report.

Both figures and tables should have captions. The caption for a figure should not simply repeat the axes. The following would be unacceptable:

"M vs.N"

The following is better:

" Plot illustrating the dependence of … (*M)* on … (*N)* ..."

A similar rule should be followed for the title of a table.

The use of something other than colors (different shading, different symbols) in figures and tables makes it easier to distinguish between items, since colors are not always copied well. It is also strongly suggested that the default gray background on Excel plots be changed to white. Also, on Excel plots, what looks good in color in PowerPoint looks terrible when copied in black and white. Lines and symbols should be black monochrome.

Figures can be line drawings (diagrams), photographs, scatter plots, bar charts, or pie charts. In complicated line drawings or photographs with many parts, numbers inside circles should identify the components, with arrows leading to the part concerned. The text should refer to these parts by name and by number. For example: "... the catalyst support (Item 16) was constructed ..." (It is necessary to use "Item" to distinguish “16” in the figure from bibliographical reference 16.)

Scatter plots are used when the independent variable (*x*-axis) is quantitative, *e.g.*, temperature. Bar charts are used when a non-quantitative independent variable is being plotted, *e.g.*, cost (*y*-axis) vs. case study number or piece of equipment (*x*-axis). Pie charts are used when the relative amounts of quantities are being compared, and the quantities form a whole, *e.g.*, distribution of capital costs between individual equipment.

In general, “line charts” (where the *x*-axis has tick marks at irregular intervals) should not be used when the independent variable is numerical. Instead, “scatter plots” should be used, as described above. Also, the use of three-dimensional bar charts or scatter plots should be avoided, especially when only two variables are used, *i.e.*, if there is only one independent variable. Three-dimensional figures are very difficult to read. That the software uses 3-d plots as a default option is not a good reason to use them.

When scatter plots or bar charts are used, numbers on the axes should all have the same number of decimal places. The appropriate number of significant figures should be used. The axis ranges should be appropriately round numbers, *e.g.*, from 0 to 20, not from 3.47 to 19.993. If possible, the origin should be within the range, in order to provide the proper perspective of size. The numbers appearing on a figure axis should all contain the same number of decimal places. Increasing magnitude should always be to the right (*x*-axis) and up (*y*-axis). If using gridlines, both horizontal and vertical gridlines should be used. Gridlines help the reader identify the value of data points; however, in most cases, only major grid lines should be used, i.e., no more than three.

When pie charts are used, the total quantity (corresponding to the whole pie) should be in a legend or outside the pie. Each slice should contain the percentage of the pie.

Additional pointers on figures:

- All plotted lines should, taken as a whole, be approximately centered with respect to the diagonals of the graph paper.

- All identifying information, the legend, should be placed in centered or block form at the top of the graph, centered or off to one side of the plot.

- If curves are to be extrapolated for the purposes of analysis, etc., indicate the extrapolation by a dotted line extension of the solid line.

- Avoid drawing free-hand curves. Use a straight edge, French curves, or computer software whenever possible.

- Understand software capability/limitations. The goal is to present a legible, useful graph of information, not a work of art!

For tables, as for plot axes, the appropriate number of significant figures should be used for the numbers. When columns of numbers appear in a table, each number in the column must have the same units. Columns should be lined up by the decimal point (or by where the decimal point would be). If a total is shown, it should be the sum of all numbers above it.

When reporting large numbers in a table (costs in millions of dollars, for example, in a Design Report), no more than three or four significant figures are usually necessary. Just because the spreadsheet reports ten or more significant figures is no reason to present all of them. It is ludicrous to present a preliminary design down to the penny, or an experimental result to ten significant figures when the measured quantities are in four significant figures. Also note that dollar figures are not generally presented in scientific notation. One million dollars should appear as $1 million (or $1,000,000, depending upon what else is in the column) but in any case not as $\$1\times10^6$.

Figures and tables in "landscape" orientation (i.e., with the long dimension of the paper oriented horizontally) should always be bound facing outward in the report, *i.e.*, with the top of the figure or table closer to the binding. ("Portrait" is the other type of orientation. Here the long dimension of the paper is vertical. This page is in "portrait.") .

Illustrations and tables requiring a page size larger than 8 1/2 x 11 inches should be bound to a page by a heavy binding strip.

<u>Equations</u>

Equations may be used in different parts of a report, as needed. The proper format for equations is as follows. Equations are usually centered. All equations are numbered serially, with the equation number, usually right-justified. Only the number appears, either in parenthesis or in brackets. Just as with figures and tables, equations should be cited by number. Similarly, Equation # is a proper name and should be capitalized. It is incorrect to refer to an equation by number before it appears. Correct and incorrect examples are presented below.

Incorrect:

"The relationship for the heat capacity difference is given by Equation 1.

$$C_p - C_v = \frac{\alpha^2 VT}{\kappa_T} \qquad (1)$$

For an ideal gas, this reduces to Equation 2.

$$C_p - C_v = R \qquad (2)”$$

Note that “Equation (1)” and “Equation (2)” appear in the text before the equations themselves.

Correct:

“The relationship for the heat capacity difference is:

$$C_p - C_v = \frac{\alpha^2 VT}{\kappa_T} \qquad (1)$$

For an ideal gas, Equation 1 reduces to:

$$C_p - C_v = R \qquad (2)”$$

Now “Equation (1)” appears only after the equation itself has been presented in the text.

While writing equations, the plus (+) and minus (-) sign should be used as needed. Terms may contain the “/” symbol, where appropriate, and this symbol is used to indicate division. The horizontal division line can be used for “built-up” equations in an equation editor, especially if the use of “/” would lead to confusion. It is considered improper format to use signs (*, ×, or ·) to indicate multiplication in an equation or anywhere else in a report, except as noted below involving exponents (powers of 10). Therefore:

$$PV = nRT$$

is correct. The following are improper:

$$P \times V = n \times R \times T$$

$$P \cdot V = n \cdot R \cdot T$$

$$P * V = n * R * T \ .$$

It is also incorrect to use the symbol ^ for an exponent in equations (or anywhere else in a report). Also, when using exponents, it is not correct to use E format. So, “6.02E23” and “6.02^23” are incorrect, while “6.02×10^{23}” is correct. (Note the ambiguity with “6.0210^{23}”)

It is observed that the equation editor automatically italicizes symbols, but not numbers. Symbols should be italicized in equations and text in the body of a report, even when not using the equation editor.

The terms and symbols used in all equations must be defined, either immediately after the equation or in a comprehensive nomenclature section. A comprehensive nomenclature section may appear immediately after the table of contents or at the end of the report, following the reference list.

General Formatting

In any report, note that monetary values should be written as "$25 million/yr" instead of "25 million dollars per year", "25$ million/yr", or "25 million$/yr."

Also, in all numbers less than one, leading zeroes should be included, *e.g.*, 0.25 instead of .25.

It is expected that numbers, symbols, and unit abbreviations will be used in the written report. It is important to learn how to insert symbols, how to use the equation editor in the word processor, and how to insert symbols, superscripts, and subscripts in the plotting software. It is recommended that equations be inserted using Microsoft Equation 3.0 (or Math Type, if it is available) rather than the equation editor that is the default in Word 2007 and 2010. (A Microsoft Equation 3.0 equation can be accessed from the "insert-object" menu.) For example, when reporting temperature, "X°C", not "X degrees C", is considered correct. Superscripts should be used in the units, for both the text and on figures, so "10 m^3" should appear instead of "10 m^3". Items like "m^3" are considered unacceptable for reports in this department.

HOW ENGINEERING REPORTS ARE USED

In the outside world, an engineering report is essentially never read in its entirety by a single person. Most of the users of these documents are too busy to sit down and read every word. However, it should be assumed that each word will be read by someone, sometime, and that there will not be an opportunity for the author(s) to explain any ambiguous passages. The report must be useful to the following types of readers:

1. The person who has only a few minutes to read the report. This is often an intelligent, non-technical person who controls millions of dollars. It is important that this person be able to find the important answers, *i.e.*, the "bottom line" immediately in the report, so as to make the right decision. If the answer is not prominently presented in the Executive Summary or the Abstract, this type of reader will judge the report to be of little value. This is not a desirable situation.

2. The technical manager. It may be assumed that this person is a chemical engineer, but it should not be assumed that the manager has any specific technical knowledge about the details of the project. This person is busy but may have enough time to read most of the

report (but not the appendices). Therefore, the manager is seeking answers quickly. As soon as these answers are found, a decision is made without reading further. Sections might be read in the following order, for example, until the answers are found: Executive Summary, Recommendations, Conclusions, Results, Discussion, and Introduction. Different readers may read the sections in different orders. Therefore, special care should be taken to put the information in the correct sections. This is part of the reason why repeating important conclusions in several places in the report (document of transmittal, abstract, conclusions) is a good idea.

3. The engineer who must use the design. This technically trained person needs to find details of how the calculations were done and how decisions were reached. The appendices are of special interest to this engineer. However, time is of the essence. The engineer wants to be able to go immediately to that portion of the appendices that deals with a specific detail. Without good organization and a good table of contents for the appendices, this is impossible. If this reader cannot find the right information, much of the effort preparing the report may have been wasted.

4. Others. Many others will try to read the report: physical-plant personnel, operators, chemists, environmental activists. The exact identity of this group is specific to a particular situation. These potential readers should also be considered when writing the report.

What can be done to see if the report meets the needs of these readers? If someone who did not author the report would agree to read it, pretending to be one of these readers, a different perspective from that of the author(s) can be obtained. A friend, a roommate, or a fellow student might qualify. Readers should be asked to look out for the following. If they cannot understand the intended message there is a problem. If they do not find information easily or cannot understand what is being said, it really does not matter whether the information is in the report somewhere or whether the results are of high quality. Also, reports written at the last minute will be obvious, especially to an experienced reader. A report with typographical errors, misspelled words, grammar faults, or confusing phrasing is insulting to the reader. That is not the desired impression when the reader is a client, supervisor, or fellow engineer.

Finally, note that it is difficult for an author to proofread a report just after writing it. A more-critical proofreading is possible by waiting even one day after writing the report. Therefore, it is suggested that preparing the final, written report not be delayed until the last minute.