A GUIDE TO TECHNICAL WRITING

A Generalized Approach to the Writing of Design Reports

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Summary

Communication is the vital act of transferring ideas from one person to another. In the scientific community, written reports are one important mechanism whereby this transfer takes place. Because of the extreme importance placed upon the skill of effective written communication by employers as well as academic institutions, this manual was written as an aid to students faced with the chore of writing technical reports.

Emphasis is placed upon organizing the report into logical sections, each section having a function, using the analogy of an automobile with its component parts. Rules for the clear presentation of data in tables and figures are also included. In addition, graphical techniques are illustrated including the rules for labelling the axes, indicating data points and drawing curves. It is believed that by following the guidelines in this manual, students can write reports which are both concise and bear the marks of professionalism.

This guide itself provides an example of the features of a well-written report.
TABLE OF CONTENTS

1. INTRODUCTION ........................................................... 1

2. FUNDAMENTAL REPORT STRUCTURE ........................................ 8
   2.1. Lead Section .......................................................... 8
       2.1.1. Title Page ...................................................... 8
       2.1.2. Summary or Abstract ............................................. 10
       2.1.3. Table of Contents ............................................... 10
       2.1.4. Introduction .................................................... 12
   2.2. Main Body .......................................................... 12
       2.2.1. Final Design Problem Definition ..................................... 12
       2.2.2. Design Alternatives .............................................. 14
       2.2.3. Final Design .................................................... 15
       2.2.4. Conclusions and Recommendations.................................. 16
   2.3. Termination .......................................................... 16
       2.3.1. References .................................................... 16
       2.3.2. Nomenclature .................................................. 19
       2.3.3. Acknowledgements.............................................. 19
       2.3.4. Appendices .................................................... 19

3. TABULAR, GRAPHICAL, CHART AND PICTORIAL REPRESENTATIONS ....... 23
   3.1. Tables .............................................................. 23
   3.2. Graphs .............................................................. 26
   3.3. Diagrams ............................................................ 27

4. MECHANICS OF REPORT WRITING .......................................... 28
   4.1. Paper .............................................................. 28
   4.2. Margins ............................................................. 28
   4.3. Font ................................................................ 28
   4.4. Pagination ........................................................... 28
   4.5. Numbers ............................................................ 29
   4.6. Equations............................................................ 29
   4.7. Symbols and Abbreviations.............................................. 30
   4.8. Headings ............................................................ 31
       4.8.1. Third-Degree Reading ........................................... 32
   4.9. Spacing ............................................................. 32
   4.10. Spelling and Grammar................................................. 32

REFERENCES ............................................................... 33
APPENDIX 1 ................................................................. 34
BIBLIOGRAPHY ............................................................. 36
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vehicular Model for Report Writing</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Reports Used to Match Writer and Reader</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Analogy of Component Parts of Report and Automobile</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>A Sample Title Page</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>A Sample Abstract</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>Conceptual Design Process</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>A Sample Reference Page in Which the References Are Listed in the Order in Which They Appear in the Text</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>A Sample Nomenclature Page</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>A Sample Acknowledgement Page</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>Rules for Effective Table Composition and Arrangement</td>
<td>24</td>
</tr>
<tr>
<td>11</td>
<td>An Example of a Well-Drawn Table</td>
<td>25</td>
</tr>
<tr>
<td>12</td>
<td>Rules for Proper Preparation and Presentation of Graphs</td>
<td>26</td>
</tr>
<tr>
<td>13</td>
<td>An Example of a Well-Drawn Graph</td>
<td>27</td>
</tr>
<tr>
<td>14</td>
<td>Rules for Proper Presentation of Numerals</td>
<td>29</td>
</tr>
<tr>
<td>15</td>
<td>Rules for the Usage of Equations</td>
<td>30</td>
</tr>
<tr>
<td>16</td>
<td>Rules for the Effective Presentation of Symbols and Abbreviations</td>
<td>31</td>
</tr>
</tbody>
</table>
**LIST OF TABLES**

<table>
<thead>
<tr>
<th></th>
<th>Steps to Effective Vehicle Production</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>...................................................................</td>
<td>5</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

Credit for effective writing is as rewarding to the student as it is to the professional. The progress of each is determined, primarily, by a demonstrated ability to communicate ideas. At the university, grades are a direct measure of how well a student can express his or her thoughts when writing examinations, term papers or reports. The emphasis is on developing skills in organizing and discussing, rather than memorizing, readily available facts or data. After graduation, employees are paid regularly for competent day to day performance but increases and promotions are reserved for those who can sell themselves through a readily appreciated presentation of their ideas. Many worthwhile recommendations and projects have been handicapped by poorly developed reports. Often for a consulting engineer, the report itself is the item to be delivered to the client. The importance of clear and concise writing cannot be overemphasized to engineering students. They must learn to discuss their laboratory results intelligently in preparation for the more rigorous demands on their communicating abilities in the professional world.

When a student or professional engineer is faced with the prospect of writing a formal or technical report, which must meet some rigid requirements of thought, style, format and appearance, there is, usually, a moment of panic. As the first waves of helplessness fade away, the average student will realize that there are four possible approaches that may be taken to produce the required manuscript by the due date. There is a choice of:

i. borrowing a good report on the same topic from an outstanding student of previous years and handing it in after changing the title page to show the new author;

ii. finding any report from previous years to use as a model;

iii. labouring for several nights in an attempt to develop spontaneously an original and, hopefully, an acceptable style of discussing the appropriate data; or
iv. finding a good reference book on report writing in the library and following the
instructions faithfully.

Most university students appreciate the consequences of adopting the first. In spite of
some very clever doctoring techniques that have been developed by enterprising students,
university instructors are able to recognize work from previous years. At the University of
Windsor, plagiarism is taken very seriously and could result in failure of the course. The second
approach only works if the style of the report being emulated is suitable for the present report
and if the report was well-written. The third approach is an honest one but really unfair to the
student because without adequate guidance it is most difficult to produce a completely
acceptable report. The time students spend in rewriting a report not meeting the required
standards, could be spent to better advantage in their learning the rudiments of report writing as
suggested by the fourth possibility.

The potential author at the professional level is more restricted than the student.
Opportunities for submitting old reports seldom arise. The commonly adopted procedure of
modelling every report along some traditionally accepted pattern does not work in all cases.
There is very little personal recognition from a manuscript that is difficult to distinguish from
others. Bad impressions created by poorly written reports are difficult to correct even by
outstanding technical accomplishments. Students and professionals alike should not
underestimate the rewards from a skilful application of the principles discussed in standard
references on report writing.

Although libraries stock a wide variety of publications dealing with effective writing,
inexperienced authors continue to submit reports that have just marginal value. A valid
complaint of novice writers is that most of the available reference material tends to be either too
highly specific or too general. Our intention is to consider report writing as a general problem
facing undergraduates, graduate students and professionals in all disciplines. This general problem may be simplified or complicated by specific situations. The particular requirements can then be treated as deviations from a basic pattern. The major task is to define a fundamental report structure.

This definition is not difficult once we appreciate the basic purpose of reports. Essentially, they are vehicles designed to carry ideas from writers to readers as illustrated in Figure 1. Most writers fail in their duty by providing the wrong design of vehicle for the requirements at hand. An automobile manufacturer who incorporates the interior of a jeep into an air-conditioned limousine for a wealthy Texan will not stay in business any longer than the consulting engineer who writes his reports in the style of a romantic novel. A writer has the responsibility of knowing and meeting the requirements of the reader.

Since the readers usually determine the advancement of the writer at the university and professional levels, it is unwise to misjudge the variations that must be planned for each distinctly different group of readers. The necessity of making modifications to a fundamental pattern is illustrated by Figure 2 in terms of the every day communication requirements between writer and reader in specific situations.
In each example the demands of the reader are distinctly different; nevertheless, there is a common purpose to each report: every manuscript is designed to convey ideas from the writer to the reader. The successful writer is one who can transfer his or her thoughts in a manner that is most logical for his or her specific group of readers. The determination of the most logical manner often proves to be a major obstacle to new writers.

The sequence of steps that must be taken to produce a vehicle for ideas can be compared to the route followed by automotive people considering the production of a new car. In each case the market must be satisfied if the producer is to remain competitive for any rewards. This analogy between report writing and automobile production may be appreciated in terms of the parallel steps discussed in Table 1.

<table>
<thead>
<tr>
<th>Professional engineer or scientist</th>
<th>Technical publication to introduce new developments</th>
<th>Other professional engineers or scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate student</td>
<td>Thesis or dissertation to demonstrate ability to do original work</td>
<td>Examining committee of professors</td>
</tr>
<tr>
<td>Professional consulting engineer</td>
<td>Memo, routine report or special report to convince or inform</td>
<td>Supervisor or management</td>
</tr>
<tr>
<td>Undergraduate student</td>
<td>Capstone design report to show student’s solution to a problem</td>
<td>University instructor</td>
</tr>
</tbody>
</table>

**FIGURE 2: Examples of Reports Used to Convey Ideas from Writer to Reader**
TABLE 1: Analogy Between Components of an Automobile and a Technical Report

<table>
<thead>
<tr>
<th>Automobile (Human Cargo)</th>
<th>Report (Idea Cargo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A thorough appreciation of the <strong>purpose</strong> or objective of the new car (is it a racing car, sports car or a family car?)</td>
<td>A thorough appreciation of the <strong>purpose</strong> or objective of the report (is it to inform, entertain or convince the reader?)</td>
</tr>
<tr>
<td>A thorough appreciation of the interests, limitations and peculiarities of the <strong>drivers</strong> (stick shift for sports car enthusiasts, hand brakes for legless drivers).</td>
<td>A thorough appreciation of the interests, limitations and peculiarities of the <strong>readers</strong> (minimize the amount of highly technical terminology for lay readers, stress repeatedly the benefits of spending money to conservative management).</td>
</tr>
<tr>
<td>A careful collection of all possible <strong>components</strong> that will insure completeness of design.</td>
<td>A careful collection of all available <strong>facts</strong> and data that may be related to the aims of the report.</td>
</tr>
<tr>
<td>A careful study of the collected components to <strong>eliminate</strong> parts that will not contribute to optimum design (eliminate turn signals on racing cars for professional racing).</td>
<td>A careful screening of the collected facts and data to <strong>eliminate</strong> irrelevant information.</td>
</tr>
<tr>
<td>A skilful <strong>arrangement</strong> of the essential components to produce a car that is most effective for its purpose.</td>
<td>A skilful <strong>arrangement</strong> of the facts and data to produce a report that will interest and impress the reader.</td>
</tr>
<tr>
<td><strong>Identification</strong> of important components by labels for the convenience of the operator (handbrake, light switches, stereo controls and windshield wiper).</td>
<td><strong>Identification</strong> of all major parts of the report by titles, headings and subheadings.</td>
</tr>
<tr>
<td>Preparation of an advertising brochure to explain the function of some important components in the model (virtues of the braking system, ease of steering and dual coffee cup holders).</td>
<td>Provision of interpretive material or comments wherever necessary to help the reader (repetition of difficult material, graphical and tabular data to interpret results, definitions of nomenclature).</td>
</tr>
</tbody>
</table>
A more critical analysis of this analogy leads, quite naturally, to a comparison of the functions of the component parts of each vehicle. Figure 3 diagrams the parallel components.

![Diagram of Car and Report Components]

**FIGURE 3: Analogy of Component Parts of Automobile and Report**

The front section of the car serves as a means of identifying the model and provides the power and steering. The **Lead Section** of a report must also be powerful enough to move the report in the proper direction. After reading the abstract, a reader should be convinced that s/he wants to read the entire manuscript. A successful writer generates reader interest by using her/his Lead Section to stress the importance and thoroughness of her/his report. Here, s/he will:

i. provide a brief summary of the findings, recommendations and conclusions;

ii. sketch briefly the order and plan of the report;
iii. define the subject material adequately so that the reader is left with no doubts about the
   topic under consideration;

iv. discuss the limits, scope and scale of the report by showing how the subject has been
   treated in the past and what is being done now; and

v. emphasize the purpose of the report.

The **Main Body** of the report corresponds to the seating section of a family car. This
section is designed to carry the important cargo. The Main Body must convey the writer's ideas
to the reader. This is accomplished by discussing in detail:

i. how the work was done;

ii. what results were obtained;

iii. the significance and interpretation of the results; and

iv. the conclusions and recommendations that follow from the results.

In a family car the trunk section is provided for the storage of cargo that complements the
humans in the seating area. Similarly, the **Terminal Section** in a report carries ideas that are not
immediately essential to the theme. Cargo of secondary importance in a report could include:

i. a list of references that might be consulted by readers who have a deeper interest in the
   topic of the report;

ii. detailed developments of the concepts discussed in the Main Body;

iii. repetitious material that is not of vital importance to the report; and

iv. recognition of the contributors to the report
2. FUNDAMENTAL REPORT STRUCTURE

Standard divisions are employed in technical reports just as standard components are used in vehicles. The order of these standard divisions in a fundamental report structure is a common and logical one that divides the report naturally into three main divisions: lead section, main body and termination, as illustrated in Figure 3.

2.1. Lead Section

Identification, power and direction are essential qualities of a well written lead section. It must inform, interest and motivate the reader to continue into and through the whole report.

2.1.1. Title Page

This can be considered as a grille-bumper design in the vehicle - report analogy. As the front end of a car serves to identify the make, model, etc., the title page serves a similar purpose. All automobile manufacturers take painstaking care in their front end designs to insure a well balanced and distinctive arrangement. An author would do well to exercise this same concern in the design of her/his title page. Incorporate into the title page:

i. a short title of the report (car name);

ii. an extended and explanatory title if necessary (car model);

iii. A statement of the reason for submitting the report which may include: the name of the person to whom the report is submitted, the contract, job or grant number, and the course name and number for which this report has been written;

iv. the author’s typed name and affiliation (license);

v. the author’s signature (and Professional Engineer’s seal, if appropriate);

vi. the city where the report was written (car manufacturer); and

vii. the date.

Figure 4 illustrates the details of a typical title page.
REDUCTION OF AIR EMISSIONS
FROM THE CORE MAKING PROCESS AT
FORD WINDSOR CASTING PLANT

Use of Life-Cycle Analysis to Select the
Alternative with the Lowest Environmental Impact

A Formal Report
Submitted to the Department of Civil and Environmental Engineering in
Partial Fulfillment of the Requirements for the Course
93-409 Capstone Design Project

by Wernher von Braun
Faculty of Engineering
University of Windsor

Windsor, Ontario
October, 1950

FIGURE 4: A Sample Title Page
2.1.2. Summary or Abstract

The summary, executive summary or abstract is a vital part of the report, usually read by more people than the report itself. This may be considered analogous to the engine of a vehicle, in that it is a concise power package providing the stimulus to get the report moving. The abstract should be a brief résumé presenting the purpose and scope of the report, the approach pursued, the results obtained and conclusions reached. Recommendations may also be included. The abstract should be able to stand alone from the report and provide a general understanding of the report contents to the reader (Co-op, undated). A common fault of most abstracts is that they are skeleton outlines, simply defining the subject matter in terms so general that they convey no information. Another common error is to simply compress and re-word the introduction (Banninga, 2000). The purpose of the abstract is to present the contents of the report in condensed form. Carefully study your data, pick out the salient facts, conclusions and recommendations, if any, to incorporate into your abstract (Gould, 1963). The contents of a well-written abstract dictate that it must be written last, when the remainder of the report has been completed.

An example of a well-written abstract is given in Figure 5. After reading this summary a researcher should know if the material in this report is of value to his or her study.

2.1.3. Table of Contents

This is a reader service providing identification of the major components of the report much like the service provided by vehicle manuals. A table of contents consists of a listing of the major sections and sub-sections of the report, each followed by the number of the page on which it begins. In a fundamental report structure, a list of figures and list of tables follows the table of contents. The list of figures contains the number, title and page number of every photograph, graph and schematic present in the report. Similarly, the list of tables
ABSTRACT

Oily wastewater at the Ford Windsor Engine plant is collected in equalization tanks where floatable and settleable oils are removed. Periodically, water from the equalization tanks is drained into a process tank and circulated through an ultrafiltration unit to bring the oil and grease content of the water from 0.5 to 25%. The water that penetrates the membranes of the ultrafiltration unit, the permeate, has had approximately 99.4% of the oil removed and is discharged to the city sewer. The remaining water is recirculated to the process tank, and periodically pumped into oil tanks for collection by a recycling contractor. Since its inception one and one-half years ago, the permeate flux has decreased 25%, in spite of periodic cleaning procedures. The odour of the hauled waste, accumulation of iron and bacteria on the membrane surface, and decreased permeate flux are indications of bacterial growth on the membranes, termed biofouling. The objective of this report was to investigate methods of preventing biofouling.

The following alternatives were considered: equalization tank aeration, process tank aeration, replacing the oil skimmer, adding caustic to the equalization tanks, installing a Zeta Rod™, installing an ion exchange unit to treat the cleaning water, and reducing the flow rate using fewer tubes. These alternatives were evaluated using a criterion function based on their anticipated level of improvement of the problem, the overall environmental effect, installation and operating costs, maintenance requirements, and ease of implementation. On this basis, it is recommended that a process tank aerator and an improved oil skimmer be installed.

The process tank aerator consists of a 970 L/min (34 scfm) or greater blower, in-tank diffuser and ancillary equipment. The total cost of this equipment and its installation is estimated at $12,300 and the operating cost is estimated at $4,500 per year. The new oil belt skimmer specified for the aeration tank needs to remove approximately 1.27 L/min of oil as opposed to the present 0.55 L/min. The oil skimmer is expected to cost $6700 to purchase and install, and $890 per year to operate.

With these improvements, it is expected that biofouling of the ultrafiltration membranes will be eliminated, and the oil content of the waste removed will increase to 45% resulting in savings of $10,000 per year to Ford.
contains the number, title and page of every table in the report. An example of these can be seen on pages iii to v of this report.

2.1.4. Introduction

A well-written introduction relates the report to the reader's needs. Sufficient background is given so that the reader will understand why the project was undertaken and the extent of the project. A preliminary problem description should be included and related to a brief description of the basic procedure followed in the project. The introduction should also provide a brief guide describing how the report is organised. In our vehicle - report analogy this section might be considered as the steering mechanism of the report whereby the writer directs his/her report to the reader's needs.

2.2. Main Body

The main body of the report is a clear, concise and logical development of the author’s solution to the design problem. Figure 6 shows a generic design process flow sheet. This includes how the final design problem definition was developed, a description of design alternatives considered, an explanation of the method used to select one alternative and further description and refinement of the final design. Conclusions and recommendations derived from the design process complete this section. The main body carries the cargo; it develops, details and discusses the ideas to be conveyed to the reader.

2.2.1 Final Design Problem Definition

The preliminary and typically open-ended problem description as presented in the introduction must be explicitly bounded and formalised into a final design problem definition. The author must describe the rational used to move from the preliminary definition to the final definition. Some elements that influence the formation of the final problem definition are:
FIGURE 6: Conceptual Design Process (adapted from Cooper & Alley, 1994)
i. a description of previous work, possibly including a literature survey,

ii. preliminary data,

iii. laboratory analysis,

iv. and preliminary assumptions.

The level of detail included in this subsection should be kept to the minimum necessary to support the final design problem definition. Details that are important but will detract from the clarity of the explanation should be included in an appendix. The final design problem definition must conclude with the specific objectives and scope of the project.

2.2.2 Design Alternatives

This section must provide sufficient detail to convince the reader that all of the important alternatives were considered and that the appropriate alternative was selected. Subsections that must be included are:

i. A description and justification of the method used to develop design alternatives. Such as:
   < brainstorming
   < consultation with others,
   < perusing literature.

ii. Descriptions of the important design alternatives with sufficient detail to convince the reader that the alternatives were investigated with the depth required to insure validity in the selection process. Descriptions may include:
   < drawings,
   < flow sheets,
   < advantages and disadvantages,
   < areas of uncertainty requiring further investigation,
   < preliminary material and energy balances,
< preliminary cost evaluations,

< preliminary implementation timelines.

ii. The description, justification and results of the selection process. At a minimum, a table summarising the alternatives and their characteristics should be included.

2.2.3 Final Design

This section must describe the detailed final design being proposed. In order to do this, the author must describe how the alternative selected in the previous section was developed into the final design. The results of important experiments, data collection activities, theoretical derivations, and calculations should be included. Detailed explanations of these activities that are not necessary for the reader’s understanding of the design development process should be referred to and included in an appendix. Explanation and description of the choices made in developing the final design, the assumptions made and areas of uncertainty must be discussed.

To clearly convey the details of the final design, figures and tables showing the following specific information that should be included as appropriate.

< drawings of proposed design:

• sketches of design showing important dimensions or parameters,

• qualitative and quantitative flow sheets,

• sketches showing installation layout.

< tables listing equipment and specifications,

< tables providing material and energy balances,

< design economics such as:

• capital and operating costs,

• profits,

• pay back time,
• return on investment,
• implementation time line.

2.2.4. Conclusions and Recommendations

Usually this will be a brief and concise summary of the conclusions reached in the study. Consistency between the conclusions and the original problem is essential. A separate heading is often used for recommendations when future action is indicated by the results and conclusions obtained.

2.3. Termination

In the termination of a report we reach the "rear-end" of the car where the excess but necessary baggage is located. Place the reference list, the nomenclature and the appendices here. They are all required for a successful completion of a well-written report but not absolutely necessary in the main body for clarity and comprehension.

2.3.1. References

In technical reports, the common practice is to list only the cited references at the end of the work under "References" or "Literature Cited." On the other hand, a bibliography is simply a listing of information sources relevant to the subject, which may or may not have been used in writing the report. The preferred approach is to cite a reference for every factual piece of information. The text citations and references are usually arranged in one of three ways:

i. numerical text citations with numbered references listed in order of appearance; or
ii. numerical text citations with numbered references listed alphabetically; or
iii. the authors name and year of publication in the text citation, with unnumbered references listed alphabetically.

Numerical text citations (often referred to as footnote numbers) should be superscript Arabic numerals either consistently with or without parentheses (e.g. ...increased the
concentration of manganese in groundwater\textsuperscript{3}, or, ...is effective at reducing trihalomethanes in drinking water\textsuperscript{(5)-(9),(12)}. Alphabetic text citations should include the authors name and year of publication in parenthesis (Jones, 1998). If the author’s name is mentioned, only the year needs to be in parenthesis (e.g. Jones (1998) derived ...). If there are two authors, both should be mentioned (e.g. Banting and Best, 1921). If there are more than two, use \textit{et al.} (e.g. Dewey \textit{et al.}, 2000). If two or more references by the same author from the same year are cited, an a, b etc. should follow the year of publication both in the citation and reference (e.g. Cork, 1985b).

Care must be taken in compiling the reference list to insure completeness and accuracy in transcription. Entries should include author (normally surname first), year of publication, title and other sufficient information to allow the reader to retrieve the reference. Figure 7 illustrates the use of method i. mentioned above. The reference section of this report uses method iii. These examples illustrate the subtle differences in the handling of books, journals, and government reports \textit{etc.}

Personal communications are extensively relied upon in engineering reports. The name of the person, date of communication, and the position and affiliation of the person must be listed in the reference. The citation should include the name of the person and the date (Cretien, June 14, 2000).

Refer to original sources whenever possible. Verbatim copying of other’s writing must be distinguished by quotation marks or placing the passage in a separate, single spaced paragraph indented on both sides.
REFERENCES


FIGURE 7: Sample Reference Page in Which the References Are Listed in the Order in Which They Appear in the Text. References 1 and 2 are for books. Reference 3 is a chapter in a book. The page numbers of the chapter are listed after the abbreviation “pp.” Reference 4 is for a journal article which appears in volume 20, number 8. References 5 and 6 are for a newspaper article and a conference proceedings, respectively. References 7 and 8 are for reports. References 9, 10 and 11 are for a thesis, patent and website, respectively. Reference 12 is for a personal communication.
2.3.2. Nomenclature

The nomenclature of a technical report identifies the symbols and letters used to represent magnitudes and physical quantities in equations and mathematical formulas. Leading journals in any discipline are excellent sources of accepted forms of nomenclature. All of the letters used in the report should be listed in alphabetical order, followed by Greek letters and symbols. The units associated with these quantities should be identified. A detailed example is given in Figure 8.

2.3.3. Acknowledgements

The complexity of technical problems normally demands cooperation among colleagues. Common courtesy and professional ethics require proper acknowledgment of assistance rendered by authors. This includes the source of financial support, where applicable. The acknowledgments can be placed immediately after the conclusions. In a thesis, it is placed immediately after the abstract.

The mechanical details of arranging a sample 'Acknowledgement' page are illustrated in Figure 9. Though not mandatory, a suggested order of appreciation is used.

2.3.4. Appendices

Appendices are used to prevent the body of the report from becoming too cumbersome and also to present useful material that may not be immediately relevant in the text. Here are found tables too detailed for text presentation, calibration data, lengthy derivations and lengthy sample calculations. If these materials are numerous, then categorize them into separate numbered or lettered appendices (viz. I, II, etc. or A, B, etc.).

When the mathematical details are so bulky that the reader could become lost in a maze of equations, place the complete derivation and/or calculation in a separate appendix. A concise summary presented logically and clearly will provide sufficient theoretical background
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cross-sectional area of channel</td>
<td>m&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>a</td>
<td>Constant defined for Eq. (9.12)</td>
<td>s&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>F</td>
<td>Force of fluid on adjacent solid</td>
<td>kg·m/s&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>f&lt;sub&gt;n&lt;/sub&gt;</td>
<td>Lowest node frequency at any position</td>
<td>cycles/t</td>
</tr>
<tr>
<td>g&lt;sub&gt;c&lt;/sub&gt;</td>
<td>Gravitational conversion factor</td>
<td>kg·m&lt;sup&gt;2&lt;/sup&gt;/(s&lt;sup&gt;2&lt;/sup&gt;·N)</td>
</tr>
<tr>
<td>P</td>
<td>Momentum</td>
<td>kg·m/s</td>
</tr>
<tr>
<td>p</td>
<td>Fluid pressure</td>
<td>kPa</td>
</tr>
<tr>
<td>P&lt;sub&gt;C&lt;/sub&gt;</td>
<td>Perimeter of channel</td>
<td>m</td>
</tr>
<tr>
<td>P&lt;sub&gt;d&lt;/sub&gt;</td>
<td>Steam-dome pressure</td>
<td>kPa</td>
</tr>
<tr>
<td>z</td>
<td>Rectangular coordinate in the axial direction</td>
<td>m</td>
</tr>
</tbody>
</table>

**Greek Symbols**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>λ</td>
<td>Latent heat of vaporization</td>
<td>kJ/kg</td>
</tr>
<tr>
<td>μ</td>
<td>Viscosity</td>
<td>g/m·s</td>
</tr>
<tr>
<td>ρ</td>
<td>Fluid density</td>
<td>kg·m&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**Superscripts**

- * Denotes dimensionless variable
- ′ Denotes deviation of quantity from steady state

**Subscripts**

- g Denotes gas or Stoma phase
- l Denotes liquid or water phase
- w Denotes test section wall

FIGURE 8: A Sample Nomenclature Page
ACKNOWLEDGEMENTS

The author expresses his sincere appreciation to Dr. A.W. Gnyp for his guidance and patience throughout this experimental investigation. In addition thanks is extended to Mr. S. Viswanathan for assistance in debugging the complex computer program developed to analyze the data. The reactor vessel would have remained a blueprint without the meticulous machining techniques employed by Mr. George Ryan. Special credit is given to Mrs. E. Sheehan, who expertly transformed unrecognizable scrawl into a readable Manuscript. The financial assistance of the National Research Council is also appreciated.
for the reader in the main body of the report.

The description of experimental equipment and procedures should be detailed enough to permit any competent reader to successfully repeat the work. The reader’s technical abilities will determine how extensive the description should be. Do not discuss recognized procedures if a reference can be given. Emphasize new or different operations as quantitatively as possible, but eliminate insignificant details. Subdivide lengthy descriptions into related parts using suitable labels.

The written description of experimental equipment can be complemented with diagrams. Judgement will dictate when a diagram will make a written explanation more concise and clear. A discussion of tabular, graphical, chart and pictorial representations appears in Chapter 3. The experimental results reported in the main body should refer to this section for the reader wishing more details about the experiment.

Source code listings of programs developed by the author should be included as an appendix if necessary. Extensive data listings may be saved on a CD-ROM and included with each copy of a thesis.
3. TABULAR, GRAPHICAL, CHART AND PICTORIAL REPRESENTATIONS

Tables and figures are two major aids available to the technical writer. Written discussions can be clarified by integrating tables and figures into the text. Tables present discontinuous, yet numerically accurate information with no limit to the number of variables. The challenge in using tables is to emphasize the most relevant trends. Figures include drawings, sketches, photographs, maps, graphs, plans and diagrams. An effort must be made to make figures accurate and not misleading (Woods, 1967). Tables and figures are most effective when they are useful, clear, self-explanatory, accurate, easily understood and remembered. They should have enough explanation in their captions to stand alone, in case they are copied and used in presentations or out of the context of the report. Avoid showing tables and figures conveying the same information.

A table or figure should be placed in a consistent manner throughout the report, either:

i. inserted in the text immediately following the paragraph in which it is first mentioned in the body (textbook style);

ii. on a separate page which immediately follows the page where it is first mentioned (thesis); or

iii. at the end of the report in a separate section (journal paper submission).

If method i. is used and the table or figure will not fit in the portion of the page remaining, it may be moved to the top of the next page. A table or figure placed sideways on the page (landscape mode) should be readable from the right hand side. Always include a minimum of one sentence summarizing what the figure or table shows or illustrates in the text (Co-op, undated).

3.1. Tables

Typically, tables are used to summarize “listed” data where:

1) non-numeric data or a mixture of non-numeric and numeric data is summarized;
2) numeric data is recorded with full numeric accuracy; or

3) A large set of related data with many variables is presented, but subsets of this data will be used for comparison by some other means.

Tables must be accurately compiled and arranged for easy readability and interpretation. The principal comparison should be between columns, rather than rows (Woods, 1967). Figure 10 outlines a few of the common rules regarding table composition and arrangement. These rules are illustrated by example in Figure 11.

Number and title every table as illustrated in Figure 11. Tables are numbered consecutively in their order of appearance throughout the text (viz. 1, 2, 3, etc.) or by individual chapters (viz. 3.1., 3.2, 3.3, etc. where the first numeral indicates the chapter).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Never place a table on two pages if it can be arranged on one. Long tables may be continued from page to page. The second page should start with a continuation (e.g. Table 2- Continued) and a header row.</td>
</tr>
<tr>
<td>2)</td>
<td>Tables must conform to the same marginal requirements as the text. If the table is too wide to be accommodated within the required margins, even when placed broadside (landscape mode), then reduction by photographic process is a possible solution.</td>
</tr>
<tr>
<td>3)</td>
<td>Box headings have the first letter of the first word and all proper nouns and proper adjectives capitalized.</td>
</tr>
<tr>
<td>4)</td>
<td>Compare items in the same column in ascending or descending order of rank.</td>
</tr>
<tr>
<td>5)</td>
<td>Align all columns of figures by the decimal points.</td>
</tr>
<tr>
<td>6)</td>
<td>Abbreviations and symbols may be used in box headings and the main body of the tables but not in captions.</td>
</tr>
<tr>
<td>7)</td>
<td>Footnotes to tables are placed immediately below the tables. These should include abbreviations used in the table but not in the text.</td>
</tr>
<tr>
<td>8)</td>
<td>Tables of more than two columns may be ruled. Minimize the number of lines used.</td>
</tr>
<tr>
<td>9)</td>
<td>When presenting very large or very small numbers use the appropriate power of 10. Either multiply the number in the table by the power of 10 (viz. $5.3 \times 10^5$) or the units in the box heading by the power of 10 (viz. pressure $\times 10^4$ psia).</td>
</tr>
</tbody>
</table>

FIGURE 10: Rules for Effective Table Composition and Arrangement
### TABLE 14: Properties of Molten Metals

<table>
<thead>
<tr>
<th>Metal</th>
<th>Melting Pt. (°F)</th>
<th>Thermal Conductivity, k (K-Btu/hr-ft-°F)</th>
<th>Heat Capacity, ( C_p ) (Btu/lb-m-°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>300°F</td>
<td>700°F</td>
</tr>
<tr>
<td>Mercury</td>
<td>-38</td>
<td>6.7</td>
<td>8.1</td>
</tr>
<tr>
<td>Potassium</td>
<td>147</td>
<td>26.0</td>
<td>22.8</td>
</tr>
<tr>
<td>Sodium</td>
<td>208</td>
<td>49.8(^b)</td>
<td>41.8</td>
</tr>
<tr>
<td>Bismuth</td>
<td>320</td>
<td>-</td>
<td>9.5</td>
</tr>
<tr>
<td>Lead</td>
<td>621</td>
<td>-</td>
<td>10.5</td>
</tr>
</tbody>
</table>

**Footnote citations are lower case letters, superscripted and follow the item explained or amplified.**

**Align columns of figures by the decimal point.**

**Use the appropriate power of ten for very large or small numbers.**

**Report only significant digits.**

**Capitalize the first word, proper nouns and proper adjectives in table captions.**

**Number and title every table.**

**Tables conform to the same marginal requirements as the text.**

**Place table footnotes here.**

Pt. = point (this abbreviation could have easily been avoided)

a Jones (1952)
b Measurement at 200°F.

FIGURE 11: An Example of a Well-Drawn Table
3.2. Graphs

Since most readers are visually orientated, a graph will often be easier to analyse and remember than written text. Line graphs or x-y graphs are used to show a relationship between two or three variables. Bar graphs can be used to illustrate the effect of a non-numeric variable upon a numeric variable. Pie charts can show the relative importance of a set of values upon the whole. All graphs should be clear, self-explanatory and accurate. A few common rules to be followed when students prepare graphs are given in Figure 12. A sample graph outlining acceptable style in composition for formal reports and theses is detailed in Figure 13.

1) Show coordinate axes and label them carefully. The dependent variable is plotted on the ordinate (bottom to top) with the independent variable along the abscissa (left to right).
2) Label each graph with a title and number.
3) The most common symbols for data points are “$, $%$$, $>$$.
4) The origin should appear on all graphs (except logarithmic).
5) Data appearing on graphs may be tabulated in an Appendix to the report to provide a record of exact values.
6) Choose the ordinate and the abscissa scales so that points can be read with precision approximately equal to the experimental error.
7) Choose the units for the ordinate and abscissa to be multiples of 1, 2, 5, or 10 rather than odd multiples, viz. 2.8, 5.6, etc.
8) Do not clutter any graph with too many curves. Identify each curve with a label. Use a key for several curves on a single graph.
9) Graph paper with a course grid is better than one with a fine grid because the ordinates and curves are more predominant when there are fewer grid lines.
10) The most prominent feature of the graph should be the data and/or trend line. Next in importance are the axes. Least important are gridlines. Therefore the line thickness should decrease in the following order: trend line, axes (including ticks), legend box, gridlines.

FIGURE 12: Rules for Proper Preparation and Presentation of Graphs
FIGURE 2: Pollutant Formation in Combustion

FIGURE 13: An Example of a Well-Drawn Graph. Two methods for scaling the axes are shown on the left and right ordinates, but only one should be used in the report.

3.3. Diagrams

The importance of schematic diagrams, dimensioned drawings, plans and exploded views in engineering report writing cannot go unmentioned. Schematic diagrams illustrate flow, but the entities in them are not to scale. Dimensioned drawings, plans and exploded views can illustrate the orientation of entities to each other. A dimensioned drawing of the apparatus constructed for a research project is usually included. Large plans should be placed in a pocket at the back of the report, but show the author's name and the date to insure proper identification if separated from the report.
4. MECHANICS OF REPORT WRITING

Careful attention to the mechanical details of a report will insure a polished appearance and professional touch. The neat well-ordered report indicates care and organized thinking. Both of these qualities help the reader to form a favourable impression of the report and the author.

4.1. Paper

Print-out manuscripts with black ink on good quality paper of at least sixteen-pound weight cut to the standard 215 x 280 mm (8.5" x 11") dimensions. Pages with unsightly marks and corrections should not be incorporated into a finished report.

4.2. Margins

Adequate borders should be provided on every page of the manuscript to allow for binding and trimming. Allow at least 38 mm (1.5") for the left-hand margin, 25 mm (1") for the top, right-hand and bottom margins. Note that the margin requirements apply to the text and not the page numbers.

4.3. Font

Use a common and easily readable font such as Arial, Courier, Helvetica or Times Roman. Use the same font throughout the report.

4.4. Pagination

All pages of the report from the title page to the Introduction are numbered consecutively with lower case Roman numerals (i, ii, etc.) centred at the bottom of the page. Although the number i is assigned to the title page, it does not appear there.

Consecutive Arabic numerals are used throughout the remainder of the report to indicate page numbers. Each major component (e.g. Introduction, Literature Survey, Experimental
Details, etc.) which forms a complete chapter in the basic report structure should begin on a new page with the Arabic numeral typed in the bottom centre.

All other pages may be numbered at the top right-hand corner or at the bottom centre. Diagrams, illustrations and tables occupying a full page can be numbered near the bottom of the page at the centre (at the same position as the first page of a chapter). The List of References, Nomenclature, and Appendices are numbered successively in their proper order of appearance with Arabic numerals.

4.5. Numbers

Numbers are used more frequently in technical reports than in most other report forms. Several rules pertaining to the use of numerals are given in Figure 14.

1) Do not start sentences with numerals; use words (e.g. Ten feet of pipe rather than 10 feet of pipe).
2) Use numerals for integers up to ten.
3) If the number to be used is not a common fraction (3/4, 1/2), it is preferable to use the decimal form, viz. 0.73.
4) Precede the decimal point in a numeral less than one by a zero, viz. 0.383.
5) If two numbers follow consecutively in a phrase, viz. 3 2 ft diameter tanks, errors due to misreading can result. Uncertainty can be eliminated by writing one of the two numbers in full, viz. three 2 ft diameter tanks. Generally the least important number is written out but if neither number deserves emphasis, use the shortest written form. Be consistent in parallel construction: three 2 ft diameter tanks, four 2 in. valves.
6) Use numerals for all data.
7) Report only those significant figures consistent with the accuracy of the readings.
8) Use numerals for percentages (10%), dates (1965), sums of money ($3000.00) and numbers combined with abbreviations (15 psia.).

FIGURE 14: Rules for Proper Presentation of Numerals

4.6. Equations

The presentation of equations in technical reports is often a source of great difficulty. Preparing a preliminary Nomenclature as the report progresses can eliminate double-use of
FIGURE 15: Rules for the Usage of Equations

1) Number each equation at the right-hand margin. Equations occupying more than one line are numbered at the right-hand margin on the last line.

2) Begin all equations on separate lines, centring them on the page if possible. Equations requiring two lines or more begin on a paragraph indentation [five (5) spaces] with each successive line indented five (5) additional spaces. For better appearance and clarity do not crowd the text around equations.

3) If the equation extends beyond one line, break it before a +, - or = sign and place that sign at the beginning of the next line.

4) Do not end a paragraph or a section with an equation.

5) In a series of equations separated by phrases or single words of text, each equation is still placed on separate lines. Include normal punctuations when equations are parts of sentences. Do not use the equal sign as the main verb in sentence.

6) Exponential expressions are preferably written as \( \exp(-ab/c) \), rather than \( e^{-ab/c} \).

7) Leave one space after trigonometric and hyperbolic functions, before and after +, -, and = signs when used as operators (\( \sin x, 2 + 2, 2x = y + z, etc. \)).

8) Do not leave a space between a symbol and its superscript or subscript (\( \sin^2, y_0 \)).

9) In built up fractions, attempt to contain the equation on one typewritten line (\( y = 2x/3z \)).

10) A recommended order of closures for parenthesis, brackets and braces, which are used when necessary to avoid ambiguities, is the following:

\[
\left\langle \left[ \{(....)\}\} \right]\right.
\]

4.7. Symbols and Abbreviations

Symbols and abbreviations are used in technical reports for clarity and conservation of space. When using abbreviations and symbols, insure that all symbols and unusual abbreviations are carefully defined in the text or nomenclature section of the report. If there are too few abbreviations to warrant a nomenclature section, abbreviations should be defined after they are first encountered in the text. Since the use of symbols and abbreviations is specialized in the various scientific fields, consistency can be maintained by referring to leading journals. Rules fundamental to the usage of symbols and abbreviations follow, in Figure 16.

30
FIGURE 16: Rules for the Effective Presentation of Symbols and Abbreviations

1) Use the symbol for percent (%) only when it is preceded by a number (e.g. 81.3%).
2) Do not abbreviate short words.
3) Except when using a nomenclature section, define all abbreviations on first use (e.g. We used green sulfur bacteria (GSB) in this ...). Avoid using abbreviations in the abstract.
4) Omit periods except when confusion would result due to their absence.
5) Do not space between letters of an abbreviations such as NASA, AECL, etc. (not N A S A, etc.).
6) Do not use an apostrophe in making an abbreviation plural (e.g. PAHs, not PAH’s)

4.8. Headings

A well-organized report reflects the logical thinking of the author. Proper headings can break the report into logical sub-sections which are easy to find by using the index. All headings should be distinguished from the rest of the text by placing the heading on a separate line and by the use of bold fonts. Be consistent with the font sizes used for each degree of heading and the spacing between the headings and the following text. A number system has been used in this report which enables the reader to understand how the section s/he is about to read fits in with the whole.

Technical reports are normally written in chapter form unless they are of such short duration that this possibility is precluded. Each new chapter title is in upper-case, bold, centred at the top of a new page, and preceded by the chapter number. The chapters of this manual illustrate these details.

When second-degree headings are used, each heading is displayed in caps and lower-case letters, and indented five (5) spaces, or about 10 mm. Subsequent paragraphs are indented five (5) spaces.
4.8.1. Third-Degree Reading

Third-degree headings are displayed in caps and lower-case letters, and indented ten (10) spaces while all subsequent paragraphs are indented ten (10) spaces.

4.9. Spacing

Reports should be typed double (line) spaced, except for figure and table captions, higher order headings in the table of contents, literal quotes and references. A double space at the end of each sentence after the period improves readability.

4.10. Spelling and Grammar

A report with numerous spelling and grammar errors may be rejected outright by the marker. A word processing program is available in the University Bookstore that checks spelling and grammar as-you-go and has an on-line thesaurus, yet costs less than the price of a textbook. Do not depend on the software to identify all errors. Have the report read by a colleague prior to submission.
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Prospect Heights, IL: Waveland Press, Inc.

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Woods, D.R. (1967) Putting technical illustrations to work. *Chemical Engineering*, Nov. 6, 241-
246.
APPENDIX 1

Principles of Effective Writing (Academic Writing Centre, University of Windsor)
Principles of Effective Writing

1. Write to express, not to impress.
   - In my opinion it is a not unjustifiable assumption that we should implement a change in procedures (pompous and inflated).
   - I think we should change procedures (clear & concise).

2. Develop your vocabulary; choose words with precision. Don’t choose a word simply because it’s long and you found it in a thesaurus.
   - “Coup” or “revolt” may be a better choice than “war.”
   - The word “use” is easily understood; writers waste time searching vainly for longer replacements such as “utilize” and “employ.”

3. Avoid unneeded words.
   - Place the car in a parked position (too wordy).
   - Park the car (concise).

4. Use active verbs.
   - It was determined by the president that the bill should be vetoed (passive).
   - The president decided to veto the bill (active).

5. Use concrete specific language.
   - The professor reorganized her class to make it interactive (vague).
   - The professor introduced multi-media lectures, small group discussions, and e-mail conferencing to make her class interactive (concrete).

6. Vary sentence length and structure to improve “flow.”
   - The Harris government may have gone too far. They have stripped away our education system. The health care system has been gutted as well. They are trying to reduce the deficit. Canadians are wondering if it will be worth it in the long run (choppy).
   - In an attempt to reduce the deficit, the Harris government has introduced massive cuts to the health and education systems. Canadians now wonder if Harris has gone too far (smooth).

7. Write with your audience/reader in mind.
   Don’t waste your time providing your political science professor with a Webster’s Dictionary definition of “government.” On the other hand, if you describe a leader as a “leftist guerilla,” be sure to provide a concrete explanation of the term’s meaning and why it’s significant. Show your professor that you’ve done your research and thought carefully about the terms used in your paper.
BIBLIOGRAPHY

