13

Reports

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As manager of a team busily finishing a funded research project on a tight deadline, you know that the final report requires careful planning to be completed on time. You've discussed the report requirements with other team members, and you've called a meeting to establish a schedule for completion. Group members have met to consider the scope of the report, and they know exactly what sections they are responsible for.

Because you have distributed a style guide for text and graphics, sections written by multiple authors will be assembled without significant revisions at the last minute.

In science and engineering literature, the term *report* describes a document that presents results. A report may assess project feasibility, provide observations and commentary on an inspection trip, specify a design solution, or evaluate environmental impact—for just a few examples.

A report may appear within another document, perhaps a memo or a letter, but larger formal reports are prepared in book format, with title page, table of contents, lists of illustrations, sections or chapters, and appendixes. The formal, final report contains some of the familiar elements of proposals and progress reports, but the emphasis is always different. A proposal says, "This is what will happen"; a progress report says, "This is what has been happening and what is expected to happen next." A final report says, "This is what happened."

Reports on the Writing Continuum

Just as a progress report is never the last word on a subject, a final report is rarely the first word. The goals and achievements of a technical project have probably been written up in laboratory notebooks, meeting minutes, proposals, or progress reports.

In the continuum of written work that proposes and records scientific and engineering activity, some elements are unchanged from document to document. A review of related research, for example, might be essentially the same in the proposal and the final report. Some elements reflect only a change in emphasis: A final report may account for the time management of a project, but it is unlikely to focus on this area as much as a proposal must. In a final report, some elements are eliminated: A final report rarely contains curricula vitae of investigators, for example, but a proposal usually does.

Availability of Reports

In most cases, a proposal has very limited circulation, while the availability of progress reports that track the status of the funded work is somewhat larger but still limited. Completion reports, in contrast, may be widely disseminated, though never so widely as journal articles. Technical reports originating in private industry are usually proprietary documents, circulated internally and not available to outsiders. But reports that result from federal grants will be indexed in the National Technical Information Service (NTIS) database; the NTIS electronic catalog contains 400,000 titles (<http://www.ntis.gov/>). Additional online and printed reference services that provide access to reports include Engineering Index, Chemical Abstracts, and the National Aeronautics and Space Administration's STAR index of scientific and technical aerospace reports (<http://www.sti.nasa.gov/Pubs/star/Star.html>). In current practice, reports are made accessible to other interested researchers though electronic searches of titles, abstracts, keywords, and even full-document searches. Therefore, the limited circulation accorded a proposal document contrasts significantly with the potentially vast audience for a *nonclassified* final report, which becomes part of the permanent record of what is known on a subject.

Audiences for Reports

Readers of formal reports nearly always represent a complex, varied audience with different purposes, different amounts of time to spend on the document, and different information needs. A cost accountant reading a report that recommends the substitution of geothermal steam for conventional electricity is more interested in the cost sections than in the technical sections that specify details about deep-drilling equipment. An environmental impact analyst may consult only the executive summary, the environmental impact section, and selected appendixes that amplify information about affected wildlife. Very few readers will read every section of a long report. In general, early sections of reports are less technical than later sections, and appendixes are usually directed at specialists.

Reports need to be constructed so that varied audiences, with varied purposes for reading, can chart their own reading paths. Folk wisdom says that 80 percent of readers will read only 20 percent of any document. You cannot therefore shortchange any part of the document. Instead, you need to make each section strong and self-sufficient.

Report-Writing Conventions

Report writing takes a good deal more intellectual activity than following a formula or a recipe. In writing some reports, you will be given a prepared outline—an intellectual template—and required to write standard sections. For other reports, you will need to devise a structure that suits your purpose, the needs of your audience, and your subject. Figure 13.1 lists conventional elements for research reports on scientific and engineering subjects.

Technical reports usually have the same three-part structure we've seen in proposals and progress reports: front matter, body, and appendixes. Within these three broad divisions, reports vary widely in choice of elements and degree of emphasis on any one element. While a student laboratory report may emphasize the way an experiment was performed, a professional research report will focus on analysis and implications for future work. A management report is more likely to emphasize conclusions and recommendations for action than methodology. An environmental impact report will follow a set of guidelines strictly prescribed by the U.S. Environmental Protection Agency, focusing on alternatives to the proposed action as well as environmental consequences.

Front Matter

Letter of Transmittal The letter of transmittal accompanies the report, identifies the item being sent, and provides a context. The letter also provides a brief overview of report contents, typically emphasizing findings of general interest (Figure 13.2).

Cover The cover should indicate names of authors, date on which the report was submitted, organization or institution in which the report was prepared, report number or other indication of the occasion for the report, and proprietary notices if they are appropriate. Many organizations have preprinted forms for use as cover pages, with identifying address and logo.

A report title should name the subject in as straightforward a way as possible. The title should serve as the report in miniature for the widest possible audience. Construct titles with informative words. In some on-

Technical Report Format

Front Matter

- Letter of Transmittal
- Cover
- Abstract or Executive Summary
- List of Figures and Tables
- List of Abbreviations and Symbols

Body of Report

- Introduction
- Theory
- Experimental Section
- Results
- Discussion
- Conclusion
- Recommendations

Appendixes

- References
- Supporting Details

Figure 13.1
Conventional elements in formal research reports.

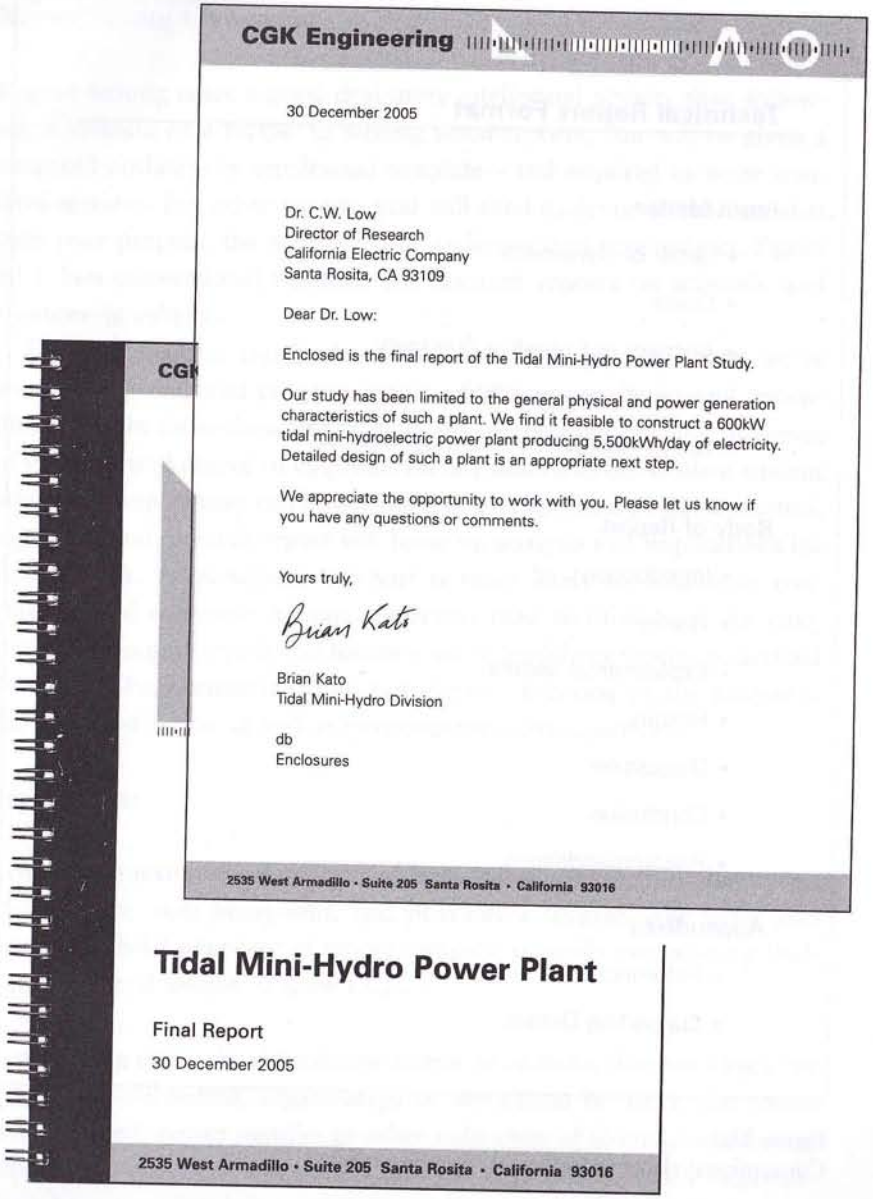


Figure 13.2
This letter of transmittal provides a context for the reported work and a summary of contents.

line databases, a keyword list is electronically generated from your title, so you need to build a title from words that represent the most important concepts in your document.

Titles can often be improved if you eliminate inessential detail. The title "Survey and Evaluation of Electrical Power Sources as to Their Potential Application with the Controlled Airdrop Cargo" is overloaded with words that have little information value. A simpler version cuts the number of words and focuses on content: "Potential Electrical Power Sources for Controlled Airdrop Cargo."

Abstract Most scientific and technical reports contain an abstract, a concise account of the problem addressed and the results. The format of abstracts sets them off from the rest of the document: They are typically written as a single paragraph and printed single-spaced, indented on both sides.

Abstracts are classified in two types: informative and descriptive. Informative abstracts are typically about 150 words long, and they present methods, results, conclusions, and recommendations of the report in miniature. An informative abstract frequently stands for the entire report; it may contain all the information that nonspecialist readers want to know about your research (Figure 13.3). Descriptive abstracts are often no more than a sentence, and they may not go much beyond the information already presented in a title. Unless you have been given explicit instructions to the contrary, you should prepare an informative rather than a descriptive abstract for any report.

Abstracts are most profitably drafted after the report has been written. Think of an abstract as a smaller document that describes, but does not evaluate, a larger document. Unlike an executive summary, an abstract does not need to simplify technical concepts or sell a subject. The audience for the abstract is likely to have the same level of technical understanding as the audience for the full report. The tone of an abstract is objective, not persuasive.

Executive Summary Management reports begin with executive summaries rather than abstracts. The executive summary is pitched at readers who may lack the technical expertise to follow particulars of the work but are interested in the implications of the report. In the

Winward, Alma H. 2000. **Monitoring the vegetation resources in riparian areas.** Gen Tech. Rep. RMRSGTR-47. Ogden, UT: U.S. Department of Agriculture, Forest Services, Rocky Mountain Research Station. 49p.

This document provides information on three sampling methods used to inventory and monitor the vegetation resources in riparian areas. The vegetation cross-section methods evaluates the health of vegetation across the valley floor; the greenline method provides a measurement of the streamside vegetation. The woody species regeneration method measures the density and age class structure of any shrub or tree species that may be present in the sampling area. Together these three sampling procedures can provide an evaluation of the health of all the vegetation in a given riparian area.

Keywords: riparian sampling, vegetation cross-section, greenline, woody regeneration

Figure 13.3
An informative abstract presents a condensed version of the report. It is self-contained, with no references to illustrations or appendixes.

foreground is concern with what the results mean and what actions should now be taken.

Executive summaries, often five to ten pages in length, contain the ideas of the report in semitechnical terms, and they replicate the format of the report in miniature, with headings and illustrations. Sometimes they are detached from the body of the report and bound separately for distribution to a much wider audience than the report will have (Figure 13.4).

The tone of an executive summary is typically persuasive, sometimes even enthusiastic, with emphasis on the importance of the problems addressed. Executive summaries stress benefits, conclusions, and recommendations rather than the way the work was done. An executive summary should be self-contained and complete, so that readers are not directed to pages of the report but have all the information they need to understand the main findings.

Table of Contents The table of contents is an important section of any report, even a short one. Include primary and secondary headings, thereby giving readers a quick overview of report contents. A table of

Value Engineering with Existing Infrastructure

An Example Using Wind Energy on the Antioch Bridge

EXECUTIVE SUMMARY

Final Report
December 22, 2006

Mel Manalis, Ph.D.
Jim Davidson
Environmental Studies Program
University of California, Santa Barbara
Caltrans Contract 53Q386

Introduction

The two mile-long Antioch Bridge spans the San Joaquin River as it flows westward towards the Carquinez Straits in a wind-swept environment. The bridge structure amplifies the wind speed as the air flows around the bridge. We were intrigued with the idea of exploiting this amplification of wind speed to produce electricity from wind turbines mounted on the bridge. Would bridge-mounted wind turbines be able to produce electricity from this flowing air at an unusually low cost and yet be compatible with bridge structural and environmental requirements?

This study identifies the technical, economic, and environmental issues germane to answering the above question. We directed considerable effort toward determining the spatial and temporal variations of the wind speed surrounding Antioch Bridge. We began anemometer studies on June, 1988 to search for and document areas suitable for electricity production from wind turbines affixed to the bridge. Subsequently, about 18,000 hours of wind energy data from several anemometers located on and near the bridge have been recorded and analyzed.

1

Discussion

1. Wind turbines are to be located at areas of maximum wind energy underneath the bridge, away from auto, maritime, and foot traffic.

2. The amount of wind-generated electricity that can be produced annually from all the amplification zones under the entire bridge is 26 times the electricity consumed by the toll plaza headquarters.

3. Eighty percent of the electricity is generated from the bridge-wind turbines in the summer, when the utility's demand for electricity is the strongest.

4. Revenues, costs, and investment incentives associated with wind-generated electricity at the bridge indicate potential for considerable cost savings.

5. Environmental impacts of bridge-attached wind turbines involve avian activity but give no cause for concern. No threatened and endangered species occur on the island.

2

Recommendations

1. Interact with Caltran's Office of Structure and Design to explore the bridge-turbine interfacing issues delineated above.

2. Develop new contracting possibilities with representatives of PG&E regarding offsetting electricity at the toll plaza headquarters with electricity generated from wind turbines located under the bridge. Perhaps these discussions could address future electricity demand for lighting the bridge.

3. Examine the compatibility of bridge-supported wind turbines with the Sherman Island Wildlife Management Plan.

3

Figure 13.4
The authors of this executive summary include an overview of their project, a brief discussion of findings, and three recommendations. They prepared the executive summary as a separate bound volume, and they included relevant maps (not shown here). (Courtesy of M. S. Manalis and J. Davidson.)

contents can also help you construct and reconstruct cogent documents. The headings provide a structural view of the document. They may reveal organizational defects that would not be easily obvious in line-by-line reading.

List of Figures and Tables If you have two or more figures or tables, provide a list with full captions. Technical readers often determine whether a report will be of interest to them by scanning the list of figures and tables (sometimes called list of illustrations). Like tables of contents, these lists are also helpful to you as you revise your writing. A review of the captions in your list of illustrations may reveal defects in logic or organization. Sometimes, you can find better ways to present your findings by relocating illustrations or writing more informative captions.

Lists of Abbreviations and Symbols Though a list of abbreviations and symbols (also called a glossary) may not be required, you should consider whether your readers could use such help. In many fields, these lists of terms are essential; even active researchers can hardly keep up with the growing number of abbreviations and acronyms. When you provide a glossary or list of abbreviations, however, you still define each term the first time you use it in your report.

Report Body

Introduction The introduction to a formal report has three functions: (1) to define the problem addressed, frequently with a review of previous work in the area; (2) to state explicitly the objectives of the present work; and (3) to summarize the main conclusions and applications of the work. Introductions may be one paragraph or several pages long. Though problem definition is the key to a successful report, all three functions of the introduction are important. Experienced report readers scan introductory sections for sentences with openings like "In this report, we examine ..." They know they will find in such sentences a concise statement of topic, objectives, and findings.

Theory Authors of research reports may develop and present their own models, or they may rely on other published work, providing citations to

the papers that developed the original models. The solutions for most problems do not require you to develop basic principles but to apply old ones. A theory section is not always needed. However, if the theoretical structure on which your report is based is innovative or particularly involved, the theory should be presented. When you rely on models developed in other published work, cite the papers that developed the original models and establish why you are citing them. Take care to review the literature accurately and carefully. Simply listing reference numbers at the end of a sentence can raise doubts about your use of sources. Be sure to explain what you are applying from each source.

Experimental Section If an experimental section is relevant to your report, use it to describe the laboratory equivalent of your problem: the tools and processes that enabled you to meet your stated objectives. Here you convert your concept of the problem into the language of the laboratory, so that readers may test your methodology against your results in their own laboratories. Clarity and accuracy are priorities. You are describing a variety of objects, materials, processes, and instruments that, used in a specific way, must deliver a characteristic set of data.

In all technical description, an overview helps readers grasp the purpose and scope of your experimental work. Complex procedures are more effectively described when they are arranged in discrete subsections. Consider providing a drawing for any complex apparatus you intend to describe in detail. And for complicated preparation processes or experimental procedures, consider placing the detail in an appendix.

Results The results section translates your findings into the terms of closely observed phenomena, the data of instruments, and the language of numerical generalization and statistical analysis. All the discussions of your report either lead up to or away from this often brief section. Results sections often retain their value long after the methods and conclusions have become obsolete.

Data may be presented in many ways. If the results are simple, note them in a prose passage. Present series of data in tables or graphs. Avoid simply noting that the data are shown in a given table or figure. Rather, draw out an important point or two about the trends shown in each table or graph and emphasize these points again in titles or legends. If

your methods of reducing data or estimating their accuracy are based on other published sources, provide the reference.

Discussion The purpose of the discussion is to evaluate results. Results do not speak for themselves; you must interpret them. Interpretation should return the reader to the original objectives stated in the introduction, as well as to the initial theoretical discussion.

Begin by amplifying the most important findings and noting any significant discrepancies. Most authors also discuss the reliability of their main findings. If you can identify errors in your own work, you lend credibility to your discussion by noting them. Even when there is no clear explanation for inconsistencies or errors, you should note their existence. To develop a discussion more fully, you may compare your results with those of other sources.

Conclusion The conclusion section restates main findings, summarizes results in light of the original problem, and draws generalizations supported by those results. The conclusion may contain suggested applications for research results, or it may connect results to other scientific issues. Sometimes the conclusion is combined with the recommendations section.

Recommendations In reports written for management, recommendations sections occupy a prominent place, while in technical reports, recommendations are usually a final, brief section, sometimes combined with the conclusion. You may or may not wish to make recommendations about directions that future research on your topic should take. If the main objective of your report has been to recommend a specific course of action, you will naturally devote an entire section to outlining a concrete and operational set of moves.

Appendixes

The appendix (plural: appendixes) contains information that is so excessively specialized, so lengthy, or so unwieldy that placing it in the body of the text would interfere with reading. Appendixes frequently contain reference sections, maps, glossaries, computer printouts, photographs,

extended descriptions of methods, and lengthy comparative data. Appendixes are both self-contained and closely connected to the body of the report.

If the appended information is of more than one kind, create two or more appendixes, each identified by letter and title, for example:

Appendix A. Glossary of Terms
Appendix B. Site Maps
Appendix C. Project Cash Flow
Appendix D. Equipment Specifications

Number the pages within each appendix with the appropriate prefatory letter (page B-3, for example, will be the third site map of Appendix B). Number figures, tables, and equations with the letter designation of the appendix in which they appear (see Figure 13.5).

A good set of appendixes is not a dumping ground for leftover figures and calculations but the location for particularly complex and specialized data that will be crucial for some readers—probably the most important readers. Make explicit connections between appendixes and report body. For example, when you discuss a proposed wind energy farm, tell readers that site maps are located in Appendix A and equipment specifications in Appendix B. List the title of each appendix in the table of contents and consider preparing a second table of contents to material in the appendixes, located just before Appendix A.

Methods in Academic Laboratory Reports

Reports prepared in professional research and development settings usually focus on results, but in academic laboratory settings, researchers and students need to write about how they got the results. A laboratory report usually provides more space for an account of how you did it than of what it means, though a good laboratory report will always draw conclusions and suggest interpretations.

Typical elements in academic laboratory reports are displayed in Figure 13.6 and can serve as guidelines for format. Like any other technical document of more than a page or two, a laboratory report will be improved by the addition of a cover page, a table of contents, a list of illustrations, and one or more appendixes to present important but

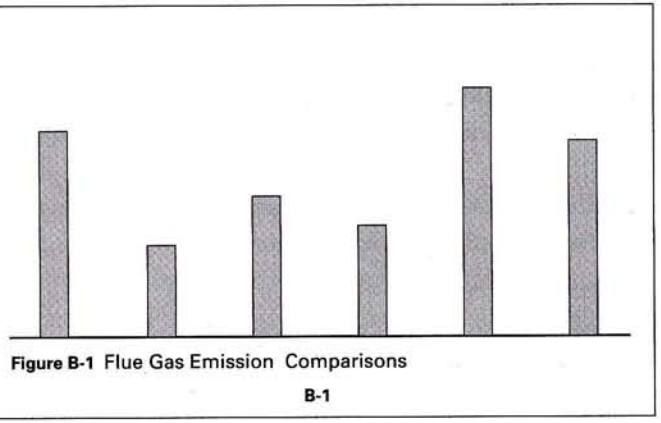


Figure B-1 Flue Gas Emission Comparisons

B-1

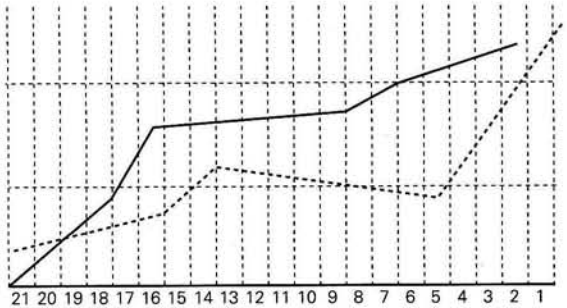


Figure B-2 Thermal Histories of Particles

B-2

Appendix C: Equipment List

- Steel fence posts
- Hammer or post pounder
- Clip board and forms
- Tally counter
- Camera and film
- Plant identification book
- Two 3-foot rods
- One 6-foot pole for use in sampling woody species regeneration
- Flagging
- Global positioning system unit (if available)

C-1

Figure 13.5
Appendixes generally contain information of interest to specialist readers. They are paginated in a different style from the body of the report and referred to within the report.

Laboratory Report Format

Front Matter

- Title Page
- Abstract
- Table of Contents
- List of Figures and Tables
- List of Abbreviations and Symbols

Body of Report

- Introduction
- Theoretical Background
- Equipment List
- Experimental Procedure
- Discussion

Appendixes

- References
- Supporting Details

Figure 13.6
Conventional components of laboratory reports.

unusually detailed or specialized data like computer code or extended calculations.

Decision-Making Processes in Recommendation Reports

Recommendation reports evaluate a process or a product and recommend (or perhaps advise against) a specific course of action. Typically, they begin with an explicit statement of what they recommend. They then specify the criteria that have served as the bases for judgment, and they compare alternatives against criteria. Finally, they list the action required to implement the recommendation (Figure 13.7). Recommendation reports are the stock-in-trade of consulting engineers, who use their special expertise to make informed recommendations to others.

Because recommendation reports serve as the bases for decisions, they must provide explicit information about the criteria that have informed the author's thinking (see Table 13.1). What are they? Why do they matter? In a report recommending the location for a new manufacturing plant, for example, criteria for comparing potential locations might include proximity to railroad tracks, state and local tax rates, and available skilled labor pool. A comparison of competing alternatives against the same criteria results in a tradeoff analysis. Candidate Plant Location A may be conveniently located with respect to railroad tracks and an outstanding pool of available skilled labor. The tax rate for A, however, may be so prohibitive that Candidate Plant Location B, with its low tax rate, is preferable despite its great distance from railroad tracks and a marginal pool of skilled labor.

For many problems, one course of action will not be clearly superior to another. In such cases, do not attempt to oversimplify; a frank discussion of your concerns will be more welcome than an attempt to conceal discrepancies. In some research settings, authors of recommendation reports are required to include a subjective rating of their confidence in the chosen alternative.

Emphasis on Alternatives in Environmental Impact Reports

A formal environmental impact report (EIR) is written in strict compliance with specifications authorized by the U.S. National Environmental

Recommendation Report Format

Front Matter

- Letter of Transmittal
- Cover
- Executive Summary
- Table of Contents
- List of Figures and Tables
- List of Abbreviations and Symbols

Body of Recommendation Report

- Recommendation
- Introduction
- Decision Criteria
- Analysis of Alternatives
- Conclusion
- Action Required

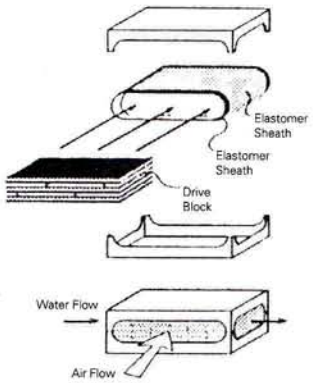
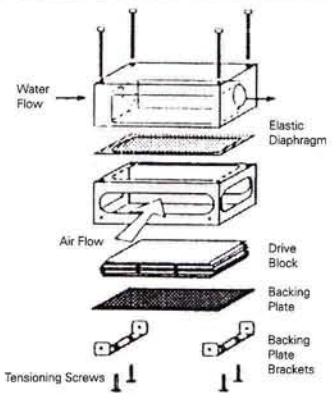
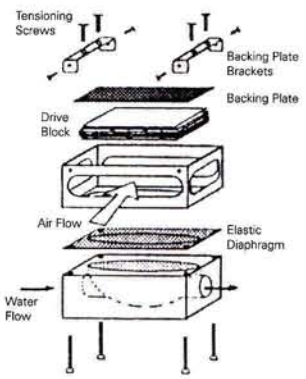
Appendixes

- References
- Supporting Details

Figure 13.7
Conventional components of recommendation reports.

Table 13.1

The authors of this recommendation report considered three design options for a converse-piezoelectric pump and rated each on six specified criteria. The summary table they have prepared is helpful to their sponsor because it includes line drawings as well as a rating scheme of plus and minus for each option. (Courtesy Frank Sager and Craig Speier.)

Criteria	Design 1		Design 2		Design 3	
						
Ease of fabrication	–	Difficult to fabricate the sealing surfaces around the plastic retainer.	+	Easy to make sealing surface with O-ring groove.	+	Easy to make sealing surface with O-ring groove.
Fabrication cost	–	The cost in machining time would be high for this design due to the accuracy required to insure a good seal for the retainer.	+	Less precision required for fabrication of sealing surfaces and less machining time.	+	Less precision required for fabrication of sealing surfaces and less machining time.
Experimental parameter control	–	Diaphragm tension not adjustable.	+	Adjustable bottom plate allows variation in diaphragm tension.	+	Adjustable bottom plate allows variation in diaphragm tension.
Hydrodynamic considerations	+	Good flow characteristics over and under the elastomer sheath.	–	Water flow cavity not hydrodynamically optimized.	+	Water flow cavity hydrodynamically optimized.
Failure mode considerations	–	Any leak in this system will result in water contamination of the drive block and the possibility of electrical short circuit.	–	Any leak in this system will result in water contamination of the drive block and the possibility of electrical short circuit.	+	Since the drive block is located above the fluid cavity, there is less chance of flooding and shorting.
Gravity considerations	–	Hydrostatic force on system at all times is working against imposed force.	–	Hydrostatic force on system at all times is working against imposed force.	+	No hydrostatic force on diaphragm.

Policy Act (NEPA). The distinctive focus in an EIR is on what is lost and what is gained with any decision. A discussion of trade-offs and compromises is, then, at the heart of an EIR (see Figure 13.8). Authors not only need to consider environmental impacts of proposed actions but also to discuss reasonable alternatives to avoid or minimize adverse impacts. A database of final EIRs as well as of draft statements provides helpful models of these important and complex reports (⟨http://tis.eh.doe.gov/nepa/docs/docs/htm⟩).

Managing Complex Report Writing and Production

Planning for Coauthorship and Deadlines

Managing the group writing process for a final report is much like the process of proposal management. Report writing will present the same task allocation and time management problems. The importance of a well-thought-out, section-by-section document plan should be obvious to any research group that has got this far.

There will be a deadline, a time by which the report must be finished and delivered. Schedules, calendars, shared understandings, and frequent group meetings are just as important here as in the completion of any other complex task. The contributions of group members need to be coordinated.

Groups should meet regularly through the research work and should consider the writing required as well as the progress of the technical work at every meeting. When the time comes to write the final report, no group member should have a clean slate, needing to start from scratch to construct sections of the document. Although no report will write itself from assorted laboratory notes and other records kept by project investigators, a report can be more efficiently and effectively written if investigators do not separate the writing tasks from the other investigative tasks of the project.

Distributing Writing and Format Guides

Many active research and development settings have an official style guide available for everyone to use (Figure 13.9). By consulting the style guide, engineers, scientists, writers, editors, technical illustrators, and others involved in document production do not need to create and learn

Environmental Impact Report Format

Front Matter

- Letter of Transmittal
- Cover Sheet
- Summary
- Table of Contents
- List of Figures and Tables

Body of Environmental Impact Report

- Purpose of Action
- Alternatives Including Proposed Action
- Affected Environment
- Environmental Consequences

Appendixes

- List of Preparers
- List of Agencies Receiving Reports
- Supporting Details
- Index

Figure 13.8
Conventional components of environmental impact reports.

Nuclear Division
Document Preparation Guide
Contract W-7405-3ng-26

Chapter 6
Page 6-65

SUBJECT: Preferred Usage

hectare	ha
henry	H
hertz (singular and plural)	Hz
hexagonal close-packed	hcp
high voltage	hv
horsepower	hp
horsepower hour	hp•h
hour	h
hundredweight	cwt
hyperfine structure	hfs

Figure 13.9
Writers in the nuclear division of one government installation refer to the *Document Preparation Guide* distributed by the publications manager. The guide covers a wide range of issues, including abbreviations and punctuation.

a new set of rules for each project. If your report follows from a group of earlier documents, you will want to plan carefully, so that the style guide for the final report has the same features as earlier documents on the subject. Standard publications practices may take time to develop initially, but the long-term payoff is saved time and improved consistency of style and appearance.

The most essential task in document design is to make sections and pages predictable. Even a simple document template will produce the same kind of information, in the same place, in the same type style on every page. (See Chapter 7 for guidelines on page and document design.)

Editing for Clarity and Accessibility

Some sections of reports have a life of their own. As you are writing, remember that titles, keywords, and abstracts may be indexed in technical databases and become part of the literature of science and engineering, independent of the report document. Executive summaries will not be indexed, but they often have a much wider distribution than the document itself. Sometimes they are printed and distributed separately, the only section that influential readers will read. Needless to say, all report sections need attention and care. But sections that will stand alone should be the focus of particularly thoughtful preparation and vigorous editing: They must pass the tests of clarity and self-sufficiency.

Many report writers deliberately invest the largest amount of editing time on the most widely read report features: titles, tables of contents, abstracts, executive summaries, headings, and captions to illustrations. Consider nonverbal as well as verbal features when you edit. Consistent use of white space to create separations between major ideas will increase the readability of your report. You may want to add tabbed dividers to increase the ease with which readers can find exactly the information they need, or you may use color to highlight key points in complex illustrations.

Bringing All Drafts and Boilerplate Up-to-Date

By the time you write a final report, you probably have both text and illustrations that you can update and reuse. If you have labeled and maintained data files carefully, you may save yourself needless duplication of effort. But allow time to review previously written material (often called *boilerplate*) with great care: A mechanical cut-and-paste effort will not be enough to assure currency and consistency. Figures and tables will always need to be renumbered from document to document, and text references to figures and tables will need to be updated accordingly. Heading styles may need alteration for consistency. Verb tenses usually need attentive editing from proposal to final report.

Using Headings to Map Report Structure

Because headings stand out from the text, they send powerful signals about the relative importance of the material that follows. Their size, placement, and typographical features are therefore important. Establish a style for headings and always take the time to edit a report for consistency in heading style.

Even generic section and subsection headings like Background, Process Description, and Conclusion will help nonspecialist readers recognize parts of a report. But reports aimed primarily at nonspecialist readers can be more effective if headings and subheadings are informative. For example, "System Efficiency and Maintenance" is more specific than "Technical Criteria." When the exact wording of headings is presented in the table of contents, readers have an easily accessed, helpfully detailed overview of the report.

Making Graphics Accessible

Tables and figures—collectively called illustrations in scientific and engineering writing—take up a large percentage of the pages in most reports. In fact, many reports contain more pages of tables and figures than of text. Every illustration is a piece of technical literature in its own right, one that may be more widely studied than the text of the report and that may actually circulate separately and be reused in another report.

Every illustration should have a caption, set above a table or below a figure. Captions should be informative—many report readers skim the text but read illustrations and accompanying information with extreme care. Caption style should be consistent throughout a report: either full sentences or sentence fragments.

Every table and figure should be numbered. For long reports, illustrations are usually numbered according to the section of the text in which they occur (Figure 4.2, for example, is the second figure in the fourth section). In shorter reports, figures and tables are usually numbered straight through. All tables and figures that are derived from sources must mention their source at the bottom of the illustration, set close enough so that the illustration never gets reproduced without the reference (see Figure 9.2).

All tables and figures should be referred to with the word "Table" or "Figure" and the designated number. Some writers like to integrate the reference into the report text; others prefer to use parentheses:

The design takes advantage of a commercially available array of solar collectors (see Figure 6.12).

or

The design, illustrated in Figure 6.12, takes advantage of a commercially available array of solar collectors.

Studies of the ways that technical readers read reports show that parentheses seem to serve an important function, guiding readers back to the place they left in the text when they moved ahead to look at an illustration.

Placement of illustrations presents extreme challenges. The conventional advice is that illustrations should be located directly after the first text reference, but this directive is often not very useful. By the time you have placed Table 2 or Figure 3, you usually find that text and illustrations are no longer on the same page. If you are committed to text and illustrations being closely connected, you can use storyboard format, consistently presenting text on the left-hand pages and illustrations on the right, or you can prepare a separate volume of illustrations so that readers can read text and illustrations side by side.

Informing Readers about Errors

If you discover serious errors in your text or illustrations after the report has been printed, prepare an erratum sheet (for one error) or an errata sheet (for more than one). List the page number and any other information that will help locate the error, such as the line number or figure number (Figure 13.10), and slip the sheet into the report document, between the front cover and the title page.

Erratum Sheet

On page 19:

Table 6, Ocean Disposal of Low-Level Radioactive Wastes, 1957–1969

should read:

Table 6, Ocean Disposal of Low-Level Radioactive Wastes, 1967–1969

Figure 13.10
This erratum notice alerts readers to an error in the report text and provides corrected information.

Publications Beyond the Report

A final report is rarely the first document on a subject, nor is it always the last. In the course of work in science and engineering, research results may be repackaged and disseminated in oral and written forms: at meetings and conference presentations; in conference proceedings, reports, and refereed journal articles. Chances are that portions of your report will appear in other documents, and your results will form the basis for further research.

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Journal Articles

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An academic research team spends three years on a project and, with some changes in direction, reports results that please both the team members and the funding agency. With the work complete, most of the team plans to move on to other projects. The team leader, however, has one more project task in mind: final results should be published in a reputable scientific journal. Publication will take little effort, the leader assures the rest of the team. All that remains is to rewrite the final report so that it meets the specifications of a journal article. Promotions, the team leader points out, may depend on this venture.

Advancement in science and engineering is frequently tied to publication of research in refereed journals, where articles submitted for publication are reviewed by several experts ("referees") who assess the validity and originality of the work. With journal publication, your contribution is now in the formal domain of technical literature. Once published, your work is accessible through secondary sources and becomes part of the