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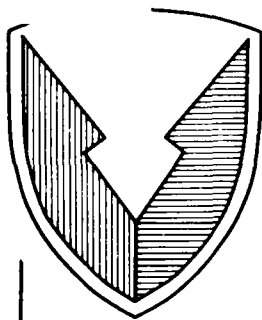
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No. 12680

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STYLE MANUAL

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By

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PREFACE

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This Fourth Revision was edited by Julie McCutcheon, a member of the Research, Development and Engineering Center Technical Editorial Office staff.

Suggestions to improve this report are welcome. Comments or requests for copies may be addressed to: Commander, U.S. Army Tank-Automotive Command, Research, Development and Engineering Center, ATTN: AMSTA-TMS, Warren, Michigan, 48397-5000.

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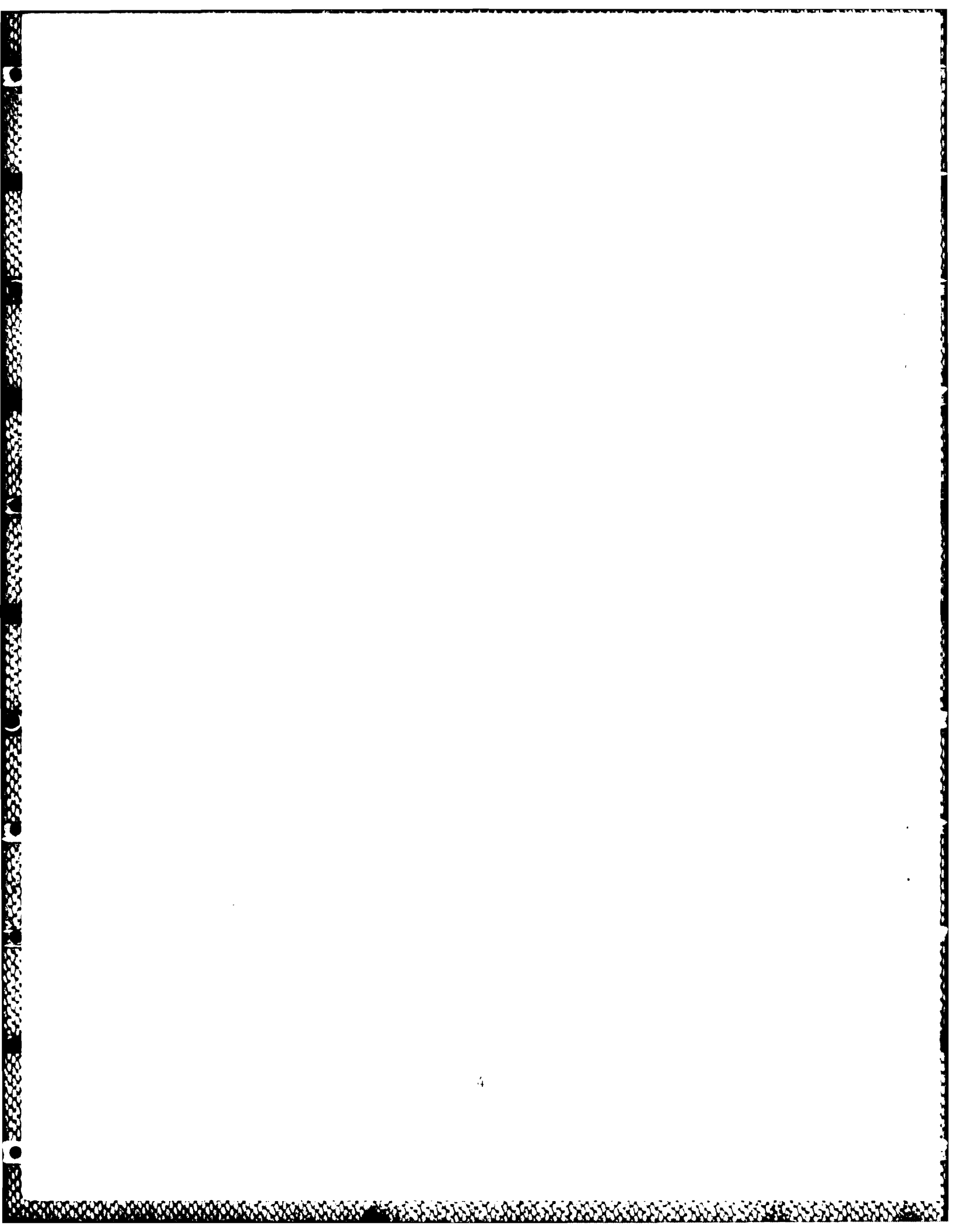


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1.0. INTRODUCTION

This manual, prepared by the Technical Editorial Office as a style guide for U.S. Army Tank-Automotive Command (TACOM) Research, Development and Engineering Center report writers, is designed to make the operation of the Technical Editorial Office more efficient, thereby increasing its productivity. One of the jobs of the office is to make sure that technical reports clearly convey and effectively document the objectives, conclusions, recommendations, materials, and methodology of engineering projects. Currently, a number of government documents offer advice on the preparation of technical reports, yet each varies in some way from the others. Perhaps because of this, reports have continued to reveal variations in format and mechanics. As a result, the office still spends as much time standardizing such variations as it does in clarifying the logical statement of ideas. To minimize the occurrence of such variations, the office has prepared this style manual which offers additional guidance for technical report writers on:

- overall purpose, organization, and format;
- punctuation and capitalization;
- abbreviating and compounding;
- spelling and word choice;
- readability;
- documentation; and
- editing.

2.0. REPORT PURPOSE, ORGANIZATION, AND FORMAT

2.1. Purpose of the Report

In composing a technical report, the engineer must keep in mind that his major goal is to provide managerial personnel with the amount and type of information needed to effectively evaluate his project. To do this, the engineer must understand the characteristics of the manager.

First, although most managers are very interested in all engineering projects and would like to spend a good deal of time thoroughly studying the details of each report, they are so overburdened by administrative duties that they cannot possibly do this. The typical manager will carefully read the introduction, the statement of objectives, the conclusions, and the recommendations, but will usually only skim the rest of the report. Thus, the reporting engineer, when writing a report, should make sure that all of his major points are clearly and concisely spelled out in the opening sections.

Secondly, the engineer must be aware of the educational level and experience of his managerial audience. He can, of course, expect his readers to be highly literate and to have a substantial knowledge of engineering methods and materials, especially those directly related to TACOM's mission. However, he cannot expect managers to have highly specialized knowledge of specific engineering fields or of complex mathematics. He will, then, want to make sure that new terminology, complicated procedures, or innovative techniques are clearly defined.

Thirdly, the engineer must be aware of the special goal orientation of managers. While they are certainly interested in immediate or short-range effects of separate research and development projects, their primary orientation is toward long-range effects and their concern is with the effective integration of all TACOM projects within their divisions. Therefore, in providing background, in stating goals and results, and in offering suggestions for improvements, the engineer must show what his particular project contributes to the overall mission of TACOM. Finally, although the average manager will not be able to study the details as thoroughly as he would like, the writer must be careful to accurately and thoroughly document the materials and methods of his project. On occasion, the manager may be asked to justify his recommendations. He should be able to find all the details he needs in the main text of the report.

In sum, the engineer must provide the managers with the quantity and quality of information that they need to make decisions regarding future projects. Understanding the overall purpose of the technical report, the engineer must then begin to focus on the specific purpose of each section. (The sections that are not discussed in detail here need no explanation.)

2.2. Organizational Requirements

Although all reports do not necessarily contain all of the following elements, those that are used will appear in the following order with the abstract appearing only on the Report Documentation Page, DD Form 1473.

- Front Matter
 - Front Cover (Required)
 - Notices
 - Report Documentation Page, DD Form 1473 (Required)
 - Summary
 - Preface
 - Table of Contents
 - List of Illustrations
 - List of Tables

- Body of the Report
 - Introduction
 - Objectives
 - Conclusions
 - Recommendations
 - Discussion (Main Text)

- Reference Material
 - List of References
 - Bibliography
 - Appendices
 - Glossary of Terms
 - List of Abbreviations, Acronyms, and Symbols
 - Alphabetical Index (Recommended for Long Reports)
 - Distribution List (Required)
 - Back Cover

2.2.1. Front Cover. The cover page requires little effort on the author's part. The Technical Editorial Office has standard "prepared" front covers that are to be used on all TACOM technical reports. Instructions for cover preparation are at par. 2.3.4.

2.2.2. Notices. Notices concerning the Department of Army position on the report, endorsement of products and companies mentioned in the report, and disposition of the report when it is no longer needed, are to be placed on the inside of the front cover. (See the inside front cover of this report and par. 2.3.16.2.)

2.2.3. Report Documentation Page, DD Form 1473. The Report Documentation Page serves as the title page in Department of Defense (DOD) reports and is page 1 (the back is page 2) in every report. This form, including detailed instructions for its completion, should be picked up by the TACOM project engineer from the Technical Editorial Office and must be completed **before** the report is submitted for editorial review. Although the instructions are quite thorough, one additional point should be noted. Guidance in choosing the "Subject Terms" asked for in Block 18 can be found in the Thesaurus of Engineering and Scientific Terms or Defense Documentation Center Retrieval and Indexing Terminology.

2.2.4. Summary. A summary may be included to provide a digest of the report, to explain the reason for the initiation of the work, and to outline principal conclusions and recommendations. A summary may be used to give more information on the content of the report than can be presented in the abstract entered on the Report Documentation Page, DD Form 1473.

2.2.5. Preface. If a preface is used, it may show the relationship of the work reported on in conjunction with associated efforts, give credit for the use of copyrighted material, or acknowledge significant assistance received.

2.2.6. Table of Contents. The purpose of the table of contents is to provide a quick overview of and ready access to report sections. As such, the table of contents should list the numbered report headings of each section and the page number on which that section begins. Format guidelines are provided in par. 2.3.5.

2.2.7. Lists of Illustrations and Tables. Like the table of contents, these lists provide quick overviews of and guides to figures and tables.

If each list is shorter than one-half page, they may be typed on the same page. Format guidelines are found in pars. 2.3.6. and 2.3.7.

2.2.8. Introduction. The introduction of a technical report provides management with the background, scope, and purpose of a particular engineering project. Additionally, where possible, it relates the specific objectives of the project to overall divisional objectives or to the TACOM mission. Usually written in past tense, it can, nevertheless, be written either as a single paragraph or as a series of numbered paragraphs; the decision should be based on the complexity of the material. In any case, the introduction should begin as par. 1.0. In writing a single-paragraph introduction, the technical report writer may wish to use the introductory paragraph of the sample report (see Appendix A) as a sample. Examples of other introductions are on file in the Technical Editorial Office. In studying these introductions, the writer should note that the first sentence includes:

- the name of the contractor (if the project is not in-house);
- the Department of Army contract number; and
- a summary of the project purpose.

The first two items given above are omitted from the introduction and included in the preface of a long report, along with details regarding contributions of individual engineers or private subcontractors. Additional sentences in the introduction provide--in as few words as possible--information on the problem(s) the project has sought to solve, the methods and materials used to alleviate each problem, and the results of these efforts. In providing such information, the engineer may wish to include a few brief (no more than one-sentence) definitions of terminology concerning the object of experimentation (such as a track system) or methods used (such as blow-molding or laser treatment). Instructions on writing definitions are given in Appendix E. The engineer may also wish to offer concise analysis of the advantages of the current process or product.

2.2.9. Statement of Objectives. The purpose of the "OBJECTIVES" paragraph is to describe the results that were intended (but not necessarily achieved) by those involved in the effort which the report addresses. In this section, the author delineates the hoped-for accomplishments, even if the actual outcome of the work fell short of these expectations. The manner in which the engineer states these objectives is dependent upon their complexity. If, for example, he can state the objective(s) in a sentence of 25 words or fewer, he may do so. (See "OBJECTIVE," p. A-13.) On the other hand, in a case involving several complex objectives of a project where "the following:" is used, list them as "bulleted" parallel independent clauses. (See par. 6.3.3.) The words "the following" are not needed when the bulleted items are dependent clauses. The "OBJECTIVES" paragraph should begin as par. 2.0.

2.2.10. Conclusions. Conclusions summarize the success achieved or, in any instance, the knowledge gained as a result of the work described in the report. If at all possible, the statement of the conclusions should parallel the content of the objectives. The conclusions should begin as par. 3.0., with subparagraphs or bullets used as needed.

2.2.11. Recommendations. Extremely important information, the recommendations allow the engineer to convey to managerial personnel the steps that can be taken to insure future success. Recommendations could also include advice on follow-on research projects related to divisional objectives or overall Command mission. The recommendations should begin as par 4.0., with subparagraphs and/or bullets employed as needed.

2.2.12. Discussion (The Main Text). As the bulk of the report, the section titled "DISCUSSION" is of great importance in substantiating the assertions made in the introduction, objective(s), conclusions, and recommendations. The engineer should, therefore, spare no effort in providing a detailed record of materials, tools, and methods involved in his project. He may organize and develop the content of the body in any manner he wishes, but the discussion should begin with par. 5.0. No other major headings should be necessary. General headings he may consider are:

- Materials,
- Design,
- Fabrication,
- Testing,
- Theoretical Formulation, and
- Packaging.

Not only should he provide a narrative summary of the various stages of research and development, but he should also provide as many tables and figures as he needs to clarify and illustrate points made in the text. It is important for him to note that photographs or drawings are meant to be visual counterparts of verbal descriptions in the text; they are not substitutes for text.

The same principle applies to graphs and tables. All the major points that these figures, graphs and tables illustrate should be part of a detailed discussion in the text. In addition, major types of information presented in a table or graph and viewpoints to be discerned should be explicitly stated at the point in the text where the table is first mentioned. Finally, each table and figure should be placed on a page separate from text as close to the point after it is first mentioned as possible. (See pars. 2.3.11. and 2.3.12. for further guidance on tables and figures.)

2.2.13. List of References. When it is necessary to cite references, identify the source to aid future readers. The references should be listed in the same numerical order as cited in the text, and in a reference list, which follows the body of the report. Each referenced item in the text should be assigned a consecutive number. Do not repeat numbers; repeat entries in the reference list instead. (See par. 7.2.)

2.2.14. Bibliography. The bibliography, if included, is a selected list of informational sources which were consulted but not quoted in the text. (See par. 7.3.)

2.2.15. Appendices. Appendices include material that is parenthetical or supplementary to the main text. In other words, material may be placed in an appendix if its inclusion in the text would disrupt the normal flow of ideas due to the amount of detail required or because it is only peripherally related to the discussion. Occasionally, related reports or studies--parts of which have been cited in the text--are included in appendices. John M. Lannon in Technical Writing gives these possible items to be included as appendices:

- details of an experiment;
- statistics;
- maps;
- complex formulas;
- long quotes (one or more pages);
- texts of laws, regulations, etc.;
- related correspondence (letters of inquiry, etc.);
- interview questions and responses;
- sample questionnaires and tabulated responses; and
- sample tests and tabulated results.

2.2.16. Glossary of Terms. Unusual terms should be described, either in the text or as parenthetical notes, when first used in the body of the report. When many such terms are used, list them alphabetically with appropriate definitions in a glossary.

2.2.17. List of Abbreviations, Acronyms, and Symbols. Define abbreviations, acronyms, and symbols when first used in the report. If they are numerous, list them in alphabetical order and with appropriate definitions on a separate page at the end of the report.

2.2.18. Alphabetical Index. For long reports, an alphabetical index is recommended.

2.2.19. Distribution List. A distribution list must begin at the last right-hand page of each technical report. As a minimum, the following four addresses must be included on the list. However, these are probably not the only ones that should appear in any given technical report. All contractors should conform to their contract specifications as well as consult with their TACOM project engineer for a complete distribution list.

- | | |
|--|---|
| (1) Commander
Defense Technical Information Center
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ATTN: DDAC
Alexandria, Virginia 22304-9990 | (2) Manager
Defense Logistics Studies
Information Exchange
ATTN: AMXMC-D
Fort Lee, Virginia 23801-6000 |
| (3) Commander
U.S. Army Tank-Automotive Command
ATTN: AMSTA-DDL (Technical Library)
Warren, Michigan 48397-5000 | (4) Commander
U.S. Army Tank-Automotive
Command
ATTN: AMSTA-CF (Mr. G. Orlicki)
Warren, Michigan 48397-5000 |

If the report has limited distribution, 2 copies should be sent to each of the first 2 addresses; if the distribution is unlimited, 12 copies are to be mailed to the first address, with 2 copies going to the second address. Regardless of distribution limitations, two copies are to be sent to the third address and one copy is to be sent to the fourth address. An extended listing of optional distribution points and their addresses is on file at the Technical Editorial Office and may be referred to at any time.

Actual distribution (mailing) of the reports is done either by the contractor or the project engineer, depending on contract specifications. However, copies for the Defense Technical Information Center must be mailed to TACOM's Technical Library (AMSTA-DDI). The library then forwards the copies to the Defense Technical Information Center.

2.3. Format Requirements

2.3.1. General. The Technical Editorial Office has adopted a standard format so that office publications will be of a uniform quality. These formal requirements are based on the criteria explained in AP 70-31, in MIL-STD-847B, and in the U.S. Government Printing Office (GPO) Style Manual. Departures from these guidelines have been made to make the reporting process more efficient.

2.3.2. Page Size and Typeface. All report pages, including illustrations and tables, should be typed on 8½- by 11-inch white paper. Because of expenses incurred in printing, foldout pages should be avoided, if at all possible. The use of dot matrix printers is not acceptable for final reports; a letter-quality printer must be used.

2.3.3. Indentation, Margins, Spacing, and Numbering Paragraphs.

2.3.3.1. Indentation. Block style should be used throughout the majority of the report; with the exception of "bulleted" items (see par. 3.2.4.), all headings in the body and lines of copy should be flush left and numbered.

2.3.3.2. Margins. The margin at the top of the page should be 1 inch. The margin at the bottom of the page should be 1 inch. (Please note that the page number is considered as part of the copy, that there is a $\frac{1}{2}$ -inch space between the text and the page number, and there must be a full 1-inch margin below the number.) Gutter margins (the inner margins between facing pages) and outer margins should be $1\frac{1}{4}$ inches wide. (See Figure 2-1.)

2.3.3.3. Spacing. The following rules apply to spacing in technical reports.

- The text of all reports is to be single-spaced.
- The text of bulleted items is single-spaced. However, a blank line is left before and after each point.
- The first major heading (1.0.) is preceded by a 1-inch margin and followed by one blank line. All other major headings are preceded by two blank lines and followed by one blank line.
- Secondary headings are preceded and followed by one blank line.
- The text of third- and fourth-level headings begins on the same line as the headings.
- Headings for appendices and addenda, i.e., "APPENDIX A" and "ADDENDUM," are centered horizontally and vertically. After two blank lines, the title begins (see p. A-1). If the title runs more than one line, it is double-spaced.
- Certain sections must always begin on right-hand pages. These include: DD Form 1473, summary, preface, table of contents, list of illustrations, list of tables, distribution list, and all reference material.

2.3.3.4. Numbering paragraphs. As a general rule, all paragraphs in technical reports are headed and numbered. This procedure provides abbreviated reference terms for entire sections of text. Thus, material that is frequently referenced--a government specification, for example--is readily accessible. However, a report occasionally includes background, or introductory material that is of such a general nature that it need not be presented as a series of numbered paragraphs. Usually such material is preceded by appropriate heading numbers and the heading "General." (See par. 2.3.13.) By and large, paragraphs in such sections should be no longer than 150 words.

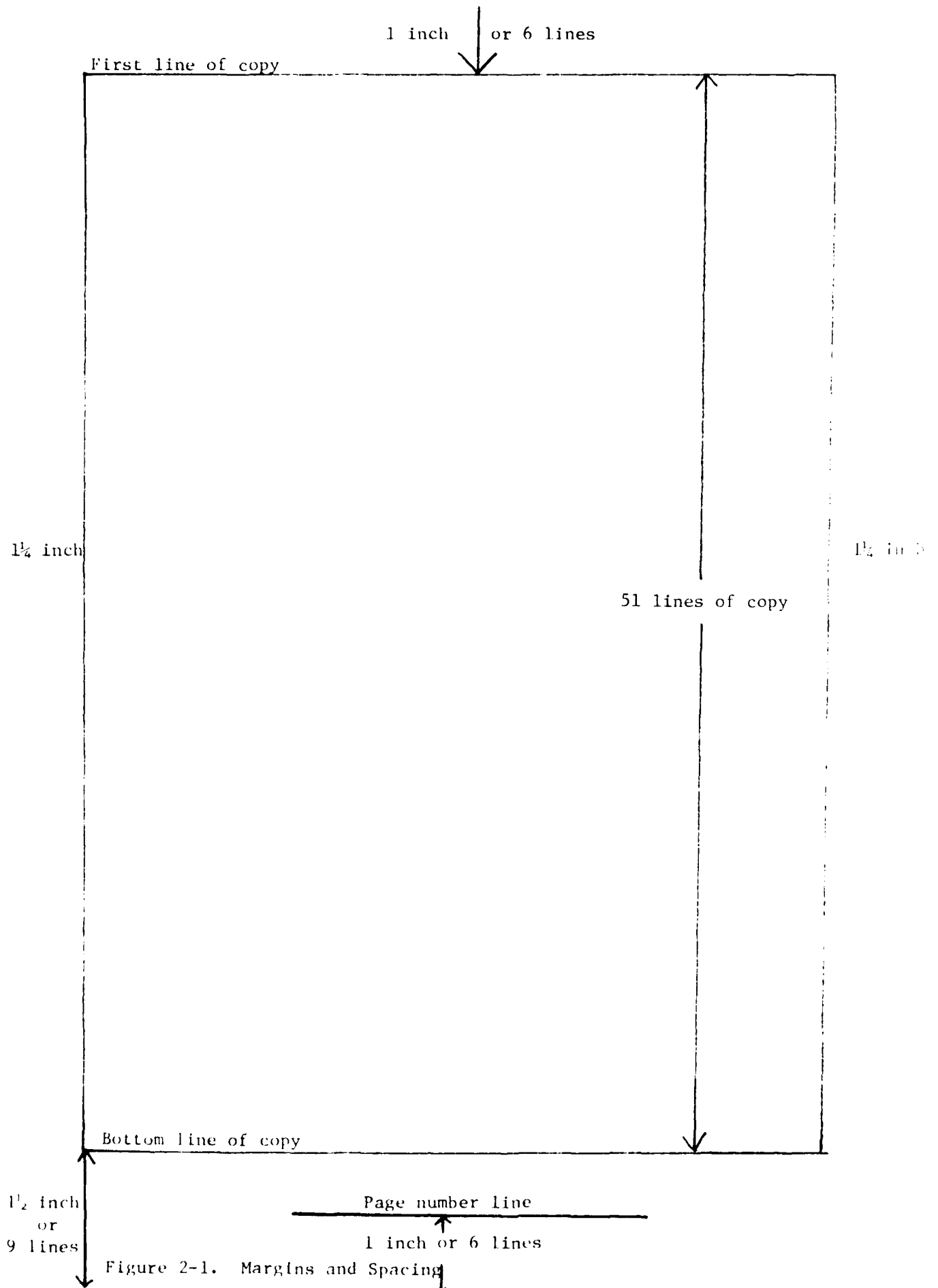


Figure 2-1. Margins and Spacing

2.3.4. The Front Cover. The general format for all TACOM technical reports is illustrated in Figure 2-2. Such blank "working covers" may be picked up from the Technical Editorial Office (AMSTA-TMS). The project engineer then fills in the following items.

2.3.4.1. Defense Technical Information Center (DTIC) control number. The rectangle in the upper right-hand corner should be left blank for the accession number assigned at the Defense Technical Information Center in Alexandria, Virginia.

2.3.4.2. The report number. Before it is edited, each report is assigned a report number by the Technical Library Services Branch, AMSTA-DDL, and recorded on a log in the Technical Editorial Office. When the report is sent in final form to the printing office, this report number is placed on the blank line following the heading which reads "RD&E Center Technical Report."

2.3.4.3. The report title. The title is separated from the report number by one blank line. All letters in a title are capitalized, and the title is centered. If the title runs more than one line, the second line should be centered under the first line as seen in Figure 2-3. In choosing words for the title, the writer should be careful to use the same technical terminology that is used by the Army in its project contract title. However, whenever possible, the engineer is advised to use widely known terms in the title so that the report can be readily accessible through systems which index by key terms. The title should not begin with numerals or unintelligible groupings of letters of the alphabet, such as "3-D Test" or "XGT111." Also, the report title should always be unclassified, if possible, even in a classified report.

2.3.4.4. The contract number. If used, the Department of Army contract number is separated from the title by one blank line.

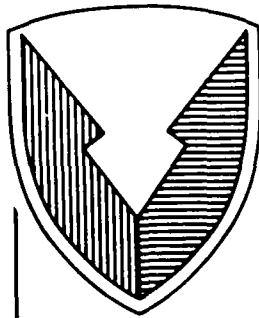
2.3.4.5. The report date. The date (month and year) that the technical report was completed is centered beneath the contract number (separated from the report title/contract number by one blank line). This date should be the same as the date in Block 14 on the Report Documentation Page, DD Form 1473. Block 13b of DD Form 1473 gives the dates that the project itself was begun and completed. (All other dates should be written in government style, i.e., 5 Jan 84.)

2.3.4.6. Author credit line. Author credits are printed in the space above the "By" line. Figures 2-3 through 2-6 illustrate the credit lines for the four types of reports submitted to the Technical Editorial Office: a sample cover for a contractor-prepared report (Figure 2-3); a sample cover for contractor-prepared report with contractor's report number assigned (Figure 2-4); a sample cover for combined contractor- and TACOM-prepared report (Figure 2-5); and a sample cover for an in-house report (Figure 2-6).

RD & E

C E N T E R

Technical Report



No. _____

By _____

U.S. ARMY TANK-AUTOMOTIVE COMMAND
RESEARCH, DEVELOPMENT & ENGINEERING CENTER
Warren, Michigan 48397-5000

Figure 2-2. Sample Blank Front Cover

2.3.4.7. Distribution statement. Limitations concerning distribution are indicated two blank lines below the "By" line, at the left margin (see Figure 2-6). An extended discussion of distribution statements may be found in AR 70-31. However, one of the following six distribution statements is generally used.

Distribution Statement A:

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED.

Distribution Statement B:

DISTRIBUTION LIMITED TO U.S. GOVERNMENT AGENCIES ONLY; (Indicate Reason and Date). OTHER REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO (Indicate Controlling DOD Office).

Distribution Statement C:

DISTRIBUTION LIMITED TO U.S. GOVERNMENT AGENCIES AND THEIR CONTRACTORS; (Indicate Reason and Date). OTHER REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO (Indicate Controlling DOD Office).

Distribution Statement D:

DISTRIBUTION LIMITED TO DOD AND DOD COMPONENTS ONLY; (Indicate Reason and Date). OTHER REQUESTS MUST BE REFERRED TO (Indicate Controlling DOD Office).

Distribution Statement E:

DISTRIBUTION LIMITED TO DOD COMPONENTS ONLY; (Indicate Reason and Date). OTHER REQUESTS MUST BE REFERRED TO (Indicate Controlling DOD Office).

Distribution Statement F:

FURTHER DISSEMINATION ONLY AS DIRECTED BY (Indicate Controlling DOD Office and Date) OR HIGHER DOD AUTHORITY.

2.3.5. "TABLE OF CONTENTS" Page (see "TABLE OF CONTENTS" on pp. 5 through 7 and p. A-7).

2.3.5.1. General. In formatting the "TABLE OF CONTENTS" page, the writer must pay close attention to placement, numbering, and capitalization of headings and to placement of page numbers.

2.3.5.2. Placement of titles. The writer should note that the first printed line on the page begins 1 inch from the top and contains the centered title in all capitals. The title is followed by two blank lines. On the third line below the title, flush with the left margin, the word "Section" should appear and only the first letter is

capitalized. On the same line, flush with the right margin, is the word "Page." Here, as well, only the first letter is capitalized.

2.3.5.3. Choice of headings. Leaving one blank line after the "Section/Page" line, the writer then begins a flush-left listing of report headings. Since it is not necessary to include front matter in the table, the list begins with body headings. They are listed with the same numbers and in the same form as in the text. (See par. 2.3.13.) With a short report (under 50 pages), major headings and secondary headings need to be included. In longer reports, list tertiary headings also. Fourth-level headings are not included regardless of the length of the report. The table also cites the list of references, appendices with corresponding titles (e.g., "APPENDIX A: SAMPLE REPORT"), distribution list, and other back matter.

2.3.5.4. Spacing of headings. Major headings are separated from preceding headings by one blank line. Secondary and tertiary headings follow one another directly.

2.3.5.5. Spacing of table items. With numbered headings, the space between the period after the last number and the words of the headings depends on the levels of headings included in the table. When only major and secondary headings are included, two spaces separate the number and the first word of each heading. When three levels are included, four spaces separate the numbers and first words of major and secondary headings and two spaces separate the numbers and first words of tertiary headings. In all cases, the first letter of each heading is vertically aligned. The last word of each heading is separated from the page number on which the section begins by spaced periods. These periods stop at the space preceding the space under the "P" in the word "Page." (See the tables of contents of this manual.)

2.3.5.6. Page numbers. Page numbers are listed flush right.

2.3.6. "LIST OF ILLUSTRATIONS" Page. The title for this page is centered 1 inch from the top and is typed in all capitals. On the third line below the title, flush with the left margin is the capitalized word "Figure." In the center of the line is the capitalized word "Title." On the same line, flush right, is the capitalized word "Page." Beginning on the second line, below the word "Figure," are the figure numbers. Each figure is given two numbers which are separated by a hyphen and followed by a period. The first is the number of the major section in which it occurs. The second is based on the order of the figure within the section and is recorded in Arabic numerals (e.g., the fourth figure in the second section would be numbered 2-4). The figure title is separated from the number by at least two blank spaces. (All titles should, however, be aligned.) Titles are separated from their corresponding flush-right page numbers by spaced periods. One blank line separates each entry.

2.3.7. "LIST OF TABLES" Page. If the lists of illustrations and tables are each less than one page, they may be placed on the same page. With the obvious difference of title, the format of the "LIST OF TABLES" page

is identical to that of the "LIST OF ILLUSTRATIONS" page with one exception: the word "Table" is written over the listing of table numbers.

2.3.8. "LIST OF REFERENCES" Page. The title of this page appears in all capitals 1 inch below the top of the page. The list of references begins on the third line below the title. Referenced items are preceded by Arabic numerals in ascending sequence. These numerals are raised one-half line and are separated from the publication information by two blank spaces. Each citation is single-spaced, and one blank line is left between citations. The page number continues the consecutive pagination of the body. (See par. 7.2. for specific information on documentation forms of individual items.)

2.3.9. "SELECTED BIBLIOGRAPHY" Page. Like the list of references, the title of this page appears in all capitals 1 inch below the top of the page. The list of references begins on the third line below the title. Referenced items are listed alphabetically by the author's last name. When the author's name is not available, the title of the work is listed first (or, as in the case of an Army regulation or military standards or specifications, the acronym and number are first), in the same alphabetical sequence. Each entry is single-spaced. The second and all subsequent lines of each entry are indented five spaces. One blank line is left between entries. The page number continues the consecutive pagination of the body. (See par. 7.3. for specific information.)

2.3.10. "DISTRIBUTION LIST" Page. The format for the distribution list is similar to that of the table of contents and lists of tables and figures. The centered heading--"DISTRIBUTION LIST"--is typed in all capitals 1 inch from the top of the page. On the third line below the title, flush with the right margin, is printed the word "Copies" and the first letter is capitalized. On the fifth line below the title, flush with the left margin, a listing of the addresses to which the report is to be sent begins. The addresses themselves are single-spaced while there is a blank line between each complete address. Directly across from the first line of each address, flush with the right margin, is printed the number of copies to be mailed to that address. The page numbers of the list begin a new series of ascending Arabic numerals preceded by the distribution, e.g., page 1 has centered at the bottom "Dist-1," page 2 has "Dist-2," etc.

2.3.11. Tables.

2.3.11.1. General. Each table included in the body text of a report should be adequately introduced. Such references should summarize the contents of the table, clarify the relationship among the table elements, and explain the perspectives to be discerned. A table is meant to clarify highly detailed textual information through its format. However, a table should always be accompanied by thorough textual analysis.

2.3.11.2. Placement of tables in the report. Each table is to be placed on a page separate from text as close to the point after it is

first mentioned as possible. Occasionally, two short tables referenced on the same page of text may be put on a single page immediately following the textual reference. (See p. A-18.) However, in no case are tables referenced in the text to be grouped together as an appendix. Additionally, tables should be restricted to a single page if possible. If the table material cannot fit on a single page, two solutions are acceptable. Preferably, the table copy will be photographically reduced so that it will fit on a single page. If the table must run more than one page, the table heading followed by the capitalized word "Continued" in parentheses, the table title, and the table column headings must be repeated at the top of each additional page of the table.

2.3.11.3. Placement on page. Unless it is not possible to do so and maintain readability, place tables so that they may be viewed without turning the page sideways. If this is not possible, place each table sideways so that it can be seen by rotating the page clockwise, although placement of the table heading and title will remain positioned as described in par. 2.3.11.4.

2.3.11.4. Table heading and title. The table heading and title begin at the left margin on a line that is 1 inch from the top of the page. The first letter of the word "Table," the first letter of the first word in the title, and the first letter of all other important words in the title are capitalized. The word "Table" is followed by a two-part Arabic numeral separated by a hyphen, the first part being the number of the section in which the table appears and the second part, a number indicating the order of the table within the section. For example, the second table in section 5 of a report would have this heading--"Table 5-2." The heading is followed by a period and is separated from the table title by two blank spaces. The title should be completed on one line if at all possible. If additional lines are necessary, they should be flush with the first letter of the first word in the title. Do not use a period at the end of the title.

2.3.11.5. Related tables. Tables that present similar information should use similar formats.

2.3.11.6. Use of unbroken vertical and horizontal lines. Unbroken vertical lines should not be used either as margin-borders or as dividing lines between table columns. Unbroken horizontal lines, however, may be used in tables. Double horizontal lines are frequently used to enclose the actual table material; that is, they are used (1) between the table heading/title and the column titles (or top-heads), and (2) between the table data columns and the footnotes (see p. A-18). A single unbroken horizontal line separates column titles and the data columns themselves.

2.3.11.7. Column top-heads. Column top-heads are separated from the double horizontal lines above them by one blank line and from the single horizontal line below them by one blank line. Unless it is impossible, each top-head is stated as a single word, of which only the first letter is capitalized. When the top-head is composed of several words, only the important words are capitalized. Further, when both single-line and

multiline top-heads occur in the same table, the single-line top-heads are aligned with the lowest line of the multiline heads.

2.3.11.8. Column/heading alignment. If the top-head is wider than the column, the column material is centered beneath it; if the column material is wider, the top-head is centered above it.

2.3.11.9. Column data alignment. In all cases where decimals appear in column data, the decimals are aligned. Numbers without decimals are right-justified so the last digits of all numbers align vertically.

2.3.11.10. Table footnotes. Table footnotes are placed below the double horizontal line following the table data. To avoid confusion with table numerals (especially in table material involving exponents), the GPO Style Manual recommends the use of asterisks, daggers, etc., or superior letters. The order of symbols should be as follows: asterisk (*), dagger (†), double dagger (‡), section mark (§), and parallel (//).² If such symbols are difficult to reproduce, superior letters may be used. The symbol or letter is flush left, and the footnote material follows it directly.

2.3.11.11. Pagination. Table page numbers continue the sequential pagination of the text. The page number is centered on a line that is 1 inch from the bottom of the page.

2.3.12. Figures.

2.3.12.1. General. Each figure (or illustration) should be thoroughly explained in the main text. If the figure is a graph or chart, the reader should be given a thorough analysis of the relationship among the elements shown in the figure. Never should one rely on so vague a statement as "Results of these tests are shown in Figure 3-4." If the figure is a photograph or line drawing, the writer should provide equivalent verbal description in the text. Appendix C provides instructions in writing technical descriptions.

2.3.12.2. Placement of figures in the report. Each figure is to be placed on a page separate from text as close to the point after it is first mentioned as possible. Two figures that are small, or two figures that give different views of an object, may be placed together on one page. When two views are given, they are labeled (a) and (b), and each letter is followed by a title explaining the figure. In no case are figures referenced in the text to be grouped as an appendix.

2.3.12.3. Placement of figures on the page. Like tables (see par. 2.3.11.3.), most figures should be placed so that they can be read without turning the page sideways. If the figure must be placed sideways, it should be placed so that it is read by turning the page clockwise, although the figure heading and title will remain positioned as described in par. 2.3.12.4.

2.3.12.4. Figure heading and title. The figure heading and title begin at the left margin at least two lines below the figure. The first letter of the first word in the title, and the first letter of all other important words in the title are capitalized. The word "Figure" is followed by a two-part Arabic numeral separated by a hyphen, the first part being the number of the section in which the figure appears and the second part a number indicating the order of the figure within the section. For example, the third figure in section 1 would be designated as Figure 1-3. This heading is followed by a period and is separated from the figure title by two spaces. The title should be completed on one line if possible. If additional lines are required, they should be flush with the first letter of the first word in the title. Do not use a period at the end of the title.

2.3.12.5. Related figures. Figures that present similar information should use similar formats.

2.3.12.6. Legends. With the exception of self-explanatory photographs or drawings, many illustrations are accompanied by descriptive legends. Here the term "Legend" differs slightly from the way it is used in MIL-STD-847B. That document uses the word "Legend" in the sense that the word "Title" has been used here. In this document, "Legend" refers to a brief list explaining the various symbols or colors used on a chart or graph.

2.3.12.7. Call outs. Wherever possible, place call outs horizontally, unboxed, and near the item called out. Make call outs consistent in size and typeface throughout a report. Use lettering at least 8 points or larger in final reproduced size.

2.3.12.8. Foldouts. Foldouts are expensive to reproduce and should be avoided, if possible.

2.3.12.9. Use of photographs, diagrams, and drawings. Photographs, diagrams, and drawings are extremely important in technical reports in that they serve as visual equivalents of verbal descriptions. However, each has its own special merit, according to Theodore A. Sherman and Simon S. Johnson, authors of the third edition of Modern Technical Writing.³ These authors suggest that photographs are best used to substantiate the truth. If, for example, a fuel tank has become distorted during field testing, a photograph can provide visual proof of this. However, photographs are limited as illustrations in that they can only show surface views. Drawings, on the other hand, can delineate surface and interior views simultaneously. They also, according to Sherman and Johnson, "make it possible to omit what is not significant and to emphasize what is important."

2.3.12.10. Quality of photographs and line drawings. Photographs should be good-quality, black and white, medium-contrast, and reproducible at the Army Duplicating Facility. Line drawings may contain bro-

ken lines as long as sufficient ink is used to prevent deterioration of line quality should the drawing be reduced. Shading is not recommended. Further information can be found in MIL-M-38784B and AR 310-3.

2.3.12.11. Use of color. Avoid the use of color if at all possible; a good-quality black and white photograph will serve in nearly all photo requirements. Color prints cost more to print due to the number of passes through the press to produce the "color" image. It is also difficult to get true register marks aligned in the press so that colors don't bleed on each other. Finally, color images rarely produce the desired effect in the final document.

2.3.13. Headings.

2.3.13.1. General. The same rule applies to subdivisions of headings as applies in outlining: there must be at least two subheadings at any given level (if any are used). Specific rules governing heading format vary according to report section and heading level. The writer must thus pay close attention to placement, numbering, horizontal and vertical spacing, capitalization, and punctuation.

2.3.13.2. The "General" heading. The capitalized word "General" is used before a paragraph(s) introductory material.

2.3.13.3. General guidelines on unnumbered headings. Headings for the following sections are centered 1 inch below the top of the page in all caps: notices; summary; preface; table of contents; list of illustrations; list of tables; list of references; bibliography; glossary of terms; list of abbreviations, acronyms, and symbols; index; and distribution list. The appendices have separate cover sheets. The lettered appendix heading for example, "APPENDIX A," is printed in all capitals and centered horizontally and vertically. This heading is separated from the centered title of the appendix (also in all capitals) by two blank lines. If this title runs more than one line, the additional lines are centered, double-spaced, under the first. (See Appendix A, p. A-1.)

2.3.13.4. General guidelines on numbered headings. Headings in the body of a report are preceded by two, three or four Arabic numerals.

2.3.13.5. Major headings in body. The following principles govern the formatting of major headings (also called first-level headings or primary headings). The statement of each major heading begins at the left margin with an Arabic numeral denoting the section number and followed by a period, a zero, and a second period. Two blank spaces separate the heading number and the heading words. All letters in major headings are capitalized. The heading should not be underlined, nor should it be followed by a period. Any text that follows a major heading begins at the left margin after one blank line. Any major headings following the text are preceded by two blank lines.

2.3.13.6. Secondary headings in body. The following guidelines apply to all secondary headings. Like major headings, secondary headings begin at the left margin with an Arabic numeral denoting the section number and are followed by a period. With secondary headings, though, this period is followed by a specific subdivision number, and a second point. The first secondary heading in section 1 would thus begin with the following: 1.1. Two blank spaces separate the heading number and the heading words. Unlike the major heading, only the first letters of important words are capitalized here and the entire word group is underlined. The heading is not followed by a period. Any text that follows a secondary heading begins at the left margin after one blank line. One blank line appears between a secondary heading and a preceding major heading or between two secondary headings.

2.3.13.7. Tertiary headings in body. The following guidelines govern the presentation of tertiary (or third-level) headings in technical reports. The tertiary heading begins at the left margin with the appropriate Arabic numerals of the major and secondary section of which it is a part. Each of these is, of course, followed by a period. After the second period, the writer states a third Arabic numeral--the number of the third-level subdivision. It, too, is followed by a period. Thus, the first third-level section in the first secondary section of the fourth section of a report would have the following numerical designation--4.1.1. This heading number, as in major and secondary headings, is separated from the heading words by two blank spaces. The first and all other important words are capitalized but the heading is not underlined. The words of the heading are followed by a period and after two blank spaces, by the text of the section, if any. Generally one should double-space between the tertiary heading and any one of the following: a secondary heading, another tertiary heading, or a fourth-level heading. If the tertiary heading is the last heading in a major section, two blank lines separate it from the next major heading.

2.3.13.8. Fourth-level headings. Fourth-level headings begin with a statement of the heading number. Flush left, the heading number contains four numbers: the major section number, the secondary section number, the tertiary section number, and the number of the specific fourth-level section. Each of these numbers is followed by a period. The number of this section (2.3.13.8.) illustrates a fourth-level heading number. The words of the fourth-level heading are separated from the number by two blank spaces and are followed by a period, two blank spaces and then the text of the fourth-level section. Only the first letter of the first word is capitalized. Spacing rules governing tertiary headings apply here as well.

2.3.13.9. Headings below the fourth level. No numerical headings below the fourth level should be used.

2.3.13.10. Headings for figures and tables. Headings for figures and tables include the word "Figure" or "Table," of which only the first letter is capitalized. The figure or table section and item numbers are

followed by the heading title, in which the important words are capitalized (see par. 2.3.12.4.).

2.3.14. Binding. The reproduced technical report will be securely fastened along the left edge. The usual binding will be side or saddle-wire stitching. Looseleaf, spiral, plastic comb, and post bindings will not be used. Cloth back-strip (binding tape) will be used only when it serves a protective purpose (par. 9-1e(3), AP 310-1).

2.3.15. Numbers in the Text.

2.3.15.1. General. As a general rule, numbers should be presented in figures rather than in words. One exception is at the beginning of a sentence. If at all possible, however, the sentence should be recast. The GPO Style Manual offers these important guidelines. Rule 12.4. states: "A figure is used for a single number of 10 or more with the exception of the first word of a sentence." Rule 12.5. reads: "When 10 or more numbers appear in a sentence and one of them is 10 or more, figures are used for each number." Rule 12.6. states: "A unit of measurement, time, or money, which is always expressed in figures, does not affect the use of figures for other numerical expressions within a sentence."

2.3.15.2. Punctuation. The GPO Style Manual offers this advice on the use of commas in long numbers in Rule 12.14.: "The comma is used in a number containing four or more digits, except in serial numbers, common and decimal fractions, astronomical and military time, and kilocycles and meters of not more than four figures pertaining to radio."

2.3.15.3. Fractions. Generally, when fractions stand by themselves or are followed by "of a" or "of an," they are spelled out. In most other cases, especially in unit modifiers (as in $\frac{1}{2}$ -in. pipe), fractions are stated as figures. The typewriter keys stating fractions should be used, although fractions may also be stated as full-sized figures separated by slash marks.

2.3.15.4. Dimensions. Dimensions should be stated in figures. When giving dimensions, the writer should use the appropriate abbreviations to denote proper measurements and should be careful to follow these measurement abbreviations with additional abbreviations such as "l" for "long," "w" for "wide," and "h" for "high." Do not use a lowercase or capital letter "X" to designate "by" in measurements. For example, state "4 in. by 6 in.," not "4 in. x 6 in."

2.3.15.5. Numbers and lists. Numbers are used with lists only when one wishes to establish a priority either of importance or sequence among items. This applies to both "run-in" lists (lists in the main text) or indented "set-off" lists (see also par. 2.2.4.). Generally, these item numbers are placed in parentheses and are separated from the item itself by two blank spaces.

2.3.16. Pagination.

2.3.16.1. Placement. Page numbers are to be centered at the bottom of the page on a line that is 1 inch above the page bottom.

2.3.16.2. Notices. No page number is listed at the bottom of the "NOTICES" page. Notices are always printed on the inside of the front cover.

2.3.16.3. DD Form 1473, other front matter, body of report, list of references and bibliography. Beginning with the Report Documentation Page (DD Form 1473), pages 1 and 2, report pages are numbered consecutively in ascending Arabic numerals through the bibliography. Section numbers do not precede the page numbers. The DD Form 1473, the table of contents, the list of tables, the list of illustrations, the first page of the report body (the introduction), the list of references, the bibliography, title pages of appendices, the first page of the text of each appendix, and the first page of the distribution list are always right-hand pages even though report pages are printed on both sides.

2.3.16.4. Appendices. Pagination in an appendix includes both the capital letter used to designate the appendix and an Arabic numeral. Pages are lettered and numbered consecutively in ascending Arabic numerals beginning with the title page for the appendix as the first page. Appendices are identified by capital letters: the first appendix is "APPENDIX A," the second is "APPENDIX B," etc. Thus, the first page in the first appendix would be designated as "A-1," while the fourth page in a third appendix would be designated as "C-4." A hyphen is placed between the letter and the number. The cover and first page of an appendix are always right-hand pages and a blank page is used between these as a left-hand page. If the pages of an appendix are already numbered and the original numbers of these pages are of no use to the reader, the numbers are deleted and the new page numbers are inserted. If both sets of page numbers are needed (and this is rare), the appendix designations (letter and number) must still be centered 1 inch from the bottom of the page. (See Appendix A of this manual.) When only one appendix is used in a report, it is labeled "ADDENDUM," and is given no letter designation. The pages of an addendum follow the consecutive pagination of the rest of the report.

2.3.16.5. Glossary. A glossary is useful in a report that uses many technical terms that need definitions (see Appendix P for aid in writing definitions). Pages in this section begin a new sequence of ascending Arabic numerals, and each numeral is preceded by the capitalized word "Glossary" and a hyphen. Thus, the second page in a glossary would be designated as "Glossary-2." This designation is centered 1 inch above the bottom of the page.

2.3.16.6. List of abbreviations, acronyms, and symbols. Pages in this section begin a new sequence of ascending Arabic numerals, and each numeral is preceded by the capitalized word "Abbreviations" and a

hyphen. Thus, the fifth page in this section would be designated as "Abbreviations-5." This designation is centered 1 inch above the bottom of the page.

2.3.16.7. Index. An alphabetical index of key terms is often useful in a long report. When it is included, each of its consecutively numbered pages is preceded by the capitalized word "Index" and a hyphen. The pages include a new sequence of numbers beginning with the first page of the index which will be designated as "Index-1." All page designations are centered 1 inch above the bottom of the page.

2.3.17. Multiple-Volume Reports. All format requirements previously listed also apply to multiple-volume reports. However, the following guidance is also provided.

2.3.17.1. Front cover. After the last line of the report's title, double-space and center the multiple-volume information (e.g., "VOLUME 1 of 2," "VOLUME 2 of 2").

2.3.17.2. "TABLE OF CONTENTS" page. A complete table of contents must be included in all volumes of any report. However, the report audience needs to be able to locate the information that appears in each volume. After the "Section/Page" line, double-space and center the phrase "VOLUME 1." Double-space again and list all information that can be found in this volume. Repeat this process until all volumes are listed. A sample of this can be seen in Figure 2-7.

2.3.17.3. Page numbering. The DD Form 1473 is always page 1 of a report, regardless of the number of volumes involved. Pages are numbered consecutively in order of Arabic numerals through the bibliography.

2.3.17.4. Exceptions. Special considerations of multiple-volume reports can be coordinated through the Technical Editorial Office to resolve situations unique to specific manuscripts.

3.0. PUNCTUATION AND CAPITALIZATION

3.1. General

Rules governing punctuation and capitalization--or what is also called mechanics--ideally help to clarify the meanings of single words and statements. The following paragraphs, therefore, provide specific advice on those areas of mechanics that can cause problems for the technical writer. Certain rules are not treated for one of two reasons: either they rarely apply in engineering report writing (such as those governing apostrophies), or their proper usage is widely known (such as the rule specifying the placement of a period at the end of a sentence). In sum, the rules which follow do not specify all uses of each punctuation mark and all cases when capital letters are used; they rather point out problem areas.

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Figure 2-7. Sample of Multiple-Volume "TABLE OF CONTENTS" Page

3.2. Punctuation

3.2.1. Period.

3.2.1.1. Headings. Periods are used after each number that precedes a heading title. Periods are only used after the heading titles of tertiary and fourth-level headings.

3.2.1.2. Spaced periods. Spaced periods are used between titles and corresponding page numbers in the table of contents, in the list of illustrations, and in the list of tables. The first spaced period is placed one or two spaces after the last word of the title (periods must be vertically aligned). The last spaced period is placed in the space immediately preceding the space below the letter "P" in the heading "Page."

3.2.1.3. Abbreviations. Periods are not used after abbreviations unless the abbreviation spells a word. Thus, one would write yd, ft, and mm instead of yd., ft., and mm., but, would write in. to abbreviate the word inch.

3.2.1.4. Periods and quotation marks. Periods are always placed inside quotation marks.

3.2.1.5. Periods and parentheses. If the material in a parenthetical statement is a complete sentence and follows a completed sentence, a period is placed inside the second parenthesis, and a period comes at the end of the preceding sentence.

Example: The engineer verified the document. (The technician verified it, too.)

If the parenthetical material is a complete sentence and interrupts another sentence, it contains no period.

Example: The engineer used the computer (the computer was fixed yesterday) to solve the equation.

If the parenthetical material is not a sentence and yet comes at the end of a sentence, there is no period following the sentence which precedes it; the period follows the parentheses.

Example: The engineer verified the document (so did the technician).

3.2.2. Comma.

3.2.2.1. Numbers. (See par. 2.3.15.2.)

3.2.2.2. Clauses. Comma usage varies with different types of clauses. A clause is a group of words containing both a subject and a verb. Independent clauses can stand by themselves as sentences. Dependent adverbial and adjective clauses must be attached to independent clauses.

Commas should be placed as follows: (1) after the first independent clause in a compound sentence (that is, a sentence composed of at least two independent clauses); (2) after an introductory adverbial clause; and (3) both before and after a nonrestrictive (nonessential) adjective clause.

Example: (1) The engineers studied the needs of the organization, and then they proposed a solution.

Example: (2) After studying the needs of the organization, the engineers proposed a solution.

Example: (3) This plastic battery box, which Blowhard designed, helps us save money.

3.2.2.3. Series. A comma is used after each item in a series preceding the word and.

Example: Track components in a combat vehicle consist of end connectors, center guides, shoes, and connecting pins.

3.2.2.4. Coordinate adjectives preceding a noun. A comma is used to separate coordinate adjectives preceding a noun when the "and" is omitted.

Example: This fast, efficient method should be explored.

3.2.2.5. Introductory participial phrases. A comma is used after an introductory participial phrase.

Example: Designed to replace the metal fuel tanks in 5-Ton Trucks, these plastic tanks are safe and cost-effective.

3.2.2.6. Conjunctive adverbs. A conjunctive adverb (thus, however, therefore, nevertheless, clearly, etc.) is (1) followed by a comma when it begins a sentence, and (2) set off by commas when it interrupts a sentence.

Example: (1) However, this procedure is more expensive than rotocasting.

Example: (2) This procedure, however, is more expensive than rotocasting.

3.2.3. Colon.

3.2.3.1. Colons and lists. A colon is used to introduce a list of items if the list is relatively short and is run into the text (either with or without numbers). If some priority of sequence or importance is to be noted, each item is preceded by an Arabic numeral beginning with 1. The numbers are enclosed in parentheses. A colon is also used to

introduce lists of items that are indented five spaces from each margin and preceded by either numbers or "bullets" (see par. 2.2.8.). Usually these items are not complete sentences. When the items are complete sentences, a period is placed at the end of the textual material before the indented list. (See also par. 3.2.4.)

3.2.3.2. Colon and emphasis. Placing a colon before a list of items certainly emphasizes the importance of those items. A colon is also used to give emphasis to a sentence following it. Usually the sentence introduced by the colon in some way explains or clarifies the information presented in the sentence preceding the colon.

3.2.3.3. Colons in proportions and ratios. Single colons are used among elements of a proportion (as in a 5:2:1 mixture). Double colons are used to show ratios.

3.2.4. Bullets. Listed items are "bulleted" for emphasis. A bullet is especially useful when one wishes to list items of equal importance. A "bullet" is made by typing a lowercase o and filling it in. The first two sections of this manual (1.0. and 2.0.) both contain bulleted lists. Use the guidelines below when "bulleting" items.

- Indent the material five spaces from each margin. The sixth space of the first line begins with a bullet followed by two blank spaces (as illustrated here).
- Skip one line between bulleted items.
- Further subdivision of bulleted items begins with a dash on the next line underneath the first letter of the heading (see par. 2.2.).

3.2.5. Parentheses and Brackets.

3.2.5.1. Parentheses. Parentheses are used to enclose the following: each item number in a list based on sequence of importance, a cross-reference instruction containing the word "see" and a heading number, and textual material that briefly interrupts the grammatical or logical flow of a sentence.

3.2.5.2. Brackets. Brackets are used to enclose the following: corrections, explanations, omissions, editorial comments, or mathematical material treated as a unit.⁶

3.2.6. Italics. The typewriter equivalent of printed italic type is underlining. The following types of material are underlined: secondary headings, titles of long publications such as books and extended reports, and words specifically identified within a passage (as in "Capitalize the word Table").

3.2.7. Hyphen. The typed hyphen is used as follows in technical writing: between elements of some compound nouns and unit modifiers (see par. 4.2.), in chemical formulas (see GPO Style Manual, Rules 6.4². and 6.44.), and at the end of a line to indicate word division. Use a double hyphen with no spaces between letters of two words for a dash-- instead of a single hyphen with a space on either side.

3.2.8. Degree Sign. Use the degree sign (°) and the word "degrees" as shown:

- 49° below zero
- -15 °C
- 45 to 65 °F
- 150 million degrees Fahrenheit
- a 45-degree angle
- 45° north latitude
- a polariscopic test of 83°

3.2.9. Other Signs/Symbols. The quotation mark (") should not be used to designate inch(es); use in. The apostrophe should not be used to designate feet; use ft without a period. The pound sign (#) should not be used for either pound or number. The percent sign (%) should only be used in tables or when it appears excessively throughout the text of a report; spell out the word percent in all other cases.

3.3. Capitalization

3.3.1. General. Chapter 4 of the GPO Style Manual offers an extensive list of words that should be capitalized.

3.3.2. Capitalization of Headings. (See par. 2.3.13. of this report.)

3.3.3. Capitalization of Proper Names. All proper names and derivatives of proper names unless they have "acquired independent common meaning" (see GPO Style Manual, Rule 3.4.) are capitalized. A common noun used as a shortened form of a clearly specified proper noun is also capitalized (as in using the word "Command" to refer to the U.S. Army Tank-Automotive Command).

3.3.4. Capitalization of Abbreviations. Capitalization of abbreviations should generally follow capitalization of the word or words abbreviated. (Refer to the technical abbreviations listed under par. 4.1.)

4.0. ABBREVIATING AND COMPOUNDING

4.1. Abbreviating

Spell out the word the first time an abbreviation is used. This is to insure that the audience understands exactly the word being used.

MIL-STD-12C (abbreviations for use on Drawings, Specifications, Standards and in Technical Documents) allows the use of the same abbreviation for several words, e.g., G or g is used for girder, glass, gyp-tal cloth, gravity, grounded (outlet), single glass, and gram.

Therefore, always spell out the word the first time it is used. Show the abbreviation in parentheses immediately following the word. Then be consistent--use the abbreviation throughout the remainder of the document.

In general, abbreviations for measurement and technical terms will be used without periods. For example, one would write yd, ft, and lb. In cases where an abbreviation spells a word (as in inch), use a period (in.). Some common abbreviations follow.

ABBREVIATIONS

abcoulomb	aC	inside diameter	id
abvolt	aV	joule	J
acceleration of gravity	g	kilo	k
afternoon	p.m.	kilogram	kg
alternating current	ac	kilometer	km
ampere	A	kilopascal	kPa
ampere-hour	Ah	kilovoltampere	kVA
ampere-turn	At	kilowatt	kW
amplitude modulation	AM	kilowatthour	kWh
angstrom	Å	liter	L
atomic weight	at wt	low frequency	LF
audiofrequency	AF	logarithm	log
azimuth	AZ	magnetomotive force	mmf
board measure	bm	maximum	max
boiling point	bp	megahertz	MHz
brake horsepower	bhp	melting point	mp
brake mean effective pressure	bmeP	meter	m
brake specific fuel consumption	bsfc	micro	μ
British thermal unit	Btu	microfarad	μf
center of gravity	CG	micrometer	μm
centimeter	cm	mile	mi
chemically pure	c.p.	miles per gallon	mi/gal
circular mil	cmil	milli	m
constant velocity	CV	millimeter	mm
cord-foot	cd ft	million	M
cosine	cos	milliradian	mr
coulomb	C	millisecond	ms
cubic	cu	minimum	min
		morning	a.m.

ABBREVIATIONS (Continued)

cubic centimeter	cm ³	net weight	net wt
cubic feet per minute	ft ³ /min	Newton	N
cubic foot	ft ³	Newton meter	N·m
cubic inch	in ³	ohm	Ω
cycles per minute	c/m	outside diameter	od
cycles per second	c/s	parts per million	p/m
decibel	dB	Pascal	Pa
decibel unit	dBu	pound per foot	lb/ft
decimeter	dm	pound-force	lbf
degree Celcius	°C	pound-mass	lbm
degree Fahrenheit	°F	pounds per second	pps
degrees per second	deg/s	pounds per square inch	lb/in ²
diameter	D	pounds per square inch absolute	psia
direct current	dc	pounds per square inch, gage	psig
electromotive force	emf	radian per second	rad/s
elevation	Fl.	radiofrequency	RF
farad	F	radius	R
field of view	FOV	revolutions per minute	r/min
foot	ft	root mean square	rms
foot per minute	ft/min	sine	sin
foot per second	ft/s	specific fuel consumption	sfc
foot-pound	ft·lb	square centimeter per second	cm ² /s
frequency modulation	FM	square foot	ft ²
gallons per minute	gal/min	square inch per second	in ² /s
gigahertz	GHz	standard cubic foot	stdft ³
gram	g	steradian	sr
gross horsepower	ghp	superhigh frequency	SHF
gross vehicle weight	gvw	thousand	k
gross weight	gr wt	ultrahigh frequency	UHF
Hertz	Hz	very high frequency	VHF
high explosive	HE	very low frequency	VLF
high frequency	HF	volt	V
horsepower	hp	volume	vol.
horsepower-hour	hph	watt	W
inch	in.	wave length	λ

4.2. Compounding

A compound word is a union of two or more words, either with or without a hyphen. It conveys a unit idea that is not clearly or quickly conveyed by the compound words in unconnected succession. The hyphen in a compound is a mark of punctuation that not only unites but separates the component words, and thus facilitates understanding, aids readability, and insures correct punctuation.

4.2.1. General Rules.

(1) In general, omit the hyphen when words appear in regular order and the omission causes no ambiguity in sense or sound.

Examples: banking hours
patent right
oil pressure

(2) Words are usually combined to express a literal or non-literal (figurative) unit idea that would not be as clearly expressed in unconnected succession.

Examples: afterglow
right-of-way

(3) Unless otherwise indicated, a derivative of a compound retains the solid or hyphenated form of the original compound.

Examples: coldbloodedness
footnoting
Y-shaped

(4) Except after the short prefixes co, de, pre, pro, and re, which are generally printed solid, a hyphen is used to avoid doubling a vowel or tripling a consonant.

Examples: cooperation
deemphasis
micro-organism
ultra-atomic

(5) Print solid two nouns that form a third when the compound has only one primary accent, especially when the prefixed noun consists of only one syllable or when one of the elements loses its original accent.

Examples: airship
footnote
locksmith
crewmember

(6) Print solid a noun consisting of a short verb and an adverb as its second element, except when the use of the solid form would interfere with comprehension.

Examples: blowout
flareback
markoff
but cut-in
run-in
tie-in

(7) Compounds beginning with the following nouns are usually printed solid.

Examples:	book	house	school	way
	eye	mill	shop	wood
	horse	play	snow	work

(8) Compounds ending in the following are usually printed solid, especially when the prefixed word consists of one syllable.

Examples:	berry	keeper	piece	weed
	blossom	keeping	power	wide
	boat	light	proof	wise
	book	like	room	woman
	borne	maker	shop	wood
	bound	making	smith	work
	brained	man	stone	worker
	bush	master	store	working
	fish	mate	tail	worm
	flower	mill	tight	wort
	grower	mistress	time	writer

(9) Print solid any, every, no, and some when combined with body, thing, and where. When one is the second element, print as two words if meaning a single or particular person or thing. To avoid mispronunciation, print no one as two words at all times.

Examples:	anybody	everybody	somebody
	anything	nothing	something
	no one	someone	everyone

4.2.2. Unit Modifiers. Print a hyphen between words, or abbreviations and words, combined to form a unit modifier immediately preceding the word modified, except as indicated in par. 4.2. This applies particularly to combinations in which one element is a present or past participle. Below is a list of rules for using hyphens in unit modifiers.

(1) Do not use a hyphen in a unit modifier consisting of two nouns.

Examples:	gust front conditions
	storm research programs

(2) Use a hyphen in a unit modifier consisting of an adjective and a noun or a noun and an adjective.

Examples:	dual-wavelength radar
	above-average frequencies
	part-load operations
	full-load performance

Exception: Print without a hyphen a two-word modifier the first element of which is a comparative or superlative, e.g., higher level decision.

(3) Use a hyphen in a combination of color terms used as a unit modifier.

Example: Silver-gray body

(4) Use a hyphen in a combination that contains numbers.

Examples: three-dimensional model
two-axis anemometer

(5) Use a hyphen when a connecting word is implied.

Examples: north-south alignment
air-sea interaction
winter-fall maxima

(6) Use a hyphen in an improvised compound containing a verb, or three (or more) words.

Examples: jack-up capability
cloud-to-ground strokes
roof-to-wall connection

(7) Use a hyphen in a unit modifier containing a present or past participle (or words in -ed and -ing forms).

Examples: broad-based support
river-crossing maneuvers
many-faceted research

(8) Do not insert a hyphen in a proper name, but use a hyphen when the phrase is used generically.

Example: Severe Thunderstorm Watch
but severe-thunderstorm watch

(9) Use a hyphen in modifiers containing the adverb well, still, or ever.

Examples: well-kept laboratory
still-new dynamometer

Exception: Do not use a hyphen with those words when they are modified by another adverb, e.g., very well kept laboratory.

(10) Do not use a hyphen in a two-word unit modifier, the first element of which is an adverb ending in "ly."

Examples: eagerly awaited moment
wholly owned subsidiary
externally mounted gun

4.2.3. Technical Terms. Print a hyphen between the elements of technical compound units of measure.

Examples: passenger-mile
light-year
horsepower-hour

Exception: kilowatthour

4.2.4. Numerical Compounds. Use a hyphen between elements of compound numbers from 21 to 99 and in adjective compounds with a numeric element first.

Examples: twenty-one
twenty-first
24-inch ruler
8-hour day

4.2.5. Fractional Compounds. Use a hyphen between the elements of a fraction, but omit it between the numerator and denominator when the hyphen appears in either or both.

Examples: one-thousandth
two one-thousandths
three-fourths of an inch
two-thirds
twenty-one thirty-seconds

4.2.6. Capital Letter Words. Use a hyphen to join a single capital letter to a noun or participle.

Examples: H-bomb
I-beam
V-necked
T-shaped
T-square
V-blade

4.2.7. Improvised Words. Print a hyphen between elements of an improvised compound.

Examples: blue-pencil
state-of-the-art
18-year-old
know-how

5.0. SPELLING

5.1. Spelling Called for by GPO Style Manual

In general, the preferred spelling of Webster's International Dictionary is to be followed. Items listed here either indicate spelling peculiar to the Army (called for by the GPO Style Manual) or items generally misused in manuscripts.

Affect, effect:

- affect--denotes influence, operation, action upon, concern.
For report purposes, always a verb.

Example: This adjustment affects the length of clutch pedal free travel.

- effect--denotes consequence of result (noun); bring about, carry out, fulfill (as a verb).

Example: Noun: The effect of preventive maintenance will be this: Your truck will be ready to go.

Verb: This rule will effect a change.

Align--this is correct. Do not spell it "aline."

All right--not alright.

Dipstick--is spelled as one word.

Disk--is the preferred spelling. Do not use disc.

Electrooptics--is the preferred spelling. Do not use electro-optics.

Fuse--to denote melting together or an electrical safety device.

Fuze--is the device used to initiate detonation or to start flame.

Gauge--is the preferred spelling. Do not use gage.

Ensure--preferred spelling. Do not use insure.

Material--parts, goods, or stock of which anything is composed or made.

Materiel--supplies, stores, and equipment of all types used by Armed Forces including instruments, vehicles, clothing, and ammunition.

Permissible--not permissable.

Pickup--one word when used as an adjective (pickup truck) or a noun (an electrical pickup).

Pick up--two words when used as a verb (pick up the signal).

Power-takeoff--the word "takeoff" when used with "power" is one word.

Road wheel--is spelled as two words.

Tailgate--is spelled as one word.

Taillight--is spelled as one word.

Time frame--is spelled as two words.

X ray--is two words when used as a noun (he examined the x ray).

X-ray--is hyphenated when used as a verb (he x-rayed the armor) or as an adjective (the x-ray machine was broken).

5.2. Words Easily Misspelled

This section presents, clearly and succinctly, the basic information about some of the most commonly misspelled words.

5.2.1. Double Consonants. A single consonant following a single vowel and ending a monosyllable or a final accented syllable is doubled before a suffix beginning with a vowel.

Bag, bagging, bagged.

Corral, corralling, corralled.

Occur, occurring, occurred.

Permit, permitting, permitted.

Red, reddish.

Refer, referring, referred (but not reference).

Control, controlling, controlled.

The following are exceptions to the rule.

Level, leveling, leveled.

Parallel, paralleling, paralleled.

Travel, traveling, traveled.

Cancel, canceling, canceled.

Label, labeling, labeled.

If the accent in a derivative falls upon an earlier syllable than it does in the primitive, the consonant is not doubled.

Refer, reference.

Prefer, preference.

Infer, inference.

5.2.2. Endings "cede," "ceed," and "sede."

Only one word ends in "sede" (supersede).

Only three words end in "ceed" (*exceed, proceed, and succeed*). All other such words end in "cede" (*precede, secede, etc.*).

6.0. READABILITY

6.1. Word Choice

6.1.1. Using Simple Language. Official writing does not demand big words or fancy phrases. Write naturally--in the words you use to speak. The sense and strength of English is in its small, often one-syllable words. Not only do they save preparation time, they improve the vigor of your writing and the clarity of your ideas.

<u>Instead of</u>	<u>Try</u>
accomplish	carry out
accordingly	so
actual	real, true
as a result of	because of
consideration should be given to the fact that	note, or note that
despite the fact that	although, though
due to the fact that	due to, since
facilitate	ease, help
goes without saying	(unnecessary--leave out)
in accordance with	with, or per
in order to	to
in regard to	on, about
in view of the fact that	because, as
perform	do
provided that	if
regarding	about, of, on

render	give, make
therefore	so
there are (there is)	(leave out)
until such time as	until
used for fuel purposes	used for fuel
(the) use of	(leave out)
utilize, utilization	use
viable	workable

6.1.2. Avoiding Word Confusion Errors.

all ready (prepared)	all together (collectively)
already (previously)	altogether (completely)
awhile (for some time)	ascent (rise)
a while (a short time)	assent (consent)
born (birth)	capital (city)
borne (carried)	capitol (building)
casual (unimportant)	complement (completing)
causal (resulting)	compliment (praise)
councilor (of council)	device (gadget)
counselor (advisor)	devise (plan, contrive)
discreet (prudent)	dyeing (coloring)
discrete (distinct)	dying (ceasing to live)
elicit (to draw)	envelop (to wrap up or in) (v.)
illicit (illegal)	envelope (the wrapper) (n.)
expose (a disclosure) (n.)	farther (distance)
expose (to lay open) (v.)	further (not distance)
indict (to accuse)	inequity (unfairness)
indite (to compose)	iniquity (sin)
ingenious (skillful)	mil (1/1000-inch)
ingenuous (simple)	mill (1/1000 dollar)
preemptory (decisive)	perquisite (privilege)
preemptory (seizing)	prerequisite (requirement)
personal (individual)	perspective (view)
personnel (staff)	prospective (expected)
precedence (priority)	principal (chief)
precedents (usage)	principle (proposition)
sometime (formerly)	spacious (space)
some time (some time ago)	specious (plausible)
sometimes (at times)	
stationary (fixed)	
stationery (paper)	

6.1.3. Overworked Words and Phrases to Avoid in Writing.

effect, effected (as a verb)
focal point
ideal, ideally
immeasurable
implement(ed) (as a verb)
render
unacceptable
vital
vast
very
extremely
excellent
commence
reflect
image
finalization
to include (including)

6.2. Sentence Structure and Grammar

Sentences, not words, are the essence of writing, just as equations and functions, and not bare numbers, are the real guts of mathematics. Most English sentences are made with a subject, verb, and direct object. The subject is a noun or a noun equivalent (pronoun, noun clause, gerund, infinitive) that is the starting point of the statement. A verb is a word that has forms (like go, goes, gone, going) and in a sentence agrees with the subject. In a typical sentence, the verb follows the subject and, like the subject, is often the nucleus for modifying words. The direct object of a verb is a word or group of words, usually following the verb, that names the recipient of the act expressed by the verb. It answers the question asked by adding "what" or "whom" after the verb. The complement is a noun or adjective in the predicate which follows a linking verb. In contrast to an object, a complement is related to the subject rather than the verb, for it follows verbs expressing condition rather than direct action. The typical order of the main sentence elements is subject, verb, object (or subject-linking verb-complement) and is the order in which we make most statements and the means by which we understand them.

6.2.1. Tense. The subject of a sentence or clause determines the verb form that goes with it. Correspondence between the subject and verb is called agreement. English verbs have six tenses: past, present, future, past perfect, present perfect, and future perfect. Tense of verbs must be consistent with the subject of the sentence and with other verbs in a passage. By using different tenses, a writer sets the time of the situation he is describing, and also indicates for the reader the continuity of the action or explanation. It is important that the verb tenses are consistent and easy to follow. Use of the proper verb tense is essential if the reader of a technical report is to know if events

being discussed have happened, are happening now, or will happen some-time in the future. Here are some guidelines to follow when preparing a report:

- The aim of the introduction is to provide a definition of the work effort to be discussed and background concerning circumstances and events which prompted the work. Thus, the introduction deals almost exclusively with events in the past and, with the exception of such statements as "the purpose of this report is _____," should be written in the past tense.
- The main body, summary, and conclusions of the report have one thing in common: They all deal with what has already taken place (completion of laboratory or field tests, etc.) and should also be expressed in the past tense.
- Present and future tense verb forms are appropriate for portions of the report dealing with recommended future courses of action.

6.2.2. Voice. In scientific writing, the whole point is to emphasize the action taken and downplay the person who did it. English grammar has two voices (of the verb)--active and passive. A verb in the active voice is a normal, simple-type verb that emphasizes the person performing the action, i.e., "he" runs dynamometer tests. The passive consists of a form of "to be" plus the past participle, i.e., dynamometer tests are run (by him). Passive verbs are natural if the subject is unknown or unimportant, and we've just said that in scientific writing, the performer is unimportant to the experiment or project.

Therefore, it is not advisable to use personal pronouns. This will force writers into heavy use of the passive voice, and thereby, preparing a technical report describing events and actions rather than stressing the importance of the individual who performed the various tasks. However, exclusive use of the passive voice is not a hard-and-fast rule. Limited use of the active voice will help to make what otherwise might be dull subject matter, more appealing to the reader.

6.2.3. Parallel Elements. One way to clarify and simplify your message is by being consistent with the use of parallel elements. Where there are two items of the same type in a sentence or paragraph, the structure of the items should be as similar as possible. Conjoined items (linked by "and") in a list should be of the same type and have the same structure.

6.2.4. Wordiness. Good writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, and a composition, no unnecessary paragraphs. This requires that the writer make every word tell. It does not mean he should make all his sentences

short, or omit detail and treat his subject only in outline. The writer should question every word. If it doesn't carry its weight, don't use it.

Example: The use of "of" in such sentence construction as "all of the samples" or "some of the units" serves no useful purpose. The word "of" adds nothing to the main idea. A better way to state it would be: "all the samples" or "some units."

6.2.5. The Complexity of a and an. The correct use of the indefinite articles a and an causes considerable confusion among writers. To standardize usage in writing, the following rules are recommended.

Example: (1) Use a before:

- words beginning with consonant sounds:
a cannon, a book
- words beginning with vowels which are pronounced like consonants: a universal joint, a 1,000-HP engine
- words with a pronounced initial h:
a hat, a horse
- abbreviations or acronyms pronounced as a word:
a SALT treaty, a TACOM employee
- number collectives and some numbers:
a dozen, a hundred
- letters individually pronounced and whose pronunciation when spelled out would have a consonant sound (for example, the letter "Q" pronounced "kyoo"): a Z, a B

Example: (2) Use an before:

- words beginning with a vowel sound:
an apple, an oval
- words beginning with a silent, or unstressed "h":
an honor, an hour
- letters individually pronounced and whose pronunciation when spelled out would have a vowel sound (for example, the letter "F" pronounced "ef"): an F, an H, an HEW office, an M1 Tank

7.0. DOCUMENTATION

7.1. Using Footnotes

Place the footnote number immediately following and half a line above the quoted or paraphrased material, as shown in the example:

Example: pertaining to radio."³

7.1.1. In the Text. Footnotes in the text are numbered consecutively from 1 to 99, and then begin with 1A1 to 1A99. The footnotes are to be listed on a separate page at the end of the document. The separate page will be titled "LIST OF REFERENCES." In the event there are less than four footnotes in the report, they may appear on the same page as the material referenced rather than on a "reference" page. When footnotes are on the same page as the referenced material, a cutoff dash is required between the text and footnote. This dash starts two lines below the text at the left margin and is 1½ inches long. If two or more footnotes apply to the same page, double-space between each footnote.

7.1.2. In Tables. Footnotes to table material are labeled independently of footnotes in the text. Each table will carry its own footnote labeling sequence (see par. 2.3.11.10.). Footnotes are to appear in block style with the author's last name first, "title" of the source, publisher, publisher's geographical location, page number, and (date). Footnotes will be divided from the text of the table by a cutoff line 1½ inches long starting at the left margin of the table. If two or more footnotes apply to the same table, double-space between each footnote.

7.2. Preparing the "LIST OF REFERENCES"

The list of references is the list of footnotes from the text. Entries are listed in numerical order as cited in the text. This is always a separate page at the end of the report.

The format for footnotes will show the sequence number raised half a line, the author (last name first), "title" (in quotes), publisher, publisher's geographical location, page, and (date). See below and p. 57.

¹ Wallace, J.D. and Holdings, J.B., "Guide to Writing and Style," Battelle Memorial Institute, Columbus, OH, p. 79 (1966)

7.3. Including a Bibliography

A bibliography is a list of selected sources the writer consulted to complete the project. This is arranged alphabetically by author's last name. When the author's name is not available, the title of the work is listed first, in the same alphabetical order. In some ways, a bibliography repeats the information contained in the footnotes (or material on the "Reference" page); however, it provides the reader with

an alphabetical index for quick reference. It lists not only footnoted sources, but all sources consulted. The entries include books, newspaper and magazine articles, research reports, etc.

Each entry is single-spaced, the second and all subsequent lines are indented five spaces, and double-spacing separates individual entries (see p. 59). Examples are as follows:

- Lannon, John M., "Technical Writing," Little, Brown and Company, Boston, MA (1979)
- MIL-STD-847B, "Format Requirements for Scientific and Technical Reports Prepared by or for Department of Defense," (1983)
- "Lightweight Tow Bars," Army Research, Development & Acquisition Magazine, Alexandria, VA (November-December 1981)

7.4. Including an Index

An index is not required, but for some long reports (over 50 pages) it may be desirable. If used, the index should list pertinent subjects under every topic for which users are likely to look. Topics are listed alphabetically. The index is to be constructed to enable the user to locate easily any part, information, or topic in the text.

7.5. Security Marking Documentation

The following information was taken from AR 380-5, DOD Security Information Program Regulation, for safeguarding classified information.

Four symbols are used most often when marking classified documents. These are:

- (TS) for Top Secret
- (S) for Secret
- (C) for Confidential
- (U) for Unclassified

Whenever a symbol is used, it must appear in parenthesis.

7.5.1. Titles. A title shall be marked by placing the classification symbol immediately following and to the right of the item.

- Example: 5.0. LOCATION OF TESTING (U)
- 5.1. Location of Testing (U)

7.5.2. Sections or Paragraphs. Each section or paragraph will be marked with the appropriate classification symbol placed immediately

following that portion's number, or in the absence of a number, the symbol will go at the start of the paragraph.

Example: 5.2.2. (U) The engine was tested . . .

(U) The engine was tested . . .

7.5.3. Illustrations, Photographs, Figures, Graphs, or Drawings. These shall all be marked by putting the appropriate symbol immediately before the caption.

Example: Figure 1-3. (U) Tracks Used on Vehicles Tested

Consult AR 380-5, Chapter IV, for any further classification information.

8.0. EDITING

The Technical Editorial Office is to make sure that technical reports clearly convey and effectively document objectives, conclusions, recommendations, materials and methodology of engineering projects. The authors and typists, no matter how competent in their fields, cannot be expected to produce a report according to particular editorial standards. The editor (through training, natural talent or both) is a master of the English language, and is sensitive to the consistency in format, abbreviations, and detail. The author, or technical reviewer, verifies technical accuracy; the editor insures that the material presents the author's ideas clearly and concisely. Therefore, no matter whether the manuscript is produced by in-house writers or by contractors, it is to be edited by people familiar with the types of regulations and recommended practices given in this manual.

Contract monitors, therefore, should be reminded that when a formal report is required, the contract must include provisions (and funding) for a preliminary draft, to allow for editorial changes and final printing.

8.1. Relationship Between Editor and Writer

The editorial review, then, is the first step on the road to a finished product. The editor must insure that the specific rules and policies (outlined in MIL-STD-847B, the GPO Style Manual and this style guide) are followed concerning the elements of a report. The editor's first concern, however, is to help an author produce an excellent report. This concern requires the editor to attend to many small details (requiring copy editing) and to various larger considerations (requiring content editing or rewriting). While straight grammatical editing--for spelling, punctuation, and sentence structure--is necessary, the editor is also concerned with the larger things: making a report as good as possible, and helping the author to be a better writer.

Good relations between the author and the editor are essential to produce a good report. As with any relationship between two people, each party must take responsibility for making the relationship work. If one party is uncooperative, the other's job becomes very difficult. Just as editors are language experts, authors are technical experts. They must be the final judges of the content of their report, assuring completeness, accuracy, and relevance. An editor may always suggest changes, but the author must take the final responsibility for the technical content. For both parties to obtain their goal--an excellent report--good relations are essential.

The editor who is without specific technical knowledge should be wary of making arbitrary changes in language that might change technical meaning. An editor might make a lovely sentence out of an awkward one by repositioning clauses and phrases; when this is done, however, technical meanings might be changed. The editor should make certain, by question marks or lists of questions with page numbers, that the author sees every major change.

Likewise, the author must read both the edited manuscript and any proof copies with great care to make sure errors do not creep in. It is important for the author to check all numbers, whether statistics, references to figures, tables, or footnotes. Tedious though it may be, this task is vital, and this is the time for changes, not later after the report is printed.

8.2. Relationship Between Editor and Typist

Most of the marks on the manuscript are formatting instructions to production people, i.e., typists and word processor operators, and are, therefore, not substantive changes. Usually these marks indicate formatting errors. Formatting procedures are found in par. 2.3. in this report. Standard proofreading symbols used by the technical editor are found in par. 8.3. Both the production people and the technical editors must become extremely familiar with proofreading symbols.

By using these symbols consistently, both the editor and the production people will be able to finalize the report and achieve the goals for which the report is written. These goals are to make it clear, concise and complete, correct, and technically accurate.

8.3. Proofreading Symbols

In reviewing a manuscript, the technical editor will use conventional proofreading marks. Shown below are the marks most often used. They should be legibly written and clearly marked in the text.

- (1) Missing punctuation--insert it.

Example: The period is missing_o

Example: In this case_f the comma is missing.

(2) Incorrect punctuation--cross it out and insert correct punctuation.

Example: After I wrote the sentence ~~g~~_h I proofread it.

(3) Misspelled or mistyped words--cross out or circle and write in correction, or correct word using insert and delete symbols.

Example: This word is misspelled. S

(4) To delete a word, use ~~o~~.

Example: Please file the ~~the~~ report.

(5) Word lined out in the text, you want to let it stand.

Example: Let it stand--used in the margin. Stet

Example: Let it stand--used in the text. - - - -

(6) Lower case a letter by drawing a diagonal line through it.

Example: The ~~f~~ar won't start.

(7) Capitalize a letter by underlining it with three strokes.

Example: We work for the uederal Government.

(8) Close up a space by using o or o.

Example: Please lock the car when ever you e leave.

(9) Insert a space by using #.

Example: The truck will ~~be~~ here later. #

(10) To indicate a new paragraph, use ¶.

(11) To insert a missing word--use a caret.


Example: The ^ is on the table. book


(12) Transposed letters or words, use u.

Example: The truck is on the ~~road~~_{road}.

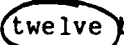
(13) To move copy left, use □.


Example: □ Use a left-facing bracket to move copy left.

(14) To move copy right, use .



Example: Use  a right-facing bracket to move copy right.

(15) Use figures or spell it out.

12 Example: There are  boys.

sp Example: There are  girls.

(16) Insert hyphen.

Example: The latest innovation will be a cost  effective 
measure.

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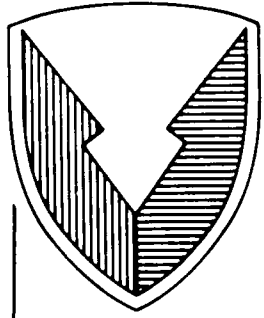
APPENDIX A

SAMPLE REPORT

RD & E

C E N T E R

Technical Report



No. 12657

LIGHTWEIGHT SADDLE TANK DEVELOPMENT

PHASE I--FABRICATION AND MATERIAL

FEASIBILITY TECHNOLOGY

CONTRACT DAAK30-78-C-0122

JULY 1982

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Warren, Michigan 48397-5000

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1.0. INTRODUCTION

This final technical report, prepared by Hollowform, Inc., for the U.S. Army Tank-Automotive Command (TACOM) under Contract DAAK30-78-C-0122, describes Phase One in the development and testing of safe, cost-effective plastic fuel tanks. Designed to replace the single metal fuel tank on the 2½-Ton Truck and the metal saddle tank on the 5-Ton Truck, these plastic tanks do not corrode or crack in normal wear and significantly reduce the possibility of rupture under stress. In addition, their lighter weight, space-saving designs, and energy-efficient fabrication process make plastic tanks more economical than existing metal tanks.

2.0. OBJECTIVE

The primary goal was to design and fabricate plastic fuel tanks that, when tested, would prove superior to the metal tanks currently used on 2½- and 5-Ton Trucks.

3.0. CONCLUSIONS

Further improvements in design and in fabrication procedures will allow us to effectively replace metal tanks currently used on 2½- and 5-Ton Trucks with plastic versions.

4.0. RECOMMENDATIONS

4.1. Aluminum Molds

The molds should be made of cast aluminum with shot-peened texture and should incorporate appropriately located, molded-in ribs and corner radii to maintain the tank shape as installed, thereby eliminating negative fuel-weight and side-wall pressure effects.

4.2. Sulfonated Tanks

Steps should be taken which will permit us to sulfonate the tanks internally.

4.3. Perforated Step-Plate

The incorporation of a perforated step-plate as a part of the tank design on the 2½-Ton Truck deserves further evaluation so that production costs can be reduced.

4.4. Standardized Connections

The feed, supply, return, and vent connections of the 2½- and 5-Ton Truck

tanks should be standardized. This will permit a common fitting to be used and then appropriately reduced to the required pipe size by way of a "close reducing bushing." This special collar fitting includes a locknut, washer, and gasket, and is similar to what is known as a "tank adapter." Cost savings will be achieved and the seal will be improved.

4.5. Further Recommendations

Recommendations derived from additional field testing should be considered in the final design and fabrication phase.

5.0. DISCUSSION

5.1. Background

Metal fuel tanks are currently used on 2½- and 5-Ton Trucks. The tank on the 2½-Ton Truck weighs 115 lbs and measures 19½ in. high, 30 in. long, and 28 in. deep. Each saddle tank on the 5-Ton Truck weighs 128½ lbs and measures 17½ in. high, 32½ in. long, and 27½ in. deep. These tanks, however, have distinct disadvantages:

- Corrosion--metal tanks corrode as a result of environmental conditions (humidity cycling in storage) and fuel degradation (chemical/microbial).
- Impact resistance--metal tanks frequently rupture at pressures under 4 pounds per square inch, gauge (psig).
- Cracking--weld-zone stress in metal tanks occasionally results in cracking.
- Heat resistance--metal tanks often explode during fires due to high thermal conductivity.
- Leakage--metal fuel tanks frequently leak at pressures under 4 psig.

Such problems can be eliminated or significantly minimized by replacing metal fuel tanks with plastic versions.

5.2. Design

The plastic fuel tanks were generally designed with dimensions identical to those of the current metal tanks so that transition would be easy. However, several minor modifications were made. One of these changes involved securing the plastic tank. First, grooves (as shown in Figures 5-1 and 5-2) were provided for the existing mounting straps. Tank slippage caused by sudden movement was thereby reduced. In addition, to compensate for the difference in strap location on the sides of the



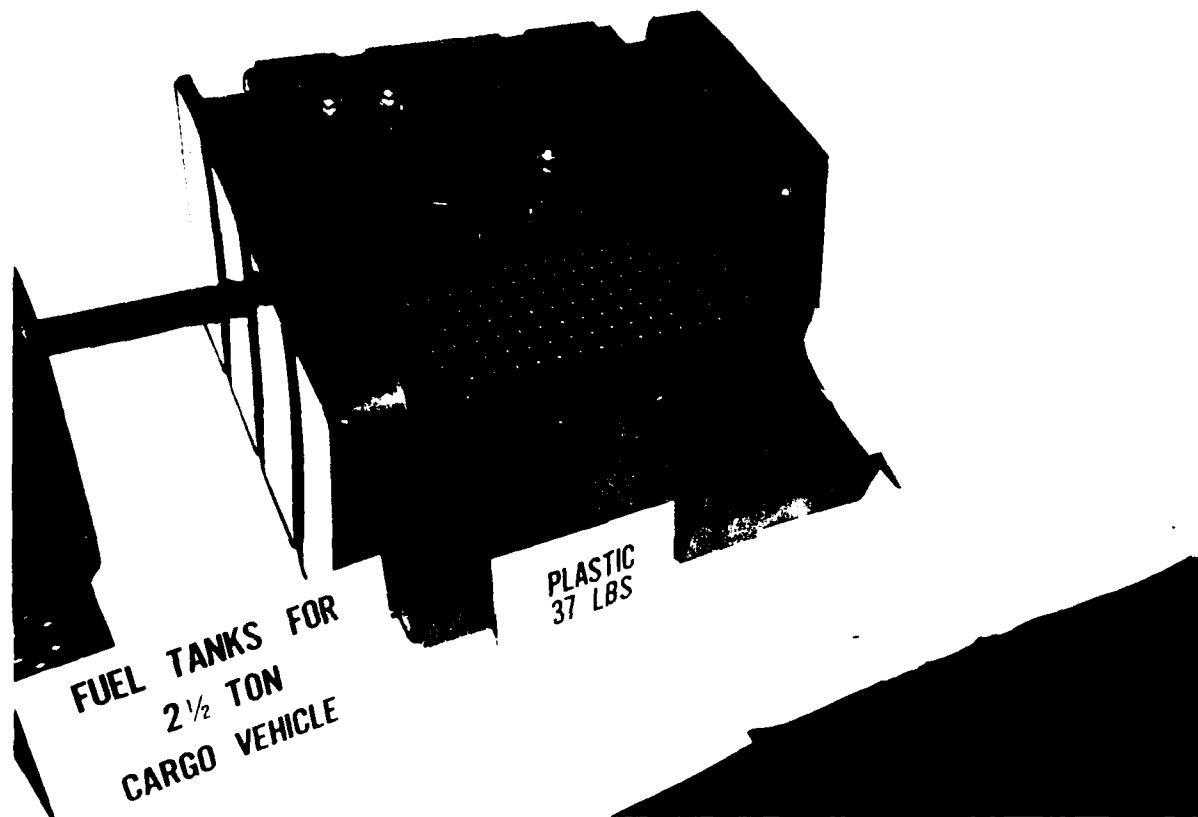


Figure 5-1. Plastic Fuel Tank for 2 $\frac{1}{2}$ -Ton Truck (Plastic Version of P/N RCSK 5701)

chassis, the groove width was increased. A more significant modification was made in the filler assembly and fill cap designed for the plastic tanks. Because using different hardware on the 2½- and 5-Ton Truck tanks is inefficient, a single design was adopted for both plastic tanks. The design chosen was that used on the ¼-Ton Truck. Not only did this substitution standardize parts, but it also provided a cap that could be easily removed in all climates. In addition, the component filler-neck assembly was modified to provide a flange for the stud mounting on the plastic tank, and the fitting hardware was designed so that the plastic would only be subjected to compressive loads since it exhibits "cold-flow" characteristics.

Molded-in ribs, which parallel the strap grooves, are needed to carry weight to the tank side-walls and thereby prevent tank deformation and resultant fuel-gauge inaccuracy. This feature was not incorporated because no suitable location for the ribs could be found.

5.3. Material Selection

After evaluating numerous types of rotational-mold polyethylene materials and discovering that nylon materials are concluded to be brittle, the customer specified that cross-linked polyethylene be used. The tanks were thus molded using Marlex CL-100, dark green, manufactured by Phillips Petroleum Co. The physical properties and impact resistance of parts fabricated from this material are provided by Phillips Petroleum and delineated in Table 5-1 and Table 5-2. Specifically, Table 5-2 reveals the impact the container can withstand without leaking.

In addition to the benefits gained from such properties, tanks made of Marlex CL-100 offer significant weight savings. At 37 lbs, the 55-gal tank designed for the 2½-Ton Truck weighs 68 percent less than the existing metal tank while at 36½ lbs, the 58-gal tank developed for the 5-ton vehicle offers a weight savings of 72 percent. These weight savings should result in improved fuel economy.

Finally, unlike metal tanks, tanks constructed of cross-linked polyethylene are subject to neither corrosion nor contamination.

5.4. Fabrication and Tooling

Currently, two types of molding--blow-molding and rotational-molding--are used to produce one-piece hollow vessels such as fuel tanks. Although the shorter molding-cycle time of the blow-molding process results in lower part costs where high volume is demanded, the rotational molding process was adopted for a number of reasons:

- The product is totally stress-free;
- Materials suitable for this process have superior physical properties;

Table 5-1. Physical Properties of Marlex CL-100*

Property	ASTM Test	Value
Density of the Cross-Linked Product, gms/cc	D1505-68	0.930-0.933
Environmental Stress Cracking Resistance, Condition A, F50, hrs	D1693-70	1,000
Tensile Strength, Ultimate, psi 2 in./min	D638-72 Type IV Specimen	2,600
Elongation, At Break, percent 2 in./min	D638-72 Type IV Specimen	450
Vicat Softening Temperature, °F	D1525-70	240
Erittleness Temperature, °F	D746-73	-180
Flexural Modulus, psi	D790-71	100,000

*Based on parts molded at 650 °F for 13 min

Table 5-2. Drop Impact of a Molded Container*

Test	Weight When Filled with Water	Temperature of Water	Drop Distance
1.	800 gm	73 °F	30 ft
2.	800 gm	-20 °F	30 ft

*Based on 2-gal container molded at 600 °F for 14 min

- Tooling cost for small volume production is low;
- Mold-tooling lead time is relatively short; and
- Wall thickness is uniform.

This process of tank production requires less energy than that used to produce metal tanks; fabrication is less expensive. Due to time constraints, molds were made from fabricated and welded steel instead of cast aluminum. Cast aluminum molds, however, offer distinct advantages. First, using such molds produces greater radius corners and better fillets: these features strengthen the walls of the plastic tank, reducing the possibility of distortion. In addition, use of a cast tool allows shot-peening of the mold interior; such an interior produces a textured surface on the tanks eliminating the high gloss finish seen on the prototypes. The product finish thus more closely matches the standard military satin, forest green finish.

Finally, the tanks were treated to reduce fuel permeation. Two methods are normally used: external epoxy coating and internal sulfonation. The external coating method was adopted, for Hollowform is neither licensed nor equipped to sulfonate. Therefore, after flame-treating the exteriors of the tanks, they were sprayed with Barafene No. 1003 (Inmount Corp) and oven-cured.

5.5. Testing

5.5.1. General. The results of the following tests demonstrate the superiority of the plastic tank in impact resistance, heat resistance, and fuel retention. Wyle Laboratories technicians assisted us in pressure and temperature tests.

5.5.2. Impact Drop Test. As a specified test requirement, a tank 3/4-full of water was dropped 20 ft onto concrete, with impact point at a 45-degree angle to axis. The test temperature was 70 °F. After dropping a tank 25 ft, the tank was pressured to 4 psig and checked for leakage using a soap solution. No evidence of leakage appeared.

5.5.3. Falling Dart Test. The requirement was to strike a sample with a 1/2-in.-radius dart of 6 lbs; distance and material temperature were not specified. Hollowform's standard test method was thus used: with sample material at -20 °F, it was struck with a 1/2-in.-radius dart. Having withstood 66 ft·lbs of pressure without visible fracture, the sample passed the test.

5.5.4. High Temperature Test. Wyle Laboratories made the following report: The plastic fuel tanks were placed on 2- by 4-in. rails in the chamber and filled to their filler necks with customer-supplied diesel fuel. The fuel tanks were then subjected to the 7-day exposure at 130 °F.

The fuel tanks completed the 7-day exposure with no signs of leakage or capillary weeping around any insert filling. (See Addendum for complete report.)

5.5.5. Leakage Test. All finished tanks were tested at 4 psig and found to be acceptable. (See Addendum.)

SELECTED BIBLIOGRAPHY

Yiakas, C. D., Data Sheet Report No. 55404, Wyle Laboratories,
El Segundo, CA (12 April 1975)

ADDENDUM

WYLE LABORATORIES

12 April 1979

Hollowform, Inc.
6345 Variel Avenue
Woodland Hills, CA 91364

ATTENTION: Mr. Roy Newton
TEST TITLE: High Temperature
REFERENCES: Your Purchase Order No. 02153
Wyle Laboratories Job No. 55404
Government Contract No. DAAK30-78-C-0122

Gentlemen:

This is to certify that the enclosed Test Data Sheets contain true and correct data obtained in the performance of the test program as set forth in your purchase order.

Where applicable, instrumentation used in obtaining this data has been calibrated using standards which are traceable to the National Bureau of Standards.

Test Results

Two Plastic Fuel Tanks, one each of Part Numbers RLSK-5701 and 19207-11669354, were submitted for a 7 day Temperature Test at +130°F. The Fuel Tanks were placed on 2" x 4" rails in the chamber and filled to their filler necks with customer supplied diesel fuel. The Fuel Tanks were then subjected to the 7 day exposure at +130°F. The Fuel Tanks completed the 7 day exposure with no signs of leakage or capillary weeping around any insert fittings. The test conditions attained are presented in the enclosed Data Sheet which includes a typical 24 hour temperature recording and the test equipment used. At the conclusion of the test, the Fuel Tanks were returned to Hollowform while still filled with diesel fuel.

Enclosures: Data Sheets (3 Pages)

STATE OF CALIFORNIA }
COUNTY OF LOS ANGELES }

C. D. Yiakas, Department Manager, being duly sworn, deposes and says: That the information contained in this report is the result of complete and carefully conducted tests and is to the best of his knowledge true and correct in all respects.

C. D. Yiakas

SUBSCRIBED and sworn to before me this 18 day of April, 1979

William H. Vanderberg, Jr.



W-781

DEPARTMENT Mechanical Systems

TEST ENGINEER *R. L. Rice*
R. L. Rice

TEST WITNESS _____

Not Applicable
DCAS-QAR VERIFICATION

QUALITY CONTROL *V. W. [Signature]*

HOLLOWFORM, INC.
6345 VARIEL AVE.
WOODLAND HILLS, CALIF. 91364

PART TITLE: 5 Ton Army Tank
PART NUMBER: 19207-11669354
CONTRACT NUMBER: DAAK30-78-C-0122

HYDROSTATIC PRESSURE TEST
=====

Serial No.	P.S.I.G.	Time Pressured	Results	Test Date	Performed By
<u>9-080-01</u>	<u>4</u>	<u>2min.</u>	<u>H2OK</u>	<u>11 April 79</u>	<u>LWB/DMC</u>
<u>9-080-02</u>	<u>4</u>	<u>2min.</u>	<u>H2OK</u>	<u>"</u>	<u>"</u>
<u>9-079-02</u>	<u>4</u>	<u>2min.</u>	<u>H2OK</u>	<u>"</u>	<u>"</u>
<u>9-079-01</u>	<u>4</u>	<u>2min.</u>	<u>H2OK</u>	<u>"</u>	<u>"</u>
_____	_____	_____	_____	_____	_____
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_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Weight of completed part: 36.5 pounds

Testing Witnessed by: Dorothy McClendon
U.S. Army Rep.
Warren, Michigan



HOLLOWFORM, INC.
6345 VARIEL AVE.
WOODLAND HILLS, CALIF. 91364

PART TITLE: 5 Ton Army Tank
PART NUMBER: 19207-11669354
CONTRACT NUMBER: DAAK30-78-C-0122

PRESSURE TEST
=====

Serial No.	P.S.I.G.	Time Pressured	Results	Test Date	Performed By
<u>9-106-01</u>	<u>4</u>	<u>2min.</u>	<u>AOK</u>	<u>27 April 79</u>	<u>LWB/HK</u>
<u>9-081-01</u>	<u>4</u>	<u>2min.</u>	<u>AOK</u>	<u>"</u>	<u>"</u>
<u>9-086-01</u>	<u>4</u>	<u>2min.</u>	<u>AOK</u>	<u>"</u>	<u>"</u>
<u>9-106-02</u>	<u>4</u>	<u>2min.</u>	<u>AOK</u>	<u>"</u>	<u>"</u>
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Testing Witnessed by: Harry Kesler
Van Nuys DCAS Rep.

LWB

HOLLOWFORM, INC.
6345 VARIEL AVE.
WOODLAND HILLS, CALIF. 91364

PART TITLE: 2 1/2 Ton Army Tank
PART NUMBER: RCK5701
CONTRACT NUMBER: DAAK30-78-C-0122

HYDROSTATIC PRESSURE TEST
=====

Serial No.	P.S.I.G.	Time Pressured	Results	Test Date	Performed By
<u>9-086-02</u>	<u>4</u>	<u>2min.</u>	<u>H2OK</u>	<u>11 April 79</u>	<u>LWB/DMC</u>
<u>9-085-04</u>	<u>4</u>	<u>2min.</u>	<u>H2OK</u>	<u>12 April 79</u>	<u>"</u>
<u>9-086-03</u>	<u>4</u>	<u>2min.</u>	<u>H2OK</u>	<u>"</u>	<u>"</u>
<u>9-086-01</u>	<u>4</u>	<u>2min.</u>	<u>H2OK</u>	<u>"</u>	<u>"</u>
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Weight of completed part: 37 pounds

Testing Witnessed by: Dorothy McClendon
U.S. Army Rep.
Warren, Michigan

LWB

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APPENDIX B

GUIDELINES FOR
WRITING TECHNICAL DEFINITIONS

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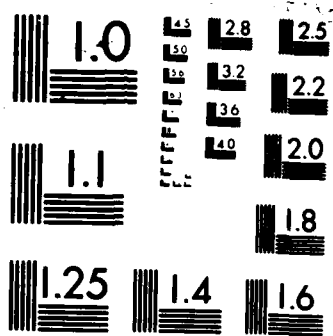
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Defining Through Simple Classification and Differentiation and Through Etymology. The writer should begin by stating the word to be defined (Holography is _____), classifying it, and then differentiating it from other items in the same class. If it is an unusual word, he also may want to give its etymology, that is, to provide information about the literal meanings of its parts [prefix(es), root(s), and suffix(es)]. He might, for example, consider this definition of chromatography (the quoted material is from Webster's Ninth New Collegiate Dictionary): Chromatography, which literally means color writing, is "the separation of closely related compounds by allowing their passage through an absorbent material so that each is absorbed in a different colored layer." Or he might study the definition of isothermal compression offered by the authors of Modern Technical Writing: Isothermal compression is the compression of a gas under such conditions that the heat generated by compression is removed as fast as it is generated, so that the temperature of the gas does not change. The meaning may be seen in that iso is a combining form meaning equal and that thermal refers to heat. Avoid "is when" or "is where" structures after the term.

Defining by Subdividing. If the word can be broken into several major classes or subdivisions, the writer should designate these classes and distinguish among them. For example, he might write the following: "There are essentially two methods of molding cross-linked polyethylene--blow-molding and rotational-molding. Blow-molding is _____. Rotational-molding is _____."

Defining Through Examples. If possible, a writer should give three or four examples of applications or products of a process. He should try to use examples that a reader might be familiar with.

Defining Through Related Terms. If the term can be easily confused with another term (either of broader or more specific meaning), the writer should distinguish between the terms.

Defining a Process. If the writer is defining a process rather than giving a technical description of a process, he will want to indicate, as the authors of Modern Technical Writing suggest, "why, where, when, and by whom the process is performed" as well as what special instruments or skills are needed for its effective performance. Often a technical definition precedes the more detailed technical description of an object or process.

Defining an Object. If a writer is defining an object, he might want to indicate its purpose, its main parts, its distinguishing attributes, and its uses. He could also include information about its origin, i.e., its invention or discovery. Appropriate figures--be they photographs, diagrams, or drawings--are also helpful as supplements to the text.

APPENDIX C

GUIDELINES FOR WRITING
TECHNICAL DESCRIPTIONS OF OBJECTS

Definition in Description. A technical description frequently begins with a simple definition of the object to be described in detail. The simple definition not only classifies and differentiates, but it also explains the overall physical features of the object--its size, shape, weight, composition, etc.

Organization of Description. The organization of the description is based on a listing of parts; however, the order in which the parts are discussed can vary. One of the following methods of organization can be used or they can be used in combination.

Organization Based on Visual Survey. The organization of a description is occasionally based on visual survey, that is, in the manner in which one looks at the parts of an object. Generally, these principles of visual perception apply: objects which are primarily horizontal in design are viewed from left to right while objects which are primarily of vertical design are viewed from top to bottom. One might also visually survey an object in a clockwise fashion or one might first survey the exterior and then survey all or part of the interior. As one seeks to show relationships among parts, one should use directional phrases such as to the right, directly below, and in the upper right-hand corner. Further, as a general rule, once one establishes a direction of movement, he should hold to it. Finally, in describing individual parts, it is helpful to provide any details of size, shape, composition, etc., which will help the reader visualize the object. For example, one might use letters to describe shape as in L-shaped, S-shaped, etc. For the most part, simple objects can be surveyed by a single-directional visual survey; more complex equipment may involve a change in directional movement or a combination of several separate moves. As a general rule however, visual survey should never move from right to left, from bottom to top, in a counterclockwise fashion, or from detail to overview.

Organization Based on the Order in Which the Parts Perform Their Functions. The organization of technical description is most frequently based on the order in which the parts perform their functions. This method is, of course, most appropriate when functions occur in sequence. If several parts function simultaneously to produce a single result in a single system, the writer should seek to clarify their relationship. If they function simultaneously as parts of different systems, he will only confuse the reader by noting their simultaneous movement. The governing principle here is logical sequence and interrelationship.

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