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THE PREPARATION OF HYDRAULIC LABORATORY REPORTS

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SUMMARY

This paper reports practices that have been found effective in the preparation of the Bureau of Reclamation's Hydraulic Laboratory reports. It discusses the desirable qualities of reports and presents methods for obtaining them. While the outlines and examples cited relate directly to laboratory reports, the principles and methods discussed are applicable to other types of technical writings and reports.

The paper stresses the importance of an outline in organizing the material for a report, and gives a simple method of expanding the outline into a finished manuscript. Procedures are suggested for preparation of the manuscript from writing the rough draft to final polishing. Suggestions for preparing attractive illustrations for the report are offered.

Finally, two methods of testing the report are given - one to determine the completeness and quality, and the other to test the readability of the text material.

INTRODUCTION

The technical report in the last decade has become increasingly important as a necessary part of scientific progress. The rapidly expanding specialized fields of science and engineering have made it indispensable in summarizing the work and progress of small units of an organization, and in coordinating the work of larger units. Since the

need for better technical writing has been fully recognized, many engineering organizations, including the Bureau of Reclamation, are attempting to improve their technical writing.

The text of this paper is arranged in the order of preparing a report from its inception to its conclusion. However, the section "Preparing the Figures" should be read before starting work on the report and preferably before starting the investigation.

ORGANIZING THE REPORT

Preliminary Considerations

Usually, the author of a report has worked with the material he is putting into report form and has in mind a detailed account of the subject matter. In any case, it is necessary for the author to become thoroughly familiar with the subject before attempting to write about it. Lacking familiarity, an author cannot write authoritatively or with a broad viewpoint. His product is likely to become an incoherent structure lacking in unity and proper assignment of relative values.

With the subject fully in mind, organization becomes a simpler task. By organization is meant the process of grouping subjects or material into proper divisions so that they may be presented in logical form. In organizing material, keep in mind the fact that you are not preparing a glorified diary. A diary necessarily contains repetitious procedures. These should be eliminated by grouping tests or procedures so that one explanation will serve for all. At this point, it is necessary that the author build up a picture of the reader--who is he, what are his interests, what does he already know about the subject, and what more

does he want to know. Then as the report is organized, determine what questions will arise in the minds of the readers and how they can be answered.

The most important single feature of a report is the proper organization of the subject matter. A report may be badly written, present a poor appearance, and contain obviously poor grammar, but its salvage value remains high if its organization has been skillfully accomplished.

A report is well organized when an extensive amount of highly technical material is presented in an interesting manner--in the least amount of space--without repetition in various phases of the presentation--when it is clear to the reader that he is following a well planned approach to the solution--and when the text may be read by the persons for whom the report is primarily written without becoming tiresome.

Be prepared to offer the reader more than cold data and figures. You, the author, know more about the data than anyone. It is your job to analyze them, supply interpretive comment, and draw logical conclusions.

Good organization is best accomplished by full and proper use of an outline.

Divisions of the Report

The main divisions of a typical report may be Summary, Introduction, Investigation (Body of Report), and Appendix. The following discussion gives the usual content of each.

Summary. The summary should be a condensed version of the report that follows. It should not be an introduction to the report.

It should be complete in itself and be an abstract of the investigation. More specifically, it should consist of brief statements covering the nature, purpose, or object of the investigation, the method of obtaining the results, and a brief review of the results obtained.

Recommendations may be presented separately or incorporated in the summary. In either case they should be labeled as such by direct statement. In some reports it may be desirable to use the term conclusions rather than recommendations.

Introduction. The introduction should introduce the subject to the reader who is sufficiently interested to continue beyond the summary. In accomplishing this, it is desirable to give the general history of previous research or the events leading to the present investigation. Certainly it will be necessary to state the need for the investigation, and the exact problem should be made known to the reader as soon as possible.

The plan of the investigation may be given briefly. Some analysis may be required if the plan is unusual or not generally understood, although extensive analysis should be avoided. Limitations on subject matter or scope of the work should be indicated here and not in the summary.

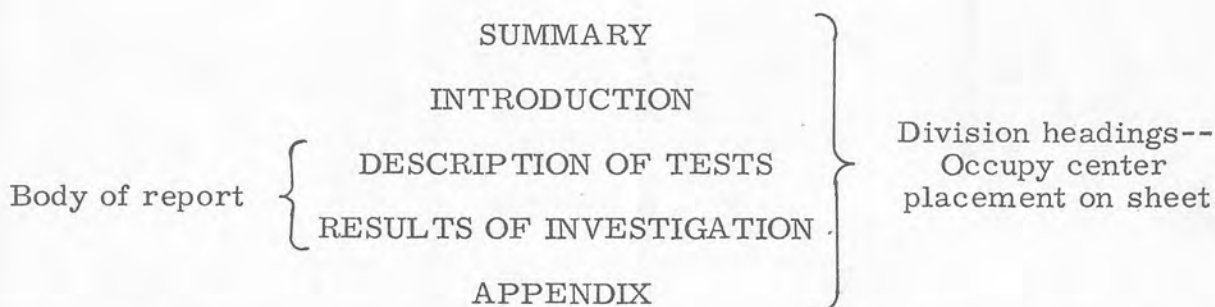
Body of the report. The body of the report usually contains the bulk of the written material and may consist of several or more divisions.

These should include information pertaining to the description of apparatus, methods used in the tests, detailed data, sample or indicated calculations, results of tests, and interpretive comment.

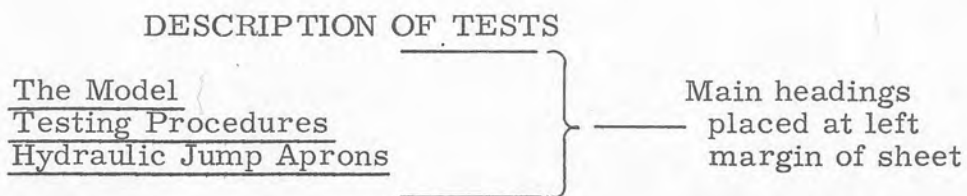
Appendix. The word "appendix" may be defined as "matter added to a book but not essential to its completeness, as a bibliography, notes, or tabular material." In general, the appendix should contain elaborate mathematical manipulations, discussions pertaining to calibrations, construction or operation of new types of testing equipment, evaluations of theories and processes, original data introduced as evidence or proof, bibliographies, and tabular matter not essential to the clarity of the text.

The Outline

The outline is an indispensable tool in organizing and writing a report. Let us start with a report consisting of five parts. These should be recorded as division or center headings in the outline.



The body of the report and the appendix should be subdivided into main headings, according to the material available for presentation. For example:



RESULTS OF INVESTIGATION

<u>Test Results - Series A</u>	}	Main headings
<u>Test Results - Series B</u>		

APPENDIX

<u>Calibration of Apparatus</u>	}	Main headings
<u>Theory of Pressure Distribution</u>		
<u>Bibliography</u>		

The structural pattern of this part of the report will probably be the most difficult to construct, and a good deal of thinking will be required to get this far. No standard form can be suggested which will fit all types of investigations. However, the problem can be met and solved as any engineering problem is solved. The subject of the investigation should be divided into smaller components, and each solved separately, keeping in mind the overall problem when working on any part.

Often there is a doubt as to how much of the investigation to include in a report. It is often believed that data and results of a negative nature are of no value and should not be included in the discussion. If only the specific problem at hand is considered, this is true, but in solving problems of a similar nature at some later date, negative results often prevent duplication of work. It has been demonstrated that for a given set of conditions, different groups of analysts working independently will often propose the same solution to a problem. If this obvious solution is found by experiment to be incorrect, and the facts are made known, future experimenters will be spared the trouble of learning for themselves the impractical nature of these same schemes.

The next step is to introduce divisions under the main headings. Indicate these divisions as paragraph headings (as used in this report).

Arrange these so that material is presented in a logical and orderly manner. It is not necessary that a chronological order be maintained in discussing a series of tests or subjects. Very often it is more convenient to group tests or subjects on the basis of similar properties or on the effects of different variables. The grouping should emphasize the important parts of the subject. The samples below show two outlines that cover the same material. Different emphasis is obtained in each case.

Outline I

DESCRIPTION OF TESTS

Hydraulic Jump Aprons A, B, C, and D

Effect of sloping floor

Effect of baffle piers

Effect of end sill

Emphasis on
various parts
of apron

Outline II

DESCRIPTION OF TESTS

Hydraulic Jump Aprons

Apron A

Apron B

Apron C

Apron D

Emphasis on
particular
aprons

Choose the outline that will require the least amount of repetition in discussing the tests. For example, if Aprons A-D are very similar, Outline II will require more repetition to describe the tests than will Outline I. Try to visualize the problems each outline will introduce or eliminate. Do more thinking and less writing. Each step should be planned to present the proper facts at the proper moment, in a way that indicates to the reader that he is approaching the solution to the problem. Try to organize your material as though you were proving a plane geometry theorem.

The reader should also be kept in mind when organizing a report. At all times the reader should be aware of the problem, the method proposed by the author for solving it, and the progress of the investigation, purely on the basis of the material presented. It

should not be necessary for the reader to have previous familiarity with the investigation to understand the full meaning of the facts presented. The reader should, by scanning the headings, be able to determine where the investigation leads, and at any time he should be able to judge his progress toward the ultimate goal.

Sectional and Other Headings

The title is the main heading in any report, and it should be selected with two points in mind; it should attract the interest of the prospective reader, and it should convey in a few words an accurate description of the contents of the report.

The same is true of the sectional headings used in the report outline. Since the headings will appear in the finished report, it is important that they be well chosen. A heading should be short so that it can be displayed in a single line (or less), and significant so that it indicates the exact content of the section it heads. Headings serve two useful purposes; they expedite the reading and understanding of the report, and they facilitate later reference to specific material.

Expanding the Outline

After the outline of the report has been arranged with main and subheadings, the outline should be expanded to include paragraph headings. Then, under each of the paragraph headings a resume' of the material to be discussed should be made, listing statements in their proper order. Outline I would appear as shown below.

DESCRIPTION OF TESTS

Hydraulic Jump Aprons A, B, C, and D

All tested for 10,000, 20,000, 50,000 cfs at max H.W. and normal T.W. Sweepout, erosion, and wave height meas. made. Pressures and water surface profiles taken. Photographed from 2 positions. Aprons A and C showed promise. Final tests to be conducted on these.

Effect of sloping floor

Deeper T.W. required. Jump not so stable. Excavation may be excessive.

Effect of baffle piers

Not effective in deep tail water. Taller piers necessary. May be impractical. Do not help sweepout limit.

Effect of end sill

Less effective in smoothing outflow. Helps prevent riverbed erosion. Optional if bed is good rock.

It should be emphasized that the entire outline should be kept as compact, but still as complete, as possible in all stages of its preparation. Thus, any reorganization deemed necessary can be completed without the time consuming operation of shuffling excessive amounts of material.

This is the secret in organizing a report. By presenting all the material in topic form on a few sheets of paper, the entire report may be seen at a glance.

It is important in the outline stage to survey the material under each heading to be certain that the heading described the material being presented. For example, under a heading "Description of Model" do not describe methods of testing or give some of the results. Confine this particular section to a description of the model.

Up to this point the outline has been intentionally kept abstract in form with little or no specific information visible, since the first problem is to make the presentation orderly and logical. Too many details in the early stages mask the general plan of presentation.

The final step in completing the outline consists of replacing the resume' with statements giving specific information rather than abstract references, using the resume' as a guide for determining the order of presentation. These statements should be written in the briefest form possible, even abbreviating words and phrases in an attempt to record thoughts rather than sentences. In this way, the flow of thought will be least disturbed by the mechanics of writing. Proper choice of words and construction of sentences are problems for later consideration.

The author should not hesitate to revise the outline as the report progresses if he finds that the actual writing out of his thoughts leads to new or improved concepts. Variations in the overall procedure may be made to suit individual preferences, but the basic process of formulating an outline is essential to good report writing.

WRITING THE REPORT

In writing the report from the expanded outline, emphasis should be placed on obtaining a text that is clear and complete, but

stated as briefly as possible in the simplest terms. The text should present an accurate analysis based on an honest evaluation of the data.

Preparing the Rough Draft

Probably the most encouraging statement that can be made to an author is that even the most experienced writer cannot produce a finished manuscript in the first writing. Considerable rewriting is usually necessary to produce a script that is worthy of the time spent in organizing and preparing the material. Abraham Lincoln, in a letter to a friend, expressed this same thought when he wrote, "I am writing you a long letter because I do not have time to prepare a short one."

When starting to write it is essential to free oneself of the attitude that writing is a disagreeable task to be disposed of in the easiest way. Some of this attitude can be overcome by mastering the subject in detail, and the remainder by actually getting started. It is easier to criticize than to create. By starting, criticizing, and rewriting, confidence is gained. With each completed section the task becomes easier.

English. The English used in a report is of paramount importance and must consist of well chosen words arranged to convey the intended information. Vague or double meaning statements should be guarded against. The meaning conveyed to the reader must be the meaning intended by the author.

Paragraphs. The paragraph, from the reader's point of view, is a yardstick by which he measures his progress. Each paragraph should be a unit, used to develop a single idea or thought. From the standpoint of reader-interest, short paragraphs are preferable, since

a solid sheet of typed material with no open spaces tends to steer the reader away. Try to build paragraphs of 3 to 6 sentences totaling less than 15 lines. Use, but do not abuse, the reader's attention. His ability to concentrate on a single paragraph is limited and varies with his interest in the subject matter and the method of presentation. The reader will not object to reading several short paragraphs, but will hesitate to read the same material if it appears in solid block form in a single paragraph.

Sentences. In constructing sentences for a report, every attempt should be made to give specific information. Often a statement that is vague and indefinite can be made specific by the proper choice of words. For example, the statement "two of the heater elements were badly corroded," provides more information than the statement "two of the heater elements were found to be defective." "Flow at the training wall was unsatisfactory" may be changed to "flow overtopped the training wall." Thus, in fewer words the same thought is expressed, but additional information is also given.

The sentence is the basic element of the report itself and should be carefully constructed. Whereas the paragraph develops a single idea, the sentence states a single thought. Just as a man can peel one potato at a time, so can he grasp easily only one thought at a time. Give him one thought in each sentence. Any attempt to do more leads to confusion. In practically every case, a long sentence which has lost its effectiveness can be broken down into two or more forceful statements.

The ideal written text consists of a mixture of medium length, clear sentences and short forceful statements. A sentence should seldom contain more than 20 words, although the complexity of the thought may alter this figure. In forming a sentence, first state the basic fact as simply as possible. If you find it difficult to phrase a particular thought try the pattern;

It did what?

Then substitute your own facts as;

Dog bites man.

If necessary add more information;

The brown dog bit the mailman.

In reading your rough draft, be sure that your sentence places the emphasis on the proper item. Change sentence structure, if necessary to achieve proper emphasis.

Words. The choice of a word is sometimes an important matter in presenting an idea. If any doubt exists that the chosen word conveys the proper meaning, the dictionary will prove to be an impartial judge. Some of our most common words have shades of meaning which should be fully understood. For example, do not say "determine" when "measure" describes the action, or, in using the word "piezometer" be sure that your reference is not to a "water column" or "manometer." "Job" may mean an automobile or a place to work. Jack may be a name, a receptacle, or a device for lifting a weight. Avoid specialized meanings of words. Try to visualize your reader and choose the proper word. If in doubt, substitute another word.

At times it is difficult to find just the right word to describe a particular action or situation. Liberal use of the thesaurus will increase

the effectiveness of a writer's vocabulary and make his statements more forceful. A book of anonyms and synonyms will also prove helpful.

Revising the Draft

Revising a completed report is not a sign of inexperience. In a report covering extensive material it is impossible for even an experienced writer to put everything in its proper place the first time. In making revisions look for misplaced material first. Scissors and stapler will take care of paragraphs or whole sections.

Next, make a definite effort to criticize and evaluate your own writing. Reading aloud will help detect faulty sentences, repetition, and awkward constructions. Another method is to type the rough draft and allow a day or two to elapse before rereading. Seeing the material in different form after a time interval has elapsed gives the writer a fresh viewpoint for self-criticism. A third method is to put yourself in the reader's place and decide whether the written material states the things he would like to know. Decide whether the report states the things you yourself needed to know in order to understand the problem, make the investigation, and formulate the recommendations.

While reading the draft test the report as a whole and each division for the qualities discussed below.

Clarity and Logic

One reason that technical reports are often laid aside after reading a page or two is that the author has failed to present his material in an orderly manner and has thereby sacrificed clarity. He has failed to assume the reader's viewpoint. Even the best engineers are not experts in all lines, and it should not be assumed that the other

fellow knows all about your subject. The very things about a project that you, the writer, take for granted and neglect to discuss because of your familiarity with the subject are the things the reader must know to appreciate your problem.

In striving for clarity, much may be gained by making certain that the logic is good and that the connections of facts or events are presented in a rational way. The writer should continually remind himself that no idea ever reaches the mind of the reader with the clarity it had in the mind of the author. Be sure that the written material leads to a conclusion in a manner that will not be questioned by the reader.

Completeness versus Brevity

A first impression might indicate completeness to be the very antithesis of brevity, but it is possible to achieve one without sacrificing the other.

Brevity is the art of stating all the facts in as few words as possible, omitting unnecessary words and phrases that clutter the description and add nothing to its meaning. Completeness, on the other hand, consists of including all the pertinent facts. Brevity should not be attained by omitting necessary information or by overcondensation. Overcondensation results in the reader spending more time deciphering statements than he would in reading a longer but clearer discussion of the same material.

Simplicity

The following statement, by a director of a large research organization, is probably true to some degree in all organizations: "We have never had a report submitted by an engineer in our organization in which the explanations and terms were too simple."

The author must be able to write about his own work in simple understandable terms. Probably the most important part of simplicity in writing concerns the vocabulary. If the vocabulary is simple enough to be understood by a great many people, the usefulness of the report will be greatly increased. Unusual or highly technical words should be used sparingly or should be defined when first used. Occasionally a word or expression of this type will be much more descriptive than a conventional counterpart, in which case it may be used, provided that the meaning is made clear to the reader and that some advantage is evident from its use.

Accuracy

A technical report must be accurate within itself. It is disturbing to the reader to find a reference to 10 feet of head when the test data shows 12. Statements based on data should be checked carefully. Spelling, punctuation, references to illustrations, and the illustrations themselves should all be checked for accuracy and consistency. Inaccuracies that are evident to the reader reflect upon the quality of the investigation. If errors of any kind are apparent to the reader, he is likely to conclude that errors are also prevalent in the portions of the investigation that he cannot check.

The conclusions and recommendations should also be checked to see that they reflect an honest evaluation of the investigation. Unless the reader can draw similar conclusions from the data and discussion offered by the author, he is apt to believe the report to be biased.

Style

The style of the report will govern, to a great extent, the number of people who will read it after scanning the contents. Reports should be written in an attractive manner. By attractive is meant not only the appearance, but the manner of putting thoughts into words. Some written material is difficult to read and to follow, and it requires great effort to finish reading a report of this type. Unless the reader is obliged to read it, he will lay it aside until he has "more time." Some text material is disagreeable to the inner senses, causing an involuntary antagonistic attitude on the reader's part. His attention is thereby diverted from the subject to the method of presenting it. In an ideal situation, the reader is entirely unaware of the mechanics of presentation.

To help in this respect, polish up the sentences. Add connecting words to your sentences. The use of transition words such as

Furthermore

In addition

Indeed

Despite

help to smooth the way from one thought to another. Try adding a few transition words to a jerky paragraph; the results are sometimes startling.

Polishing a report is as important as polishing a roller bearing. Friction must be reduced to obtain smooth performance. This should not be carried to an extreme, however. Most experienced writers have had to release a report before everything was to their satisfaction.

Furthermore, the author always has the feeling that the report might have turned out better had he attacked the problem in another way.

PREPARING THE FIGURES

The well known proverb which states in effect, "A picture is worth a thousand words," applies in particular when the picture is used in a report. Proper use of illustrations saves time and effort for both the author and the reader. Illustrations should be selected and prepared for a definite purpose. No illustration should be included in the report unless it has real utility and can be integrated with the text.

Illustrations may be used for any of three reasons: first, to clarify the text and avoid the need for long or involved discussions; second, to present data in graphic form, which is frequently more useful than tabular form; and third, to add to the interest and attractiveness of the report. The first two factors are usually well understood by technical workers, for they are accustomed to reducing their ideas to drawings or charts. The third factor, that of added interest and attractiveness, requires special consideration. Illustrations which are primarily informative can often be made interesting by changing the ordinary method of presentation. Perspective or wash drawings are usually more interesting than line drawings. Simple graphs which present a limited amount of data in clear fashion will always be more attractive to the reader than complicated charts which can be deciphered only with great effort. Isometric drawings may often replace the usual plan, elevation, and section views to create interest.

Photographs

Photographs are an important part of a report since they expose the investigation to the reader. With a well chosen photograph the reader is made to feel that he is taking part in the investigation rather than merely reading about an event that took place in his absence. Photographs often allow the reader to see or judge for himself the effect of different variables on the final result, the appropriateness of the equipment, and to some degree, the quality of the investigation.

For these reasons, photographs should be planned in advance of their need. The report should be kept in mind throughout the investigation and the photographs taken with a view to illustrating the material which must be covered in the report. This method is far superior to that of attempting to select suitable illustrations from a random collection of photographs after the investigation has been completed. With a haphazard system, the most effective pictures are often the ones that were not taken.

Drawings and Charts

Careful preparation of drawings is as essential to the clarity of a report as the careful preparation of the text. An improperly prepared drawing can confuse as easily as it can clarify. As a matter of economy, drawings made for one purpose are often placed in a report to illustrate another. The resulting clutter of irrelevant details thus confuses the reader and presents a formidable appearance to what is usually a relatively simple problem.

Clarity should be the main objective in preparing drawings for a report. An attempt should be made to present the subject so that its meaning is immediately clear to the reader. The drawing should not be

crowded to present a mass of detail in a small space. Graph paper should never be used for drawing paper. Even though the original drawing appears to be clear, reproductions made from the original will lack contrast and present a confusion of unintelligible lines.

Simple line drawings are usually preferable to construction type drawings which show complete details and dimensions. By showing only the essential parts of a subject, clarity is obtained and emphasis is placed on the desired part.

Horizontal and vertical scales on charts should, when possible, be identical, to insure easy use. When this is not possible, easy to read scales should be chosen. Paper ruled with 10 divisions per inch should be marked in units of 1, 2, 5, or 10. Paper ruled with 12 divisions per inch should be marked 2, 4, 6, etc. In no case should the scale be chosen so that one ruled division represents $2\frac{1}{2}$ units, etc.

TESTING THE REPORT

The engineer should realize that he will be judged on the basis of his reports. Indeed, his future progress may depend on his ability to prepare an acceptable report. Poor writing reflects poor thinking. Thinking and writing cannot be dealt with separately; they complement each other. A report shows what the author knows about his work. It shows how he thinks and how he meets problems. A report is often the only record of results that have come from months of thought and effort. It is frequently used in judging the quality of the investigation. It may also serve as the basis for determining all future action on the project. If the report is well written, showing careful observations and sound

reasoning, and contains no obvious errors, the conclusions and recommendations will probably be accepted. If it is poorly written and contains apparent discrepancies, even though showing careful observations and sound reasoning, the results are open to question since the evidence before the reader indicates a careless or incompetent worker.

It is extremely important, therefore, that you test your report before releasing it.

The best test is to submit your report to a carefully chosen colleague. Choose a person who is familiar with your work but who is not aware of the details of your investigation or the results obtained. Choose a fair minded individual who possesses good judgment and has a genuine interest in what you are doing.

Then listen to his comments and do something about them. This is not the time to argue with him to justify your own actions. The mere fact that he has questioned certain items indicates that something is wrong. Experience has shown that other readers will question the same items. The safe procedure is to remove the stumbling block by rearranging or rewriting.

As part of his review, ask your colleague to evaluate your report from the following chart. Compare his evaluation with your own.

IF YOU HAVE WRITTEN A GOOD REPORT YOU SHOULD BE
ABLE TO ANSWER "YES" TO THE FOLLOWING QUESTIONS.

IS YOUR REPORT

1. COMPLETE

- (a) Does it provide the reader with all he needs to know?
- (b) Does it leave the reader with the feeling that the goal of the investigation has been achieved?
- (c) Are the illustrations integrated with the text to provide a unified presentation?

2. CONCISE

- (a) Are statements direct and to the point?
- (b) Have irrelevant details and unnecessary repetition been eliminated?

3. CLEAR

- (a) Is the logic good? Are the facts arranged in the order the reader needs to know them?
- (b) Is the vocabulary sufficiently simple to attract readers?
- (c) Can the meaning of each sentence be determined with a single reading?

4. ATTRACTIVE

- (a) Are the cover and binding colorful and attractive?
Are the illustrations clear and inviting?
- (b) Does each page have sufficient open areas to suggest an easy to read report?
- (c) Are the main parts of the report well labeled and easy to find? Is the purpose of the report clearly stated and are the conclusions readily apparent?

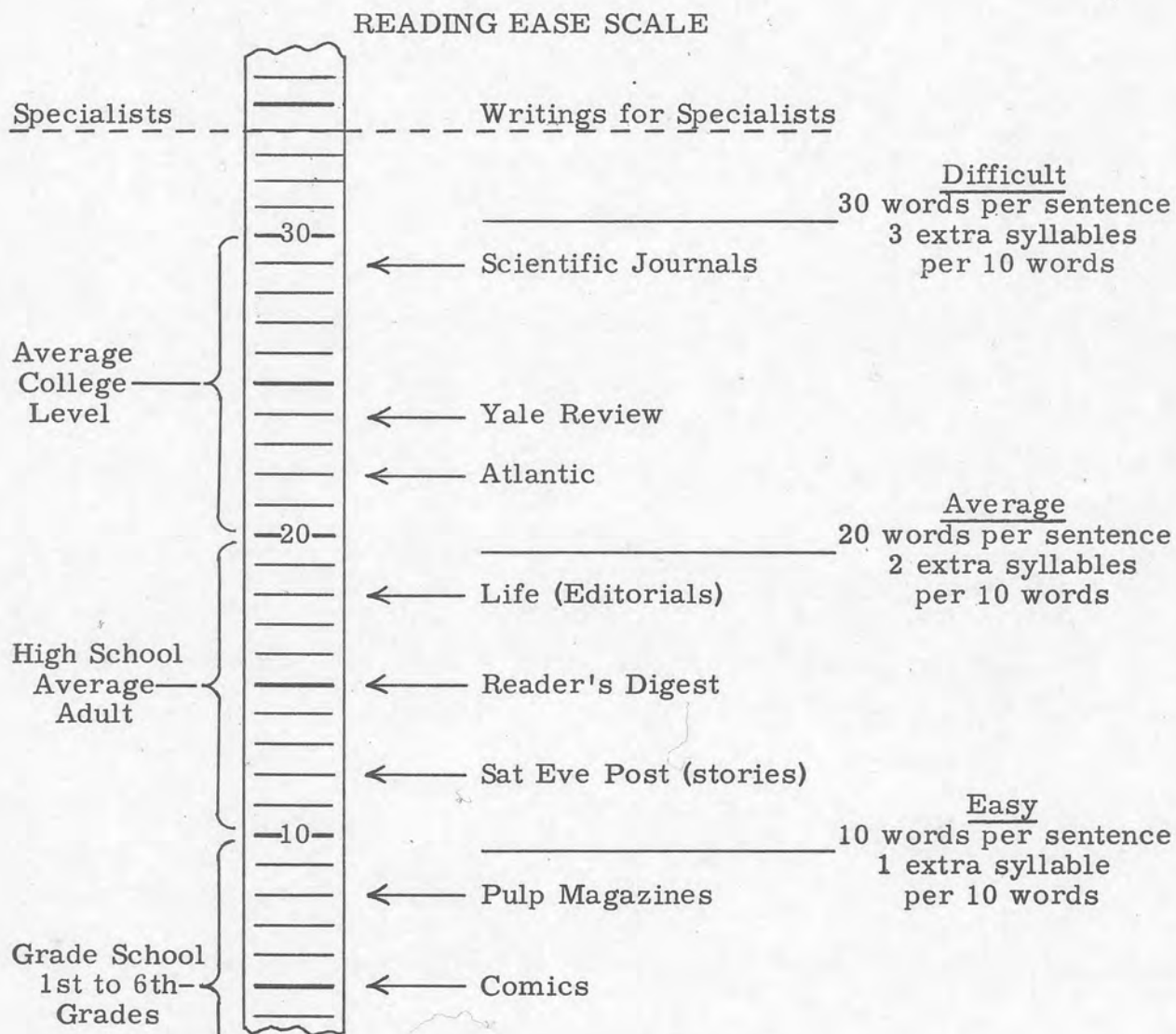
5. APPROPRIATE

- (a) Are the conclusions stated with conviction?
- (b) Does the report accomplish its intended purpose?
- (c) Is the report free of antagonistic statements and outmoded language?

READABILITY TEST

To determine the readability of your report, give it the following test.

1. Determine the average number of words per sentence in five or more consecutive sentences.
2. Count the third, fourth, fifth, etc., syllables in a 100-word sample.
3. Average the values obtained in 1 and 2 and check average against scale below. Adjacent to the scale are ratings for well known publications and three groups of readers. At the extreme right is a word rating in terms of the numerical rating on the scale.



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