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TECHNICAL WRITING FOR ENGINEERS

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Introduction

Most engineers during their careers are given continual responsibility for writing various kinds of communications. That can include such documents as administrative memos, letters, reports, and instructions both technical and non-technical. Each communication will address its own particular or unique need. Those needs will be determined by the nature and subject of the communication and by the special interest of the person(s) who is targeted to receive the communication.

Therefore, a key element to writing effective communications is to determine at the very onset who is going to be the receiving party of the communication. An additional consideration is to decide how much technical detail will be required for the person(s) who will be reading your communication. For example, if you are writing a technical memorandum to a group of engineers within your own field, the level and extent of technical detail may be considerable without causing the loss of your audience. However, even under those conditions, the technical detail should not be overdone but should be as simple as you can make it without sacrificing necessary content.

Language Simplification

The most effective communication is achieved when there is a meaningful flow of ideas. They should not be unduly complicated by special qualifiers, exceptions or minute details

only loosely related to the subject at hand. Special qualifiers and exceptions to the subject can be handled by listing them in a separate paragraph or in a footnote. By doing this, you can ensure that the flow of ideas will not be interrupted by qualifiers and your readership will be grateful for your thoughtful consideration.

It is fair to say that the best communication is one that is written in a simple but comprehensive format. Technical writers will tell you that they can write a memo of ordinary length and it will not take very long to do that; but if you want a very concise one, it will take a lot longer.

Some of the greatest political speeches of history have been the shortest ones that have been succinctly but thoughtfully crafted. One that comes to mind is Abraham Lincoln's Gettysburg address. You may not be writing political speeches but the principle of packing meaningful ideas into a short communication shares the same principle. That principle involves putting your thoughts and ideas into simply-constructed sentences that are short and to the point but not overly elaborate.

Reports and Other Technical Writing

Status reports

Progress reports

Project crisis reports

End of project reports

Status Reports

Each one of the above reports has its own individual style requirements as it relates to a particular place in the calendar timeline. For example, Status Reports deal with the project's condition or status as of the moment in time established by the date of the report. In a report of this type you would not go back and discuss events more than one month prior to the present time. Likewise, you would not discuss events which you plan several months from now. However, you might discuss the next month's anticipated events since the proximity in time is so very near.

Progress Reports

Progress reports should cover events which occur over the established time period for the report. It could be weekly, bi-weekly, monthly, quarterly, yearly, or any time period it is desired to cover. What should be remembered is to keep the events reported upon confined to the time period established for the report.

Project Crisis Reports

A **Project Crisis Report** is a special report which might be required at some unpredicted time during the project's lifetime. There could, of course, be more than one crisis, which would then usually require a report for each crisis event. And if things go well, there may be no crisis at all. This is what all project engineers and managers hope for. A Project Crisis Report would cover the problem which has arisen, how serious it is and how it impacts upon

the successful completion of the project. It might also cover proposed solutions to the problem, how they will be evaluated, and how much additional time and money the resolution is expected or predicted to cost.

The initial Crisis Report will be the beginning of a series of reports which follow up on the initial report. They will continue until the crisis is considered managed and contained. Project managers will always be interested in how a project crisis will affect schedule, cost, and survivability of the project. One should always be sure to address such issues in a report of this nature. You may discover that there are further aspects and ramifications of the crisis which will need to be reported upon and discussed in the initial Crisis Report and in follow-on reports dealing with the crisis.

End of Project Report

An **End of Project Report** involves a historical description of the project from inception until completion. It will include project technical history accumulated throughout the development and testing phases and will continue on to the final project events until the project is completed and accepted. It may be a rather lengthy document and can be somewhat time-consuming to write. The individual most qualified to write such a report will be someone who has been responsibly involved with the project from inception to completion.

This report has potential value as both an in-house historical document and as a technical document which can quickly answer “point in time” questions which may arise years after the product has been placed in service. There will be very few who will volunteer to write this report. A possible resolution in such a situation would be to break the report into several smaller sub-sections and assign these sections to various qualified individuals who have accurate technical knowledge and memory of the project’s history. If this is done, then one person should be appointed to be responsible for organizing and editing these sub-sections into one all-inclusive final report. The final report should be reviewed and approved by the project manager when the final report is completed.

Test Procedures

Test Procedures is a type of technical document which is required during most engineering development phases. They are usually highly stylized and are arranged in chronological order of how the tests will be conducted. There are exceptions to chronological order of testing since parallel testing can be conducted in order to save time. Parallel testing would probably require the use of additional identical prototypes, however. (Prototypes are exact models of the product which will be tested. For the testing to be valid, the prototypes must be identical.).

Parallel testing involves breaking down chronological tests into a separate series of tests. For example, if the chronological tests are “A + B + C + D” then this would require a single prototype to complete test A and then complete test B and then test C and finally, test D. Parallel testing could be broken down into four separate tests: A,B,C,D. This would then require four identical prototypes with each prototype completing only one test. Clearly, this would reduce the length of time for testing by a factor of 4. Or, there could be variations of

this by having two prototypes on hand and requiring Prototype 1 to complete tests A and B. Prototype 2 would then complete tests C and D. This would reduce the testing time by half.

All test procedures must be initially well thought out since they will be critically reviewed several times during and even after the test procedures have been conducted. If they are discovered to be inadequate during testing, they may have to be revised and retesting with the revised procedures may be required.

In many cases involving government-related contracts for military and many other types of government products; conformance to established government test procedures will be mandated. In such cases your responsibility may involve interpreting the government specifications which define the test procedures.

Proper interpretation of the specifications is necessary to ensure that the detailed government test procedures you identify and write in your test procedures will satisfy the government's concerns for quality assurance. A convenient way to do this is to copy the appropriate sections of the specification verbatim from the government specifications. You are allowed to copy from government specifications and standards because they are in the public domain. Their preparation has already been paid for by the use of public funds and the information they contain are therefore available without further cost to the public.

Test Reports

Test Reports are used to describe what transpired when a product was tested by following and using the Test Procedures document. They are reportorial in nature and simply describe what happened to the product during and upon completion of the testing. Sometimes they may contain an analysis of the nature of a failure and sometimes recommendations may be made for design changes to the product as a result of the test. However, such recommendations are not necessarily required to be included in the test report.

Contracts

As an engineer you may be required to write contracts for products or services you need to purchase for your project or for the organization you work for. Again, this is a type of document that needs to be written in relatively simple language. A contract which is written in simple but understandable language is easier to enforce in a court of law than one which has an undue complexity. It will also minimize misunderstandings which can easily arise from a second party trying to interpret a contract written in an unnecessarily complex fashion. A good procedure to follow is to write the entire contract in non-legal terms and simply describe the good or services you wish to purchase. Then, after you have completed that task, use the document as the basis for a final writing of the contract. Keep the language simple but adequately descriptive.

As you go through this procedure, the Contracting Officer of your organization, or the legal staff, is usually available to assist you if you have questions about any aspect of the contract. After you have completed the document, the legal staff can (and should) review the contract for its adequacy of language and for any and all legal ramifications it may have.

Remember that as an engineer you are not expected to be a lawyer but you are expected to be able to adequately and completely describe the good or services you wish to purchase. You will also be expected to be able to define the performance or quality of that good or service. Once you have gone through the procedure of writing one or two contracts, the following ones will be much easier to write.

You may quickly develop a facility for contract writing as you realize that successful contract writing reinforces and contributes to the project control you need for successful project management. A judicious and careful use of the contract language will help you to achieve the results you want for your project.

Project-related Letters

Letters are another form of technical document that engineers will be required to write during their careers. The largest category of letters is probably those that occur between the engineer and a contracted body. This could be a manufacturer, it could be a company supplying a product or a service or it could be a governmental body, such as a city, county, state, or federal agency. In some cases it could be an educational institution or a research facility. Thus it is apparent that there may be several diverse organizations that may supply a product or service to the engineer's parent organization.

In any of the above situations, the guidelines for letter writing are the same. Keep the language and sentence structure simple, but complete. Avoid undue complexity and long complicated sentences. Organize your written material in relatively short paragraphs of eight sentences or less. Ideally, each paragraph should have one or two central ideas. No paragraph should have more than three or four ideas. Shorter and less complex sentences will keep the reader's attention focused on the main thrust of the paragraph.

Too many ideas in a paragraph can dilute the thought process especially if they are not skillfully connected. Each paragraph should have a purpose which is clear to the reader. The purpose could be to give information, to state a specific problem or a problem area, or to present a proposed course of action. There could be other essential ideas contained within a paragraph, in addition to these examples. If a purpose is not clearly apparent in a paragraph, then you should rewrite the paragraph until such time that the objective(s) become quite clear.

Specification writing

Specification writing can be a bit tedious but specifications are an extremely important part of the engineering and procurement process. They form the basis for precisely defining the kind of good or service you hope, and expect, to receive from the procurement process.

There has been a change within the US government procurement practice when it comes to specification writing. This change took place about a couple of decades ago when it was realized in government procurement circles, that specifications written for performance and those written for design could produce great variance in the product which was delivered. So instructions were given to government engineers that their specifications for products had to be written as performance specifications and not as design specifications.

When contract specifications are written as performance specifications, the burden of producing a product which will meet the government's contractual expectations is placed upon the contractor. However, if a contract specification is written by the government engineer as a design specification, and the resulting product does not meet the government's expectations, the government is held in the courts to be the party who is responsible for causing the contractor to produce a sub-performance product.

Also, if a government contract is written largely as a performance contract but a design specification element is inadvertently placed within it, then the contractor has a legal claim in court against any sub-performance complaint which might later arise on the government's part.

Performance-based specifications are the safer way to go in both government and in private sector arenas but there also is a caveat here. The caveat is that a stipulation must be added to the performance-based specification which defines exactly how the specified performance is to be judged or measured; and who will do the measuring and make the judgement as to whether the performance has been met. Failure to do so, can open the door to argument and dissent by the contractor after the product has been delivered. This could then lead to litigation and delay in completing the contract.

Video Script Writing

At some point in your career you may be asked to write a script for a video to illustrate some particular aspect of a project. This is not a formidable thing to do but initially it may seem to be a daunting task. You can begin this task by laying out a time-based plan for the shoot. Start by describing in writing each scene that you need to film. This will give you an estimated shoot time required for each scene. That is to say, you will be matching the shoot time to equal the time required to read the written description for the scene.

Conversely, you can make a dry run-through of the shoot and keep a time-log for each scene. Then by using the time-log you can determine the amount of narration needed for each scene. Some may find this to be an easier method.

You can then fine-tune this process in the following manner. Determine what the final narration time will be for your written material by having a narrator read the material and observe how the reading or narration time relates to the written material. Rewrite the material to fit the assigned time or if this does not work for you, then you can increase the time for each scene until the narration and scene length are compatible.

By adjusting either the narration or scene length, you will quickly have a final script and scenario which can then be used to create the video. Normally, the video will be shot first without sound and then in the editing room, the narration can be added to the sound track. However, if your video budget is small and you are feeling lucky, you can have the narration performed at the same time as the video shoot. However, I do not recommend this procedure if this is your first effort because you will have less control over the final result.

Statement of Objectives

A **Statement of Objectives** is a very useful document for several engineering situations. The Air Force finds that a Statement of Objectives is very useful for establishing mission requirements for new aircraft development and for allowing this document to serve as broad performance specifications. The contractor who signs onto a Statement of Objectives can then establish his own aircraft design and specifications to achieve the end result.

A Statement of Objectives has a very useful purpose in clarifying thinking about how any project should be organized to achieve certain desired results. For example, when examining many organizations' long range or short range planning, the thinking process is not always crystallized when it comes to defining specific objectives.

A Statement of Objectives forces management to seriously and thoughtfully consider what their true objectives are. Usually, what happens is that it generally falls to engineering managers to construct this document by interpreting what they believe top management of the organization desires.

By preparing the Statement of Objectives and submitting the document for top management review, it will quickly come into focus whether or not the document truly represents the organization's mission regarding this particular technical arena. The document has then truly served a vital role in crystallizing management thinking.

This has to be done diplomatically, of course and the Statement of Objectives should be submitted with proper respect to superiors in management. However, it has been true in the author's engineering experience, that nearly all upper management officials are pleased to review such a document and may even be favorably disposed to having the engineer take this initiative. From management's perspective, this document can aid in clarifying, justifying, and perhaps defending the overall project from threatening budget cuts at some future date.

On a lower management level, a Statement of Objectives can serve the Project Engineer or Project Manager well on the occasion when he is handed an order to come up with a design to perform a particular function. The engineer or manager should not even start the design until he is able to generate a Statement of Objectives and have his superiors sign on to it. Only in this way can he ensure that the design he undertakes will satisfy what his superiors initially think that they want. He should also generate a list of Design Objectives and Design Requirements prior to starting his design. This list should also be submitted to his superiors for review and signature prior to initiation of the design effort.

Design Objectives and Design Requirements

Design Objectives differ from Statement of Objectives in that it postulates that a conceptual or operational design has been envisioned. A Statement of Objectives is presented as a fairly broad scope of desired future activities that will lead to a desired end. Design Objectives are more design specific and present a more detailed picture of a design or operational concept than a Statement of Objectives. Preparation of Design Objectives would almost always follow along a timeline after the preparation of a Statement of Objectives. You could think of a Statement of Objectives as a non-detailed map of the United States. And then you could

make the analogy that Design Objectives and Design Requirements when laid out on that map would show an interstate highway that traverses the country and would show traffic flows, bridges, intersections, exits, and entries and other highway detail on that interstate.

A good, solid project plan would contain both Design Objectives and Design Requirements. Design Objectives could also be thought of as a dream-list from which it would be nice to have everything shown on that list. Time and money constraints would usually make that not possible. Usually, a project has to settle for Design Requirements.

So, for the real world we have a list called **Design Requirements**. Everything on that list is a must-have item. Sometimes during the course of a project, a Design Objective can morph into a Design Requirement if it is extraordinarily desirable, doable, and affordable.

Patents, Related Writing and Record Keeping

At some point in your career, you may be called upon to lay the groundwork for the necessary paperwork needed for pursuing a patent of your own or for your peers. The first thing to do in such a situation is to establish and maintain a daily journal of all activities relating to the invention. An invention is described as a new and novel way of creating a device, machine, design or process which advances the state of the art and is not obvious. The journal which you use needs to be bound and not be in a loose leaf format.

The activities which are recorded should clearly state or relate what was done for that particular day. At the end of each page or successive group of pages, the inventor or inventors should sign and date the page(s). At least two witnesses should read and attest that they understand the document and they should then also sign their names and date their signatures. Do not make erasures or tear out any pages or portions of pages. If a correction needs to be made, simply rule out the offending material and have the inventor sign and date the correction.

The record keeping in the notebooks should continue until the project is completed. If any changes, additions, or improvements are made to the invention after it is initially completed or during its development, these changes or additions should be duly noted in the notebook. All notebooks should be kept guarded and preserved for later use by a patent attorney. If the material fills up one bound notebook, another notebook should be started and consecutively numbered. In this way a chronological sequence of events will be created which can be logically followed later by the patent attorney or patent agent who will later prepare the patent.

A patent search should be made early on in the invention process. Often, a patent attorney will want to be involved in this process. This is because there can be a big variance in the quality of patent searches and he may want to specify who performs this service. Patent searches were originally done by hand by individuals or specialized agents having access to the Patent Office library where copies of all patents are stored.

Now, with the advent of the computer, the Patent Office has a Web Site and a database on line which allows patent searches to be done by computer by anyone with computer search knowledge. It is a fairly complex process since patents are categorized into Classes and Sub-

Classes and a knowledge of how Classes are related to the prior art you wish to search for is necessary. There are about 430 major Classes. Each Class has its own page and there are about 300 to 400 Sub-classes under each Class heading. Altogether there are about 140,000 Sub-classes!

Also a limitation of this method is the fact that the Patent Office database only extends back to 1976. Search of this database would not reveal a patent granted earlier than 1976. However, a distinct advantage is there is no charge for searching the Patent Office database. Copies of patents you find which you wish to print out can be printed out online but it is a bit time consuming. This is because the printout of each patent must be monitored by you while it is printing and each page must be called up and addressed separately. If you want to print out say 20 patents which relate to the idea you are searching, it can take quite a long time.

There are several subscription sites which can be searched on-line but they vary in quality and in subscription price. One subscription service costs basically \$100 per month and then charges small amounts for other related services such as printing out patents of interest and sending them to you. The advantage of this particular service is that their patent database goes back to 1945 and would reveal prior patents of most late technology.

The Small Business Development Center at various universities will do electronic patent searches whereby they utilize all three database sources such as the Patent Office, IBM and a private subscription service as well. Each university would need to be contacted to learn their charges for this service.

The Patent Office a few years ago established regional Patent Office Libraries in all fifty states. In the midwest, there is one in Kansas City, Missouri and one in Little Rock, Arkansas. At one of these libraries you can do hand searches and on-site electronic searches using their computers. Since original copies of the earlier patents would not be available at all 50 library sites, the earlier patents have been put in micro-fiche format and a hand search would have to be in that media for most patents prior to 1976.

Before the Patent Office issues a patent, they will conduct a hand search which can reveal patents granted since the Patent Office was established in the late 1700s by the United States Continental Congress. Their search can also include the search of prior art related to your patent application idea in other countries. A foreign patent of your invention in another country can and probably will preclude your getting a U.S. patent on your invention idea. Patent attorneys can prepare your patent application based on the prior art revealed through electronic searches. Many attorneys will do this but others may require that a hand search also be done to ensure that no surprises are turned up by the patent office during their search involving your patent application.

It is usually advisable to first conduct an electronic search since it is quick, relatively inexpensive and could reveal prior patent(s) involving your idea or prior art relating to your idea. These patent references are necessary for your patent attorney to use when he writes up the application. Also if the electronic search reveals constraining prior patents then you can cut your financial losses and not spend any further monies on an idea which has already been patented.

Hand search charges can range from \$600 to \$1200 depending upon who does them and the complexity of the idea being searched. Depending upon the novelty of the idea, it is a judgment call on the inventor's part and the patent attorney's part as to whether a hand search should be done. Most attorneys will either recommend it or require it. In any case, if the hand search is not done, it is the inventor who takes the financial risk for proceeding without it. Individuals can also conduct their own hand searches but the searches must be done in one of the Patent Office regional libraries or at the Patent Office library in Washington, D.C.

Patent attorneys frequently prefer to control the searching process and consider it to fall under their umbrella of services since the quality of searching can vary. If a patent attorney has worked well with a certain group or individual(s) doing patent searches, the quality of his patent application for you can be enhanced. Conversely, if the patent attorney must work from an electronic search which has been inadequately or poorly done, then his patent application for you will likely be adversely affected as well.

Many patent attorneys use a search firm in the Washington, D.C. area where the Patent Office is located. The search firm they use will often, prior to their search, personally visit with the Patent Office patent examiner who will eventually be charged with examining the patent application. The search firm does that so the Class category of the patent application will be correctly and precisely identified before the search begins and their search can then focus in on that Class category. This greatly shortens their search time and effort. They guarantee their search results so that no other prior art surprises occur later during the examination process.

Another thing to keep in mind is that any electronic search source (other than one under the aegis of an attorney) will not be able to give you a legal interpretation or opinion about any patent which seems to conflict with your own invention/idea. So you are then left hanging in a quandary without legal advice, opinion or guidance about how you should proceed in such a situation.

During the recording process, a description of the invention should be written which clearly explains all aspects of the invention. This could include a brief description of prior history of the art, the current art and how the invention will advance the current state of the art.

Before submitting the recorded material to a patent attorney, it is helpful to the effort to prepare a written description which contains the following information shown in the headings below:

Title of the invention

Background information, general and technical

Background as it relates to the field of invention

Background, as it relates to the prior art

Summary of the invention, including its operation

Objects and advantages, what does the invention do

Description of the drawings, if there are drawings

List of the reference numerals on the drawings

Physical description of the invention

If it is a process describe the machinery or procedures involved with it.

Operation of the invention

Scope of the invention, conclusions and any ramifications

Abstract (brief and concise summary of the invention limited to 250 words)

Reviewing and Rewriting Your Material

Any material that you write should be reviewed several times by yourself and rewritten as needed. A good practice is to let it sit overnight if your time schedule permits you to do that and if the material is of sufficient length to justify it. The reason for using this tactic is that having a fresh look at your material, after you have been away from it for some time, can be very insightful. It can result in your seeing new ways to frame an idea or rewrite a paragraph or sentence for greater clarity of expression.

However, if you can do this for only two or three hours, even that short time period can be helpful. But it is much better if you can leave the material overnight or for a weekend and then have another look at it after a significant amount of time has elapsed. It can also be helpful if you can have a co-worker, whose literary judgement you respect, read your material and give you an opinion concerning whether it is clear to the co-worker or whether they feel it needs to have some sections rewritten.

Technical writers need to give some attention to the concept of excessive pride of authorship. It is important to preserve objectivity about your writing and not fall into the trap of letting your words become set in concrete early on. A beginning writer may not want to change anything he has written and may even become defensive when his writing is even mildly critiqued by a second party. It is important to de-sensitize yourself to having your writing reviewed and critiqued. You will never be able to produce quality written material unless you are able to do this.

Nearly all writers can improve their material by a persistent and continuous review of their own material and an examination of each word to see whether better choices can be made to improve the writing. In my younger days I had a huge admiration for the literary works of the great American author Mark Twain. I had always imagined that he created his great works by a single stroke of effortless writing. Many years later I still have that admiration of his body of work. Then, one day when in my mid-twenties, I had the privilege of visiting a museum dedicated to his writing when he was a budding reporter on the newspaper, the Territorial Enterprise located in Virginia City, Nevada.

In the museum were several manuscripts written in the original hand writing of Mark Twain. In looking over the manuscripts I was struck by an interesting observation. Within each sentence structure of the manuscript there were numerous changes to the wording and sometimes to the sentence structure itself. Many words had been crossed out and another word written above it. Then that word would be crossed out and another word placed above that word. Some words had as many as six or seven words written above a word that Mark Twain had originally penned.

So the valuable lesson that I learned was that even the great American author Mark Twain was not able to pen his creative writing in one easy stroke. He had the genius of understanding that changing and rewriting your material is not only just okay but absolutely

essential toward achieving the objective of clarity of thought and getting that expression just right.

He was a master of the art. It was a moment of epiphany for me. From that point in time forward, writing became much easier for me because I immediately “got it” and adopted Mark Twain’s philosophy of making as many changes and iterations as the material required. If you decide to adopt this philosophy as well, it will serve you admirably as you continue to develop your expertise in technical writing.

And concerning rewriting your material, nothing is easier to do now that the computer is so readably available. It allows an almost limitless number of iterations before a final version is reached. It’s not unusual to find up to twenty iterations of a document prior to reaching the desired version. A handy tip is that each version should have a date and time so that you can keep accurate track of hard copies which have been printed. Or you can use an alphabet letter to identify each version, which will limit you to 26 versions!!! Then if you go beyond that, you may have to double alphabet-letter each one. Or maybe come up with a different system of identification. Some word processing programs, such as Word 97, have features which allow you to track changes to your documents and may merit your consideration. This feature can be helpful if several people are working on and editing the same document.

Copyrighting Your Material

Copyrighting is governed by the intellectual property laws within your country of residence as well as by the Berne Convention for the Protection of Literary and Artistic Works (1886) if your country is a signatory to the Convention. The United States is a member state and altogether there are 182 sovereign state signatories. A work which is copyrighted in any member state is accorded equal protection in any of the other 181 signatory states. As a general rule, authored written works are copyrighted for the life of the author and will be valid for a minimum 50 years after his death (Some countries who are signatories to the Berne Convention will allow a copyright for the life of the author and for 75 years after his death.) This will not benefit the author, of course, but will be a benefit for his heirs.

Since 1967 the Berne Convention has been administered by the World Intellectual Property Organization (WIPO). The United States joined and became a party to the Berne Convention and WIPO in 1989.

To give notice that your work is protected by copyright you need to take a couple of steps. The first step is to place the copyright symbol © on the published copy of your work followed by the year of your published work and your name. For example: © 2005 John Doe.

Anyone who sees the published work with this copyright mark will realize that a copyright is being claimed, who is claiming it and the year the work was published. This notice will prevent an infringer from claiming that his infringement was accidental.

The second step is to register your copyright claim with the U.S. Copyright Office. Registration with the Copyright Office will give you better standing in a future court in the event that you need to prosecute for an infringement action. For instance, it should

enable you to petition the court for statutory damages and attorney fees and obtain judgment for these damages, court costs and expenses. Otherwise, you may have to be content with a simple cease and desist court order but without compensation for damages.

Happy Writing!