1 Elements of Technical Writing

The ability to communicate clearly is the most important skill engineers and scientists can have. Their best work will be lost if it is not communicated effectively. In this chapter, elements of the technical style of writing are examined. Technical writing differs in presentation and tone from other styles of writing; these differences are described first. The most important elements of the technical writing style to be discussed are conciseness and unambiguity. The chapter ends with a discussion of proofreading and some helpful hints in developing technical writing skills.

Presentation and Tone

Technical communication differs from fiction in many ways. In mystery novels the reader is kept in suspense because the writer has hidden important clues that are explained at the end of the story to produce a surprise. In contrast, the readers of technical writing are given the important conclusions at the beginning, followed by evidence supporting those conclusions. The following example illustrates the difference. The simple question *Do we have any mail today?* can be answered by a man sitting on his porch in two ways.

He could say: "I got up out of my chair and sauntered out to the mailbox. I looked up before opening the box and saw the mailman going down the street past our house. When I opened the mailbox there was nothing in it, so I don't think we'll have any mail today."

Or he could answer: "No, we won't have mail today. The mailbox is empty and the mailman has passed our house."

Note that in the first reply, the reader must wait until the end of the story to find the answer. This is typical of fiction writing. In the second reply the answer is given up front and then justified. The tone of the second reply is kept factual. This is what technical writing should do.

Number, Voice, and Tense

Most technical communication is done in the third person. Pronouns like *you*, *I*, and *we* are to be avoided. Only Nobel laureates may write in the first person without seeming to be pompous.

Readers probably studied voice in an English class. As a reminder, examples of the different types of voice are:

Active voice:	The ice melted at 0°C.
Passive voice:	The ice was melted by convection heating.
Imperative voice:	Place the ice in a convection oven until the ice melts.

The imperative voice is seldom used in technical communication except when giving instructions about how to do something. It tends to sound like the author is ordering the reader to do something. There is a strong temptation to overuse the passive voice in technical writing to avoid using *I* and *we*; however, it is good to use the active voice wherever possible.

Past and perfect tenses are used in technical writing, because they are used to report something that has happened. The difference in tenses is illustrated by the following:

Past tense:	A break in the circuit interrupted the current.
Perfect tense:	A break in the circuit has interrupted the current.

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It is usually best to pick a tense and be consistent with it in your writing. Frequent shifting of tenses can leave the reader confused. Occasionally, the past perfect tense can be used to describe a prior event. The previous example written in the past perfect tense is "A break in the circuit had interrupted the current." An exception when it is okay to use the present tense is when stating an enduring truth like "Current passing through a resistor causes it to heat up."

Conciseness

A hallmark of good technical papers and reports is that they are as concise as is consistent with being complete and unambiguous. Most readers are busy people, and the writer should avoid wordiness and redundancy. In writing a technical report, one can often assume that the audience is familiar with the scientific and engineering terminology.

Consider the following excerpt from the middle of a doctoral thesis proposal.

> A schematic illustration of the spot friction welding process is shown in Figure 1. The process is applied to join the two metal sheets as shown. A rotating tool with a probe pin is first plunged into the upper sheet. When the rotating tool contacts the upper sheet, a downward force is applied. A backing plate beneath the lower sheet is used to support the downward force of the tool. The downward force and the rotational speed of the tool are maintained for an appropriate

> time to generate frictional heat. Then, heated and softened material adjacent to the tool deforms plastically, and a solid-state bond is made between the surfaces of the upper and lower sheets. Finally, the tool is drawn out of the sheets as shown in Figure 1.

This could be rewritten in a much more concise form without any loss of meaning as:

> Figure 1 is a schematic illustration of spot friction welding of two sheets. A rotating tool with a probe pin is plunged into the upper sheet. A backing tool beneath the lower sheet supports the downward force of the tool. The force and rotational speed are maintained long enough to generate heat. The heated material adjacent to the tool deforms plastically and forms a solid-state bond.

Note that the number of words is reduced from 130 to 66. The word *process* is unnecessary and overused. *Welding process* means welding; likewise *machining process* means machining and *rolling process* means rolling. The fact that the force is applied to the rotating tool is obvious, that the bond is between the upper and lower sheets is also obvious, and saying that the tool is removed is not needed.

Another example is taken from a draft of a doctoral thesis.

> For decades, study of fracture has been one of many important topics that have attracted enough interest, due to its implication in a wide range of practical and real-life problems. Automotive safety, for one

> example, has been a focus and major challenge facing the industry. Structural integrity and failure is one of the key areas that are closely connected to automotive safety. For instance, in a rear car-to-car crash event, the main concern on the recipient car is fuel system integrity, or in other words, the condition of the fuel tank and fuel pipes. If the rear structure of the recipient car fails to protect the fuel tank or the fuel pipe from being crushed or punctured, any subsequent crack in the fuel tank or fuel pipe will lead to fuel leakage, which poses immediate danger of fire burst. A full-vehicle finite element (FE) model with well over one million elements and tens of millions degrees of freedom is currently developed to help vehicle design within the automotive industry. These large-scale models can now be solved on a group of high-speed workstations or small computers by the process of multi-process parallel computing. However, given such a large-scale model, the failure or failed component may well be within a small or localized area; as aforementioned, a crack in the fuel tank or fuel pipe. It is still lacking in an FE model to simulate reasonably how a crack initiates and grows under impact loading.

This paragraph could be shortened to:

> Structural integrity is closely related to automotive safety. For example, in an end-to-end crash, the fuel system integrity is crucial. Full-vehicle finite element models (FEM) with more than a million elements and ten million degrees of freedom are currently being

> developed to aid vehicle design. However, these models do not reasonably simulate crack initiation and growth under impact loading.

Unambiguity

Technical writing should be unambiguous so the audience knows exactly what the writer intends.

Consider the following paragraph from a student report:

> The cast is removed from the oven and molten metal was poured into the mold until the sprue filled. The mold is cooled until the metal is no longer red-hot. It is then placed into a water bath to remove the investment from the casting.

Here there is confusion between the words *cast*, *mold*, and *investment*. It is not clear what is meant by the word *cast.* It is unnecessary to refer to filling of the *sprue*, and the word *bath* adds nothing. A shorter and more precise version might be:

> Molten metal is poured into a preheated investment mold. When the casting is no longer hot, it is plunged into water, facilitating removal of the investment.

Consider the sentence *A gray iron casting consists of a steel matrix with a flake-graphite phase, which can come out of solution and lower the density of the final casting*. The wording *Gray iron consists of a steel matrix with a flake-graphite phase, which lowers the* *density of the final casting* would be clearer and more concise.

Another form of ambiguity is when a writer refers, for example, to a *copper aluminum alloy*. This could be interpreted either as a *copper-base aluminum alloy* or a *copper-containing aluminum-base alloy*.

Reflexive pronouns should be used carefully in technical writing. The antecedent to words like *that, which, he, she,* and *it* must be unambiguous. In the sentence *The addition of magnesium to iron above that of its boiling point converted it to a ductile state*, the antecedents of *its* and *it* are unclear. The reader will not be able to tell whether magnesium is added above the boiling point of iron or of magnesium and whether iron or magnesium is made ductile.

Another common source of ambiguity is to refer the reader to a table of data or a figure without explaining what the reader is to learn from looking at it. Good figure captions can eliminate some of these problems, but they are not a substitute for good writing.

In all cases, the writer must make clear what work was done by the author and what was learned from the literature. Citations like *It is known that*..., *They believe that*..., and *Most engineers agree that*... should be avoided unless specific references are given.

Use of Acronyms

Occasional use of acronyms can reduce the number of required words. Each acronym should be introduced by writing the full phrase out. For example, *scanning electron microscopy (SEM)*. The number of acronyms used in a paper should be kept to a minimum. There is no need to introduce an acronym if the term is only used two or three times. Each acronym requires the reader to learn a new bit of jargon, which can make reading more cumbersome.

An example of the excessive use of acronyms is *Compared to other SPF processes, the ABRC process offers the possibility for scaling up the production of UFG Mg sheets. The high pressure of the ECAE process is also avoided.* This could be rewritten as *Alternate biaxial reverse compression can be used to produce large quantities of ultra-fine-grain Mg for superplastic forming while avoiding the high pressures required in equal channel angle extrusion.*

Proofreading

All writing should be proofread, with the specific aims of checking for grammar, spelling, and word errors; eliminating repetition of words and ideas; checking the flow of thoughts; and seeing if sentence length is varied. Reading a manuscript aloud or rehearsing an oral presentation to oneself will reveal clumsy wording. For example, the sentence *The radiograph was used to show where defects were in the specimens, such as voids and porosity* would read better as *The radiograph was used to show where defects, such as voids and porosity, were in the specimens.*

There are different rules to follow for using adjectives and adverbs. Adjectives modify only nouns. Adverbs may modify either verbs or adjectives. One common misuse is found on the traffic sign that says *Drive Slow* instead of *Drive Slowly*. *Slow* is an adjective whereas *slowly* is an adverb, so *Drive Slow* is grammatically incorrect. In technical writing, both *slow heating* and *heating slowly* are correct. In the first case, *heating* is used as a noun, and in the second *heating* is used as a verb.

Agreement between subject and predicate can be checked by leaving out all words between them. For example, *A group of circuits with resistors, capacitors, and other circuit elements are shown*... may sound correct but when read as *A group are shown*, the need to change *are* to *is* becomes apparent.

Contractions of words, such as it’s for it is and can’t for cannot, are acceptable in common speech and fiction writing, but they should not be used in technical writing.