

ENGINEERING NOTEBOOKS

If engineering work is to have lasting value, it must be recorded. Records are especially important in work such as testing and design, and professional notebook-keeping is absolutely essential for documenting research and development work.

Engineering is man's endeavor to manage and improve his activities and environment and, as with all human endeavors, it involves both successes and failures; however, engineers are people trained to learn and progress from experience. "While engineers can learn from . . . mistakes what not to do, they do not necessarily learn from successes how to do anything but repeat the success without change." (Henry Petroski, *To Engineer is Human*, Random House, New York, 1992). Encountering the limitations of tools, materials, methods, principles, and ideas often teaches more than success.

The engineering notebook records both successes and failures. However, not all engineers keep notebooks. Much of the work that falls to engineers is directed, that is, the engineering that is to be conducted is prescribed in detail by the engineer's supervisor or client, or predetermined by the very nature of the task; engineers doing such work seldom keep notebooks. It is the responsibility of the person directing the work to keep the essential record. Engineers accustomed to doing directed work must recognize the occasions when unexpected occurrences require that they take initiatives based on their individual engineering skills, and immediately begin professional record-keeping.

PROFESSIONAL NOTEBOOK-KEEPING

Professional engineering practice requires that the performance of engineering work and the results be recorded first in engineering notebooks in the handwriting of the engineer or persons responsible to the engineer. When information in separate forms—such as drawings, circuit diagrams, blueprints, graphs, forms used to collect data, photographs, computer printouts, and procedures—is essential to the original record, these are usually incorporated by reference but are sometimes affixed to a notebook page. Although all information about a project might be assembled in a collection of such documents, those compilations cannot serve all the purposes of an original notebook record. The log of an engineering project can also be maintained in electronic (computer) files (see Appendix 1); however, this presents difficulties when the record is needed (to be discussed here) as corroborative evidence in legal proceedings.

THE USES OF ENGINEERING NOTEBOOKS

First, entering the record of an engineering project in a notebook is a tool for the engineer; second, this original record is the most authoritative source for reviewing the engineering work after it is completed.

The discipline required to make a complete, concise record as the work progresses leads the engineer to make and/or focus on a plan of the work, and as the work progresses, compare it to the plan. The need to set things in writing causes the writer to organize thoughts and interpret observations that might otherwise be overlooked and/or forgotten. Notebookkeeping thus can yield moments of insight that might not otherwise occur. As the record builds, the engineer can review the work completed in the order in which it was conducted and reexamine it for indications whether or not it was conducted to the engineer's satisfaction.

Because engineers must be responsible for their individual work, questions about it can be expected to arise in their own minds as well as the minds of others; as a result, the engineer should expect to have to prepare reports. The engineer therefore needs the notebook to be able to recall every essential part of the work.

The information in engineering notebooks is needed by the engineer's coworkers, management, or client/customer, any of whom may be working on the same or a related project or may need to repeat the work. Patent professionals need original records for such purposes as understanding an invention, establishing the priority of an invention, and determining who the inventor or inventors are. For these reasons, records of the origin of information must be made, along with the contributions of individuals and the dates of their contributions.

Most important, notebooks are often taken into courts of law as evidence for the truth of any assertions the engineer or the engineer's employer or client may make regarding such matters as failure of designs or devices, injury to persons, or damage to the environment. In the United States, engineering notebooks may be used as evidence in proceedings within the US Patent and Trademark Office; for example, in *interference* proceedings. Interference proceedings are conducted to determine who was first to make an invention when two or more competing inventors or companies file patent applications with equal or overlapping claims.

Although most engineering notebooks are never needed for examination in legal proceedings, in any case they are valued for offering recourse to the original engineering. They are therefore ordinarily preserved by the owners indefinitely against such possibilities as loss, destruction, or access by unauthorized persons. The professional engineer respects notebookkeeping and approaches it with the resolution to be thorough, completely honest, and forthcoming, and as objective as possible, and records credit to others where credit is due. Furthermore, the engineer should record the work and the results of the work without speculation or comment on the related work of others in the field; any statement that can possibly be given an adverse interpretation in subsequent legal proceedings will be given such interpretation by opposing counsel.

Evidence of the engineer's concern for these standards or lack thereof may be looked for along with the engineering information. Although the engineer cannot know *when* the note-

book will be examined, *where*, *by whom*, or *for what purpose*, the aim must be to keep a notebook that will stand any test for completeness, honesty, engineering ability, and professionalism. (The test for professionalism is whether the work is for the good of society.)

WHAT INFORMATION IS COLLECTED IN AN ENGINEERING NOTEBOOK?

The notebook comprises a concise, complete, and authentic record of the engineering on a project *as the work progresses* that afterward can be read and understood. It includes, in the order in which the engineer deals with them, such topics as a statement of a problem, premises, procedures applied, essential observations and experience acquired, discussions of significant matters, names of persons who contributed significantly and indications of what their contributions were, and results and conclusions.

The record will be concise if nothing is entered that is trivial or that can be incorporated instead by reference. The record will be complete if essential resources to the work and individuals who contributed importantly can be identified, dates on which the work took place can be verified, and a reader could repeat the work exactly as it was conducted.

WHO PRESCRIBES THE RULES FOR ENTRIES INTO THE ENGINEERING NOTEBOOK?

Because engineers are professionals, they could be expected to fulfill the purposes of notebook-keeping without having rules prescribed for them; however, the information recorded by the engineer (and the notebook itself) is ordinarily the property of the engineer's employer or client. That party has overriding concerns, among the most important of which are any need for support for proving or disproving legal matters. The engineer who is self-employed may have no one with whom to share responsibility for the work, and therefore must be especially attentive to notebook-keeping because of possible legal consequences. What goes into a notebook is therefore partly prescribed by certain rules that will make the notebook useful and beyond reproach in a court of law, and on balance prescribed by guidelines for good engineering.

The prescriptions of the law professional are mainly based on concerns that the notebook not be susceptible to even a suggestion that the record is not authentic, ethical, and honest in every way. For example:

- It must not appear that anything could have been altered dishonestly after its original date of entry.
- All entries must clearly have been made in chronological order.
- Corrections to original entries must be made in such a way as to plainly show that the correction was an honest one and when the correction was made.
- The entries on each page must be signed by the writer who entered them, and on the date they were entered.
- The record must show that it was regularly read and understood by a person or persons who affixed their signatures and the date they read and signed.

RULES AND GUIDELINES FOR NOTEBOOK-KEEPING

Notebooks are frequently used by an engineer to record his or her individual work. Also, two or more engineers working on the same project may keep notebooks for their contributions to the same project, in which case cross-references must be entered between the different engineers' records. In addition, rather than a notebook being associated with a particular engineer, a notebook is frequently designated to be associated with a particular project or part of a project, or piece of operating or test equipment, in which case all assigned personnel make entries in the same notebook. In all cases, however, it is necessary that the record allow clear distinction and identification of each individual's entries.

Guidelines for notebook entries are discussed in the following paragraphs.

Use the Proper Book. Start with a book that is bound with a strong stitched binding and printed with page numbers. (Any unbound notebook or adhesive-bound book that may come apart in long storage may be susceptible to the suggestion that pages could have been inserted or removed from the original record.) The convention is that the notebook pages are prepared for writing on one side only; the right sides are numbered and are the only place for official entries. For convenience, a notebook size is preferred that is suitable for machine photocopying of entries. Ruled paper should be used for the discipline it promotes, and quadruling is often preferred as it lends itself to entering information in the form of tables, graphs, and diagrams directly on the page. Preferably, the official pages are preprinted with, in addition to page numbers, a form at the top of each page for identification of the work in progress (title, project number, and so forth), a form at the bottom of the page that provides a place for the writer to sign and date his signature, and words such as "read and understood by," "witnessed by," or "witnessed and understood" (depending on the preferences of the engineer's legal advisor) with a form for this person or persons to affix their signatures and the dates of their signing.

Make All Entries Permanent. Use indelible ink for all entries in an engineering notebook. (Any other writing may not be preserved and, in any case, could not easily be proved not to have been altered.) An ink that lends itself to machine copying is preferred.

Record the Basis for Beginning the Notebook. Identify the notebook with a serial number. (Ordinarily the notebooks used have a serial number already affixed by the printer at the designation of the owner.) On the first page enter the name of the engineering project or machine the notebook is to be associated with, the person or persons responsible for keeping the notebook, and the serial numbers of any related notebooks (such as a prior one the record is to be continued from, or notebooks kept by other personnel doing work on other parts of the same project). Designate and label pages to be used for a table of contents (TOC). Enter the topics and subtopics of notebook entries on the TOC in the order in which they are recorded and label each with the date of making the TOC entry.

Make Changes and Corrections Understandable. Whenever it is found immediately after making an entry that it was not made as intended, or was made with a mistake, cross out the entry with *one thin line* (so the original remains plain to any

reader at a future time), follow the entry with an entry of the preferred notation, and initial and date the alteration.

Label Regular Entries. Begin each page with an identification of the work (for example, by the title of a project, subproject, or entry, or perhaps a project number), and preferably the engineer's own sequential number for a unit of work, such as Evaluation No. 23, Test Design IA, Experiment 46, Run IIIB, etc.

Make Cross-References. Connect the record to that of prior or simultaneous related work. Write a concise statement for the background of the work, such as why the engineering is needed or who asked for it. If the record to be entered is to be a continuation of the record for a project other than that of the immediate preceding entry, include "continued from page ___" to connect the entry to the page on which the last entry was made before the work was interrupted.

List the Objectives. Write the clearest possible statement of the objective(s) of the unit of work, and enter any revision of objectives in the future at the point in the record where the revisions are made.

Record a Plan for the Work. If a series of units of work is to be conducted, it will be useful to enter a plan. For a single unit of work, it will be helpful to enter the procedure that is desired to follow. (The notebook is the best place for the engineer to have such records to review, and helps direct the work of technicians and other engineers who may be participating in the work.)

Record Procedures, Observations, and Significant Discussion. Insofar as possible, all implementations and observations made during the course of the work should be recorded at the work site and at the time they are made, or as close to that place and time as possible. Obviously, entries must be concise as well as complete. Descriptions of procedures and designs should not be entered when they can be found elsewhere. Often these require only a reference, such as to an entry on a previous page.

The notebook should not be cluttered by entering anything that is generally assumed, widely known, or conventional; however, when such knowledge needs to be identified, a notation should be included that will lead any reader to a reference for the source.

Data should be entered as collected so that any calculations and interpretation subsequently applied can be reviewed. Space is never allowed between entries for entering information at a later date. (That information can be entered when it becomes available with a reference to the earlier, related entry.)

All unusual or unique aspects of the work should be noted and commented on as concisely as possible. The names of persons who contributed significantly to the work should be entered, with their individual contributions indicated.

Close Off Each Entry. When a writer considers an entry complete for the moment, or another writer must make an entry, the first writer must draw a line across the page and sign and date the entry.

Incorporate Printed Documents. Because entries must be complete yet concise, it is often useful to affix a clipping to the official page, such as part of an instrument chart, a computer printout, or an original sketch. In fact, such entries often provide the most direct, authentic presentation of what needs to be recorded. Such materials should be attached to the page with permanent glue and should be signed and

dated by the originator. With some insertions, such as photographs, the insertion should be attached in a way that allows access to any identifying information that may be on the reverse side.

Law professionals also advise that documents that are part of the engineering record and not affixed to the notebook should always be signed and dated by the originator, labeled with a cross-reference to the notebook or other document which is uniquely identified, and in most instances, signed and dated by witness. For additional information, see Ref. 1.

Use Unofficial Pages for Nonessential Entries. Because most engineering notebooks are prepared for official entries on only the right-hand page, the reverse sides or left-hand pages are ordinarily used by the engineer for notes and calculations that are entered there for convenience ("scratch pad") rather than for the record. It is in fact desirable to enter calculations on the unofficial page facing the official record; should some error be found in a numerical record, it will then be possible to check the original calculation of that record. Moreover, printed materials are often affixed to the left-hand page when it is helpful to have them there for reference but not essential to have them there for understanding the official record.

Summarize Results and Conclusions. Refer to or summarize such matters as the significant results calculated from raw data; enter a summary description of what was designed, built, or accomplished relative to the objectives of the work; enter the implications or significance of the work.

Include Essential References. Identify references either in context (parenthetically) or collected under a separate heading. These are needed only when information or principles are applied that were innovative or at least come from sources not likely to be known by or readily accessible to a reader.

Complete Every Page. When it is decided that no more entries will be made on a page (such as at the completion of a work unit), the person completing the page should proscribe the use of any remaining space by drawing a diagonal line across the space and labeling the diagonal with his or her initials and the date.

However the page is completed, the person doing so must immediately sign and date the bottom of the page and, at the earliest convenience of all parties, have one or two persons who are not working on the project (*witnesses*) sign and date the page. The dates of their signing are important to prove the existence of the record at the time the witnesses read it. All pages must be witnessed in this manner; it cannot be known what matter may come to be focused on in a court of law, or when, or for what reason.

Choose Appropriate Witnesses. Legal advisors differ as to whether the persons asked to affix their signatures on the pages of the engineer's entries should be certifying that they have read and understood the entries, or should be certifying something else, such as that the page was complete and authentic when they signed it.

In any case, witnesses should be selected who are disinterested; that is, they have no concern with personal gain or loss from the recorded work. These persons therefore need not have observed the work being carried out; however, persons chosen should be near enough to the work and work site to be aware of the engineer's work, so that they could, if necessary, answer questions relative to the authenticity of the entries on the page.

SUMMARY

Professional engineering practice requires that the engineer or persons responsible to the engineer keep a concise, complete and authentic handwritten record in a bound notebook from the beginning to the end of a project. The record must be made in a manner such that another engineer could repeat the work solely on the notebook record. Furthermore, because the engineer's employer or client—or the engineer in his or her own right—may need the notebook to support or disprove assertions made in legal proceedings, the notebook must be kept without any gaps or irregularities or hints of such that could interfere with its use as corroborative evidence.

What goes into a notebook is therefore partly prescribed by certain rules that will make the notebook useful and beyond reproach in a court of law, and on balance prescribed by guidelines for good engineering. Rules and guidelines for notebook-keeping are ordinarily prescribed by employers and their legal advisors, and the recommendations offered herein were prepared with the same considerations.

APPENDIX 1. ELECTRONIC NOTEBOOKS

In this age, when more and more information is being gathered by computerized devices, processed by computers, and stored by computers, engineers are abandoning pen and paper in favor of writing on computers. In fact, the log of an engineering project can often be more easily maintained on a computer. However, this presents difficulties when the record is needed to corroborate evidence in legal proceedings.

As most files kept on computers can be easily modified without leaving any trace of the modification, much more extensive testimony is required to establish and defend how the record was created and maintained. For this reason it is desirable to keep a sufficient contemporaneous written record to corroborate the electronically stored data. Recent literature (1) has described several approaches to increasing the evidentiary value of a set of electronic files. However, until such procedures are widely proven and recognized, engineers will have to weigh the ease of making an electronic record that can be made reliable for legal proceedings only with great difficulty, with the inconvenience of keeping a handwritten notebook that will be an authentic, reliable record.

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