Contracts, Specifications and Engineering Relations

By DANIEL W. MEAD

THIRD EDITION

Rewritten by THE STAFF OF MEAD AND HUNT, INC.

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Preface

The purpose of the book remains unchanged in setting forth the important relations with which the engineer or architect should become familiar when starting his professional career. The basic treatment of ethics closely follows the treatment originated by D. W. Mead, the original author.

All chapters have been rewritten and much of the text material has been reorganized. The style of English has been modernized to correspond with current usage so that the text may be more readily understood by today's technical students. The chapter covering the use of English also reflects this changed style, and the chapter covering reports and business letters has been rewritten to present current usage, the forms which are given as samples being of the type currently used in business transactions. In the chapters dealing with legal matters every effort has been made to use legal terms precisely, but the language used was chosen to be, wherever possible, within the scope of the technical student's vocabulary.

In the chapters on specifications numerous sections from specifications have been included as samples. These samples have been taken from specifications which are being currently used by consulting engineering and architectural firms. A complete set of specifications which was recently issued by a consulting engineer and used for actual construction work has been included as an appendix.

In the original edition much space was devoted to detailed descriptions of materials useful in construction work because such information was not readily available elsewhere at that time. In the third edition much of this material has been deleted because numerous societies and associations now distribute standard specifications for materials and processes. A list of such societies and associations has been included as Appendix B.

The firm of Mead and Hunt, Inc. selected Dr. Joseph Reid Akerman as editor and principal author for the third edition because of his background in both the academic and professional engineering fields. Dr. Akerman received his B.S. degree in mechanical engineering from the Georgia Institute of Technology in 1932; his M.S. from the University

of Michigan in 1933; and his Ph.D. from the University of Wisconsin in 1952. Dr. Akerman has been a Registered Professional Engineer since 1937 and has had considerable experience as a professional engineer. At the present time he is Associate Professor of Mechanical Engineering at the University of Wisconsin. He is a member of the American Society of Heating and Air Conditioning Engineers, the American Society for Engineering Education, and Sigma Xi.

Further acknowledgment is given to Ralph E. Axley, member of the law firm of Schubring, Ryan, Petersen, and Sutherland, for his review and comments on the legal aspects of contracts; to Leo F. Pratt, member of the firm of Mead and Hunt, Inc., Consulting Engineers, for his advice on specification forms and writing; and to W. E. Schubert, Vice-president and General Manager of the Wisconsin Michigan Power Company for furnishing the specifications used on one of the projects constructed by his company, which are included as Appendix A.

HAROLD W. MEAD, *President*
Mead and Hunt, Inc.

Contents

CHAPTER 1

The Engineer and His Education

1-1. The Functions of the Engineer. The functions of an engineer are those of a designer, a supervisor, a constructor, an operator, an investigator, and an adviser. It is his duty to formulate an ideal and from it to create a reality. He must investigate conditions and determine means by which those conditions can be utilized or modified to meet certain ends; he must advise his employer as to the feasibility of the project proposed, the cost which will be entailed, and the results which will be accomplished; he must develop ideas and elaborate plans; he must also consider and prescribe the methods and manner of construction; he must supervise or superintend the execution of the work and see that it is properly constructed and that the ideal is realized; and often, after completion, he must see that the works which have been created from his plans and under his supervision properly fulfill the functions for which they are designed.

The field of engineering work includes all those branches of technical service and of business and professional work which have to do with the utilization of natural resources for human benefit. The function of engineering service is the adaptation of the laws and resources of nature to utilitarian purposes. It usually involves the practical consideration or the active utilization of natural conditions and natural resources through construction. It requires technical training either through practical experience and parallel study, or through study followed by practical experience. Engineering in its broadest extent includes the trades, the business, and the profession. The skilled artisan and mechanic and the skillful draftsman are the fundamental practical units of the engineering trade. The manufacturer, the builder, and the contractor represent engineering business and are the active agents in the realization of the ideals in concrete form and frequently in the development of these ideals. The designer and the estimator, the inspector and the superintendent, and the assistant engineer are the fundamental units of the engineering profession, of which the chief and the consulting engineers

are the culmination. Architecture is the application of art to engineering construction, but it is no less a branch of engineering. Names and titles are but words and have but little significance aside from the active duties and responsibilities which a given vocation, position, or business involves. All the vocations mentioned obviously have innumerable combinations in their actual performance and vary greatly in their relations one to another and in their relative importance. The young technical graduate may progress through various subordinate positions to the higher professional activities as chief on important engineering work, or he may through minor industrial vocation attain important positions in the industrial world. Every vocation when properly exercised is both honorable and of great importance to human welfare. Those vocations which involve great responsibility, important fiduciary relations, great skill, extended experience, high intellectual development combined with ability of intense practical application, and executive and business ability of a higher order, often receive the greatest rewards both in public respect and in financial returns. The positions of great responsibility, however, usually involve so great a degree of personal devotion and the sacrifice of so many of those personal pleasures of life that demand a large amount of time and energy in their enjoyment, that there are few who are willing to pay the price of the greatest professional success. All engineering success is a consequence of personality, native ability, opportunity, and application; normally it may be achieved just to the extent that the individual is willing to pay the price of intelligent devotion to its attainment.

1-2. Engineering Relations. In fulfilling the duties of his vocation, whether it be in the trades, the business, or the profession, the engineer comes in contact with men in almost every walk of life. The young engineer is first brought into contact with his employer and with men who are similarly employed. With his advancement, relations will be established with customers and clients, and the work he is called upon to perform is likely to entail relations with many others. It may require the employment and supervision of workmen; it is likely to involve contact with manufacturers and contractors; it may involve contact with officials of private or public corporations, clients, lawyers, investors, bankers, and a great variety of other persons having various interests more or less antagonistic. In his relations with the different men encountered in the various lines of engineering work, conflicts of personal opinions, personal interests, and personal rights will arise which must frequently affect his course of action. A clear appreciation of the proper attitude he should assume in these various relations, and of his proper personal and professional conduct, is of great importance to his growth, development, and future usefulness.

The engineer is frequently called upon to assist in the preparation of designs and plans for various structures and plants and must possess a knowledge of principles of design, strength, and adaptability of materials and the various demands for strength, capacity, and service that must be fulfilled. In many cases certain hazards and contingencies will be involved in both the construction and utilization of the structure or plant. These must be foreseen and considered in his design. In most cases the work, structure, or plant designed and constructed must be used, maintained, or operated by men whose capacities and capabilities will vary depending on its location and the conditions of its installation, and the human element must therefore be duly considered throughout the engineer's entire work.

The engineer must frequently take part in the preparation of estimates, specifications, and contracts. Estimating requires a knowledge of ways and means, an appreciation of the contingencies which may be encountered, and a knowledge of costs of labor and material and of transportation and construction charges. The preparation of contracts and specifications requires and extended knowledge and experience; it involves certain legal and certain customary requirements, a knowledge of how work can and should be performed, and a sense of fairness and equity. Proper care in the performance of these duties will largely obviate the chances for misunderstandings and disputes, will reduce future complications, and will render the engineer's further duties less difficult and more satisfactory.

After the design is completed, and the plans, estimates, specifications, and contract papers are prepared, arrangements for the performance of the work of construction must be made. This usually includes the preparation of advertisement, instructions to bidders, and forms of proposal. The work must be let, and if it is public work, the advertisement must be placed and the letting conducted in conformity with the laws and ordinances which prescribe the methods which must be followed in order to secure a valid and binding contract.

The engineer's work is not completed when the contract is signed: he must inspect, supervise, or superintend the work; he must see that its reasonable requirements are carried out. In the supervision of work, the engineer becomes an arbiter with greater or less power in deciding upon the meaning of the plans and in interpreting the specifications. He must see that justice is done to both parties to the contract. He must be fair and impartial, and this in spite of the fact that he is to an extent an interested party. He is employed by his client to supervise the work and to see that it is properly done, and is normally biased by his employment. There may also be errors, omissions, or uncertainties in the plans and specifications due to his own faults or neglect, and his decision may

involve either an admission that his plans and specifications are not wholly adequate for their purpose or the infliction of unjustified hardships and expense on the contractor. In all such cases every engineer owes it to himself and to his profession to see that all his decisions are made in a spirit of fairness, with malice toward none and justice for all.

The engineer may represent the other side of the contract, that is, the contractor. He may be the contractor; he may be employed to assist the contractor or to take charge of the construction. Here he must possess not only technical knowledge of design but practical knowledge of construction and construction methods. His knowledge must extend to the principles of business and business methods; he should possess a knowledge of men and of the method of handling labor; and he should possess a knowledge of business and engineering law. He must have a good understanding of the rights and privileges not only of both parties to a contract but also of labor and of the public. In this type of work it is impossible to cover every detail of the construction in the contract and specification documents, and much is left to the competency and honesty of the contractor. Some few contractors will take advantage of this fact and skimp the work to increase their profits, but most find more satisfaction in honest, dependable, and competent work, which builds a lasting reputation. There are few, if any, cases of large contracting firms which have been successful over a long period of time without a reputation for integrity and dependability.

The young engineer may enter commercial life; he may represent the manufacturer in the sale or installation of machinery, materials, or supplies. In such a position he will work under a great variety of conditions and will deal with many different types of customers. It becomes important for him to familiarize himself with the product, with all its advantages and disadvantages, under all possible conditions of use. If the sales engineer enjoys the confidence of a prospective customer, he may be requested to act as a consultant for the customer in selecting equipment, laying out processes, etc. There is always some temptation in these circumstances for the engineer to make a recommendation based on the commissions to be received rather than on the suitability of the equipment which he sells. Yielding to this temptation may give some immediate profit but in the long run is usually ruinous. A satisfied customer is not only a permanent customer, but the best possible reference. Every customer of this kind will improve and enlarge the clientele of the engineer's firm and will establish a valuable personal acquaintance and reputation which will often be a distinct advantage in future sales or in later life if the engineer seeks other employment.

He may be called upon to supervise the installation of machinery and equipment and to train personnel in the operation of the project. These

installations seldom operate at maximum efficiency until minor adjustments and modifications are made, and in the making of these changes the engineer must use initiative and ingenuity. Tact, diplomacy, and ability to get along well with people are required, and every proper effort must be made to see that all parties involved are satisfied.

The engineer may be called before the court to give evidence in professional matters, and his experience and professional knowledge become of great importance. Here he must be self-possessed, clear, and exact; he must be able to express himself so that he will convince the judge or jury not only of his professional knowledge and experience, but of his honesty and integrity as well, and this must frequently be done in the face of a cross-examination intended to show that he is ignorant, incompetent, and dishonest.

In giving expert evidence his attitude and his purpose should be marked by honesty, integrity, and fairness. He should never lend his professional knowledge and reputation to bolster up fraud and deceit. If he is tempted to do this in order to assist the ends of his client, he should remember that such action on his part will seriously injure his reputation and limit his future usefulness.

In his diversified work the engineer may have to appear before councils, legislatures, boards of directors, meetings of stockholders, bankers, and investors and explain engineering projects. He must show the necessity and justice of required legislation, or the injustice and inadequacy of existing or proposed laws. He must show the necessity, desirability, or advantageous results to be derived from certain projects or from certain improvements to works already constructed. He must show the safety of investments and the certainty of adequate returns. This work requires not only a fund of professional information, but the ability to talk and to write clearly and convincingly in such language that his audiences will understand the matter placed before them and appreciate the truth of the proposition proposed.

The engineer may be called upon to report on undeveloped projects; and his investigations must be so complete, his data so definite, his proposed plans so well developed, his estimates so conservative, his conclusions so thoroughly founded, and his report so clear and complete that it will bear the critical examination of experts who will be called upon to review the project and pass upon its feasibility. He may be called upon to review such reports made by others in similar lines, and large financial investments and interests which need careful consideration and protection may depend upon his report.

In reviewing such a project, he must pass not only on its possibilities as an engineering endeavor, but on its probable success as a business venture. Here, much more than purely engineering principles are in-

volved: the legal rights under the state or the national laws must be considered; the probable demand for the services or product of the development must be investigated; the hazards and contingencies involved must be appreciated; the possible methods and expense of financing must be known; and no element that goes to make up a complete commercial success can be neglected if the engineer is to retain his clientele and reputation. In this work he is confronted with many opinions and influences: the promoter, anxious to finance his project; the company, desirous of floating its stocks and bonds; the manufacturer, anxious for financial assistance—each perhaps thoroughly convinced of the feasibility of his project and yet with insufficient experience or breadth of vision to take into account all the elements of the problem. The engineer must remain unprejudiced; he must sift the wheat from the chaff, the fact from the theory, and arrive at a conclusion as to whether or not the project is feasible and the investment sound. Upon his ability to arrive at correct conclusions depend his fitness and usefulness for this important work.

The engineer is sometimes called into a semijudicial position as appraiser or arbiter. Sometimes property interests involving millions of dollars are subject to his judicial determination. The calls to such positions are based only on a high professional standing and a reputation for fairness, honesty, and integrity.

To qualify himself to fulfill these various functions properly should be the aim of every young engineer.

It is evident that the wide range of work outlined above requires not only technical knowledge and experience, but the ability for proper and clear oral and written expression, and a knowledge of finance, economics, business methods, and legal relations.

ENGINEERING EDUCATION

1-3. Technical and Scientific Preparation. The essential aim of engineering education is not so much to impart technical knowledge to the student as to furnish the training which will enable him to understand and investigate the conditions which surround a problem, to determine the fundamental principles on which its successful solution depends, to ascertain and analyze the elements which influence or modify it, to design the structures and work needed for its successful development, and to supervise or superintend the proper construction of such structures or works and carry them to successful and economical completion.

The amount of knowledge that can be retained in the mind at any one time is limited. The time spent in a university course, as well as the

mental capacity of the student, are both too limited for the acquisition of anything more than the elements of knowledge needed by the practicing engineer. Even the practicing engineer can retain only those facts and principles that have been especially impressed on his mind by constant use. The most important goal for the student, in or out of college, is not the acquiring of a detailed knowledge of engineering principles, natural laws, technical methods, and detailed facts (except where such matters are needed for immediate use) but learning to ascertain and apply the correct principles and data when needed for professional purposes.

The engineer must have a comprehensive understanding of the elements that underlie his problem and upon which its proper solution depends. He must know what and how to investigate, and how to analyze and weigh the influence of every factor involved. He must be able to see or to determine the value and effect of each element in the problem; and he must know whether the knowledge needed for these ends is available, where it is to be found, and how to acquire it. He must understand ways and means as affecting both construction and operation, and, so far as possible, he must have developed his judgment, his sense of justice and equity, and his common sense.

All knowledge is more or less related, and every subject bears more or less directly on every other subject. It has been said that if any man knows all that can be known of any one subject, he knows all that there is to be known of every other subject. Such a comprehensive knowledge is of course ideal and impossible to acquire, but a broad foundation of many subjects is necessary to a true appreciation of any one. This is especially true of technical knowledge; and for a broad knowledge of any specialty it is both desirable and necessary that the engineer have at least a general knowledge of other specialties.

The present tendency toward specialization is, when carried too far in a university course, a serious mistake if the desire is to educate engineers instead of to train skilled workmen. The ideal university for the education of the engineer is not a trade school. His education should be largely general, and special branches should be handled so as to develop a broad rather than a narrow viewpoint. The student should be shown how these special branches are related to the general field which he is studying.

One of the most important elements in the instruction of the young engineer is to teach him to appreciate not only his own specialty but also the specialties of others. The engineer who is educated in only one specialty and does not have the background necessary to compare it with others is poorly prepared. There is perhaps no more narrow man than the specialist who knows nothing but his own specialty. He is an unsafe

guide except along his own narrow lines, because when his work must coordinate with that of others, he has no true perspective of relative importance or of relative values. Recently an architectural firm was designing an office building and decided to do the mechanical design work as well as the architectural designing. The heating system selected was a radiant-floor-panel system formed by embedding steam pipes in the concrete floor slab. With this system proper control of the temperatures proved to be impossible and at times the floor became much too hot for the comfort of the workers in the offices. The architectural design was well accepted and brought much acclaim to the architect but it was finally necessary to hire a heating consulting engineer who had to redesign the system completely to make it satisfactory.

The courses of study in engineering schools usually cover most branches of engineering in a fairly satisfactory manner when the purposes of the studies are understood and appreciated. The principles and methods on which investigations and practice must rest are fairly well developed, and the young engineer, when he leaves his engineering school, is fairly well prepared to undertake the minor calculations, operations, and designs in the practice of his profession. The engineering graduate must not overestimate his capabilities. His education is not finished, it has only begun. He has prepared a foundation; and if it is well laid, he has already accomplished much. He must now build the superstructure, and to do this successfully will require constant and strenuous effort.

When the young engineer enters practice, he still needs to acquire experience and to study, observe, and investigate subjects connected with his specialty, all of which is necessary for advanced work and which he can obtain to the best advantage while practicing his profession. For success the engineer must have a working knowledge of:

1. The fundamental principles of those sciences on which his work depends and their application
2. Those methods and calculations which must be applied in such practice together with skill and accuracy in their use
3. The English language, including the ability to prepare and present both clear and concise oral and written explanations of engineering problems
4. Business and engineering law, upon which the success of most engineering projects depends, and without which few correct reports, specifications, or contracts can be prepared
5. Those essential principles which concern the personal relations of the engineer with his friends, with his employers and clients, with his business associates, with labor, and with the public, and also those

principles of judgment, equity, and ethics upon which the highest success of every man depends.

The engineer must acquire judgment and a knowledge of men as an essential part of his education; these can come only with experience and observation.

The engineer should also acquire a correct perspective of his own capabilities and limitations. Self-knowledge is perhaps the most important knowledge: On the one hand, it will prevent the individual from attempting those things for which he is unfitted and thus eliminate failures which would result in more or less serious consequences, both to himself and to others; and on the other hand, it will give him the necessary confidence to undertake those things for which he is properly prepared and which will make him of the greatest value in his professional life.

The tendency of engineering education is frequently not toward the developing of judgment. If textbooks and instructors are considered infallible, if lectures are taken without question, the development of judgment is certainly not stimulated. An earnest effort should be made by the young engineer to understand the limitations of theory and the conditions under which judgment, based on experience, must be used. The use and abuse of formulas should be appreciated and their limitations realized. Every experienced engineer should recognize the convenience of formulas. He must also understand the danger of carelessness in their use, realizing that the application of all theory to practice must be modified by judgment in order to take into account factors often unrecognized in theoretical considerations.

1-4. A Knowledge of English. A knowledge of English, and the ability to express his meaning in clear, concise, and convincing language, both oral and written, are assets of great value to the engineer.

The ability to prepare and present, orally or in writing, an analysis of the problem to be solved is often as important as the ability to recognize and solve the problem. Preparing the engineer to discuss the conditions that exist intelligently, to present the principles involved properly, and to describe clearly the proper methods of procedure to be followed so that each of these matters will be understood by the business or professional man by whom the problem is presented, is a most important function of education. The ability to do this can be acquired only by practice and by the constant endeavor of the engineer in the preparation of his work to place himself in the mental attitude of the one who is to hear or read the matter presented.

At almost every step the engineer is called upon to prepare reports, papers, or specifications involving the general or detailed description of

works built or proposed. The engineer is often required by his clients or superior to examine projects in order to determine the line of action necessary or desirable under the conditions that exist, and perhaps the feasibility, nature, extent, character, and cost of the construction or works which should be installed to accomplish the purpose desired. In such cases he must be able to describe in clear language the conditions which he finds and the factors which will affect the proposed project, and to give in a logical manner the reasons for his recommendations concerning the character, extent, and cost of the work.

When labor, material, supplies, or works are to be furnished or constructed, either as a whole or in part, by others than the owner (and there are few constructions where material at least is not to be so furnished), the engineer must describe clearly and in detail the character and extent of those parts which are to be so furnished. Few designs are complete in themselves without such descriptions, and frequently the proper preparation of these descriptions or specifications is among the most important of the duties of the designer. Proper specifications are fully as important as the maps, plans, and designs, and are no less essential for the explanation of the proposed work. Frequently a design, which may be based on precedent or, partially at least, on the published plans of others, is much less difficult to prepare than the specifications which must describe in detail the materials and character of the construction, and particularly the practicable qualities of material and the methods which must be followed in their economic manufacture or construction. Even where work is to be done by the direct employment of men by the owner and not under contract, proper specifications are essential as a basis for correct estimates of cost and for the proper performance of the work.

Material, labor, machinery, or supplies to be purchased or contracted for must be ordered and an agreement more or less formal for furnishing these must in every case be entered into. Such agreements vary from the simple form of a verbal order and acceptance for the smallest items to very elaborate contracts and specifications for the most complex machinery or plants costing thousands of dollars. If such agreements are not properly and clearly prepared, they may involve needless misunderstandings and expensive litigation. Precision and clearness of language become of greater importance as the interests involved are larger. In order to prepare correct technical reports or specifications, the engineer must possess a knowledge of technical language; and this is acquired only by professional study and practical experience in special lines.

The field covered by reports and specifications is broad and touches almost every limit of human activity, and the ability to prepare them properly is acquired only by long experience, careful study, and detailed

knowledge. Certain principles, however, can be readily acquired and understood, and if followed, will lead the way to success in this work.

1-5. Legal Relations. It is the duty of every citizen to inform himself in regard to the fundamental and elementary laws under which he lives and on which his legal rights and privileges depend, so that he shall have a clear conception of his own rights and privileges and those of his neighbors and business associates.

It is important for the engineer to acquire a knowledge of those fundamental principles of law which clearly govern and control his social and business relations and special professional activities, including the laws of contracts, in which he is often especially interested either as a principal or as an arbiter. These principles in their general relations can be readily understood, but their specific application, particularly under many complex limiting conditions, becomes exceedingly difficult and calls for the advice of those who have given special study to the subject under consideration.

The engineer should be sufficiently informed concerning those legal matters which affect his duties and responsibilities to know when all ordinary legal requirements are observed in drawing up such engineering papers as may be necessary in his work; and to see that the actions, attitudes, and decisions of himself and his subordinates are legal and that the legal rights of his clients, business associates, and of himself are properly conserved. In all cases of importance, legal advice is essential and should be obtained. Few lawyers in ordinary practice, however, possess the knowledge of engineering contracts or of the conditions of construction that is necessary in order to draw a satisfactory contract for construction work. Engineering contracts, as well as technical specifications, should be prepared by the engineer and submitted to the attorney to see that the legal requirements are properly covered.

The engineer, to be successful in professional practice, must also be informed on the laws which affect his particular specialty. The municipal engineer and contractor should understand those municipal laws which affect municipal works and which both limit and control municipal activities. The hydraulic engineer should understand the laws of riparian ownership and those governing the acquiring of water rights and the construction of water power, irrigation and drainage projects, and the legal requirements of navigation, logging, fishways, etc. The mechanical engineer should understand something of patent laws and of the various other laws which affect his specialty. In each branch of engineering there are certain legal relations the knowledge of which is indispensable to successful engineering practice. There are so many laws that no lawyer in general practice can be thoroughly informed on all legal matters and the engineer in practice frequently becomes better informed on those