Engineering Standards 101

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Abstract

Standards exist which are frequently encountered in the practice of engineering. Many engineers are employed full time in a job where each manufactured item produced by their company conforms to the requirements of a published standard (e.g., boilers/ASME). Other engineers rarely require knowledge of or use standards in their daily work.

The purpose of this paper is to introduce undergraduate students to the world of Standards as they apply to the practice of engineering. The paper should be useful in classes such as Introduction to Mechanical (or other) Engineering or in Seminar classes in the early phases of the undergraduate engineering curriculum.

The paper discusses Standards from the perspective of:

1. Why do we need Standards?
2. How does one determine whether there is a standard for a given product or situation?
3. How are Standards generated?
4. When are Standards applicable
5. Which, if any, Standards are required by law?
6. How may one obtain copies of Standards including earlier versions?

Introduction

Earliest recorded history indicates a need to measure time, length, and mass (weight). The biblical earth was created in seven days and Noah's ark length was measured in cubits. Travel and trade required that there be generally agreed upon standards for measurement. The standards were set using various methods (an inch was the width of a man's thumb) and typically were recognized only locally. The modern world requires that there be universally accepted ways to quantify measurements.

The French adopted the metric system during Napoleon's time (1793). The meter became the standard length and the standard liquid capacity and weight measures were also included. There arose some confusion in using the new metric system; however, the French adopted the system for good in 1837.

In the United States, the National Bureau of Standards was established in 1901 and placed in the Treasury Department. It was established to function as a national physical science laboratory to improve physical measurement, determine physical constants and critical properties of materials, and render technical services to other government agencies. It is responsible for maintaining and developing the country's standards of measurement.

Why Do We Need Standards?

Evolving society demanded that measurement go beyond quantifying time, length, and mass. Safety, health, and the necessity to evaluate products using a common basis gradually led to the development of "product-based" Standards. For example, steam boiler explosions killed or maimed hundreds of people during the 1800's. It was

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therefore recognized that there needed to be some method to design safe steam boilers. The ASME (American Society of Mechanical Engineers) eventually produced and made available to design engineers a standard detailing how one designs a safe boiler or pressure vessel. ASME currently derives a portion of its income from the sale of the Standard. Other Standards assure that the food we consume and the gasoline we purchase meet certain specifications.

Although they are rarely discussed in a classroom environment, Engineering Standards permeate our daily lives and the practice of engineering. For example, your office chair and the ink in your pen are manufactured so as to meet expectations enumerated in appropriate Standards.

Beginning engineering students immediately encounter the classroom application of Standards in their required course work. The classically required engineering drawing course utilizes standardized abbreviations prescribed in the ANSI/ASME (American National Standards Institute/American Society of Mechanical Engineers). Y1.1-1989, Abbreviations for Use on Drawings and in Text. Drawing dimensions and tolerancing should be done to conform to ANSI/ASME Y14.5M-1994, Dimensioning and Tolerancing. The students' Chemistry 101 instructor should have knowledge of ANSI/NFPA (National Fire Protection Association) 655-1993, Prevention of Sulfur Fires and Explosions and ANSI/NFPA 491M-1991, Manual of Hazardous Chemical Reactions.

Note also, that the Students' daily activities cause them to interact with a myriad of products that were designed, manufactured, or operate in compliance with Engineering Standards. Many components on their automobiles (i.e., gasoline, oil, tires, nuts, bolts, washers) were manufactured to comply with Engineering Standards, as was the water heater that produces their shower water.

Do Standards Apply to This Product?

There does not exist a Standard for every product which one encounters. For example, SAE (Society of Automotive Engineers) develops and publishes Standards dealing with nuts, bolts, washers, tires, and fuel lines; yet, there is not "standard" automobile. Quite often the applicable Standard is noted on the product itself. Examinations of a residential water heater (or its pressure/temperature relief valve), a red plastic gasoline container, or a can of automotive motor oil will reveal the Standard that applies to this product. Catalogs listing various products (chains, ropes, air filters, etc.) will often reveal that the product conforms to the specifications of a listed Standard. Most manufacturing plants or design engineering firms will have a W.W. Grainger or McMaster-Carr catalog on their book shelves. These catalogs (and the company web sites) are excellent references detailing products for which there is an applicable Standard.

The modern worldwide web provides an almost unlimited amount of information on Standards. For example, an entry of "SAE and Standards" returned a list of 3,488 results dealing with this topic. Several of the listed results are sites that offer Standards for sale.

Consulting mechanical engineers involved in product failure need to determine early on in their investigation whether there is a Standard applicable to the specific failure. Since Standards generally evolve, it is necessary to note the Standard that was in effect on the date of the manufacture of the product.

How Are Standard Generated?

The need for a standard may arise from various sources. It is obviously desirable that a nut purchased in one store mate with a bolt obtained at a different store. Compliance with the appropriate SAE standard ensures that the two will mate. Note however; that ABC Bolt Company has no obligation to manufacture it bolts in compliance with the Standard; this will be dictated by the market for nuts and bolts.

There are numerous agencies that develop Standards used in the modern practice of engineering. Typically, the Standard will be developed in an area of interest associated with a group most closely connected with the subject of the Standard. Thus the Society of Automotive Engineers (SAE) develops and publishes Standards dealing with steel

fasteners, tubing, spark plugs, wheels, tires, hydraulic hose, brake fluid, and many other items associated with powered vehicles.

ANSI (American National Standards Institute) is an impartial organization that does not develop standards. Its function is to act as a clearinghouse for standards developed by agencies such as ASME, SAE, NFPA, etc. ANSI "guarantees that the standards writing group used democratic procedures that gave everyone who will be "directly and naturally" affected by the use of the standard an opportunity to participate in the development work or to comment on the document's provisions." *(1996 Catalog of American National Standards*, 5, page 2).

The purpose of this paper is to discuss the process by which a need for an Engineering Standard arises; and once the need is established, what is the methodology for development of the Standard.

Although this discussion will focus on a specific need (prevention or reduction of fire and explosions ignited by static electricity); the procedures, techniques, and methods for the development of a desired Standard will be generic to other areas of engineering practice.

The mission of the National Fire Prevention Association (NFPA) is to "reduce the worldwide burden of fire and other hazards on the quality of life by developing and advocating scientifically based consensus codes and standards, research, training, and education". (*www.nfpa.org/catalog/Home/AboutNFPA*) NFPA is an international nonprofit membership organization founded in 1896. Its current membership is more than 75,000 in 100 nations. NFPA currently publishes more than 300 safety codes and Standards. Their codes and standards have helped save lives and protect property around the world.

It was early recognized that three ingredients were necessary to create a fire or explosion; fuel and oxygen (generally in air), and an ignition source. Note that the fuel/oxygen mixture must exist in the proper proportions. Experimentation indicated that a static electricity discharge with sufficient energy could serve as a source of ignition for a fire or explosion. NFPA, in order to reduce the worldwide burden of fire and other hazards, proceeded to develop a standard dealing with static electricity as an ignition source.

How are Standards Created?

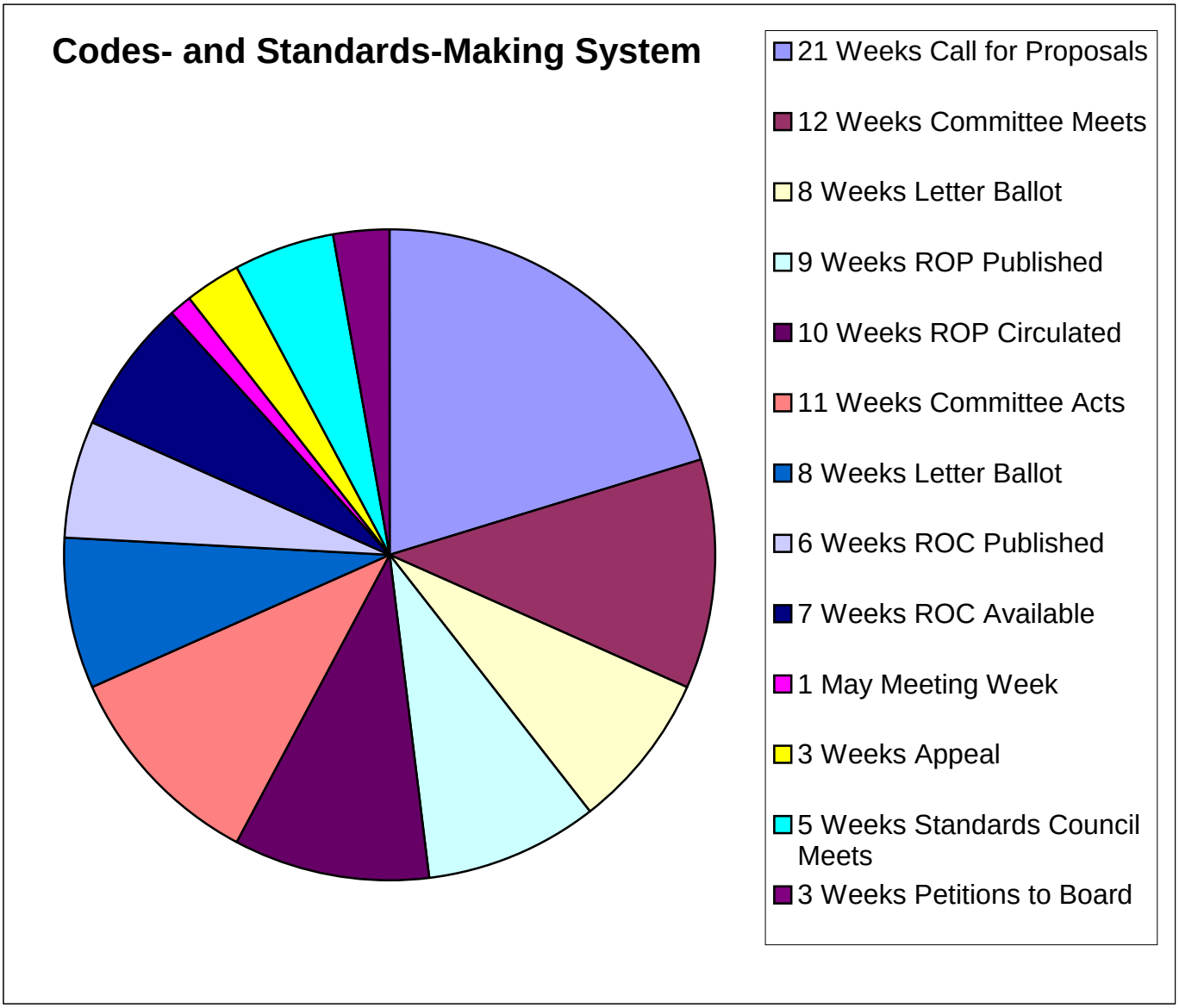
Need. The need for a standard may arise from various sources. For example, modern automobile engines require lubricants much superior to those used in the early days of the internal combustion engine. SAE, jointly with the American Petroleum Institute (API) developed, and regularly updates, appropriate standards dealing with the classification and performance of engine oils. In many cases, standards need to be regularly updated in order to be relevant.

Call for Proposals. Once a need for a standard (or change to an existing one) is established; the Codes and Standards Committee (within NFPA in our example) most closely associated with the topic solicits proposals. The proposals may be generated by technical committees within the standards setting agency or from general members of the engineering community. Proposals arrive at the appropriate technical committee for evaluation and are either accepted or rejected. Note that proposed actions may lead to the establishment of new technical committees within the organization. NFPA 77 is the Standard dealing with static electricity. A project addressing static electricity was initiated in 1936. A progress report was presented in 1937. A tentative edition of NFPA 77 was adopted in 1941. The revised versions of the Standard were officially adopted in 1960, 1961, 1966, 1972, 1977, 1982, 1988, and 1993.

Committee Membership. NFPA has over 200 committees with a combined membership of approximately 600. The members are volunteers who come from a wide range of professional expertise. Members represent governing agencies, fire services, educational institutions, businesses, insurance companies, industries, and consumers. The standards that are developed are truly "consensus" in nature. The Static Electricity Technical Committee responsible for developing and updating NFPA 77 includes members from industry, safety, consultants, explosive manufacturers, insurance companies, and university electrical engineers.

Proposed Standard. The proposals received by NAPA for a suggested amendment, deletion, or additions to an existing Standard (or a proposed new Standard) are referred to the appropriate technical Committee (TC) for action. Committee meetings are held to formulate appropriate actions to be taken to respond to the proposals. Proposed actions are either approved or disapproved by a ballot circulated to members of the Technical Correlating Committee (TCC). The TCC manager and coordinates the activities of a project within which more than one technical committee (RTC) functions. At this point a Report on Proposals (ROP) is generated which details the actions taken by the technical committee. The ROP is circulated for a specified length of time. A ballot circulated to all committee members follows further committee actions. Further input is provided in a Report on Committee (ROC) that summarizes actions taken by the committee relative to comments received in the proposal. This report is made available for a specified period of time prior to the final phases of the development process. Final meetings and appeals would be considered prior to final adoption of the proposed material. For NFPA the process from start to completion requires approximately two years. Figure 1 (source from pdf "Schedules for Processing Committee Reports" at www.nfpa.org/Codes/NFPADirectory) depicts the process unique to their development of standards or proposed changes to standards.

Figure 1: Codes- and Standards-Making System



The process begins with 21 weeks allocated to Call for Proposals and proceeds clockwise as shown by the arrow. Note that this process is unique to NFPA. It should be noted, however, that a similar technique would be used by other standard setting agencies to develop their documents.

Note that an excellent discussion of the standards development process used within NFPA can be found on their web site www.nfpa.org/codes and associated links. The process would be similar for other groups or technical societies that develop standards.

When are Standards Applicable or Legally Required?

Standards generally do not take the effect of law. As stated earlier, ABC Bolt Company has no legal requirement that their bolts use SAE-specified thread configurations. In general, good business practice will require ABC to use the generally accepted thread configurations. The codes and Standards developed by NFPA frequently become the basis for legal requirements. The codes are frequently adopted by municipal agencies and incorporated into law. Codes and Standards are also frequently referenced in the Code of Federal Regulations published by the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA). For example, OSHA requires (by law) that a conveyor located in a sawmill comply with Standard ANSI/AME B20.1. Department of Transportation (DOT) regulations published in the Code of Federal Regulations also take the effect of law. Examination of the label on your automobile seat belt will indicate that it conforms to a Federal Motor Vehicle Safety Standard (FMVSS). This Standard having been published in the Code of Federal Regulations, takes the effect of law.

It is often necessary to complete a search of available databases to determine if Standards have legal binding and this may vary from state to state. For example; the state of California has recently enacted law that does not allow portable gasoline containers to have more than one opening. Thus, a container that may be legally sold in Mississippi (or most other states) cannot be legally sold in California.

Note again, that the most recently published version of a Standard may vary from a previous version; and in judging a product, the Standard that existed on the date of manufacture of the product is applicable. The preamble to OSHA indicates that the most current revision of a standard is the one to be in effect.

How are Standards Obtained?

Standards produced by governmental agencies (either state or federal) can typically be obtained directly from the world wide web at no cost. Standard setting agencies such as ASME, SAE, NFPA, etc. sell their standards to the public, generally at modest cost. Web search will indicate how to purchase the Standards (typically online). ANSI, as indicated, acts as a clearinghouse for a variety of Standards developed by others (ASME, SAE, etc.) The Standards can be purchased online at the ANSI web site. A good resource for early versions of Standards is either the society (ASME, etc.) or www.global.ihs.com.

Conclusion

Standards, either directly or indirectly, affect our everyday lives in many ways. A handicapped person using a sloped wheel chair ramp is assisted by the fact that the slope in the ramp is specified by standard CABO/ANSI A117.1 – 1992. This Standard typically takes the effect of law when municipalities adopt it. Standards adopted by OSHA are also considered to be legally required; whereas many standards are considered to only from the basis of minimum acceptable performance. Standards frequently become of interest in the legal arena when failed products are examined. A product manufacturer should always market a product that meets (or exceeds) any requirements listed in a standard even though there may be no legal requirement to do so. Many product catalogs (W.W. Grainger, McMaster-Carr Supply Company) list applicable standards applying to products which they sell such as PVC pipe and wire rope. It is not uncommon to find the standard noted on the product, such as one would observe a note of the appropriate ASTM standard printed on PVC pipe.

Our experience has been that engineering faculty rarely uses the opportunity to introduce students to the world of Standards. Many instances arise where this can be easily done with no loss of time or continuity in the presentation. Opportunities arise in both lecture, and especially, in laboratory courses. Introduction to standards at the undergraduate level will better prepare our new graduates to more effectively perform their jobs in whatever workplace they find themselves after graduation.

References

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