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## **The Role of Standards Education in Engineering Curricula**

Standards are documents that serve to formalize procedures, rules, or guidelines for industry to follow. Global competitiveness and quality of life are ensured through the development and use of voluntary consensus standards. Growing awareness of the importance of standards has led to an increasing interest in teaching about standards and standardization at the university level.

This paper will explore what role standards play in the marketplace today and how engineering students can benefit from the knowledge of standards. Provided will be examples of how standards are currently being incorporated in the classroom and also case studies that can be used to further standards education.

# **The Role of Standards Education in Engineering Curricula**

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Globalization in the marketplace and rapid changes in technology in the 21<sup>st</sup> century demand that engineers acquire the skills necessary to be immediately effective upon graduation. In addition to the math and science skills important in engineering curriculum, today's engineers must be familiar with the mandated federal, state, and local regulations that create the boundaries of their work.

Within these regulations, standards are technical documents that play an important role in defining specific procedures, rules and guidelines. Knowledge of standards can also contribute significantly to the bottom line of companies that use engineers to develop new markets for products and help to protect them from litigation. Although the Accreditation Board for Engineering and Technology's (ABET) criteria for engineering curriculum now requires that faculty must ensure that their programs incorporate appropriate engineering standards<sup>1</sup>, more emphasis needs to be given to teaching about standards and standardization at the university level.

For the purposes of this paper, "standards" are authoritative technical documents that define a specific test procedure or specify the quality and safety attributes of a material, product, system or service. Used effectively, standards help to improve the reliability of materials, contribute to public welfare and the overall quality of life, and facilitate regional, national and international commerce. In the U.S., standards are voluntary until quoted in regulation or used in a contract between buyer and seller. In many countries outside the United States, national standards bodies (NSBs) in each country help dictate the standards that will be developed and generally use government funds to do so. The U.S. standards development system is much different, in that industry typically decides what standards are to be developed and contributes heavily to costs involved in their promulgation.

In the United States, there are some 400 standards development organizations (SDOs). Over 200 of these SDOs are accredited by the American National Standards Institute (ANSI), which was formed in 1918 as a federation of the U.S.-based developers. ANSI plays a significant role in defining the rules and procedures to be followed by accredited SDOs. For example, ANSI guidelines require "fair and balanced participation of stakeholders," which ensures adequate representation by all interested parties. Although not a NSB nor a SDO, ANSI does serve as the representative body in the U.S. to the International Organization for Standardization (ISO). In the ISO standards development process, technical advisory groups (TAGs) are formed in each country wishing to participate in a given technical area. In the U.S., a consensus position on a given standard is developed in each TAG and reported through ANSI as the official U.S. vote.

In contrast to the ISO process, many U.S.-based international standards developers utilize a development process that allows for direct participation from all interested parties. Founded in 1898, ASTM International, the largest U.S.-based international standards developer, develops standards in more than 90 industry sectors through over 135 technical committees. Known for their high technical quality and market relevance, these standards are an important part of the information infrastructure that guides design, manufacturing and trade around the globe. More

than 4000 ASTM International standards have been either adopted or used as the basis of national standards in over 125 countries. ASTM's process allows for industry, government, academia and consumers from around the world to come together in a single forum to voluntarily develop needed standards with a high degree of technical content and market relevancy.

Recognizing the important role that standards play in the marketplace, industry continues to contribute to the development process and uses the resulting products. Through participation, industry experts are able to stay up-to-date on the latest technology and standardization, as well as affect the standards that shape their business. A paper presented at the American Society for Engineering Education's (ASEE) 2008 Annual Conference<sup>2</sup> pointed to the fact that one company's principal devotes 25% of their time to standards development activities. As industry members begin to mutually shape the content of standards, they share expertise and come to understand how they can influence future development to benefit their own interests. SDOs can serve as a fertile training ground for new and experienced engineers alike.

Standards are commonly used by industry experts in developing countries to raise the level of quality and safety as an economy grows. One such example has been the use of standards in Colombia by the construction industry to improve the reliability and quality of the concrete used in that country. The United Nations estimates 28 million new housing units are needed in Latin America to relieve crowding and substandard conditions.<sup>3</sup> Through a memorandum of understanding (MOU), ASTM International helps countries use updated standards for construction. In Colombia, ASTM International and the Instituto Colombiano de Normas Técnicas y Certificación (ICONTEC) and the Asociación Colombiana de Productores de Concreto (ASOCRETO) partner to provide training workshops and information exchanges. Colombians also directly participate in the ASTM International technical committees that develop standards, which helps ensure that these technical documents reflect local conditions and needs. For example, today more than 75 industry experts from Colombia participate on ASTM Committee C09 on Concrete and Concrete Aggregates.

Likewise, governments around the world help to shape and develop the standards portfolio in key sectors. Particularly when a proposed standard relates to health and safety, governments are more inclined to develop the technical standard themselves, and it is often codified in a technical regulation without the help of SDOs. However, at other times, government is actively involved in the voluntary process of private developers. In fact, Public Law 104-113, The National Technology Transfer and Advancement Act of 1995, requires that federal agencies in the U.S. use consensus based, voluntary standards as alternatives to specifications that had previously been developed only for government use. The strategy allows government to work as an equal partner with industry, researchers and consumers to develop highly relevant standards. The Law has already saved the federal government billions of dollars in procurement costs and has lessened overlap and conflict in regulations. Once developed, governments may choose to then reference voluntary standards in their regulations that they know have already attained acceptance from the industries required to use them.

In today's global economy, government regulation plays a critical role in multinational companies' ability to be successful. If duplicative standards are referenced in regulations from different countries, it can interrupt the flow of goods across borders, or result in duplicative

testing on imported goods. In addition, reduced tariffs on imports and exports, made possible through trade agreements, has emphasized the need to monitor standards and regulations that can be used as non-tariff barriers to trade. Recognizing the need to monitor these non-tariff barriers, an international treaty called the Agreement on Technical Barriers to Trade (TBT) entered into force with the establishment of the WTO at the end of 1994. The TBT agreement requires that when "...the technical regulation may have a significant effect on trade of other Members....," it shall be reported. Engineers and other business people who are aware of standards activities and their use in regulation around the world can strategically benefit their organizations.

In addition to standards and regulation, conformity assessment is the third piece that plays a key role in today's marketplace. Conformity assessment is the evaluation of a process, product or service's compliance with a relevant standard or regulation. Many electrical products, for example, require certification through organizations such as Underwriters Laboratories (UL). Manufacturers of UL-certified products must demonstrate compliance with the appropriate safety requirements. Conformity assessment requirements can cost a company millions of dollars and it's critical for engineers to be aware of these obligations.

Standards are important to industry in terms of marketing and liability as well. An engineered product, having risks associated with its use, can benefit in both of these aspects. From a marketing standpoint, producers of a "risky" product can benefit by saying that the product meets the industry standard, especially when the standard is related to safety. Knowledgeable manufacturers can even point to the fact that the Consumer Product Safety Commission (CPSC), charged in the U.S. with monitoring consumer products for safety, is an active participant in the standards development process. The CPSC has the authority to regulate the sale and manufacture of more than 15,000 different consumer products. It's clear that adherence to industry standards significantly reduces a company's liability from claims of negligence.

Academia has long played a part in standards development by presenting research and proposing new standards based on the most recently discovered technology. University researchers and industry stakeholders often work side-by-side to develop new standards and update existing standards. Emerging fields like composite materials attract a large number of university faculty interested in doing research and in publishing their work on the latest standard they have helped to develop.

Presently, standards are being used in university curricula, but typically the focus is on the standard's technical requirements and not on the process of a standard's development. When introduced in the majority of engineering classes, standards are introduced as tools, often only to be used in the laboratory as would be a test tube or crucible. Academicians who have participated in the standards development process often make the best teachers for students who need to know, not only about the technical aspects of standards, but the processes that go into developing them. Students who learn about the process of developing standards are more likely to participate in their development and add value for future employers. Without active engineers in the standards development process, the standards factory becomes devoid of its workers, and society as a whole suffers.

## Standards Courses

A course introducing the importance of voluntary international standards was developed into an Oklahoma State University Environmental Science graduate course in Sustainability and International Standards. The curriculum uses an innovative experiential learning approach whereby students research and develop a standard using the ASTM International process. It is intended to provide graduate students with a broad understanding of the cross-functional and interdisciplinary issues associated with standards, the process of standardization and global governance.<sup>4</sup>

Middle Tennessee State University (MTSU) is home of the Concrete Industry Management (CIM) program. This program is a joint initiative between MTSU and leaders from the concrete industry. Because of the interest in and need for appropriately trained personnel, the concrete industry made a substantial commitment to this venture, even providing consultants to ensure the program meets industry needs. One specific course includes a review of model building codes, building officials and their function, and concrete industry codes and standards. Since its founding in 1996, the CIM program has produced over 250 graduates for the concrete industry.<sup>5</sup>

In March of 2004, Chang Wook Kang, Ph.D., professor at the Department of Information and Industrial Engineering at the Ansan Campus of Hanyang University in South Korea, began to investigate standards education for engineering students. Soon afterwards, Dr. Kang approached the Korean Standards Association (KSA) and obtained financial support from KSA to run the course. KSA also organized a committee consisting of the professors who volunteered to teach the standardization class at their universities who discussed what tools were needed to teach the course and how it should be managed. The Korean government, through KSA, decided to financially support the writing and distribution of a textbook on standardization. Understanding the role of standards is a critical factor for technology development and national competitiveness.<sup>6</sup>

The Catholic University of America's School of Engineering offers a course entitled "Strategic Standardization" with the purpose of creating a level of awareness, or enhancing awareness, for graduate engineering students on significant issues associated with standards and the process of standardization. In particular, the course focuses on development of global technology standards from a U.S. perspective because the process of globalization directly affects the fields of engineering and technology management. The course syllabus states, "The future of the United States economy depends, in significant part, on effective management of its standardization system and effective participation in development of international standards."<sup>7</sup>

## Case Studies

Where There's Smoke... There Doesn't Have to be Fire<sup>8</sup>

Primary targeted academic discipline: Fire Protection Engineering

This case study describes how the National Fire Protection Association (NFPA) has worked to have laws requiring cigarette companies manufacture ignition resistant cigarettes that can help prevent house fires. The NFPA has formed the Coalition for Fire-Safe Cigarettes (CFSC), which includes organizations such as ASTM International. The CFSC has worked to get almost all

states to pass fire-safe cigarette laws. The CFSC initiative requires compliance with ASTM International Standard E2187, Test Method for Measuring the Ignition Strength of Cigarettes.

Smoking material was the major cause of an average of 14,000 fires a year in the U.S. from 2000 to 2004. These fires resulted in 700 to 900 fatalities each year, along with over 1,000 injuries and upwards of \$350 million in property damage. The ASTM test method E2187 was originally approved in 2002 by ASTM International Committee E05 on Fire Standards. E2187 “provides a standard measure of the capability of a cigarette, positioned on one of three standard substrates, to generate sufficient heat to continue burning and thus cause ignition of bedding or upholstered furniture.” Cigarettes that conform to E2187 have a reduced ignition propensity that makes them less fire-prone and have been branded “fire-safe.” The NFPA coordinated the creation of the CFSC in 2006, which calls on manufacturers to produce and market cigarettes that comply with ASTM E2187, and encourages states to pass legislation similar to a 2003 New York state law which was the first to mandate the use of E2187.

The standard E2187 was brought into ASTM E05 by Dr. Richard Gann, a representative from the National Institute of Standards and Technology (NIST). Dr. Gann had worked on developing this method for years at NIST and eventually he felt that the method was ready for the rigors of the ASTM balloting process. During the development phase, Dr. Gann got the cooperation of cigarette manufacturers which took about ten years. After the cigarette companies agreed to this type of cigarette, Dr. Gann brought the document to E05. Those cigarette companies are on committee E05 and participated in further development of the document until it was first approved in 2002. The first version that was approved by a state was E2187-02b (the 3rd version of E2187 in 2002), and that version was adopted by the State of New York.

Working at the state level, rather than the federal level, has proven to be a successful strategy for the CFSC. Fire-safe cigarette laws are currently in effect, have been passed or have been filed in more than 40 states. Cigarette manufacturers have been cooperative and some have vowed to convert their entire production of cigarettes to those that meet the cigarette fire safety standard by 2009.

The E2187 standard is the basis of the fire-safe cigarette law that is now in place throughout Canada, and it is being considered for legislation in other parts of the world as well.

Accompanying Question and Answer Worksheet

<b>Proposed Question</b>	Can countries outside the U.S. adopt E 2187?
<b>Proposed Answer</b>	Yes, countries outside the U.S. can adopt E2187. There is no single organization that is the only source of international standards, that has the most technically up-to-date and market-relevant solutions for an industry or government. Compliance with the World Trade Organization’s Technical Barriers to Trade principles identifies an organization as capable of developing international standards. Canada was the first country outside the U.S. to adopt E2187 and other countries around the world are currently considering E2187 for legislation.

<b>Proposed Question</b>	ASTM Standard E2187 is described in the case study. What aspects of this standard make it important and able to be used by cigarette manufacturing companies?
<b>Proposed Answer</b>	As stated in the scope, E2187 “provides a standard measure of the capability of a cigarette, positioned on one of three standard substrates, to generate sufficient heat to continue burning and thus cause ignition of bedding or upholstered furniture.” This standard allows cigarette manufacturers to test the ignition propensity of their cigarettes, and ultimately reduce that propensity. In addition, a statement on precision in the standard allows potential users of the test method to assess in general terms its usefulness in proposed applications. By conforming to E2187, cigarette manufacturers can produce “fire-safe” cigarettes which may help prevent many of the 14,000 fires started by smoking material each year.

<b>Proposed Question</b>	Why do legislatures use voluntary consensus standards in legislation? What are the benefits of this approach? How do these voluntary standards become mandatory when laws are passed? (Think outside the article and external research may be helpful)
<b>Proposed Answer</b>	In 1995, the National Technology Transfer and Advancement Act was passed which deals with standards in legislation. The law “directs that all Federal agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies, using such technical standards as a means to carry out policy objectives or activities determined by the agencies and departments.” According to the National Research Council (NRC), federal agencies adopt voluntary consensus standards because they are an “effective means of securing public interests.” The NRC also reports that voluntary standards-setting is faster than regulatory standards-setting. In a case such as the “fire-safe” cigarette, the voluntary consensus Standard E2187 was initially incorporated into the New York State law. It became mandatory for cigarette manufacturers in New York to comply with the standard. Other states followed their lead, and have cited E2187 in their state legislation of “fire-safe” cigarette laws.

### From Earth to Engine<sup>9</sup>

Primary targeted academic discipline: Chemical Engineering, Environmental Engineering

This case study describes how Zimbabwe is addressing the need for sustainable fuel production and the need to empower local farmers by turning to standards. Using ASTM International standards, the Zimbabwe government and NGOs are creating an extensive program promoting research about biodiesel made from the oil of seeds produced by locally grown *Jatropha* plants. In addition, Zimbabwe’s production of ethanol has used ASTM standards.

Renewable energy resources have been receiving widespread attention, particularly in the pursuit of sustainable development and other environmental considerations. In Zimbabwe, that pursuit includes responding to Kyoto Protocol dictates and investing in greener technologies that will help reduce carbon emissions and curb undesirable effects of climate change and global

warming. Consequently, government policy has shifted from the use of traditional, conventional fossil fuels — diesel and petroleum-based products and lubricants — to such biofuels as biodiesel and ethanol-based fuels. As it works to mitigate its energy deficiency and pursue environmentally friendly technologies for energy exploitation, Zimbabwe has concentrated largely on cultivating *Jatropha curcas*, a perennial oilseed plant. Since 2002, the country has unrolled an extensive program promoting research about biodiesel made from the oil of seeds produced by locally grown *Jatropha* plants, with ASTM International standards guiding the research.

Zimbabwe’s Technical Committee CH20 initiated a program calling for extensive research to characterize biodiesel blends made from *Jatropha*, adapting D 6751, Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels, which uses soybeans as its basis. In addition, Zimbabwe’s government and NGOs instituted a program encouraging local subsistence farmers to grow *Jatropha* plants as a business.

Planting *Jatropha* for biodiesel production has become a viable business in Zimbabwe, and similar initiatives elsewhere have gained widespread acceptance. For example, a total of 41,044 hectares of *Jatropha* have been planted in Swaziland, Zambia, Madagascar and Malawi. In Swaziland, a total of 9,244 hectares, of which 1,227 hectares are managed plantations and a further 8,017 hectares are under contract farming, have been planted, while in Zambia, 2,411 hectares are managed plantations and 20,760 hectares are under contract farming. The crops have helped to reduce poverty levels and improve rural employment, creating thousands of jobs.

Accompanying Question and Answer Worksheet

<b>Proposed Question</b>	What is the “Kyoto Protocol” and why are biofuel standards important to this agreement?
<b>Proposed Answer</b>	The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas (GHG) emissions .These amount to an average of five per cent against 1990 levels over the five-year period 2008-2012. The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Projects such as the development and use of biofuel standards can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO <sub>2</sub> , which can be counted towards meeting Kyoto targets.
<b>Proposed Question</b>	ASTM D 6751 Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels is quoted in the case. What aspects of this standard make it important and able to be used by the Standards Association of Zimbabwe?
<b>Proposed Answer</b>	ASTM D 6751 allows laboratories who extract biodiesel from <i>Jatropha</i> to characterize performance under prescribed conditions. D 6751 is a “performance” specification that prescribes minimum environmental and functional requirements without specifying in detail such things as composition,

	<p>size, density, and other measurable basic parameters. Any formulation, then, that performs up to the demands of the standard will be deemed to qualify under the standard. Performance standards, like D 6751, thus provide the necessary assurance of predictable outcome without constraining imaginative problem-solvers in their efforts to achieve that outcome.</p> <p>ASTM International standards are copyrighted and, in most cases, to develop a derivative standard based on an ASTM standard is not permitted. However, through the Memorandum of Understanding program, ASTM's agreement with the Standards Association of Zimbabwe (SAZ) allows and encourages SAZ to either adopt ASTM International standards or use them as the basis of their national standards.</p>
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<b>Proposed Question</b>	ASTM International standards are developed and used voluntarily around the world. Who decides which standards are acceptable in various situations?
<b>Proposed Answer</b>	There is no single organization that is the only source of international standards, that has the most technically up-to-date and market-relevant solutions for an industry or government. There are different ways of developing, and different sources of, international standards. Some standards users may look at the process by which the document was developed, or at the way in which the resulting standards are applied and used in the marketplace, to demonstrate their international acceptability. Compliance with the World Trade Organization's Technical Barriers to Trade principles identifies an organization as capable of developing international standards.

<sup>1</sup> ABET Criteria for Accrediting Engineering Programs, See [http://www.abet.org/forms.shtml#For\\_Engineering\\_Programs\\_Only](http://www.abet.org/forms.shtml#For_Engineering_Programs_Only)

<sup>2</sup> AC 2008-353: Sustainability and International Standards, ASEE 2008 Conference Proceedings

<sup>3</sup> see Jha, Abhas K. "Low-income Housing in Latin America and the Caribbean." *En Breve*. Jan. 2007 available at [http://siteresources.worldbank.org/INTENBREVE/Newsletters/21182026/Jan07\\_101\\_LowIncomeHousing\\_EN.pdf](http://siteresources.worldbank.org/INTENBREVE/Newsletters/21182026/Jan07_101_LowIncomeHousing_EN.pdf)

<sup>4</sup> AC 2008-353: Sustainability and International Standards, ASEE 2008 Conference Proceedings

<sup>5</sup> See <http://frank.mtsu.edu/~concrete/index.html>

<sup>6</sup> See [http://www.astm.org/SNEWS/MARCH\\_2005/kang\\_mar05.html](http://www.astm.org/SNEWS/MARCH_2005/kang_mar05.html)

<sup>7</sup> See <http://www.strategicstandards.com/Perspectives.html>

<sup>8</sup> See [http://www.astm.org/SNEWS/MJ\\_2008/wilhelm\\_mj08.html](http://www.astm.org/SNEWS/MJ_2008/wilhelm_mj08.html)

<sup>9</sup> See [http://www.astm.org/SNEWS/MJ\\_2008/chiwozva\\_mj08.html](http://www.astm.org/SNEWS/MJ_2008/chiwozva_mj08.html)