Licensure: Toward Technical Competence and Ethical Professionalism

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Licensure as a professional engineer is an investment in your future, and can be a beneficial — and even necessary — credential.

Engineering licensure helps to protect the public from incompetent or unscrupulous engineers, whose decisions and actions can affect public health, welfare, and safety. AIChE recommends that its members become licensed as Professional Engineers (P.E.s) because it helps to ensure a competent and ethical chemical engineering workforce.

This article describes the professional licensure process for chemical engineers, including the benefits of licensure, the requirements for taking the exam, and strategies for preparing to take the exam. It also discusses what a registered professional engineer must do to maintain his or her license, as well as the role of engineering boards in licensure and impending changes surrounding the examinations themselves.

Why become a licensed P.E.?

The Chemical Principles and Practice of Engineering Exam (often referred to simply as the Chemical PE Exam or PE exam) is the gateway to professional licensure for chemical engineers in the U.S. The exam evaluates whether a candidate has met the minimum competency level of an engineer with four years of industrial experience. Professional licensure can be an asset to one's career, and may lead to greater job opportunities and in some cases job security. Earning a P.E. license shows employers and clients that an engineer has met high technical and ethical standards through education, work experience, examination, and peer review.

Licensure might also be beneficial, or even required, when you start a new job or change responsibilities. For example, many engineering design firms encourage their engineers to be licensed, and licensure is often mandatory when working in government, consulting, or serving as an expert witness.

Many companies based in countries without licensing laws, particularly in the Middle East, now require job applicants to be licensed in a U.S. jurisdiction (the 50 states, the District of Columbia, Guam, Puerto Rico, the U.S. Virgin Islands, and the Northern Mariana Islands) or to pass the PE exam to show that they are technically competent. (Licensing standards outside the U.S. are beyond the scope of this article.)

All U.S. state legislatures require registration (*i.e.*, licensure) of engineers who offer their services directly to the public. All jurisdictions require a licensed engineer to be in responsible charge over the engineering design of buildings, structures, products, machines, processes, and systems that can affect the public health, safety, and welfare. Meanwhile, many engineering jobs, especially those in large companies, currently do not require practitioners to have a P.E. license, because statutes in some jurisdictions allow what is known as an industrial exemption. The industrial exemption is

P.E. Session at AIChE's Spring Meeting

AIChE's 2013 Spring Meeting and Global Congress on Process Safety, Apr. 28–May 2, in San Antonio, TX, will feature a session on P.E. licensure (Tuesday, Apr. 30), where attendees will learn about licensure from the point of view of the engineer, the employer, and the public, as well as the critical issues connected with P.E. licensure. For more information, visit www.aiche.org/spring.

based on the premise that large firms have a vested interest in their products and in protecting the safety and welfare of their employees, their facilities, and the general public. Large companies are in a position (and have strong motivation) to take responsibility for their employees' decisions and actions, and also have the financial resources to cover liability should it arise.

Not all jurisdictions grant an industrial exemption. However, leaders of organizations such as the National Council of Examiners for Engineering and Surveying (NCEES) (see discussion below) advocate eliminating the industrial exemption — on the premise that this would better protect the health, safety, and welfare of the public.

Licensure in your jurisdiction

To become licensed in the U.S., engineers must meet the standards for education, experience, and eligibility established in their jurisdiction and enforced by the jurisdiction's engineering licensing board.

Typically, becoming licensed requires an engineer to:

1. have a bachelor of engineering degree from a four-year engineering program accredited by the Engineering Accreditation Commission (EAC) or the Accreditation Board for Engineering and Technology (ABET)

2. pass the Fundamentals of Engineering (FE) exam, which tests basic engineering knowledge

3. work as an engineer for a given number of years (typically four or five) under the supervision of experienced engineers (sometimes explicitly P.E.s)

4. provide documentation to the licensing board showing proof of the required education, FE, and work experience

5. pass the Principles and Practice of Engineering (PE) exam.

While these basic licensure requirements are fairly uniform, they vary among jurisdictions. To provide some uniformity to the requirements, licensing boards are members of the NCEES. The NCEES holds an annual meeting at which board members vote on proposed changes to NCEES Model Law and Model Rules (*i.e.*, recommended best practices to encourage uniformity among jurisdictions).

Application of the Model Law varies among jurisdictions. For example, the Model Law states that if you are a practicing engineer with a BS in engineering from an accredited program, you must pass the FE exam and have four years of qualifying professional experience before being eligible to take the PE exam. However, a few jurisdictions require only two years of experience, and some require no experience. Some jurisdictions permit waiving the FE exam based on one's education and experience. Boards also differ on education requirements from non-accredited engineering programs.

To confirm the requirements for your jurisdiction, visit www.ncees.org/Licensing-boards and contact your licensing board.

Education requirements

All U.S. jurisdictions require a minimum of a Bachelor of Science engineering degree, or equivalent, from an EAC/ABET-accredited four-year engineering program. Candidates holding a degree from a foreign university, from a non-EAC/ABET-accredited U.S. program, or a non-engineering degree must provide proof of the necessary engineering education. In such cases, the board will likely require the use of the credentials evaluation service *(1)* provided by NCEES. This online process involves requesting that your academic institution provide transcripts and course details to NCEES. After evaluating the documentation, the NCEES staff provides a verdict on the engineer's eligibility and identifies any deficiencies.

The NCEES credentials evaluation service can also be

The Role of Licensing Boards

A jurisdiction's licensing board usually consists of licensed engineers and surveyors, and often includes members of the public, such as architects and lawyers. Most jurisdictions have a single board that covers engineers and surveyors, while some have separate engineering and surveying boards. Board members may be from any engineering discipline. However, the majority of engineers on most boards are civil and structural engineers. Engineering board members are appointed by state governors for a fixed term (usually four to six years).

The boards' services include:

• *Assisting with and approving new licensures.* Contacting one's home licensing board is the first step in applying for new licensure or reactivating a license. Boards provide information on licensing requirements, and evaluate each applicant's qualifications to become licensed in the jurisdiction.

• *Evaluating public complaints.* Licensing boards evaluate the merits of complaints lodged against engineers or engineering companies. Boards can suspend, revoke, place on probation, fine, reprimand, and recover costs from licensees who are found guilty of violating the jurisdiction's rules.

• *Setting standards for licensure.* The boards establish rules for licensure in their jurisdiction, which may or may not follow the best-practices contained in the NCEES Model Law and Model Rules. Most states require legislative approval for changes. Boards accept public input when proposing and deciding upon changes.

Finally, board members constitute the NCEES membership. They attend the NCEES annual meeting, where they vote on proposed changes to the Model Law and Model Rules. They may also serve on NCEES exam development committees.

Licensure in Multiple Jurisdictions

If you need licensure in multiple states, it will be useful to establish an NCEES record, which consolidates your credentials. Once established, your NCEES record can be used across jurisdictions, reducing the time required to become licensed in new jurisdictions. If multiple jurisdiction licensures are required in your position, your company will probably help you to establish the record and pay associated fees.

To establish an NCEES record, you need to supply the NCEES with:

- all relevant educational transcripts
- employment history
- references.

NCEES staff will verify and compile this information, along with your FE and PE exam results, into your record. Once the record is established (usually a two- to three-month process), the NCEES can send your record electronically to any board.

Most state licensing boards accept the NCEES record, and some boards now require all applicants to have an NCEES record. Once established, you should keep it updated, especially before sending it to a new board. Note, too, that being licensed in one jurisdiction does not guarantee licensure in another one, because licensing requirements are not the same in all jurisdictions. For more details on establishing and maintaining an NCEES Record, see www.ncees.org/records.

valuable if you anticipate registering in more than one jurisdiction (see sidebar, above); a single evaluation can be used by licensing boards in every jurisdiction.

The sidebar on p. 61 addresses possible changes to the education requirement for PE exam candidates.

Fundamentals of Engineering exam

The authors of this article encourage students to take the FE exam in their senior year of college or shortly afterwards, even if they do not plan to become a licensed engineer. Many engineers who take the FE years after they graduate find the exam as hard, or harder, than the PE exam, because the FE exam tests knowledge (*e.g.*, statics) not commonly used by practicing chemical engineers. (The specifications for the FE exam will change in 2014, when a dedicated Chemical FE exam will debut. The new exam will emphasize knowledge more common to practicing chemical engineers.)

The NCEES website (www.ncees.org/Exams/FE-exam) provides details on the 2013 FE exam, which will be administered in April (as this issue goes to press, registration is closed for this date) and October. The exam consists of two four-hour modules given in one day. The morning session is a general module with 120 multiple-choice questions covering basic math, science, and engineering. In the afternoon session, chemical engineers usually select the chemical module from among several engineering options available. It contains 60 multiple-choice questions that test chemical engineering knowledge. Topic areas (specifications) for the current FE exam can be found at the previously cited URL.

A few points of advice about taking the FE exam in 2013:

- Examinees must take to the exam site both the exam authorization notice obtained from the NCEES and a valid, government-issued, photo identification.
- The FE exam is a closed-book test. However, at the exam site, examinees will receive a reference handbook that contains all of the formulas needed to answer the questions.
- Examinees are forbidden to take extraneous items, such as cell phones, paper, or pencil, into the room. Pencils are provided, and the exam booklets are used for scratch paper.
- Only those calculators approved by the NCEES and listed at www.ncees.org/exams/calculator-policy may be used.
- Wrong answers are not penalized, so examinees should answer all questions, even if with an educated guess.

To help candidates prepare for the FE exam, the NCEES offers sample exams and the reference handbook (www.ncees.org/Exams/Study-materials/?exam=FE). Familiarity with the handbook can save precious time during the actual exam. If you take a practice exam, time yourself. Be sure to check units — a major source of error, especially on timed tests.

Note that the current NCEES Model Law waives the requirement for taking the FE exam for those who have earned a PhD. However, check with your own board to ensure that they grant this waiver. Also, some boards may waive the FE exam requirement for engineers with extensive practical experience.

In 2014, the FE exam will become a computer-based test (CBT), and will be offered numerous times throughout the year at commercial testing centers. The computer-based chemical engineering FE exam will contain only one module and will incorporate math, science, general engineering, and chemical engineering questions. Table 1 lists the new exam

Table 1. Beginning in 2014, the Fundamentals of Engineering (FE) Exam will cover these subjects.

Mathematics	Probability and Statistics
Engineering Sciences	Computational Tools
Materials Science	Chemistry
Fluid Mechanics / Dynamics	Safety, Health, Environmental
Thermodynamics	Heat Transfer
Materials and Energy Balances	Mass Transfer and Separation
Chemical Reaction Engineering	Process Design and Economics
Process Control	Ethics and Professional Practice

specifications. More information is available at www.ncees.org/cbt and through NCEES social media (http://twitter.com/ncees; http://facebook.com/ncees).

Work experience

Work experience requirements vary significantly among jurisdictions and depend on one's education level. Most boards follow the Model Law, which requires a minimum of four years of engineering experience for those with a BS in engineering from an accredited program. Only three years are required for those with an MS in engineering, and two years for those with a PhD in engineering. Note that work experience must be of a grade and character that indicates to the board that the candidate is competent to practice engineering.

Required documentation

After passing the FE exam and acquiring the necessary experience, an engineer can apply to take the PE exam. This involves providing documentation to the board that proves that the candidate is qualified to become a P.E in that jurisdiction. This typically includes:

• proof of education, usually a copy of school transcripts; some boards require the applicant to use the NCEES credentialing service

• references who can verify the candidate's work experience and quality of character; up to five references may be required, and usually three must be licensed engineers.

Licensure candidates must contact their board to obtain specific documentation requirements and to obtain authorization to take the PE exam. Missing the board's deadline for documentation can delay you taking the exam for six months.

Principles and Practice of Engineering Exam

In 2013, PE exams will be offered on April 12 (as this issue goes to press, registration is closed for this date) and October 25. Exam schedules are posted at http://ncees.org/exams/exam-schedule. Deadlines for applications vary, but typically are about 60 days before the exam. This provides the board time to verify documentation.

The PE exam consists of two four-hour modules, each containing 40 multiple-choice questions, covering the following subject matter: mass and energy balances and thermodynamics (18 questions); plant design and operations (16); heat transfer (13); fluids (13); mass transfer (11); and kinetics (9) *(2)*. More details on the exam — including study materials, sample exams and solutions — are available at www.ncees.org/Exams/PE-exam.

Practicing engineers usually become highly proficient in certain areas and lose proficiency in less-used areas. To identify your weak areas, take practice exams when you feel you are test-ready, and practice under timed conditions. (Be sure to use one of the NCEES-approved calculators.) Most examinees benefit from self-study and refresher courses, such as those provided by P.E. volunteers at AIChE local sections. Some universities offer refresher courses in FE topics that could be useful for PE test candidates.

While the FE exam contains mostly quantitative questions, the PE exam includes both quantitative and qualitative questions that reflect both practical knowledge and technical skills. Qualitative questions — for example, a question that asks which mode of heat transfer is dominant in a given situation — test your understanding of basic concepts and take relatively little time to answer. A quantitative question, on the other hand, might ask you to calculate a heat-transfer coefficient.

To test your knowledge rather than your look-up skills, and to shorten the time needed to work on a question, the exam usually provides basic data such as pipe diameters and molecular weights. Questions involving engineering calculations (*e.g.*, a pressure drop calculation) are in U.S. engineering units, while scientific calculation questions (*e.g.*, a heat of reaction calculation) may be in International System (SI) units.

The PE exam has the same restrictions as the FE exam regarding pencils, paper, and calculators. However, unlike the FE exam, the current PE exam is an open-book test. Practicing at home with your own books should help you to identify which books you will most likely need. At the least, it is helpful to take to the exam the latest edition of *Perry's Chemical Engineers' Handbook*, a chemistry handbook, and a set of steam tables. You might also consider taking the NCEES *Fundamentals of Engineering Supplied-Reference Handbook*, which contains most of the commonly needed equations in a concise format. You may take a bound set of notes in a simple binder. Bookmarks in books are permitted as long as there is no loose paper. (Test-takers may not write in anything but the exam booklet.) A straight edge to read charts and nomographs is useful as well.

After the exam, the NCEES will report the results to your board. Your board will then contact you, via letter or email. If you fail, a report will identify the areas where you did not perform well. Many engineers who retake the exam pass the second time. However, passing rates drop dramatically for those failing more than twice. If you fail the exam several times, your board may require that you acquire additional education before taking the exam again.

Statistics show that passing rates are highest for those taking the exam with four to six years of experience.

Like the FE exam, the PE exam will eventually become a computer-based test, although no timeline has been set. The CBT format will offer new ways to ask questions, such as having real-time operations questions to test practical knowledge.

Potential Changes to P.E. Licensure Requirements

The NCEES Model Law states that, in 2020, education requirements for initial engineering licensure should be increased to require a BS degree of 150 semester hours or a master's degree or equivalent (MOE) to take the PE exam. At present, the "equivalency" is a BS degree with 30 additional semester hours of formal coursework, with at least 15 hours being engineering courses.

This change is controversial because, if implemented, licensure will effectively alter engineering education and workforce requirements. Engineering societies have developed websites that present supporting (*e.g.*, www.asce.org/PPLContentWide.aspx?id=7058) and opposing (*e.g.*, www.licensingthatworks.org) arguments for the change. NCEES provides a history of the initiative at http://ncees.org/About_NCEES/Engineering_education_initiative.php.

Justification FOR requiring an MOE for licensure

Arguments in favor of the MOE requirement for licensure come from proponents' concern that the number of hours required to obtain a BS has decreased over the past few decades — from more than 140 hours to 120 hours in some schools. It is thus assumed that the technical knowledge of graduates must also have decreased. Some proponents do not think that all engineers need to be licensed and suggest that BS graduates not obtaining the additional hours be classified as engineering interns. Proponents claim that the push for dual BS/MS programs is one way that higher education could produce more-capable engineering graduates in a culture where job opportunities are extremely competitive. They also suggest that the new standard would increase the prestige of engineering.

Justification AGAINST requiring an MOE for licensure

Opponents of the MOE plan argue that it fails to account for the quality of BS curricula and treats all BS programs of less than 150 hours equally. According to an analysis of the most recent American Society of Engineering Education (ASEE) data for 222 engineering schools, the average time required for BS engineering degrees is 130 hours, and has decreased an average 1.5 hours (total) over a nine year period (http://community.nspe.org/blogs/licensing/archive/2011/08/16/the-engineering-credit-slide-continues.aspx). There has been no evidence that the reduction in hours has affected the preparedness of BS chemical engineering graduates. The MOE requirement also ignores the value of undergraduate co-op programs, in-house training courses, and continuing education short courses — such as those offered through AIChE. Such courses are critical for practicing engineers, and rarely are found in universities' curricula because of their specialized nature, sometimes involving proprietary information.

The MOE requirement would limit licensure to only those accepted into graduate school or to schools providing non-degreed, postgraduate education. Such restricted access to graduate education could create a two-class engineering structure. It also contradicts the notion of minimally competent engineers with four years of experience being able to pass the PE exam.

AIChE's position on the MOE requirement for licensure

AIChE strongly encourages engineers to pursue additional formal education. However, current AIChE leadership — along with the leaders of eight other major engineering societies, the American Council of Engineering Companies (ACEC), and the Executive Board of the ASEE Engineering Deans Council — firmly oppose the MOE requirement for licensure.

Current Master's or Equivalent Status

Because each jurisdiction is an independent entity, the NCEES cannot mandate that jurisdictions adopt the Model Law's MOE change. Jurisdictions can adopt the plan completely, or with modifications, or reject the plan entirely.

However, the Model Law states that jurisdictions should allow eight years for implementation, to enable future PE exam candidates to prepare for the new requirements. To meet the 2020 target date, jurisdictions needed to adopt MOE by 2012. Later adoption of MOE will delay the first year that MOE can be enforced.

No jurisdiction has adopted MOE. One state board proposed the change several years ago, but it was withdrawn and not proposed in 2012. Several state boards are considering implementing MOE in 2013. Meanwhile, an informal survey at the NCEES 2012 annual meeting indicated that a majority of boards will not attempt to implement the change in the next 10 years.

If no jurisdiction adopts the MOE change, jurisdictions' education requirements for P.E. licensure will remain unchanged. On the other hand, adoption of the model in a jurisdiction could limit those P.E.s who don't have MOE credentials from becoming licensed in a jurisdiction enforcing the MOE standard.

License renewal

Most boards require that a P.E. license be renewed every two years. Boards notify licensees of the renewal date and the applicable renewal fee (which may be paid by an employer). If a license has lapsed, the engineer may be assessed additional fees and be required to show proof of meeting continuing professional competency (CPC) requirements (discussed in the next section) before the license can be reactivated. The amount of time that jurisdictions allow for a lapsed license to be renewed varies from 60 days to five years; after that point, it becomes an expired license. Once a license expires, most boards require the engineer to reapply for licensure.

If a licensee requests and is granted inactive status, the licensee may return to active status by notifying the board in advance of this intention, by paying appropriate fees, and by meeting board requirements (including demonstration of continuing professional competency, as discussed in the next section) as a condition of reinstatement.

Article continues on next page

The FE and PE Exam Committees

The NCEES coordinates FE and PE exam development, administration, and scoring. The FE and PE exam committees are looking for P.E.-licensed volunteers to help write questions and develop exams. If you are interested in volunteering for either committee, visit www.ncees.org.

Continuing education

Most jurisdictions require licensed engineers to maintain continuing professional competency (CPC) in their field by obtaining credits referred to as professional development hours (PDHs). The typical requirement is 15 PDHs per year (see www.ncees.org/licensing-boards or contact your board for requirements). Some boards require that proof of PDHs be provided with each license renewal. Whether or not that is the case, it is imperative that you maintain documents that verify your PDH credits. Most boards allow excess PDHs to be carried over to the next renewal period.

The CPC activity must be "focused on the advancement, extension, and improvement of the scientific knowledge and professional skills of the licensee and on the enhancement of professional ethics" *(3)*. The NCEES Model Law requires that at least one PDH be devoted to ethics in each renewal period. Check with your board for the continuing education requirements in your jurisdiction, and to verify that your PDHs meet its requirements.

Chemical engineers can obtain PDH credits through AIChE's instructor-led training courses, eLearning sessions, and short courses held at major AIChE meetings (www.aiche.org/education), and by viewing webinars, such as those in the ChemE on Demand archive (www.aiche.org/chemeondemand).

Engineers can also earn PDHs through professional activities, such as:

- giving technical presentations
- organizing technical sessions at meetings
- writing technical papers and books
- teaching traditional or short courses
- participating on technical committees (including the FE or PE exam development committees).

A discussion of the work of these committees, including opportunities for licensed engineers to become involved, is posted on AIChE's ChEnected blog: http://chenected.aiche.org.

Summing up

Regardless of your current chemical engineering job, becoming a licensed P.E. is an investment in your future. Many employers say that having a P.E. offers greater career opportunities.

Although the licensure process may seem daunting, the education and experience requirements for P.E. licensure are natural components of one's career. Your jurisdiction's licensing board, professional societies like AIChE and its local sections, and licensed colleagues can help you prepare for the PE exam. Also, AIChE's Career and Education Operating Council supports activities that prepare young professionals and engineering students for future P.E. licensure.

The distinction of having "P.E." after your name can set you apart in a crowd. We recommend that you pursue this standard of excellence as a part of your career. CEP

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Additional Reading

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