

AC 2007-287: FACULTY REWARD SYSTEM REFORM FOR ADVANCEMENT OF PROFESSIONAL ENGINEERING EDUCATION FOR INNOVATION: RETHINKING A NEW MODEL TEMPLATE FOR UNIT CRITERIA OF PROFESSIONALLY ORIENTED FACULTY

Donald Keating, University of South Carolina

DONALD A. KEATING is associate professor of mechanical engineering, University of South Carolina, and chair ASEE-Graduate Studies Division.

Thomas Stanford, University of South Carolina

THOMAS G. STANFORD is assistant professor of chemical engineering, University of South Carolina

John Bardo, Western Carolina University

JOHN W. BARDO is chancellor, Western Carolina University.

Duane Dunlap, Western Carolina University

DUANE D. DUNLAP is professor, interim dean, Kimmel School, Western Carolina University, and program chair ASEE-Graduate Studies Division.

Dennis Depew, Purdue University

DENNIS R. DEPEW is dean of the college of technology, Purdue University.

Gary Bertoline, Purdue University

GARY R. BERTOLINE is professor and assistant dean for graduate studies of the college of technology, Purdue University.

Mark Schuver, Purdue University

MARK T. SCHUVER is director of the Rolls-Royce-Purdue Master's degree program, Purdue University.

Eugene DeLoatch, Morgan State University

EUGENE M. DeLOATCH is dean, school of engineering, Morgan State University, and a past president of ASEE.

Stephen Tricamo, New Jersey Institute of Technology

STEPHEN J. TRICAMO is professor of industrial and manufacturing engineering, and former dean of engineering and technology, New Jersey Institute of Technology.

Albert McHenry, Arizona State University

ALBERT L. McHENRY is provost of Arizona State University Polytechnic, and ASEE- vice president of public affairs.

Timothy Lindquist, Arizona State University

TIMOTHY E. LINDQUIST is interim dean, college of science and technology, Arizona State University Polytechnic.

Joseph Tidwell, Boeing Co.

JOSEPH P. TIDWELL is director of JACMET, Arizona State University Polytechnic.

Harvey Palmer, Rochester Institute of Technology

HARVEY PALMER is dean of the Kate Gleason college of engineering, Rochester Institute of Technology.

Mohamad Noori, California State Polytechnic University

MOHAMAD NOORI is dean of the college of engineering, California State Polytechnic University.

David Quick, Rolls-Royce Corporation

DAVID H. QUICK is Manager, R&D Customer Requirements, R&T Strategy, Liberty Works (tm) Rolls-Royce North American Technologies, and past chair ASEE-Corporate Members Council.

Roger Olson, Rolls-Royce Corporation

ROGER N. OLSON is Lead Stress Engineer, Rolls-Royce Corporation, and a director of ASEE-College Industry Partnership Division.

Samuel Truesdale, Rolls-Royce Corporation

SAMUEL L. TRUESDALE is manager of employee development, engineering business improvement organization, Rolls-Royce Corporation, and program chair, ASEE-College Industry Partnership Division.

Faculty Reward System Reform for Advancement of Professional Engineering Education for Innovation: Rethinking a New Model Template for Unit Criteria of Professionally Oriented Faculty

I. Introduction

This is the third of three invited papers prepared for a special panel session of the National Collaborative Task Force on Engineering Graduate Education Reform that is focusing one of its primary tasks on faculty reward system reform in order to advance professional engineering graduate education for enhanced creative engineering practice for technology development & innovation across the country.

Based upon the findings of the first two papers of this panel session and the positive response for faculty reward system reform perceived at the 2006 annual ASEE conference, this paper recommends guidelines and a path forward for developing new unit criteria for faculty in professionally oriented graduate engineering programs. The suggested framework correlates with the nine levels of proficiency in the practice of engineering recognized by the National Society of Professional Engineers (NSPE), the American Society of Civil Engineers (ASCE), and that used in industry and government service.

II. National Collaborative: Purposeful Advancement of Professional Graduate Education for Creative Engineering Practice and Technology Innovation

Initiated in 2000 by leaders of the ASEE-Graduate Studies Division, College Industry Partnership Division, and Corporate Members Council, the National Collaborative Task Force on Engineering Graduate Education Reform is a coalition of innovative faculty, academic leaders from research and comprehensive universities, and engineering leaders from industry who are working together to respond to the urgency for reshaping engineering graduate education to better serve the needs of the modern practice of engineering to strengthen the nation's capability for technology development and innovation in industry for U.S. economic competitiveness and national security purposes.

A) The Need for Reform — Of Faculty Reward Systems for Professionally Oriented Faculty in Engineering

Whereas appropriate faculty reward criteria exists for research-oriented faculty in the nation's colleges of engineering, who are teaching and pursuing scholarship relevant to the practice of scientific research for scientific inquiry and discovery purposes, appropriate faculty reward does not exist at the majority of the nation's colleges of engineering for those professionally oriented faculty who are teaching and pursuing scholarship relevant to the creative practice of engineering itself

The National Collaborative Task Force concludes that although existing faculty reward systems are excellent for research-oriented faculty, and celebrate inquiry and discovery, they are insufficient for professionally oriented faculty at the nation's colleges of engineering.

The National Collaborative Task Force strongly believes that if we as a nation are to make a sustainable advancement in professional engineering graduate education that strengthens the innovative capacity of the U.S. engineering workforce in industry for economic competitiveness and national security purposes, then we must respond to the existing need for faculty reward reform for those faculty who will be sustaining this advancement in professional engineering graduate education over the long-term.

As William Wulf, president of the National Academy of Engineering, pointed out in his plenary address to the American Society of Engineering Education annual conference in 2002, there is urgency for engineering education reform to promote the nation's technological welfare, but this reform should be a watershed change to include curricula reform, process reform, and faculty reward reform.¹

As Wulf pointed out:

- “I want to talk about what should be - but aren't yet - watershed changes in engineering education. I hope to communicate the urgency I feel for the need for these changes, as well as something of their nature. Most, but not all, of what I will say is contained in one or more recent reports (American Society for Engineering Education, 1994; National Research Council, 1995; National Science Foundation, 1995). So, much of my message is not "new news," but little of what these reports recommend has been implemented, and indeed there seems to be little sense of urgency. Quite the contrary, there is widespread complacency, in my view. And, in some areas, I feel even the reports don't go far enough.”
- “I should make three introductory remarks before getting to the substance. First, a caveat: I am going to paint with a broad brush. I know there are exciting, innovative programs in a number of engineering schools. Perhaps most schools are trying one or two novel things. My remarks are an effort to generalize the status of the entire engineering education enterprise; this kind of approach will explicitly miss these "points of light.”
- “Second, a word about my view of what an engineer does, since this colors my ideas of how an engineer needs to be educated. Science is analytic - it strives to understand nature, what is. Engineering is synthetic - it strives to create what can be. My favorite operational definition of engineering is "design under constraint." Engineering is creating, designing what can be, but it is constrained by nature, by cost, by concerns of safety, reliability, environmental impact, manufacturability, maintainability, and many other such "ilities." Engineering is not "applied science." To be sure, our understanding of nature is one of the constraints we work under, but it is far from the only one, it is seldom the hardest one, and almost never the limiting one.”
- “Third, the practice of engineering is changing. Indeed, those changes are what underlie the urgency I feel for a new approach to engineering education. Growing global competition and the subsequent restructuring of industry, the shift from defense to civilian work, the use of new materials and biological processes, and the explosion of information technology - both as part of the process of engineering and as part of its product - have dramatically and irreversibly changed how engineers work. If anything, the pace of this change is accelerating. Although there are exceptions, in general, engineering education has not kept up with this changing environment. I think it is only a slight exaggeration to say that our students are being prepared to practice engineering in a world that existed when we were trained a generation or two ago. They are not being prepared for the 21st century.”
- “So, what needs to change? A lot, I think! Most obviously, we need to focus on curriculum, pedagogy, and diversity. ... But the need for change goes deeper ... We need to scrutinize the current system of faculty rewards ... Recall that my definition of engineering is design under constraint. I believe the process of design is a synthetic, highly creative activity. Can you think of any other creative field on campus where the faculty are not expected to practice or perform? Art, music, drama? Even if you don't buy that engineering is creative in the same way as art or music, performance-oriented professions such as medicine and law expect their faculty to practice that profession. Can you imagine a medical school where the faculty was prohibited from practicing medicine? Yet, this is just the situation we have in engineering.”

- “Engineering faculty are, for the most part, judged by criteria similar to the science faculty, and the practice of engineering is not one of those criteria. The faculty reward system recognizes teaching, research, and service to the profession, but it does not give the same status to delivering a marketable product or process, or designing an enduring piece of the nation's infrastructure.”

“Of course, what you measure is what you get. For the most part, our faculty are superb "engineering scientists," but they are not necessarily folks who know a lot about the practice of engineering. At most schools, for example, it's hard to bring someone onto the faculty who has spent their career in industry, even though such people would be extremely valuable to the students; their resumes simply don't fit what the reward system values. Sometimes, it's even hard to get recognition for a sabbatical in industry ... Please understand that I am not criticizing the current faculty. I am one of them, and I respect my colleagues greatly. Rather, I am criticizing a system that prevents us from enriching faculty with a complementary set of experiences and talents.”

B) Responsive Universities — Relevancy to the Creative Professions in the 21st Century

The National Collaborative agrees with president Wulf's point of view of the need for watershed reform in the U.S. system of engineering education and suggests as the Kellogg Commission has pointed out — in order to remain relevant to their constituencies, and to be more effective — universities must change.²

Whereas universities have traditionally celebrated the importance of research-oriented faculty who teach and pursue the advancement of scientific research [either fundamental research or directed scientific research] for inquiry and discovery purposes, the National Collaborative Task Force believes that modern universities in the 21st century must change to better serve the professional educational needs of their various constituencies, such as the profession of engineering.

As Alfred P. Sloan remarked:³

“Too often we fail to recognize and pay tribute to the creative spirit.”

The National Collaborative Task Force agrees with this perspective and believes that universities should celebrate also the creative worth of those professionally oriented faculty who teach and by their professional scholarship and engagement are pursuing other creative pursuits [that are non-research oriented] focusing on the advancement of the practice of engineering for creative technology development and innovation, and other creative engineering works. Toward this aim, the National Collaborative is serving as a primary change agent and catalyst for institutional transformative change for professional engineering education at the graduate level with its constituency of university and industrial partners.

C) A Look at Other Professions — Sample Guidelines of Unit Criteria for Professionally Oriented Faculty

During its investigation phase, the National Collaborative has looked extensively at representative model templates of complementary unit criteria for professionally-oriented faculty that are being used in other professions, such as law.⁴ The National Collaborative notes also that broader guidelines for scholarship have been defined that extend beyond the landmark work of Boyer.⁵ And, proficiency levels of creative work have been defined also within the profession of engineering itself for advanced practice.^{6,7}

Notably, in *The Disciplines Speak*, Diamond and Adam [2000] have defined six characteristics that complement traditional scientific research and publication that “most disciplines considered as scholarship, professional, or creative” *products* resulting from the creative scholarly process.⁸

These characteristics identified by Diamond and Adam include:

- 1st The activity requires a high level of discipline [professional] related expertise
- 2nd The activity breaks new ground or is innovative
- 3rd The activity can be replicated or elaborated
- 4th The work and its results can be documented
- 5th The work and its results can be peer reviewed
- 6th The activity has significance or impact

III. Setting Some Preliminary Guidelines and Recommendations: Complementary Unit Criteria for Professionally-Oriented Faculty in Engineering

The National Collaborative Task Force believes that the six characteristics defined by Diamond and Adam help to provide us with the roadmap we need to develop specific unit criteria for a complementary faculty reward system for professional oriented faculty in order to advance professional engineering graduate education for creative practice. The work by Schoen [Reflective Practitioner] also suggests several professional characteristics that differentiate the creative work of the reflective practitioner in the professions from that of the work of research scientists.⁹

A) Professional Scholarship of Engineering, Teaching, Engagement

In order to implement sustainable reform and to develop professional cultures that reward and encourage professionally oriented faculty in engineering, the National Collaborative Task Force believes that the term scholarship should be defined in its broadest sense to include original creative work of a professional nature in the practice of engineering that meets the six criteria that Diamond and Adam put forth.

The definition should include the professional realm of engineering from project engineering, technical program making, through technology policy making for the purposeful advancement of technology relevant to the creation / development / innovation of new, improved, or breakthrough technology in the form of products, processes, systems, operations, or organizational leadership infrastructure conducive to innovation or other meaningful creative engineering works performed in the spirit and mission of the profession of engineering for the advancement and betterment of human welfare.

Thus, the professionally oriented faculty that we are addressing would be termed Practitioner / Scholars who are teaching at the professional graduate level for the advancement of the practice of engineering. Subsequently, in order to complement existing research-oriented unit criteria, the National Collaborative recommends that professionally-oriented unit criteria for merit promotion would include three areas:

- a) Scholarship of Engineering
- b) Teaching
- c) Engagement [Service in the Profession]

B) Progressive Qualifications / Grades in the Practice of Engineering

The National Collaborative Task Force concludes that in order to create and sustain high-quality professional education for professionals that the professions themselves are the accrediting agencies that recognize the qualifications required for advancement in the professions.

As ASCE point out — “The purpose of the grade descriptions is to enable employers and employees to ascertain an individual’s professional grade. The grade descriptions can be a helpful tool for encouraging engineers to improve their ability in order to qualify for higher grades and to facilitate agreement between the employer and the employee regarding each engineer’s level of responsibility.”

Thus, the Task Force recommends that the progressive professional qualifications that are reflected by the nine progressive levels/grades of proficiency for the practice of engineering as set forth by the National Society of Professional Engineers (NSPE) and the American Society of Civil Engineers (ASCE) serve as the comparable professional guidelines of merit for practitioner / scholars who are teaching at the assistant professor level, the associate professor level, and at the professor level for high-quality programs of professional graduate education for engineers [See Appendixes C, D].

Accordingly, the National Collaborative Task Force recommends that the primary areas of professional merit for unit criteria for professionally oriented faculty for the Assistant Professor Level, for the Associate Professor Level, and for the Full Professor Level correlate with the progressive professional qualifications / grades reflected by Appendix C and D as follows:

- Assistant Professor — Level 4 Engineering
- Associate Professor — Level 5 Engineering
- Full Professor — Level 6 Engineering

IV. Suggested Guidelines for Professional Unit Criteria — Leading to the Assistant Professor, Associate Professor, and Professor Levels

The National Collaborative Task Force is evolving a preliminary set of guidelines for professional unit criteria that builds upon a combined framework of the six characteristics [defined by Diamond and Adam] and the nine progressive proficiency levels of the practice of engineering [defined by NSPE and ASCE]. The guidelines build also upon the notable work of several universities that are undergoing reform in project-based learning and engagement.^{10, 11}

A) Formulating Preliminary Guidelines — Work in Progress for Professional Graduate Education for Engineers

The National Collaborative Task Force suggests that the guidelines presented herein for professionally oriented unit criteria are a work in progress. And they should serve as a conceptual prototype for later refinement and improvement for shared best practice with constant vigilance on sustaining faculty reward for practitioner / scholars / teachers and on advancing professional graduate education for engineers to enhance the innovative capacity of the U.S. engineering workforce in industry.

The National Collaborative Task Force reaffirms that the overall mission of the national initiative for advancement in professional engineering graduate education is to enable the further professional growth of advanced practitioners within the U.S. engineering workforce to unlock their creative potentials to further enhance their creative, innovative, and leadership capacity within the practicing profession for enhanced U.S. competitiveness and national security purposes.

As such, the National Collaborative Task Force firmly believes that this unique national initiative has the potential to leverage U.S. industry’s capability for engineering creativity, technology development and innovation across all states and regions of the country.

B) Mission and Intent of the Faculty — Professional Graduate Education for Engineers

The Task Force believes that the primary mission of the professional faculty [practitioner / scholar] is that of teaching other creative professionals — who are engaged in on-going engineering practice — and helping them to pursue further professional graduate education that enables the further development of their creative, innovative, and leadership potentials for meaningful creative work in engineering.

As an advanced teacher of creative professionals, the practitioner/ scholar will also grow through his / her progressive scholarship, teaching, and engagement in the profession for public service. But as a teacher of creative professionals, the professionally oriented faculty should be rewarded commensurate with teaching as his or her primary aim in order to sustain the primary mission and focus of the professional school as professional education for engineers.

Thus, the value of this teacher of creative professionals to regional industry, to the university, to each state, and to the nation is multidimensional and far reaching over the long-term in leveraging U.S. innovation across the nation for U.S. economic competitiveness and national security purposes.

The unit criteria described herein has been defined specifically for professionally oriented faculty who are pursuing work at the university focusing on the advancement of the practice of engineering for the creation, development, leadership and innovation of technology or other meaningful creative engineering works of practice, its scholarship, its teaching, and its engagement for professional service.

As such it is not intended for unit criteria for research-oriented faculty as it is different. This unit criteria recognizes that the practice of engineering and the practice of scientific research are two different pursuits serving distinct missions and purposes.

C) Guidelines for Professional Unit Criteria — Leading to the Assistant Professor, Associate Professor, and Professor Levels

The guidelines for professional unit criteria shall consist of four general areas.

- (a) Comparable Professional Qualifications
 - General Characteristics
 - Direction Received
 - Typical Duties & Responsibilities
 - Responsibility for direction of Others
 - Typical Position Titles
 - Typical Professional Attainments
 - Licensure Status
 - Professional Experience
 - Academic Qualifications
- (b) Teaching
- (c) Scholarship of Engineering
- (d) Engagement [Service in the Profession]

Assistant Professor Level – Engineering Level 4

Suggested Guidelines for Professionally Oriented Unit Criteria Leading to Tenure and Promotion

(a) Comparable Professional Qualifications

General Characteristics. As a fully competent engineer in all conventional aspects of the subject matter of the functional area of the assignment, plans and conducts work requiring judgment in the independent evaluation, selection, and substantial adaptation and modification of standard techniques, procedures, and criteria. Devises new approaches to problems encountered. Requires sufficient professional experience to assure competence as a professional. Independently performs assignments with instructions as to the general results expected. Receives technical guidance on unusual or complex problems and supervisory approval to projects. May supervise a few engineers or technicians on assigned work.

Direction Received. Independently performs most assignments with instructions as to the general results expected. Receives technical guidance on unusual or complex problems and supervisory approval on proposed plans for projects.

Typical Duties & Responsibilities. Plans, schedules, conducts, or coordinates detailed phases of the engineering work in a part of a major project or in a total project of moderate scope. Performs work which involves conventional engineering practice but may include a variety of complex features such as conflicting design requirements, unsuitability of conventional materials, and difficult coordination requirements. Work requires a broad knowledge of precedents in the specialty area and a good knowledge of and practices of related specialties.

Responsibility For Direction of Others. May supervise or coordinate the work of engineers, technicians, and others who assist in specific assignments.

Typical Position Titles. Engineer or Assistant Engineer, Resident, Project, Plant, Office, Design, Process, Research, Chief Inspector, Assistant Professor.

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Associate Grade or Equivalent)/Member of Technical Societies (Member Grade); Publishes engineering papers, articles, text books

Licensure Status. Licensed Professional Engineer [when appropriate].

Professional Experience. Requires a minimum of three years of experience in engineering practice.

Academic Qualifications. Professional Masters or Doctoral degree in engineering or equivalent.

(b) Teaching

The National Collaborative Task Force on Engineering Graduate Education Reform strongly reaffirms a learner-centered teaching approach and engagement theory reflected by Haworth and Conrad [seminal work for the Council of Graduate Schools] as the foundational philosophy for teaching in high-quality professional graduate programs for all levels of teaching from assistant professor, associate professor, through full professor.¹² At the advanced professional level of teaching, the assessment of teaching is very different from that of teacher assessment of traditional undergraduate engineering education because the approach to professional graduate education for experienced practitioners is quite different.

- The teaching philosophy is founded upon “our definition of high-quality programs as those which contribute to enriching learning experiences for students [practitioners] that have *positive effects on their growth and development*.”
- The theory of teaching in high-quality programs is “organized around one central idea: student, faculty, and administrative engagement in teaching and learning. That is, high-quality programs are those in which students, faculty, and administrators invest significant time and effort in *mutually supportive teaching and learning*.”
- The engagement theory of teaching quality is based upon:
 - (a) Learning-centered approach aimed at enabling the further professional growth and development of the practitioner [continuous student]
 - (b) Learning organization of diverse and engaged participants
 - Diverse and engaged experienced faculty
 - Diverse and engaged experienced students [practitioners]
 - (c) Participatory cultures for learning and innovation
 - Shared program direction
 - Community of learner / practitioners
 - Risk-taking environment
 - (d) Interactive Teaching and Learning
 - Critical dialogue
 - Integrative learning
 - Mentoring
 - Cooperative peer learning among practitioner students
 - Out of class activities

(c) Scholarship of Engineering

The professional Scholarship of Engineering is defined in its broadest sense as purposive creative work that is performed in the advancement of the practice of engineering and brings about new or improved solutions from project engineering levels, technical program making levels, through technology policy making levels of practice.

Creative scholarship of engineering practice usually focuses on the deliberate conceptualization, development, and innovation of new, improved, or breakthrough technology that is conceived [designed] and devised to bring about effective solutions to meet the hopes, wants, and needs of man for the general advancement and betterment of human welfare or other meaningful, creative engineering works to meet real-world needs.

The outcome of this creative engineering scholarly work is new, improved, or breakthrough technology in the form of new and improved products, processes, systems, or operations. At the technical program and policy levels of professional engineering, the results of creative scholarship can be measured by improvement of the engineering infrastructure or leadership process that facilitates this creative engineering work. Professional scholarly work can be measured by the following metrics:

- The activity requires a high level of professional related expertise
- The activity breaks new ground or is innovative
- The activity can be replicated or elaborated
- The work and its results can be documented
- The work and its results can be peer reviewed
- The activity has significance or impact

(d) Engagement [Service in the Profession]

The National Collaborative defines engagement as a creative professional pursuit in the spirit and intent of the practicing profession of engineering which is service. The Task Force believes also that real engagement is a function of the manner by which high quality programs are financially sustained to permit the full creative, innovative, and leadership potential of the practitioner / scholar / teacher to be fully developed and engaged in the profession. This support, to allow and unlock creativity to flourish, requires support by the university to perform this engagement, rather than performing engagement to support the university which too often happens. For sustainable funded high-quality professional graduate programs [using the model of professional schools of law], the Task Force believes that engagement [service] in the profession of engineering can take many forms to include:

- (a) Consultancy in engineering practice
- (b) Integrating Service, the University, and Engineering to real-world needs of society, industry, and the nation for the advancement and betterment of human welfare to improve the quality of life
 - By the deliberate recognition of meaningful unmet needs
 - Conceptualization of new ‘ideas and concepts’ [invention, design, development] that bring about effective solutions to meet these needs [Exploratory Development] through proof of feasibility
 - Further advanced development and systems development for innovation into operations
 - Engineering leadership of this holistic process to facilitate the culture for continuous technology development & innovation for service to the local, regional, national, and international community
- (c) Participatory service within Technical or Professional Societies [ASME, ASCE, NSPE, IEEE, ASEE, ASES, SME et.al.] to advance the profession
 - Member Grade
 - Participation in conferences as presenters / panel members / authors
 - Participation in conferences as session moderators, program chairs
 - Participation in leadership capacity as officers of committees, programs, divisions, societies

Associate Professor Level — Engineering Level 5

Suggested Guidelines for Professionally Oriented Unit Criteria Leading to Tenure and Promotion

(a) Comparable Professional Qualifications

General Characteristics. As a fully experienced professional, applies intensive and diversified knowledge of engineering principles and practices in broad areas of assignments. Make decisions independently on engineering problems and methods, and represents the organization to resolve important questions and to plan and coordinate work. Requires the use of advanced techniques and the modifications and extension of theories, precepts and practices of own field and related sciences and disciplines. The knowledge and expertise required for this level of work usually result from progressive experience. Consults supervisor concerning unusual problems and developments. Supervises, coordinates, and reviews the work of a small staff of engineers and technicians. Estimates personnel needs, schedules and assigns work. As individual engineer or staff specialist, may be assigned to projects by others.

Direction Received. Supervision and guidance relate largely to overall objectives, critical issues, new concepts, and policy matters. Consults with supervisor concerning unusual problems and developments.

Typical Duties & Responsibilities. One or more of the following: 1) In a supervisory capacity, plans, develops, coordinates, and directs a large and important engineering project or a number of a small projects with many complex features. A substantial portion of the work supervised is comparable to that described for engineer IV; 2) As individual engineer, carries out complex or novel assignments requiring the development of new or improved techniques and procedures. Work is expected to result in the development of new or improved techniques and procedures; or development of new or refined equipment, materials, processes, products, and/or methods; 3) As staff specialist, develops and evaluates plans and criteria for a variety of projects and activities to be carried out by others. Assesses the feasibility and soundness of proposed engineering evaluation tests, products, or equipment when necessary data are insufficient or confirmation by testing is advisable. Usually performs as a staff advisor and consultant as to a technical specialty, a type of facility or equipment, or a program function.

Responsibility For Direction of Others. Supervises, coordinates, and reviews the work of a small staff of engineers and technicians, estimates personnel needs and schedules and assigns work to meet completion date. Or, as individual researcher or staff specialist may be assisted on projects by other engineers or technicians.

Typical Position Titles. Senior or Principal Engineer: Resident, Project, Office, Design, Process, Research, Assistant Division Engineer, Associate Professor, Project Leader.

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks.

Licensure Status. Licensed Professional Engineer [when appropriate].

Professional Experience. Requires a minimum of five years of experience in engineering practice.

Academic Qualifications. Professional Masters or Doctoral degree in engineering or equivalent.

(b) Teaching

The National Collaborative Task Force on Engineering Graduate Education Reform strongly reaffirms a learner-centered teaching approach and engagement theory reflected by Haworth and Conrad [seminal work for the Council of Graduate Schools] as the foundational philosophy for teaching in high-quality professional graduate programs for all levels of teaching from assistant professor, associate professor, through full professor.¹² At the advanced professional level of teaching, the assessment of teaching is very different from that of teacher assessment of traditional undergraduate engineering education because the approach to professional graduate education for experienced practitioners is quite different.

- The teaching philosophy is founded upon “our definition of high-quality programs as those which contribute to enriching learning experiences for students [practitioners] that have *positive effects on their growth and development*.”
- The theory of teaching quality is “organized around one central idea: student, faculty, and administrative engagement in teaching and learning. That is, high-quality programs are those in which students, faculty, and administrators invest significant time and effort in *mutually supportive* teaching and learning.”
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 - Shared program direction
 - Community of learner / practitioners
 - Risk-taking environment
 - (d) Interactive Teaching and Learning
 - Critical dialogue
 - Integrative learning
 - Mentoring
 - Cooperative peer learning among practitioner students
 - Out of class activities

(c) Scholarship of Engineering

The professional Scholarship of Engineering is defined in its broadest sense as purposive creative work that is performed in the advancement of the practice of engineering and brings about new or improved solutions from project engineering levels, technical program making levels, through technology policy making levels of practice.

Creative scholarship of engineering practice usually focuses on the deliberate conceptualization, development, and innovation of new, improved, or breakthrough technology that is conceived [designed] and devised to bring about effective solutions to meet the hopes, wants, and needs of man for the general advancement and betterment of human welfare or other meaningful, creative engineering works to meet real-world needs.

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- The activity requires a high level of professional related expertise
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- (c) Participatory service within Technical or Professional Societies [ASME, ASCE, NSPE, IEEE, ASEE, ASES, SME et.al.] to advance the profession
 - Member Grade
 - Participation in conferences as presenters / panel members / authors
 - Participation in conferences as session moderators, program chairs
 - Participation in leadership capacity as officers of committees, programs, divisions, societies

Professor Level — Engineering Level 6

Suggested Guidelines for Professionally Oriented Unit Criteria Leading to Tenure and Promotion

(a) Comparable Professional Qualifications

General Characteristics. As a senior engineer, has full technical responsibility for interpreting, organizing, executing, and coordinating assignments. Plans and develops engineering projects concerned with unique or controversial problems which have an important effect on major organization programs. This involves exploration of subject area, definition of scope and selection of problems for investigation and development of novel concepts and approaches. Maintains Liaison with individuals and units within or outside the organization with responsibility for acting independently on technical matters pertaining to the field. Work at this level requires extensive progressive experience.

Direction Received. Supervision received is essentially administrative, with assignments given in terms of broad general objectives and limits.

Typical Duties & Responsibilities. One or more of the following: 1) In a supervisory capacity a) plans, develops, coordinates, and directs a number of large and important projects or a project of major scope and importance; or b) is responsible for the entire engineering program of an organization when the program is of limited complexity and scope. The extent of his or her responsibilities generally requires a few (3 to 5) subordinate supervisors or team leaders with at least one in a position comparable to level V; 2) As individual engineer conceives, plans and conducts development in problem areas of considerable scope and complexity. The problems must be approached through a series of complete and conceptually related studies, are difficult to define, require unconventional or novel approaches, and require sophisticated techniques. Available guides and precedents contain critical gaps, are only partially related to the problem or may be largely lacking due to the novel character of the project. At this level, the individual engineer generally will have contributed inventions, new designs, or techniques which are of material significance in the solution of important problems; 3) As a staff specialist serves as the technical specialist for the organization (division or company) in the application of advanced theories, concepts, principles, and processes for an assigned area of responsibility (i.e. subject matter, function, type of facility or equipment, or product). Keeps abreast of emerging technologies and developments affecting the organization for the purpose of recommending changes in emphasis of programs or new programs warranted by such developments.

Responsibility for Direction of Others. Plans, organizes, and supervises the work of a staff of engineers and technicians. Evaluates progress of the staff and results obtained and recommend major changes to achieve overall objectives. Or, as individual engineer or staff specialist may be assisted on individual projects by other engineers or technicians.

Typical Position Titles. Senior or Principal Engineer, Division or District Engineer, Production Engineer, Assistant Division, District or Chief Engineer, Consultant, Professor, City or County Engineer.

Typical Professional Attainments. Member of Professional Society (Member Grade).Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks.

Licensure Status. Licensed Professional Engineer [when appropriate].

Professional Experience. Requires a minimum of ten years of experience in engineering practice.

Academic Qualifications. Professional Masters or Doctoral degree in engineering or equivalent.

(b) Teaching

The National Collaborative Task Force on Engineering Graduate Education Reform strongly reaffirms a learner-centered teaching approach and engagement theory reflected by Haworth and Conrad [seminal work for the Council of Graduate Schools] as the foundational philosophy for teaching in high-quality professional graduate programs for all levels of teaching from assistant professor, associate professor, through full professor.¹² At the advanced professional level of teaching, the assessment of teaching is very different from that of teacher assessment of traditional undergraduate engineering education because the approach to professional graduate education for experienced practitioners is quite different.

- The teaching philosophy is founded upon “our definition of high-quality programs as those which contribute to enriching learning experiences for students [practitioners] that have *positive effects on their growth and development*.”
- The theory of teaching quality is “organized around one central idea: student, faculty, and administrative engagement in teaching and learning. That is, high-quality programs are those in which students, faculty, and administrators invest significant time and effort in *mutually supportive* teaching and learning.”
- The engagement theory of teaching quality is based upon:
 - (a) Learning-centered approach aimed at enabling the further professional growth and development of the practitioner [continuous student]
 - (b) Learning organization of diverse and engaged participants
 - Diverse and engaged experienced faculty
 - Diverse and engaged experienced students [practitioners]
 - (c) Participatory cultures for learning and innovation
 - Shared program direction
 - Community of learner / practitioners
 - Risk-taking environment
 - (d) Interactive Teaching and Learning
 - Critical dialogue
 - Integrative learning
 - Mentoring
 - Cooperative peer learning among practitioner students
 - Out of class activities

(c) Scholarship of Engineering

The professional Scholarship of Engineering is defined in its broadest sense as purposive creative work that is performed in the advancement of the practice of engineering and brings about new or improved solutions from project engineering levels, technical program making levels, through technology policy making levels of practice.

Creative scholarship of engineering practice usually focuses on the deliberate conceptualization, development, and innovation of new, improved, or breakthrough technology that is conceived [designed]

and devised to bring about effective solutions to meet the hopes, wants, and needs of man for the general advancement and betterment of human welfare or other meaningful, creative engineering works to meet real-world needs.

The outcome of this creative engineering scholarly work is new, improved, or breakthrough technology in the form of new and improved products, processes, systems, or operations. At the technical program and policy levels of professional engineering, the results of creative scholarship can be measured by improvement of the engineering infrastructure or leadership process that facilitates this creative engineering work. Professional scholarly work can be measured by the following metrics:

- The activity requires a high level of professional related expertise
- The activity breaks new ground or is innovative
- The activity can be replicated or elaborated
- The work and its results can be documented
- The work and its results can be peer reviewed
- The activity has significance or impact

(d) Engagement [Service in the Profession]

The National Collaborative defines engagement as a creative professional pursuit in the spirit and intent of the practicing profession of engineering which is service. The Task Force believes also that real engagement is a function of the manner by which high quality programs are financially sustained to permit the full creative, innovative, and leadership potential of the practitioner / scholar / teacher to be fully developed and engaged in the profession. This support, to allow and unlock creativity to flourish, requires support by the university to perform this engagement, rather than performing engagement to support the university which too often happens. For sustainable funded high-quality professional graduate programs [using the model of professional schools of law], the Task Force believes that engagement [service] in the profession of engineering can take many forms to include:

- (a) Consultancy in engineering practice
- (b) Integrating Service, the University, and Engineering to real-world needs of society, industry, and the nation for the advancement and betterment of human welfare to improve the quality of life
 - By the deliberate recognition of meaningful unmet needs
 - Conceptualization of new ‘ideas and concepts’ [invention, design, development] that bring about effective solutions to meet these needs [Exploratory Development] through proof of feasibility
 - Further advanced development and systems development for innovation into operations
 - Engineering leadership of this holistic process to facilitate the culture for continuous technology development & innovation for service to the local, regional, national, and international community
- (c) Participatory service within Technical or Professional Societies [ASME, ASCE, NSPE, IEEE, ASEE, ASES, SME et.al.] to advance the profession
 - Member Grade
 - Participation in conferences as presenters / panel members / authors
 - Participation in conferences as session moderators, program chairs
 - Participation in leadership capacity as officers of committees, programs, divisions, societies

V. Conclusions – A Work in Progress for Planned Reform

The work of the National Collaborative Task Force on faculty reward system reform is a work in progress. But the progress to date is clear. Unit criteria for professionally-oriented faculty and for research-oriented faculty must be complementary but they must be different because the mission, purpose, and scholarly functions of these two pursuits are different. The National Collaborative notes that scholarship for advancement of the practice of scientific research and scholarship for advancement of the creative practice of engineering are distinct pursuits serving different purposes. However, neither pursuit should be perceived as second rate to the other if we are to advance the U.S. profession of engineering to its potential for creative work for the common good.

But, the National Collaborative Task Force believes that reform of higher education can not occur without real transformative change at the universities. If the value system of the university changes to include the professional realm of the practice of engineering for innovation, as it must to improve U.S. economic competitiveness and national security, then the faculty reward system must change for those professionally oriented faculty who will be instrumental in making and sustaining this advancement in the U.S. system of professional engineering education. This is not an either or strategy but rather a broadening of university perspective to include the multifaceted missions and diversity of creative scholarship that modern universities must serve in the 21st century to remain relevant to their constituencies.

The National Collaborative Task Force believes that this change can be positive and brought about through planned reform in a logical, straight forward manner as a complement to the existing faculty reward system for scientific research [either basic or directed] for inquiry and discovery. The Task Force believes that this reform will strengthen the capability of the 21st century University in its endeavors to place more focused emphasis on professional engineering education to develop the nation's engineers as champions, innovators, and leaders within the practicing profession and to improve teaching at both the undergraduate and the professional levels of engineering. As such, the National Collaborative Task Force will continue its work and take the next steps to clarify needed action for this planned reform.

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Appendix A

Systematic Engineering Process for Needs-Driven, Creative Technology Development & Innovation in Practice

Needs ⇨ Engineering ⇨ Technology



Directed Scientific Research
to gain a better understanding
of phenomena when needed or
anticipated during the technology
development project

Appendix B

Functions of Creative Engineering Practice and Scientific Research

Practice of Engineering

Creative Technology Development

... The role of needs-driven systematic technological development in industry and government is the purposeful invention [design] and innovation of new or improved concepts, techniques, materials, devices, products, or systems and manufacturing processes. Its aim is to meet the hopes, wants, and needs of society, through change towards its general betterment, brought about by engineering development. It is creative and non-repetitive work and ranges from exploratory engineering development, with concept and invention, through the experimental phases of feasibility to the advanced development and design of production prototypes and introduction into manufacturing or operations. The primary resource of needs-driven technological development is the conceptual ideas of creative engineers ... the innovative men and women ... who bring about needed change for the benefit of mankind.

“Technology does not exist to serve itself. It is there to work for people – to improve the way they live, to safeguard their health, to preserve their environment(GE)” By technology, we refer to any “systematic, organized body of applicable interrelated concepts and ideas that is rational and valid enough to stand up under the test of experimental demonstration and experimental validation, and represents a common experience regardless of the society or nation in which it is observed (Alstadt).”

Practice of Scientific Research

‘Basic’ and ‘Applied Research’

... The role of basic (fundamental) research in industry and government is the pursuit of new scientific knowledge within specific fields of interest, which could be of potential use to the future business of the organization. Its aim is to discover and to gain a better understanding of phenomena through creative in-depth investigation at the frontiers of a scientific discipline. The results of this investigation will extend the existing body of scientific knowledge useful to the organization in the future.

... The role of applied (directed-strategic) research in industry and government is the pursuit of new knowledge in direct support of technology development projects within the organization. Its primary aim is to discover, understand, and describe new physical phenomena useful to the understanding of specific phenomena anticipated or uncovered during the course of a technology development project. The results of this in-depth investigation and analysis will extend the existing body of scientific knowledge with committed use for the organization.

A secondary purpose is to provide technical consultation to other divisions of the organization whenever the existing body of specialized knowledge within the research group is needed for immediate problems.

Appendix C

Stages of Professional Maturation, Autonomy, and Responsibilities in the Practice of Engineering for Responsible Leadership of Technology (NSPE / ASCE)

<u>Stages of Growth</u>	<u>Typical Responsibilities-Autonomy-Judgment</u>
ENGINEER IX (GS-16, 17, 18)	An engineer-leader at this level is in responsible charge of programs so extensive and complex as to require staff and resources of sizeable magnitude to meet the overall engineering objectives of the organization.
ENGINEER VIII (GS 15 or Academic Dean)	An engineer-leader at this level demonstrates a high degree of creativity, foresight, and mature judgment in planning, organizing, and guiding extensive engineering programs and activities of outstanding novelty and importance. Is responsible for deciding the kind and extent of engineering and related programs needed for accomplishing the objectives of the organization.
ENGINEER VII (GS 14 or Distinguished Professor or Academic Department Head)	In a leadership capacity, is responsible for an important segment of the engineering program of an organization with extensive and diversified engineering requirements. The overall engineering program contains critical problems, the solutions of which require major technological advances and opens the way for extensive related development.
ENGINEER VI (GS 13 or Full Professor)	In a leadership capacity, plans, develops, coordinates, and directs a number of large and important projects or a project of major scope and importance. Or, as a senior engineer, conceives, plans, and conducts development in problem areas of considerable scope and complexity. The problems are difficult to define and unprecedented. This involves exploration of subject area, definition of scope, and selection of important problems for development.
ENGINEER V (GS 12 or Associate Professor)	In a leadership capacity, plans, develops, coordinates, and directs a large and important project or a number of small projects with many complex features. Or, as an individual principle engineer, carries out complex or novel assignments requiring the development of new or improved techniques and procedures. Work is expected to result in the development of new or refined equipment, materials, processes, or products. Technical judgment knowledge, and expertise for this level usually result from progressive experience.
ENGINEER IV (GS-11 or Assistant Professor)	Plans, schedules, conducts, or coordinates detailed phases of engineering work in part of a major project or in a total project of moderate scope. Fully competent engineer in all conventional aspects of the subject matter of the functional areas of assignments. Devises new approaches to problems encountered. Independently performs most assignments requiring technical judgment.
ENGINEER III (GS-9 or Academic Instructor)	Performs work that involves conventional types of plans, investigations, or equipment with relatively few complex features for which there are precedents. Requires knowledge of principles and techniques commonly employed in the specific narrow areas of assignments.
ENGINEER II / I (GS-7 / GS-5) Entry Level Engineer	Requires knowledge and application of known laws and data. Using prescribed methods, applies standard practices/techniques under direction of an experienced Engineer.

Reference: Nine levels of engineering — NSPE, ASCE and U.S. Department of Labor.

Appendix D

Qualifications, Growth Levels, Proficiencies, and Professional Leadership Responsibilities for the Practice of Engineering – NSPE / ASCE

Engineer IX

Equivalent Federal General Schedule Grade
Senior Executive Service (GS - 16, 17, 18)

General Characteristics. An engineer in this level is either: 1) in charge of programs so extensive and complex as to require staff and resources of sizable magnitude (e.g., research and development, a department of government responsible for extensive engineering programs, or the major components of an organization responsible for the engineering required to meet the objectives of the organization); or 2) is an individual researcher or consultant who is recognized as a national and/or international authority and leader in an area of engineering or scientific interest and investigation.

Typical Position Titles. Director of Engineering, General Manager, Vice President, President, Partner, Dean, Director of Public Works

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer VIII

Equivalent Federal General Schedule Grade
(GS-15)

General Characteristics. Make decisions and recommendations that are recognized as authoritative and have a far-reaching impact on extensive engineering and related activities of the company. Negotiates critical and controversial issues with top-level engineers and officers of other organizations and companies. Individuals at this level demonstrate a high degree of creativity, foresight, and mature judgment in planning, organizing and guiding extensive engineering programs and activities of outstanding novelty and importance.

Direction Received. Receives general administrative direction

Typical Duties & Responsibilities. One or both of the following: 1) In a supervisory capacity is responsible for a) an important segment of a very extensive and highly diversified engineering program, or b) the entire engineering program when the program is of moderate scope. The programs are of such complexity that they are of critical importance to overall objectives, include problems of extraordinary difficulty that often have resisted solution and consist of several segments requiring subordinate supervisors. Is responsible for deciding the kind and extent of engineering and related programs needed for accomplishing the objectives of the organization, for choosing the scientific approaches, for planning and organizing facilities and programs, and for interpreting results; 2) As individual researcher and consultant, formulates and guides the attack on problems of exceptional difficulty and marked importance to the organization or industry. Problems are characterized by their lack of scientific precedents and source material, or lack of success of prior research and analysis so that their solution would represent an advance of great significance and importance. Performs advisory and consulting work for the organization as a recognized authority for broad program areas or in an intensely specialized area of considerable novelty and importance.

Responsibility For Direction of Others. Supervises several subordinate supervisors or team leaders, some of whose positions are comparable to Engineer VII, or individual researchers some who whose positions are comparable to Engineer VII. As an individual researcher and consultant may be assisted on individual projects with other engineers and technicians.

Typical Position Titles. Chief Engineer, Bureau Engineer, Director of Research, Department Head or Dean, County Engineer, City Engineer, Director of Public Works, Senior Fellow, Senior Staff, Senior Advisor, Senior Consultant, Engineering Manager.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer VII

Equivalent Federal General Schedule Grade
(GS-14)

General Characteristics. Make decisions and recommendations that are recognized as authoritative and have an important impact on extensive engineering activities. Initiates and maintains extensive contacts with key engineers and officials of other organizations and companies, requiring skill in persuasion and negotiation of critical issues. At this level individuals will have demonstrated creativity, foresight, and mature engineering judgment in anticipating and solving unprecedented engineering problems, determining program objectives and requirements, organizing programs and projects, and developing standards and guides for diverse engineering activities.

Direction Received. Supervision received is essentially administrative with assignments given in terms of broad general objectives and limits.

Typical Duties & Responsibilities. One or both of the following: 1) in a supervisory capacity is responsible for a) an important segment of the engineering program of an organization with extensive and diversified engineering requirements, or b) the entire engineering program of an organization when it is more limited in scope. The overall engineering program contains critical problems the solution of which requires major technological advances and opens the way for extensive related development. The extent of responsibilities generally requires several subordinate organizational segments or teams. Recommends facilities, personnel, and funds required to carry out programs which are directly related with and directed toward fulfillment of overall organization objectives; 2) As individual researcher and consultant is a recognized leader and authority in the organization in a broad area of specialization or in a narrow but intensely specialized field. Selects research problems to further the organization's objectives. Conceives and plans investigations of broad areas of considerable novelty and importance for which engineering precedents are lacking in areas critical to the overall engineering program. Is consulted extensively by associates and others with a high degree of reliance placed on the scientific interpretations and advice. Typically, will have contributed inventions, new designs, or techniques which are regarded as major advances in the field.

Responsibility For Direction of Others. Directs several subordinate supervisors or team leaders, some of whom are in a position comparable to Engineer VI, or as individual researcher and consultant, may be assisted on individual projects by other engineers and technicians.

Typical Position Titles. Principal Engineer, Division or District Engineer, Department Manager, Director or Assistant Director of Research, Consultant, professor, Distinguished Professor or Department Head, Assistant Chief or Chief Engineer, City or County Engineer.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status, Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer VI

Equivalent Federal General Schedule Grade
(GS-13)

General Characteristics. Has full technical responsibility for interpreting, organizing, executing, and coordinating assignments. Plans and develops engineering projects concerned with unique or controversial problems which have an important effect on major organization programs. This involves exploration of subject area, definition of scope and selection of problems for investigation and development of novel concepts and approaches. Maintains Liaison with individuals and units within or outside the organization with responsibility for acting independently on technical matters pertaining to the field. Work at this level usually requires extensive progressive experience.

Direction Received. Supervision received is essentially administrative, with assignments given in terms of broad general objectives and limits.

Typical Duties & Responsibilities. One or more of the following: 1) in a supervisory capacity a) plans, develops, coordinates, and directs a number of large and important projects or a project of major scope and importance; or b) is responsible for the entire engineering program of an organization when the program is of limited complexity and scope. The extent of his or her responsibilities generally requires a few (3 to 5) subordinate supervisors or team leaders with at least one in a position comparable to level V; 2) As individual researcher or worker conceives, plans and conducts research in problem areas of considerable scope and complexity. The problems must be approached through a series of complete and conceptually related studies, are difficult to define, require unconventional or novel approaches, and require sophisticated research techniques. Available guides and precedents contain critical gaps, are only partially related to the problem or may be largely lacking due to the novel character of the project. At this level, the individual researcher generally will have contributed inventions, new designs, or techniques which are of material significance in the solution of important problems; 3) As a staff specialist serves as the technical specialist for the organization (division or company) in the application of advanced theories, concepts, principles, and processes for an assigned area of responsibility (i.e. subject matter, function, type of facility or equipment, or product). Keeps abreast of new scientific methods and developments affecting the organization for the purpose of recommending changes in emphasis of programs or new programs warranted by such developments.

Responsibility For Direction of Others. Plans, organizes, and supervises the work of a staff of engineers and technicians. Evaluates progress of the staff and results obtained and recommend major changes to achieve overall objectives. Or, as individual research or staff specialist may be assisted on individual projects by other engineers or technicians.

Typical Position Titles. Senior or Principal Engineer, Division or District Engineer, Production Engineer, Assistant Division, District or Chief Engineer, Consultant, Professor, City or County Engineer.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade).Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer V

Equivalent Federal General Schedule Grade
(GS-12)

General Characteristics. Applies intensive and diversified knowledge of engineering principles and practices in broad areas of assignments and related fields. Make decisions independently on engineering problems and methods, and represents the organization in conferences to resolve important questions and to plan and coordinate work. Requires the use of advanced techniques and the modifications and extension of theories, precepts and practices of the field and related sciences and disciplines. The knowledge and expertise required for this level of work usually result from progressive experience.

Direction Received. Supervision and guidance relate largely to overall objectives, critical issues, new concepts, and policy matters. Consults with supervisor concerning unusual problems and developments.

Typical Duties & Responsibilities. One or more of the following: 1) In a supervisory capacity, plans, develops, coordinates, and directs a large and important engineering project or a number of a small projects with many complex features. A substantial portion of the work supervised is comparable to that described for engineer IV; 2) As individual researcher or worker, carries out complex or novel assignments requiring the development of new or improved techniques and procedures. Work is expected to result in the development of new or improved techniques and procedures. Work is expected to result in the development of new or refined equipment, materials, processes, products, and/or scientific methods; 3) As staff specialist, develops and evaluates plans and criteria for a variety of projects and activities to be carried out by others. Assesses the feasibility and soundness of proposed engineering evaluation tests, products, or equipment when necessary data are insufficient or confirmation by testing is advisable. Usually performs as a staff advisor and consultant as to a technical specialty, a type of facility or equipment, or a program function.

Responsibility For Direction of Others. Supervises, coordinates, and reviews the work of a small staff of engineers and technicians, estimates personnel needs and schedules and assigns work to meet completion date. Or, as individual researcher or staff specialist may be assisted on projects by other engineers or technicians.

Typical Position Titles. Senior or Principal Engineer: Resident, Project, Office, Design, Process, Research, Ass't Division Engineer, Associate Professor, Project Leader.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Member Grade); Publishes engineering papers, articles, textbooks

Engineer IV

Equivalent Federal General Schedule Grade
(GS-11)

General Characteristics. As a fully competent engineer in all conventional aspects of the subject matter of the functional area of the assignments, plans and conducts work requiring judgment in the independent evaluation, selection, and substantial adaptation and modification of standard techniques, procedures, and criteria. Devises new approaches to problems encountered. Requires sufficient professional experience to assure competence as a fully trained worker, or, for positions primarily of a research nature, completion of all requirements for a doctoral degree may be substituted for experience.

Direction Received. Independently performs most assignments with instructions as to the general results expected. Receives technical guidance on unusual or complex problems and supervisory approval on proposed plans for projects.

Typical Duties & Responsibilities. Plans, schedules, conducts, or coordinates detailed phases of the engineering work in a part of a major project or in a total project of moderate scope. Performs work which involves conventional engineering practice but may include a variety of complex features such as conflicting design requirements, unsuitability of conventional materials, and difficult coordination requirements. Work requires a broad knowledge of precedents in the specialty area and a good knowledge of and practices of related specialties.

Responsibility For Direction of Others. May supervise or coordinate the work of engineers, drafters, technicians, and others who assist in specific assignments.

Typical Position Titles. Engineer or Assistant Engineer, Resident, Project, Plant, Office, Design, Process, Research, Chief Inspector, Assistant Professor.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Member Grade), Member of Technical Societies (Associate Grade or Equivalent)/Member of Technical Societies (Member Grade); Publishes engineering papers, articles, text books

Engineer III

Equivalent Federal General Schedule Grade
(GS-9)

General Characteristics. Independently evaluates, selects, and applies standard engineering techniques, procedures, and criteria, using judgment in making minor adaptations and modifications. Assignments have clear and specified objectives and require the investigation of a limited number of variables. Performance at this level requires developmental experience in a professional position or equivalent graduate level education.

Direction Received. Receives instructions on specific assignment objectives, complex features, and possible solutions. Assistance is furnished on unusual problems and work is reviewed for application of sound professional judgment.

Typical Duties & Responsibilities. Performs work which involves conventional types of plans, investigations, surveys, structures, or equipment with relatively few complex features for which there are precedents. Assignments usually include one or more of the following: Equipment design and development, test of materials, preparation of specifications, process study, research investigations, report preparation, and other activities of limited scope requiring knowledge of principles and techniques commonly employed in the specific narrow area of assignments.

Responsibility For Direction of Others. May supervise or coordinate the work of drafters, technicians, and others who assist in specific assignments.

Typical Position Titles. Engineer or Assistant Engineer, Project, Plant, Office, Design, Process, Research Chief Inspector, Assistant Professor

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Certified Engineer Intern/Licensed Professional Engineer

Typical Professional Attainments. Member of Professional Society (Associate Grade/Member Grade), Member of Technical Societies (Associate Grade or Equivalent)

Engineer I/II

Equivalent Federal General Schedule Grade
(GS- 5, 7)

General Characteristics. This is the entry level for professional work. Performs assignments designed to develop professional works knowledge and abilities, requiring application of standard techniques, procedures, and criteria in carrying out a sequence of related engineering tasks. Limited exercise of judgment is required on details of work and in making preliminary selections and adaptations of engineering alternatives.

Direction Received. Supervisor screens assignments for unusual or difficult problems and selects techniques and procedures to be applied on non-routine work. Receives close supervision on new aspects of assignments.

Typical Duties & Responsibilities. Using prescribed methods, performs specific and limited portions of a broader assignment of an experienced engineer. Applies standard practices and techniques in specific situations, adjusts and correlates data, recognizes discrepancies in results, and follows operations through a series of related detailed steps or processes.

Responsibility For Direction of Others. May be assisted by a few aides or technicians.

Typical Position Titles. Junior Engineer, Associate Detail Engineer, Engineer-in-Training, Ass't Research Engineer, Construction Inspector.

Education. Bachelor's Degree in engineering from an ABET accredited curriculum, or equivalent, plus appropriate continuing education.

Licensure Status. Certified Engineer Intern/Engineering-In-Training

Typical Professional Attainments. Member of Professional Society (Associate Grade), Member of Technical Societies (Associate Grade or Equivalent)