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COMING OF AGE

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SUMMARY

This paper reviews the history and development of fire protection engineering from the late 1800's to the current day. The author discusses origins of the Society of Fire Protection Engineers and its role in defining the discipline. Future challenges facing the profession are presented. These include technical and liability issues surrounding new engineering methods, professional engineering registration and the increasing importance of fire protection engineering education.

The 1980's may well be recorded as the decade fire protection engineering made the most dramatic progress in its evolution as an engineering discipline. One of the great milestones of this period was inauguration of the SFPE's *Journal of Fire Protection Engineering* in early 1989. This first-of-its-kind journal will serve as a vehicle for authors to present their ideas to the fire protection engineering community after critical review by knowledgeable peers. And it will serve as a credible record of the technology as it unfolds into the future.

It seems fitting that an early issue of the *Journal* should record some of the historical underpinnings of the profession and its professional society. Part I of this paper presents an historical backdrop to development of fire protection engineering in the United States. Part II reviews the strengths and weaknesses of fire protection engineering as we know it today. And Part III discusses future challenges to be faced during this time when the profession is coming of age.

PART I - HISTORICAL BACKGROUND

It goes without saying that engineers have had much to do with the world being the way it is today. Up until the early 1700's, life centered on an agrarian society with its work being accomplished from the natural power of animals, people, wind and open channel flow of water. Commercial enterprise was supported by simple tools used by craftsmen and farmers.

In the latter part of the 18th century, Scottish engineer James Watt made one of the great inventions that would cause rapid and irreversible change throughout the civilized world. His development of the first practical steam engine unleashed an entire frontier of industrialization. Mastery of steam power, coupled with breakthroughs in how to use the plentiful supply of coal to produce iron and steel, set the stage for the Industrial Revolution. And, little did James Watt know, triggering of the Industrial Revolution would plant seeds for development of the fire protection engineering discipline.

It wasn't long before the Industrial Revolution spread to North America in the early 19th century. Entire new cultural, commercial and industrial centers sprang up throughout the United States, linked together by previously unimagined transportation capabilities – steam locomotives, steamships, bridges, locks and canals. Along with this, of course, came large mills and manufacturing facilities and an entire new financial infrastructure of banking and insurance.

Little did public officials, industrialists or financiers know that these new centers of commerce and industry were being built with all the ingredients for self-destruction. During this period of unbridled industrial development, major urban conflagrations occurred in numbers of American cities ranging from New York to Seattle to Charleston. The Great Chicago Fire alone (1871) destroyed 17,430 buildings, killed 300, left 90,000 homeless and wiped out an entire world market center for grain, livestock and lumber. Insurance company bankruptcies resulting from these catastrophies were common.

Obviously something had to be done and, as might be expected, the engineers of the day rose to the challenge. Many of what are commonly known today as great institutions of fire protection were established during this era.

According to Bugbee*[1], the idea of preventing and controlling fires by an "intelligent engineering approach" originated in the northeastern United States early in the 19th century. Among the prime movers were Edward Atkinson, leader in development of what we know today as the Factory Mutual System and John B. Francis, Chief Engineer of the Locks and Canal Company of Lowell, Massachusetts. Francis, known then as the "father of hydraulic engineering", developed early concepts of industrial yard mains and hydrants, watchman service and private fire brigades for protection of mill properties. Interestingly, both fire protection engineering pioneers played a key role in making the case for creating Massachusetts Institute of Technology, testifying to the Massachusetts state legislature that fire waste due to lack of applied science was, in itself, more than justification for creating this proposed institution of technology. Both served on MIT's governing corporation for many years.

Factory Mutual Laboratories was organized in 1886 by Charles J. H. Woodbury, regarded by some to be the first fire protection engineer (MIT Class of 1873). John R. Freeman (MIT Class of 1876), another fire protection engineering pioneer and a product of the Factory Mutual Laboratories, won a gold medal from the American Society of Civil Engineers (ASCE) for his landmark work in fire protection hydraulics. Freeman later served as president of both ASCE and the American Society of Mechanical Engineers (ASME) and was cited by President Herbert Hoover as "the foremost of American engineers".

William H. Merrill, a young engineer of the late 19th century (MIT, 1889), did pioneering work in electrical safety, most notably in connection with the 1893 Chicago World's Fair. Merrill later founded Underwriters Laboratories (1894) for the fire testing of devices and materials. The first laboratory facility was set up on the second floor of a fire station in the City of Chicago.

Influenced by the work of Freeman and Frederick Grinnell (a pioneer in fire sprinkler system design) other leaders of the day determined to create the National Fire Protection Association (1896) to bring together viewpoints and..."if possible, an agreement in general principles governing fire protection".

In 1903, academia formally joined the ranks of institutions attacking the American fire problem. At that time, Chicago's Armour Institute of Technology (now IIT) created the first baccalaureate degree program in fire protection engineering, with support from Underwriters Laboratories. Joseph D. Finnegan, a chemical engineer graduate of MIT, served as the early long-term department head at Armour for 30 years until he was succeeded by John T. Ahern in 1946. The Armour program received a substantial boost in the 1920's with 25 annual four year scholarships from the stock insurance industry...worth well over $300,000 per year in today's economy.

In 1924, NFPA's Robert S. Moulton proposed the idea of a special NFPA section for fire protection engineers...the unsuccessful attempt received "lukewarm" reception at the time.

Again, in 1937, inspired by a paper given by Professor Finnegan at the NFPA Annual Meeting, Charles H. Fischer proposed creation of a fire protection engineering focus within NFPA. The NFPA Board of Directors found the matter "inexpedient to advance at the present time". However, in response to a growing interest and concern, the NFPA did create a Committee on Fire Protection Engineering in 1939, for the purpose of "promoting instruction

* *Most of the historical information in this part of the paper was abstracted from "A Brief History of the Society of Fire Protection Engineers" by Percy Bugbee (SFPE 1975), with permission from the author. Mr. Bugbee's original contribution to documenting the history of SFPE and his permission to abstract his work are gratefully acknowledged.*

in fire protection in universities, colleges and technical schools".

The time for creation of a fire protection engineering professional society was near at hand in 1948 when NFPA President John L. Wilds appointed a special committee "to consider the professional status of fire protection engineering...". IIT's Professor Ahern was appointed Chairman. On December 7, 1948, Ahern' s committee met in Chicago and voted to recommend that NFPA sponsor "an American Society of Fire Protection Engineers" for the purpose of certifying members as to their proficiency and developing minimum standards which will be acceptable to the National Council of State Boards of Engineering Examiners". After considerable work on the part of the Committee and NFPA staff, on July 17, 1950, the NFPA Board voted to implement the concepts presented by Ahern.

The provisional organization was completed in October 1950 with John J. Ahern elected president. Membership in the Society of Fire Protection Engineers was limited to NFPA members.

At the first SFPE Annual Meeting held in Detroit, Michigan (May, 1951) President Ahern set the tone with his eloquent address...

> "Modern science and technology have bestowed on us the highest standard of living in the history of mankind but with these benefits we have also received a challenge to be able to use the most concentrated sources of heat and power ever available to the world without destroying our fellow men. It is a real challenge that calls for the best in us to keep abreast of the scientific developments and to enable our fellow citizens to participate to the fullest extent in the benefits of modern technology without suffering horrible death or disfigurement as a result of fire."

> "Not for one moment do we believe the mere organization of such a Society (SFPE) will gain respect for fire protection engineers. We must earn that respect. You do not legislate respect. We will receive only the respect we have earned."

> "This Society, with your active participation and help will be a real asset to the fire protection field and will focus attention on the vital part which the fire protection engineer plays in our national life."

As pointed out by Bugbee[1], in May 1951, the Society of Fire Protection Engineers was finally "on its way". And it wasn't long before the Society began to spread its wings.

The first local chapter was chartered in 1953, in Chicago. By 1958 there were eight local chapters, membership stood at about 1,000 and the Northern California-Nevada Chapter was already pushing to have SFPE become autonomous from NFPA. Later, in 1967, SFPE President Joseph E. Johnson addressed the Annual Meeting with the view that "...the time has now arrived for a change in our relationship with NFPA". And the Executive Committee set to work to develop an orderly and friendly separation of SFPE from NFPA.

After several years of additional planning and committee work, the Society of Fire Protection Engineers was incorporated as an independent professional society on February 10, 1971. Less than a year later, D. Peter Lund was employed as the Society's first full-time Executive Director. At that time, the society had 21 local Chapters and membership stood at 1,438.

It is doubtful that Edward Atkinson and John Francis foresaw the emergence of a fire protection engineering discipline when they were using applied fire science arguments for creation of MIT in the 1860's. And it is likewise probable that John R. Freeman, engineering gold medal winner and former President of ASCE and ASME, would not have imagined he would be regarded as one of the early, great fire protection engineers as we know the concept today. While fire protection engineering has made great progress, it should also be borne in mind that the discipline started generations behind other more traditional engineering fields. When SFPE was holding its second Annual Meeting in Chicago in 1952, ASCE was celebrating its 100th anniversary!

PART II - CURRENT STATUS

SFPE now stands with a membership of over 3,200 and 40 local Chapters in the United States, Canada, Europe and Australia. The actual total number of practicing fire protection engineers (including non-SFPE members) is not known, but may well exceed 6,000. In the 18 years since SFPE's independence, enormous progress has been made in the Society, the profession and its underlying base of science. It would be useful to chronicle this progress against the key components of a "profession" as described by IIT President H. T. Heald at the first Annual Meeting of SFPE. Dr. Heald's description of what constitutes a profession or "discipline" can be condensed as follows:

(1) Body of knowledge.
(2) Strong motive of service over profit.
(3) Qualification in individual competency and character.
(4) Education.
(5) Recognition of status (including licensing).
(6) Assuring the public of member competence.

Some of these attributes are within the short range control of the profession. For example, the SFPE can monitor the competency and character of its members through its membership criteria; the Society's Qualifications Board has always taken this charge very seriously and is one of the hardest working elements of SFPE. Society membership criteria are quite in concert with those used by other disciplines. Self-imposed standards of quality, along with a contemporary code of professional ethics, help assure the public of competent and honorable service (SFPE's current Canons of Ethics were adopted in May, 1984, based on the model published by the American Association of Engineering Societies).

Other of Dr. Heald's characteristics of a profession are not within short range control of fire protection engineers; they are heavily influenced or controlled by others and/or require more extensive time and resources for achievement. And, yes, some require generous measures of diplomacy. The following will discuss three of these more elusive but fundamentally important aspects of a profession: (1) body of knowledge; (2) professional registration; (3) education. The three are, of course, interrelated.

Body of Knowledge

While all engineering disciplines have common roots in the sciences, over the span of time discrete theories and practices have emerged where specialization is needed to effectively solve the engineering problems of the day. As pointed out in 1965 by SFPE President Joseph Johnson [2]

> "Industrialization, with its need for greater scientific and technical knowledge, was the birthright of specialization. The scope of engineering grew – expanding to the extent that engineers organized and sub-divided into chosen fields".

The "body of knowledge" distinguishes accountants from architects; and it establishes practical differences between engineering specialties. The knowledge required to practice each profession differs from discipline to discipline.

Where does one find the fire protection engineer's body of knowledge? Certainly, a survey of what is actually used in the practicing fire protection engineer's office today would yield a variety of references including:

- NFPA codes and standards
- Insurance industry guides, practices and data sheets
- *SFPE Handbook of Fire Protection Engineering*
- *NFPA Fire Protection Handbook*
- Proprietary fire protection systems design guides
- Test Standards (UL, ASTM, ISO)
- Research reports (NBS, FM, UL,

FRS, NRL)

- *Fire Technology, Journal of Fire Protection Engineering, Fire Journal, Fire Safety Journal*
- Model building codes (BOCA, ICBO, SBCC)

Published documentation supporting the fire protection engineer covers a fairly wide spectrum in terms of engineering rigor and utility. Some journal articles and research reports are peer reviewed and based on highly rigorous theoretical derivations, testing and verification, but are not found in the day-to-day reference library of practicing engineers. This is for several reasons. Many research papers are published by researchers, mainly for reading by other researchers. The papers are not necessarily written in engineering practice terms; indeed, often the concepts being presented are not yet ready to become widespread "accepted engineering practice".

In other cases, state-of-the-art publications are not used on a daily basis because the techniques described in them are too time consuming for the engineer who is facing project deadlines, tight budgets or production quotas. Or, in some cases, the engineer may view new techniques described in the research papers and reports as "too risky". He or she may be unwilling to base engineering design on methods which have not yet become widely accepted in practice or have not been endorsed/verified by nationally or internationally respected authorities.

Other technical fire publications are widely used in the fire protection engineer's office on a daily basis. These would be expected to include national and internationally recognized model codes and standards such as those promulgated by NFPA, the *NFPA Fire Protection Handbook* and model building codes. Many of these reference documents are written for a wide range of users, many of whom are not engineers. While one might hold the opinion that many of these standards and references should be used with sound fire protection engineering judgment, the fact remains that they are also written for and widely used by non-engineers.

In the more established engineering fields, one would find volumes of knowledge used almost exclusively by each discrete discipline. For example, the common day-to-day techniques for structural analysis would be published in documents mainly written for use by engineers. Rarely would these techniques be used by non-engineers without direct supervision.

And so, if a discrete body of knowledge is one of the key parts of a profession as suggested by Dr. Heald, where does fire protection engineering really stand today? The answer probably is "somewhere in between"... well beyond where we started and some distance from where we will ultimately arrive!

Without question, the body of knowledge supporting fire protection engineering has grown enormously. NFPA now publishes 260 codes, standards, recommended practices, manuals and guides written by as many technical committees; NFPA committee membership totals some 4,000 engineers and non-engineers. The principal U.S. repository of technical and scientific fire literature at the National Institute of Standards and Technology (NIST - formerly National Bureau of Standards) has grown from a limited collection in the early 1970's to current holdings of some 33,000 titles.

Much of the body of knowledge has not yet found its way to the fire protection engineer's daily practice; much is not published primarily for use by engineers. It's probably safe to say that, at the current time, most of the published references used in current practice are not discrete to the fire protection engineering discipline...they're used by persons with a range of technical and non-technical backgrounds.

Professional Registration

Professional registration is one of the cornerstones of a credible engineering discipline. It is the most commonly recognized method for measuring competency among all the disciplines and it is the basis for state government regulation of engineering practice. This is also one of the elements of the profession that is outside the short range control of SFPE and its members.

It is no easy task for a "new" engineering discipline to enter into the professional engineering registration mainstream. First, the overall operation of national and state-wide professional engineering registration programs is dominated by the founder disciplines; these more mature disciplines might understandably be viewed as "conservative" in protecting the quality and credibility that has been established in the engineering field for well over a century. It was fundamentally necessary for fire protection engineers to prove themselves among the other disciplines and for SFPE to become a "trusted player" in the broader engineering community. (This is the context for the word "status" as used by Dr. Heald in 1951 and for the idea of earning respect offered earlier by Ahern).

In addition to the challenge of being accepted among engineering peers, other long-range challenges are outside the direct control of fire protection engineers. Most prominent is the fact that decisions to offer professional engineering registration examinations are made by the independent state boards of registration. Each state must be convinced of the need for offering examinations in fire protection engineering.

Fire protection engineers in the United States have made remarkable progress in this area of developing a true engineering discipline. In the 1970's, it was virtually impossible for a fire protection engineer to find a state registration board which would administer the fire protection engineering professional practice examination. Today, the National Council of Engineering Examiners (NCEE) offers national examinations in fire protection engineering, currently utilized by 32 state boards. Given the many obstacles to this kind of progress, these are indeed impressive results. And, they were made possible by the collective efforts of practitioners through the Society of Fire Protection Engineers; through regular participation in NCEE; and through untiring efforts of the SFPE Engineering Registration Committee and volunteer examination problem writers and graders.

The progress made in this area would not have been possible without the fire protection engineering discipline becoming "one of the players". The National Council of Engineering Examiners supports engineering registration examinations for 14 disciplines including the founder disciplines and about 10 "non-traditional" fields like fire protection engineering, petroleum engineering, and ceramic engineering. Fire protection engineers have emerged as vigorous participants in the non-traditional area. These and other activities in the broader engineering community are essential to gaining needed recognition and positioning fire protection engineers to hold professional status.

Finally, and relatively new on the fire protection scene, are certification programs for engineering technicians and engineering technologists. These certified personnel are part of the overall technical analysis and design team working under supervision of professional engineers. In the U.S., certification examinations are administered by the National Institute for Certification in Engineering Technologies (NICET), sponsored by the National Society of Professional Engineers. In recent years, with leadership from individual SFPE members, national fire protection engineering technology examinations were developed for the subfields of automatic sprinkler system layout, fire alarm systems and special hazards systems layout. Again, this is an area where the fire protection engineer has played a role in the mainstream of professional recognition. Already, there are more certified engineering technicians and technologists in the fire area than there are registered professional engineer members of SFPE.

Overall, fire protection engineers have made remarkable progress in the professional registration arena, given so many factors outside short-term direct control.

Education

Education is, of course, the foundation of any profession...and is another key attribute underscored by IIT President Heald at the first Annual Meeting of SFPE. Good progress has definitely been made in the continuing education arena, due in no small measure to the ongoing efforts of SFPE's Engineering Education

Committee. But, traditionally, it has been the formal engineering degree programs that have been the bedrock of the professions. If we were to look to the founder disciplines as role models, we would observe:

Undergraduate programs, offering degrees in the discrete discipline, teaching knowledge of engineering principles and state-of-the-art practices to young men and women who are entering the job market or going on to graduate study.

Master's programs, offering graduate degrees in the discrete discipline, training practitioners for the job market and in preparation for doctoral work. Graduate students also serve as a pool of workers to help professors with their teaching and research, contributing to the body of knowledge.

Doctoral programs, offering degrees in the discrete discipline; preparing highly specialized expertise for industry and creating a pipeline of qualified personnel to serve as faculty; doctoral students also help professors with their teaching and research, making major contributions to the body of knowledge.

College and university faculty, with doctoral degrees in the discrete discipline, teaching future practitioners, doing important research to add to the body of knowledge and writing definitive textbooks.

The milestones in fire protection engineering education are as follows:

1903 Illinois Institute of Technology started bachelor of science program in fire protection engineering. Terminated in 1982. Master's program started in 1982. Terminated 1986.

1937 Oklahoma State University started degree program in fire protection. Now operates as a 4-year bachelor's degree program in fire protection and safety technology.

1956 University of Maryland started bachelor of science degree program in fire protection engineering.

1973 University of Edinburgh, Scotland, created master of science program in fire safety engineering. Terminated in 1983 .

1979 Worcester Polytechnic Institute started master's degree program in fire protection engineering.

While noteworthy accomplishments have been made in building this aspect of the fire protection engineering profession, progress has been unsteady compared to other areas of development. As noted above, four schools started fire protection engineering degree programs since 1903; half decided to terminate their FPE curricula in the past six years. The probable reasons for this halting progress are many including economics, supply and demand issues and the state-of-the-art itself. The absence of an effective pipeline to supply advanced-degree fire protection engineering faculty has definitely been a factor; and there has been a serious shortage in fire protection engineering textbooks.

The economics of higher education are generally well known; overall, tuition income alone usually only covers a part of the university's operating budget. The smaller academic departments, like fire protection engineering, may lack critical mass and can be viewed as more costly in terms of the resources required to educate each student. This means that financial support by industry and government is critical to FPE curricula, particularly for private universities which are not tax subsidized. In a climate of increasing costs and declines in overall engineering enrollments, smaller, non-traditional departments can be open targets for university budget cutters.

In addition to philanthropic support, research grants have several positive effects on FPE higher education. First, of course, the primary purpose of the research grant is to add to the body of knowledge...which helps all academic programs. Second, the financial investment itself helps build critical mass in the academic department, financially supports students and faculty and helps the school justify investment in laboratories, instruments and other educational facilities. Finally, research investments by government and industry play a vital role in sponsoring faculty development. Faculty development may be the single most critical issue facing the future of fire protection engineering education.

In today's academic environment, the doctoral degree is important to faculty promotion in the ranks – from assistant professor to associate professor to full professor; and this is important to earning tenure as well. Typically young men and women who are headed for engineering faculty careers first earn their BS degree in the discipline, then their master's and finally the doctorate. This covers a time period of about 10 years of higher education. The doctoral dissertation is typically based on scholarly research in the field, financially supported by government or industry.

Unfortunately, in fire protection engineering there has not been adequate opportunity for this faculty development scenario to take hold. There has not been a generally recognized opportunity for young men and women to make an early career commitment to fire protection engineering and progressively build scholarly capability with a BS degree in fire protection engineering, then a master's in fire protection engineering and, finally, a doctorate in the same field.

This problem compounds itself from the research investment viewpoint. While the availability of fire research funding has been declining somewhat, millions of dollars have been granted to American engineering professors and their graduate students over the past 10 to 15 years. However, due in part to the absence of a strong family of FPE curricula at the graduate level, most of these investments have gone to non-fire protection engineering departments. For example, of some 18 NIST grants to American universities described in the Center for Fire Research grant summaries for 1987[3] all went to departments of mechanical engineering or other non-fire protection engineering disciplines. Had a greater portion of these and other research investments been made in fire protection engineering departments, supporting faculty and students who made early career committments to fire protection engineering, higher education in the field would definitely have shown stronger progress toward building the profession.

The forces of supply and demand are probably also factors which have affected the growth of fire protection engineering education. Compared to the founder disciplines, this is a "narrow market". Further, given the body of knowledge actually used in contemporary practice, a discrete fire protection engineering degree has not been required. In fact, 72 percent of SFPE members practicing fire protection engineering do not hold FPE degrees[4].

Overall, when compared to the models of the founder disciplines, perhaps fire protection engineering has made limited progress in building its educational base. But there are realistic and understandable reasons that more progress has not been made. The flag has been planted at several university campuses; growth in sophistication of the technology itself will increase the demand for specially trained fire protection engineers and for colleges and universities to train them.

PART III - FUTURE CHALLENGES

And what are the great challenges the fire protection engineering profession must face into the 21st century? The three attributes of a profession just reviewed will continue to represent the areas needing focus: the body of knowledge, registration and education.

Body of knowledge

Earlier it was suggested that a sizable body of knowledge has developed; a high percentage is published for use by non-engineers; and another sizable portion is highly technical in nature but has not yet found its way to daily engineering practice. It is the latter body of emerging technology that will serve to flesh out that which is the discipline of fire protection engineering.

The great developments between now and the early part of the 21st Century will be in areas of knowledge discretely used by fire protection engineers and generally not used by non-engineers. These areas can generally be described as "engineering methods".

Former SFPE President Harold E. Nelson has discussed the differences between the body of knowledge described as engineering methods and that of the historical system of consensus codes[5]. He indicates the consensus codes have been dominated by judgment, with credible technology input being a minor factor. He expresses the opinion that traditional consensus codes represent a relatively rigid set of requirements, the value of which is not always apparent. He concludes that "innovation, rational design and cost control are constrained and frustrated."

In contrast, Nelson observes that the opportunity now exists to undertake quantitative analyses of fire hazards and to apply sound engineering to hazard management decisions. He indicates that this change from the traditional method of consensus code writing is possible because of advances in fire science and engineering that have progressively emerged over the past two decades. Nelson describes engineering methods developed by research scientists and engineers with the aim of predicting "the course of fire, response of firesafety features, and the resulting impact on people, property and productive missions". He notes that

> "...there is an emerging fire protection engineering technology with the power to evaluate firesafety performance of a building or other facility that may differ widely from current prescriptions of traditional building code requirements".

The idea of predicting with reasonable certainty how fires will develop and how fire protection systems will perform is similar to the second generation techniques of other disciplines. For example, while in the early days structural support systems may have been sized based on judgment, experience and empirical evidence, today's structural engineers can mathematically simulate dead loads and static and dynamic live loads and calculate structural frame performance with reasonable confidence.

There literally has developed a logjam of new fire technology, waiting to find its way to the engineer's daily practice. As described earlier, the NIST collection of technical and scientific fire literature grew from a limited collection in the early 1970's to its current holdings of 33,000 titles. The NIST Center for Fire Research is adding new aquisitions at the rate of nearly 30 documents each week.

There now are substantial indications that contemporary engineering methods are coming closer to daily practice. Most significant is the over 800 pages of technical material found in the First Edition of the *SFPE Handbook of Fire Protection Engineering* written by over 50 experts and published in September, 1988. The handbook's Editor-in-Chief, Philip J. DiNenno, prefaces this bellweather publication with the following observations[6]:

> "Fire protection engineering is at a threshold in terms of technical development. Substantial progress has been made in developing a theoretical and analytical foundation for the profession. These scientific underpinnings have for the most part not been integrated into daily practice ... One of the primary objectives of this handbook is to facilitate the integration of theory and practice by providing this information in a readily accessible form".

This first-of-its-kind handbook covers subjects ranging from fundamentals on heat transfer and fluid mechanics to state-of-the-art applications in predicting fire development and smoke spread; the emphasis is on quantitative calculation methods.

On a limited scale, these methods are actually starting to find their way into codes and standards. For example, Appendix C of NFPA 72E "Automatic Fire Detectors"[7] allows procedures to be used to calculate detector response considering various fire growth rates, ceiling heights and other ambient conditions. This allows installed detector spacings to differ from Underwriters Laboratories (UL) listed spacings. The SFPE and ASCE are discussing development of a new national standard for calculating the fire resistance of structures ... as an alternative or complement to the traditional ASTM E-119 fire endurance test. UL is already using calculation methods to extrapolate fire endurance times between known test points[8].

The momentum of new technology cannot be denied. Just as the breakthroughs of 18th century pioneers like Scottish engineer James Watt enabled the Industrial Revolution and resulting irreversible changes in modern world culture, breakthroughs of the past 20 years in fire science have set into motion irreversible change in fire protection engineering.

At the American Association of Engineering Societies Leadership Conference in 1985, H.C. McDonald of Lawrence Livermore National Laboratory discussed how society manages risk[9]. He commented on the development of new technology and its impact on engineering practice:

> "New computer aided design, analysis, and engineering tools will allow for a new standard of reliability and performance against which all products will be judged. Also, new risk analysis algorithms that handle very large fault trees and diagrams are becoming available and the **pressure to apply them will increase independent of their validity**" (emphasis added).

McDonald concluded his remarks with the following thought concerning emerging technology:

> "...engineers will need to have global knowledge at design time because that is what they will be held ever more accountable for at trial time."

Howard W. Emmons is widely recognized as one of the founders of modern fire modeling. He may well be a current-day equivalent of James Watt in terms of unlocking entirely new technology which will have profound and irreversible effects.

Emmons has used his Harvard Computer Fire Code computer program to retrospectively model the MGM Grand Hotel fire which occurred in Las Vegas, Nevada, in 1980[10]. This disastrous fire killed some 85 people. Emmons demonstrates how the behavior of the fire could have been predicted and concludes..."It is also clear that had the present level of fire modeling been possible when the MGM Grand was built (in the early 1970's) it should have been used." This notion may eventually raise an entire range of ethics and liability issues.

As the fire protection engineering body of knowledge grows in size and sophistication, and as new engineering methods become more widely documented in the open literature, pressure to use them will increase. It will be the responsibility of the profession to evaluate these new methods and assure that only those which are of proven quality are used in engineering practice. Refereed journals, like the *Journal of Fire Protection Engineering*, will serve an ever more critical function by providing forums for critical review of technical concepts among knowledgeable peers.

As time goes along, the profession will be called upon to face a whole set of questions. Included among them:

- How will new engineering methods interface with consensus standards and model codes?
- What new liabilities will this new technology cause for SFPE and its members?
- Will SFPE become a standards-making organization with respect to engineering methods?
- What impact will new published methods have on engineering registration?

- How will the profession effectively educate practicing engineers and entry level personnel in the emerging body of knowledge?
- What financial implications will new developments have on SFPE?

Registration

While good progress has been made in professional registration, many challenges lie ahead. The basic steady-state chores of maintaining the current fire protection engineering registration program requires persistence and hard work. On-going activities must be conducted with the NCEE; and all states must be encouraged to use the NCEE examination. On-going efforts are also required by SFPE volunteers to write and grade examinations for NCEE and the respective states.

New issues will also arise. There are some schools of thought in the greater engineering community that could lead to major changes in the concept of professional engineer registration. The idea of specialty certification is being discussed in some circles. Some would propose specialty certification examinations as a substitute for professional engineer licensing. Others hold that specialty certification is needed beyond the professional engineer level. Others feel that specialty certification is "a cut below" professional engineer registration. The Board of Certified Safety Professionals is discussing the concept of a fire protection specialty certification program.

Some feel that no specialty examinations whatsoever should be provided and that all engineers should be tested and registered simply as professional engineers. These are areas that will require close monitoring and participation by fire protection engineers.

The new engineering methods discussed earlier will definitely have an impact on professional engineer registration efforts. How and when should these new engineering methods be built into professional engineer examination questions? How will examination writers decide when a new engineering method is well enough proven to constitute "accepted engineering practice"? Who will decide when the new engineering methods become "accepted"?

Professional responsibility and ethics are also part of the professional engineer registration process. Internationally known experts referenced earlier (Nelson, Emmons) have published their opinions that effective engineering methods are available now. Nelson indicates that the opportunity now exists to use engineering methods to predict the outcome of fires...with a payoff of "measured safety, innovation and cost effectiveness"[5]. Emmons effectively says computer models should be used now to give "quantitative support to the qualitative ideas that the fire protection engineer feels on the basis of experience". As these new opportunities become more widely discussed in the open literature, increased pressure will mount to use them, as earlier pointed out by McDonald[9]. Questions for the future will include...what is the burden of the practicing engineer to use these methods in addition to the tests of code compliance? What are the liabilities for non-use or misuse? What is the burden of the profession to discourage non-engineers from using these engineering tools?

Engineering registration issues for the future include:

- More of the same; persistence, participation; examination writing and grading.
- Closely monitoring specialty certification issues and having a voice in national decision making.
- Defining "accepted engineering practice"; incorporating new methods in registration examinations, when appropriate.
- Dealing with questions of professional ethics and liability.

Education

It is unfortunate that fire protection engineering education, the keystone of the profession, has suffered setbacks in the past six years. This is especially so at a time when the technology of the profession is just coming of age. As the logjam of new technology finds its way to the engineer's daily practice, the need for academic training in the field will grow at an accelerating rate. Fire protection engineering education must be a top priority for the profession, in the near term. This includes academic programs, faculty development and publication of sorely needed textbooks.

As the profession moves into the future, the problems of the past must be recognized and resolved. Every effort should be made to further strengthen and assure the long-term vitality of existing programs. A larger family of degree programs must be achieved. This includes baccalaureate curricula in fire protection engineering and engineering technology as well as master's and doctoral programs to produce practitioners, scholars and teachers of the next generation. Greater emphasis must be given to assuring financial support to fire protection engineering education and channeling research investments to the fire protection engineering academic departments.

In the U.S., issues surrounding demographics are also of serious concern to the engineering community and higher education alike. In a recent *Engineering Education* article titled "Demographics of the Engineering Student Pipeline"[11], Betty M. Vetter reports that the size of the college age population will shrink in most of the years through 1996, for a total drop of about 25 percent and then hold level through about 2005. To compound matters, the fraction of young men and women choosing engineering as a profession is also declining. Also reporting in *Engineering Education*[12], J. Ray Bowen of the University of Washington indicates that the percentage of U.S. college freshmen opting for engineering careers declined from 12 percent to 8.5 percent between 1982 and 1987.

Overall, there is no question that the pipeline of engineering manpower will shrink significantly over the next 15 to 20 years; it would be foolhardy for the fire protection engineering profession to believe it will not be affected. Aggressive efforts will be required to recruit young people into fire protection engineering careers, especially among minority and women populations which have historically been under-represented and which will be the only realistic opportunities for making up the shortfall. (Note: Vetter also reports that the Hispanic and black population is growing much faster than the white non-Hispanic population and that "sometime in the first half of the 21st century, minorities will be a majority of the U.S. population").

Finally, the continuing education of practicing engineers cannot be overlooked in the years ahead. The SFPE has long had an active and effective continuing education program, serving the needs of members and non-members alike. These needs should be expected to grow.

If new technology and engineering methods will be finding their way to engineering practice at an accelerating rate, effective continuing education programs will be essential. In addition, the expanded need to teach new concepts will be compounded by the engineering pipeline crisis mentioned above.

Thomas L. Martin, past president of Illinois Institute of Technology and chairman of a National Academy of Engineering Committee on Career Long Education for Engineers, has described a crisis in American "intellectual capital"[13]. He points out that, at a time when the U.S. most needs technological know-how to be competitive in the international marketplace, its intellectual capital is declining at an accelerating rate. He indicates this is due to the "graying" of the American technological workforce, the decreasing birth rate, the changing ethnic composition of the country and the shifts in student interests. A greater burden will emerge for "retraining" older engineers in new engineering methods in addition to other strategies for making up the engineering shortfall.

In review, major challenges for the future of fire protection engineering education include:

- Every effort must be made to strengthen and assure long-term vitality of existing degree programs.

- A larger family of degree programs must be created at BS, MS and PhD levels.
- Overall financial support to degree programs must be assured, including greater emphasis on FPE degree programs by research sponsors.
- Advanced degree FPE faculty must be developed and sorely needed textbooks written.
- A strong recruiting effort will be needed to compensate for a shrinking engineering workforce pipeline.
- The profession will have greater need for career-long learning.

SUMMARY

The concept of fire protection engineering grew out of the Industrial Revolution, in response to the need of the day. Since then, the profession has grown in size and stature. While still decades behind other disciplines, the field has made credible progress in important areas that generally serve to define a profession including its body of knowledge, professional registration and education. Of all the key areas, the profession has experienced the most difficulty in development of academic degree programs.

A substantial body of knowledge has developed over the past 15-20 years, much of which has not yet found its way to engineering practice. However, the emergence of new engineering methods is unavoidable based on research that has already been completed. This may lead to entirely different philosophical approaches to firesafety and will create entirely new issues of professional ethics and liability.

A permanent academic infrastructure must be put in place to train practitioners, perform research and produce advanced degree scholars of the next generation. This includes strengthening existing programs and expanding the family of curricula at the BS, MS, and PhD levels. Serious attention must also be given to the engineering workforce pipeline and career-long learning for practitioners.

From the standpoint of SFPE, the Society must take on new burdens in helping the profession manage this period of change. Currently operating without any technical staff, expansion of the payroll and the need to increase sources of income must also be dealt with.

As in life itself, this process of coming of age could be painful for a period of years and, at times, fraught with confusion or uncertainty. The profession must build on its past successes, find its way through this period of change and reach another plateau in its professional stature. It is hoped that this article will stimulate further discussion of these and many other issues surrounding this exciting and challenging period in the life of fire protection engineering in the U.S. and in other countries.

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