In Response to a National Need: FIRE PROTECTION ENGINEERING AT WORCESTER POLYTECHNIC INSTITUTE

By

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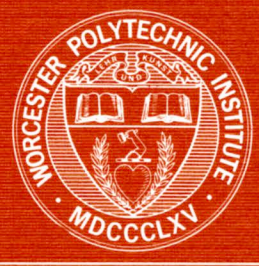

FIRE PROTECTION ENGINEERING: BACKGROUND

The notion of an engineering specialty in fire protection began to emerge in the latter part of the last century, when major conflagrations were taking place and a number of insurance companies were going bankrupt as a result. The first academic program in fire protection engineering began in 1903 at the Armour Institute of Technology (now Illinois Institute of Technology) in Chicago[1]. As in many other facets of fire protection during the era, strong support came from the insurance industry. The second baccalaureate curriculum was not started until 1956 at the University of Maryland. The first master's degree curriculum in fire protection engineering began in 1973 at the University of Edinburgh, Scotland.

In 1951, the Society of Fire Protection Engineers (SFPE) was created as a professional section of the National Fire Protection Association. In 1971, the SFPE became independent of the NFPA, serving as the professional association of fire protection engineers. Today the SFPE has a membership of over 3,000 engineers, worldwide.

Fire protection engineering is a viable engineering career specialty. The demand for fire protection engineers is substantial; students graduating from IIT and the University of Maryland commonly receive several high-paying job offers. According to SFPE surveys over the years, the demand has been about 1,000 fire protection engineers (FPEs) each year. Figure 1 illustrates the various types of employers of SFPE members. The insurance industry accounts for a major percentage of this employment, although in recent years the trend has been toward a lower percentage of insurance employers and a higher percentage of "consulting" and industrial employers.

The employment of fire protection engineers in the fire service has been fairly limited over the years, but as fire service problems become more technically oriented, the idea of using fire protection engineers in civilian positions is beginning to receive notice. In a recent article published in *Fire Engineering* magazine[2], J. Gordon Routely, fire protection engineer for the Phoenix, Arizona, Fire Department indicated a number of the values of a fire protection engineer to the public fire service, such as:

- Complex code interpretations and evaluation of "tradeoffs"
- Building department liaison
- Research and planning
- Technical aspects of fireground operations
- Special studies
- Apparatus and equipment specifications
- Data system development

As noted earlier, the job market demand for fire protection engineers has been on the order of 1,000 graduates annually. Unfortunately, the two schools which offer BS fire protection engineering degrees have only been generating on the order of 50 to 75 graduates each year. Consequently, a large percentage of practicing FPEs have

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[1]IIT is now planning to close its BS curriculum and begin a Master's Program next year.

[2]*Fire Engineering,* Volume 135, No. 4, April, 1982.

degrees in other engineering disciplines and have learned their fire protection skills on the job and through continuing education. Figure 2 illustrates the academic degrees held by practicing fire protection engineers who are members of SFPE.

Insurance	46.8%
Consulting	15.2%
Industry	14.3%
Equipment	9.7%
Government	7.5%
Education	1.7%
Other	4.8%

FIGURE 1
Fire Protection Engineering Employers
Source: SFPE Profile of the Fire Protection Engineer, August, 1982.

Fire Protection	25.2%
Mechanical	16.3%
Chemical	10.2%
Civil	14.2%
Electrical	7.3%
Industrial	5.6%
Other Engineering or Technical	12.2%
Non-Technical	9.0%

FIGURE 2
Degrees Received by FPEs
Source: SFPE Profile of the Fire Protection Engineer, August, 1982.

All state governments have engineering licensing laws by which practitioners are "registered" to practice their trades. Modern registration processes require 16 hours of examination. The first eight hours is known as the "Engineering in Training" (EIT) examination, which can be taken by college seniors. This examination tests the engineer's knowledge of engineering fundamentals.

After several years of practice, the engineer qualifies for the professional engineer, or PE, examination, which tests the engineer regarding specialty skills. After passing both these examinations and achieving an adequate number of years of experience, the engineer qualifies for the PE designation.

According to the SFPE, 49 percent of its members are registered professional engineers, a fairly high percentage compared to other engineering societies. Last year, the National Council of Engineering Examiners (NCEE) offered its first nation-wide professional FPE examination which is recognized by many states. This national examination is thought by many to be a breakthrough in the recognition of fire protection engineering as a legitimate engineering discipline.

From an academic standpoint, fire protection engineering is very much a multidisciplinary profession—a complex subject touching on many technical subject areas. Practicing fire protection engineers must be trained in the many facets of technology so that they can assist in technically sound decision making affecting the safety of people and property. Knowledgeable practitioners must have a diversity of subject matter skills, including: fluid mechanics, structural design, materials science, chemistry, physics, combustion and fire theory, physics, mathematics, statics, dynamics, electricity, mechanical systems and hydraulics. In other words, a fire protection engineer needs to know something about most of the other engineering disciplines.

In addition, the fire protection engineer commonly finds himself involved in the "softer sciences," including management, human behavior, social sciences and engineering economics. The properly trained fire protection engineer represents a wealth of knowledge which can be productive in most any firesafety decision-making process. The fire protection engineer must be articulate in these subjects and persuasive in his viewpoints, and must offer the credibility needed to be recognized as a provider of sound advice.

STATE OF THE ART

While fire protection engineering has been with us for some 80 years as an academic discipline, the state-of-the-art is decades behind other engineering specialties. Figure 3 is a subjective illustration of the growth of knowledge in the technical and scientific aspects of fire protection. This body of knowledge has grown dramatically, particularly since World War II. The National Bureau of Standards' Center for Fire Research alone has invested millions of dollars

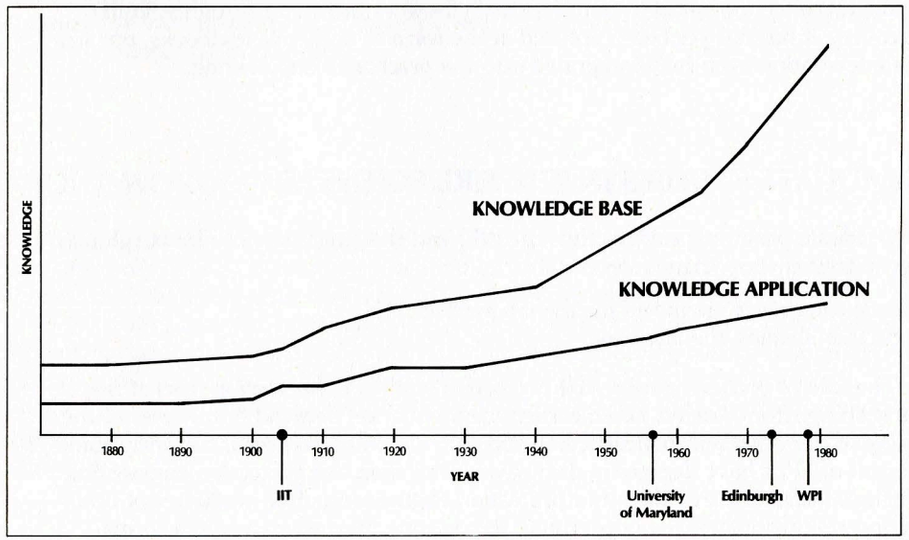

FIGURE 3

in the discovery of new knowledge relating to firesafety. Similar efforts have been taking place at Factory Mutual Research Corporation, Harvard University and other institutions worldwide.

As we learn more about fires and fire prevention and control techniques, these discoveries are normally summarized in research reports. For the most part, researchers have written their new discoveries in research papers to be read by other researchers. However, the fire protection engineer is a practitioner. Over the years, not enough has been done to convert our new information about fire into a disciplined body of knowledge for use by the practitioner. Thus, as shown in figure 3, there has been an ever widening gap between what we know about fire and its control and what we actually practice.

A most significant example illustrating the gap between knowledge and practice relates to our scientific understanding of fire behavior. A tremendous number of research papers exist on the subject. Moreover, since the turn of the century academic curricula have treated fire protection subjects at multiple levels, including four-year engineering programs, four-year engineering technology programs, two-year programs and vocational educational schools. But to my knowledge, there is nowhere a hardcover, scholarly textbook which treats the subject of fire behavior in an academic fashion. Speaking before an insurance group in Hartford, Connecticut, last February, Dr. Dougal Drysdale, of the University of Edinburgh, Scotland, compared technology transfer in fire protection to the state of science in 17th Century England, during the early days of the scientific revolution. Said Drysdale:

> New concepts and ideas were discussed at meetings of learned societies or exchanged by letter between individuals. This was the age of Isaac Newton, Robert Boyle, and Christopher Wren, a period of tremendous intellectual vitality. It was during this period that the very basics of science and engineering were established for the first time.

Fire protection engineering is at the point in its life when the intellectual foundation for the discipline is very close to achieving its "scientific revolution." Though the technological basis has virtually been established through scientific discovery, it has not yet been captured in the form of academic textbooks, nor has the information been fully integrated into the practice of engineering.

GRADUATE STUDIES IN THE FIRE SCIENCES

Graduate programs such as those at WPI and the University of Edinburgh play two extremely important roles:

- Producing more engineers for the job market.
- Further shaping the discipline.

The idea of producing more fire protection engineers for the job market is fairly straightforward. As noted earlier, the job market demand is in excess of the ability of our academic institutions to supply them. Also, as noted, currently some 75 percent of FPEs have degrees in disciplines other than fire protection engineering. Master of science curricula in fire protection engineering offer graduates of other engineering disciplines the opportunity to continue their education in a formal academic setting, thereby broadening their skills. Many of these engineers holding

degrees in other disciplines are already employed in fire protection jobs and have plans to make long-term careers in the profession. Many of them have the desire to return to school on a part-time basis to earn the MS degree. In addition, master of science curricula can serve the needs of college or university engineering seniors currently studying in one of the traditional disciplines who want to continue studying on a full-time basis in the fire-protection field.

The graduate study purpose of "strengthening the discipline" is perhaps more philosophical in nature but is even more overriding in the long term. Other professional disciplines, whether they be engineering, management, or law, have numbers of advanced degree scholars located on college and university campuses. MS and PhD scholars in the other professions are common. These scholars are usually looked upon as the leaders in their disciplines. It is these scholars who probe into the future, develop new analytical techniques, document the discipline in the form of scholarly textbooks and teach those coming up through the profession. To date, no schools of fire protection engineering have generated MS or PhD scholars, teachers or researchers. All of our advanced degree talents have come from other disciplines, such as physical chemistry, mathematics and other physical sciences.

Advanced degree curricula can play a vital role in filling the gap between scientific knowledge and practice. It is these academic scholars who potentially have the ability to read and understand the scientific literature. It is they who are close enough to the real world of practice to translate that information, record it and teach it in a form that can be digested and used by various practicing members of the fire community. In this case, it is not only fire protection engineers who are practitioners. It is common for academic institutions to not only serve the needs of the more intellectually oriented levels of practice, but the technicians and the tradesmen as well. Often, advances in scientific discovery find their way into the many levels of the trades and academic institutions play a key role in making that happen.

Fire protection engineering has reached the stage where MS and PhD fire protection engineers will soon be entering the scene. Such scholars will contribute enormously to textbook documentation of the discipline. They will, in essence, help organize the various pieces of knowledge which represent the technology. WPI is already contributing in this area.

ABOUT WORCESTER POLYTECHNIC INSTITUTE

WPI is the third oldest engineering college in the United States. At the present time, it enrolls over 3,000 students. In addition to a broad range of undergraduate studies, the Master's degree is offered in 14 disciplines and the doctorate in eight.

In 1971, WPI adopted an innovative new philosophy of engineering and scientific education, making the transition from a traditional engineering college to a modern technological university. WPI has been widely acclaimed for its student/career oriented approach. Traditional interdisciplinary barriers have been broken, opening the way to the nurturing of nontraditional disciplines such as fire protection engineering.

CENTER FOR FIRESAFETY STUDIES

The WPI Center for Firesafety Studies was formally established in 1978. The Center has three primary objectives:

- Education
- Research
- Technology Transfer

The educational objective is aimed at bringing the latest knowledge of firesafety technology to the practitioner. This objective is being met through the master of science curriculum and a series of fire-related short courses and seminars which have been held on the WPI campus since 1975.

The Center's research objective is to uncover new knowledge about fire behavior and fire prevention and control techniques. But until we have strengthened our faculty capabilities and devoted adequate attention to the educational objective, we do not anticipate extensive research activity in the short term.

Two projects are underway. Through a grant from the United States Fire Administration, WPI's Alden Research Laboratory is performing a study of residential automatic fire sprinkler systems. Professor Robert Fitzgerald is also leading a research project under a grant from the American Iron and Steel Institute. The objective of this project is to develop a design methodology for calculating the fire resistance qualities of steel frame structures. The development of this firesafety design method will enable the designer to calculate the fire endurance qualities of steel frame structures rather than relying only on destructive laboratory tests.

The technology transfer objective is aimed at interpreting research literature and translating that information in terms that a practitioner can use and understand. Currently, this objective is receiving low priority, in favor of the educational program itself.

THE WPI MSFPE PROGRAM

The master of science curriculum at WPI completed its fourth semester of operation in May 1982. We have currently enrolled over 30 fire protection engineering students who have degrees in a broad variety of disciplines in engineering and the physical sciences. Many of our students are currently employed in fire protection careers and are studying part time. All of our fire protection courses are held in the evenings to accommodate the schedules of our working students. In the Fall of 1982 we began offering a program to full-time graduate students.

Figure 4 shows the seven principle fire protection engineering courses which we are developing at the current time. For the most part, our course development efforts find us with two severe shortages:

- Books
- Teachers

By contrast, the Mechanical Engineering Department at WPI, with which we are co-located, has ample numbers of MS and PhD mechanical engineering scholars available to serve as teachers. Further, the library shelves are filled with scholarly

FIRE DYNAMICS
The physics, chemistry, and dynamics of fire behavior. Topics include fire properties of gases, liquids, and solids; heat transfer; products of combustion; fire spread; fire effects; explosions. Emphasis is placed on the dynamic aspects of fire phenomena.

RISK EVALUATION
Evaluation of risks such as those encountered in manufacturing operations, chemical production, energy production, storage, and transportation. Emphasis is placed on the assessment and management of risk.

FIRE PROTECTION SYSTEMS
The design and evaluation of systems and devices to sense, control, extinguish, or confine unwanted fire. The influence of installation, reliability, and maintenance is integrated into design decisions. Emphasis is placed on the evaluation of standards.

FIRE AND CASUALTY INSURANCE PRACTICES
Financial risk management and decision-making from an industrial-commercial management viewpoint. Insurance rate-making, adjustment, and policies as factors in making engineering-economic decisions.

FIRE PROGRAM MANAGEMENT
The management of community and private fire protection programs. Emphasis is on the assessment of needs, planning, organization, and evaluation.

ENGINEERING BUILDING FIRESAFETY
Analysis and design of buildings for firesafety using hazard analysis and incorporating specific firesafety strategies into a systems methodology. Both compartmented and non-compartmented buildings will be designed for criteria of life safety, property protection, continuity of operations, operational management, and cost.

FAILURE ANALYSIS
The reconstruction of fire incidents. Emphasis is placed on organization and techniques of scientific failure analysis including fire behavior, equipment performance, code effectiveness, and building research.

FIGURE 4
Major FPE Courses

textbooks in the various subjects of mechanical engineering. Unfortunately, in fire protection engineering, we have the luxury of neither, In a way, we are in a "chicken or egg" situation. This state-of-the-art of fire protection engineering, heretofore, has not produced advanced degree scholars in the fire sciences. Thus, the shortage of teachers. Further, it is often the advanced degree scholars at colleges and universities who write textbooks. Thus, the shortage of books. Which comes first, the curriculum that produces the scholars or the scholars that produce the curriculum and the books?

As an example of how we are trying to resolve these shortages, I would characterize our course titled Fire Dynamics as our "centerpiece course." This is the course which addresses the subject of "how fires burn."

Our approach to this course first started with a search for one of the world's leading experts in the subject. Subsequently, Dr. Dougal Drysdale of the University of Edinburgh, Scotland, was invited to WPI as a visiting professor under a grant from Connecticut General/Aetna Insurance Company, Hartford, Connecticut (now CIGNA). Dr. Drysdale arrived on the campus in January 1982. His assignment was

to teach the course "Fire Dynamics," to write the textbook on the subject, and to develop a lesson plan and required visual aids. A WPI faculty member, who is appropriately qualified, was designated an understudy to Dr. Drysdale during his visiting professorship to assist him in developing the text and the course.

At the completion of Drysdale's assignment, the course has been taught, the textbook and related materials have been developed and one of WPI's teachers is now prepared to teach the course on future offerings. With respect to this specific course, the shortage we experienced in textbooks and teachers has been principally resolved.

We plan to use a similar technique for development of many of the other major courses in our curriculum, which are in need of teachers and textbooks. For example, under grants from three other insurance companies, Dr. Robert Fitzgerald of the WPI faculty is nearing completion of another textbook on Building Firesafety Evaluation, the first of its kind ever to be written. Using this technique, we will not only solve our textbook and teacher shortages but, we believe, will also contribute to the development of the discipline itself. It is our intention to make the textbooks and related educational materials available to other colleges and universities, and to business and industry, who can make good use of them.

In the meantime, concerning those courses for which we do not have the time and the resources to write textbooks and fully attack the shortages, we subsist with textbooks borrowed from other disciplines and the use of adjunct faculty, doing the best we can with what's available.

SUMMARY

These are exciting times for the fire science and technology educator, particularly in the field of fire protection engineering. While the field has been around since the turn of the century, we are turning the corner from what had been more traditionally an art than a science to a true discipline based on engineering principles. For the most part, the technology exists. Graduate studies in the fire sciences have an important role to play in producing more practitioners for the job market, in organizing scientific knowledge in the form of textbooks, design guides and other tools of the trade, and in producing advanced-degree scholars who will help bridge the gap between scientific understanding and the work-a-day world.

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