expensive and time-consuming to keep up-to-date. The certification process should be reserved for suppliers of A-type items with respect to both criticality and dollar volume.

In addition to establishing minimum standards that every supplier must meet, certification is like a bidding process for long-term relationships. Companies use the certification process to choose the best in the class—just like they use various criteria to hire students based on grades, dean's list, and personal evaluations. Most often, the requirements for suppliers are equivalent to the company's internal standards for itself with respect to excellence in quality and reliability.

The number of suppliers chosen can vary from one to several. Often, supplier organizations that do not make the grade are encouraged to improve. Many companies help potential suppliers upgrade those capabilities on which they are rated as deficient. Accepted suppliers are regularly reviewed to make certain that they maintain their "winning" status. Thus, although certification aims at long-term relationships, it is subject to reassessment. Often, smart buyers raise acceptance standards while assisting certified suppliers to meet the new and more stringent standards.

The rating procedures include formal evaluations of price, quality, delivery time, and the ability to improve all three, and more. Suppliers' productivity improvement programs are expected to result in lower prices. Suppliers' total quality management (TQM) programs are monitored for expected improvements. ISO 9000 standards and the Baldrige Award criteria provide the foundation. Lead-time management programs track delivery time reduction. Time-based management concepts form added bases for evaluation.

The buyer's materials management information system (MMIS) has to be able to handle many suppliers and potential suppliers for hundreds and even thousands of A-type items. Who does this successfully? The list is impressive. Chrysler, Dell, Ford, General Motors, Hewlett-Packard, Honda, IBM, Motorola, Texas Instruments, Toshiba, Toyota, and UPS are only a few of the companies that have made public their use of certification programs. Certification procedures blossom with the use of the systems approach (see Enrichment Activity 12).

Spotlight 12-1 Stephanie Louise Kwolek—Inventing Kevlar

Breakthrough Discovery—Inventing Kevlar

Photo courtesy of DuPont.

When Stephanie Louise Kwolek was a little girl, she wanted to be a fashion designer. She did not know at the time that she would ultimately create body armor that would save the lives of more than 3,000 police officers. Her father was an amateur naturalist and encouraged her scientific curiosity. Later, after her father died when she was 10, she decided to become a doctor. Pursuing that plan, she studied chemistry at Pittsburgh's Carnegie Institute of Technology, now known as Carnegie-Mellon University.

When Stephanie received her Bachelor of Science degree, she accepted a research job with DuPont until she could pursue her dream of medical school. She soon discovered that she liked the work so much, with its continuing challenges and academic environment, that she decided not to leave. In 1946, she was one of a few women working in chemical research. DuPont had already commercialized nylon successfully. Dacron polyester and Lycra Spandex were in the pipeline. DuPont was eager to develop next-generation high-performance fibers.

In 1964, Ms. Kwolek made an astounding breakthrough, discovering that molecules of extended-chain aromatic polyamides would form liquid-crystalline solutions. These solutions could be spun into highly orientated, very strong, and very stiff fibers. Dupont called this new material Kevlar, well-known for its use in bulletproof vests. It is also employed in more than 200 other end-use applications, including fiber

Spotlight 12-1 (Continued)

optic cable, radial tires, brake pads (a replacement for asbestos), skis, safety helmets, mooring and bridge cables and air-water-spacecraft outer shells. Many kitchens are equipped with hot surface handlers called "Ove" Gloves™.

Kwolek has earned 28 patents in her 40-year tenure as a research scientist and received highest honors in her field. She was inducted into the National Inventors Hall of Fame in 1995 and received the National Medal of Technology in 1996. In 1997 she was presented with the Perkin Medal from the American Section of the Society of Chemical Industry. The later two awards are rarely awarded to women. She has publicly supported and encouraged young people to believe in themselves and not to fear thinking differently. She believes that the creative process can be taught to a certain extent by exposing young people to books about creative people and by meeting and talking with creative people.

Today Stephanie Kwolek sees many people entering into research with the objective of quickly getting into management after acquiring some experience. This leaves little opportunity to make discoveries, particularly ones that open a new field. Such discoveries generally take more fundamental thinking and work than just making a modification to an existing product. New foundations have to be constructed from fresh observations.

Kwolek would like to see corporations place greater emphasis on long-term research. She does not see how people can be creative if they are constantly distracted. There must be time to read, think, and keep up with the literature. In her complex field of fiber research, she was given the freedom to amass a tremendous amount of knowledge that she used in making her discoveries. Without such a knowledge base, Kwolek thinks that it would be difficult for people to make breakthrough discoveries.

Even with a deep knowledge of fiber technology, Stephanie Kwolek had to use all her intuition, perseverance, and hard work to achieve her breakthrough. The moment of discovery was exciting because it was so unexpected. She had been assigned to look for the next-generation high-performance fiber. Kwolek started working with the more intractable para-orientated aromatic polyamides, which are made up of rod-like molecules, unlike the very flexible molecules in nylon. Not only did she have to make the polymers but she also had to find a solvent for them. She finally succeeded in finding a solvent, but the solutions turned out to be unlike anything she had previously seen in the laboratory. They were cloudy, opalescent upon being stirred, and of low viscosity, making them seem like poor candidates for successful new fibers. Normally, these questionable solutions would be discarded.

To get a fiber, a polymer solution must be forced through the very tiny holes of a spinneret. The person in charge of the spinning unit refused to spin Kwolek's cloudy, low-viscosity liquid-crystalline solution. He said it would plug up the holes of his spinneret and, furthermore, it had the viscosity of water, unlike regular polymer solutions. He believed the solution was cloudy because of particulate matter. After much discussion, he did spin it, and it spun with no problems. The first sign that Kwolek really had something unusual occurred as she stood by the spinning equipment and tried to break some of the newly spun fibers. Unlike nylon, this fiber was very difficult to break by hand. At that moment, Stephanie Kwolek knew she had found an extraordinary fiber. Her discovery created an entirely different field of polymer chemistry. Dupont immediately went to work on aspects of a product that is more than five times stronger than the same weight of steel.

This story of successful breakthrough discovery highlights why serious research scientists contend that it is a management responsibility to find ways to provide incentives for people to stay in research long enough to build a body of knowledge and experience for long-term research results.

Stephanie Kwolek retired in 1986, showing the world that science is not practiced by gender. It is a human enterprise, open to all. In 2007, Stephanie Kwolek is an 84-year-old hero who is honored now and then by visiting police officers who tell her she saved their lives. She spends her time actively promoting science and science education.

Review Questions

1. What did Stephanie Louise Kwolek do that is so remarkable?
2. Who uses Kevlar, and what is unique about it?
3. Ms. Kwolek believes that research results are slowed down and impaired because many who enter research have the objective of getting into management as soon as possible. Is this likely to become a widespread problem? If so, what can be done about fixing the problem?
4. How are breakthrough discoveries different from incremental steps of invention? Who was it that said "Eureka!" to signal an unexpected breakthrough?
5. Knowledge management is crucial to breakthrough discovery. Why is this so, and what can be done to enhance support for knowledge management?

Sources: "Hall of Fame Interview: Stephanie Kwolek," by Jim Quinn, *American Heritage of Invention & Technology*, Winter 2003, Volume 18, Number 3; http://www.chemheritage.org/EducationalServices/FACES/poly/readings/slk2.htm; http://www.usatoday.com/news/nation/2007-07-04-kevlar-inventor_N.htm; http://www.chemheritage.org/classroom/chemach/plastics/kwolek.html.